Department of Economics

Urban Growth Across Three Continents : The Blessing of Human Capital and the Curse of Volatility

Steven Poelhekke

Thesis submitted for assessment with a view to obtaining the degree of
Doctor of Economics of the European University Institute

Florence, May 2008

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Jury Members:

Professor Frederick van der Ploeg, University of Oxford, (Supervisor)
Professor Giancarlo Corsetti, EUI
Professor William Strange, University of Toronto, Canada
Professor Harry Garretsen, University of Utrecht, The Netherlands

– …Alle intellectuele beroepen bestaan uit het continue verrichten van dingen die, apart genomen, heel eenvoudig zijn, na een gigantische voorbereiding. Een ei bakken op de top van de Mount Everest, dat is het.
– Denk je? De uitvinder van de telescoop hield twee vergrootglazen achter elkaar, een voor z'n oog en het andere met gestrekte arm voor zich uit. Wat een kolossale uitvinding was dat niet!
– Maar als je in die tijd een vergrootglas hebben wou, kon je niet naar een opticien gaan om er een te kopen. Dan kon je het zelf gaan zitten slijpen. En daar zit de moeilijkheid.

— Willem Frederik Hermans

Voor Hilde

Preface

Declaration

I declare that this dissertation is the result of my own work, except for the usual student-supervisor discussions and Chapter 5, which is coauthored. No part of this dissertation has previously been submitted for any similar qualification or degree.

Steven Poelhekke (May 2008)

Journal submissions and a prize

At the time of writing none of the articles have yet been accepted for publication in journals. However, Chapter 3 has been submitted to the Annals of Regional Science, Chapter 4 to the Journal of Development Economics (under revision), and revised versions of Chapter 5 to Oxford Economic Papers and The Economic Journal and is available online both as EUI ECO and CEPR Discussion Paper. An early version of Chapter 2 is available as EUI ECO Working Paper and has been awarded the 1st prize in the 2006 graduate student paper competition by the North American Regional Science Council, at the NARSC 2006 conference in Toronto, November 2006. In addition to the chapters included here, I also wrote together with Rick van der Ploeg, 'Globalization and the rise of mega-cities in the developing world'. It is forthcoming in a special issue of the Cambridge Journal of Regions, Economy and Society.

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Urban Growth Across Three Continents: The Blessing of Human Capital and the Curse of Volatility

by Steven Poelhekke

This dissertation is concerned with the empirical determinants of urban growth in developed countries, and the effects of macroeconomic volatility in less developed countries, on urbanization and long run income growth. Four chapters are presented.

Chapters 2 and 3 deal with urban population growth in the USA and employment growth in Germany. In both cases metropolitan areas grow faster if the initial concentration of highly skilled workers is higher. Chapter 2 looks at which city characteristics lead some cities to attract more skilled workers than others, resulting in a diverging pattern of skill concentration among cities. The chapter shows that this is not a self-reinforcing process. One of the more robust findings is that a personal services sector is a positive amenity. The number of skilled workers is expected to increase faster in metropolitan areas where this sector is abundant. The personal services sector is intensive in low-skilled labor which gives a new sound to the popular belief that only a highly-skilled culture sector will attract more skilled workers. The second chapter shows that divergence of the concentration of skills and its effect on metropolitan growth is very similar in Germany. It also shows that there may be positive interaction effects between similar but different skill levels. For example, workers with vocational training have a larger effect on total employment growth if the local concentration of technical professionals is high as well.

In Chapter 4 we turn to the developing world. Cities in developing countries have been growing very fast, but surprisingly also in periods when economic growth to create manufacturing jobs was absent. Rural-urban migration is modeled as a response to aggregate volatility. Households in rural areas cannot cope with negative shocks and are forced to move to cities which offer more diverse sources of income, because financial markets are incomplete and households have credit constraints. We furthermore show from country-panel evidence that rural natural resource production (including agriculture) is much more risky than urban manufacturing sectors. Shocks come from natural causes such as rainfall, and from volatile world resource prices. This mechanism may be more important than the traditional view which models urbanization as a transitory process when countries move from an agricultural base to a manufacturing base.

Chapter 5, in collaboration with Frederick van der Ploeg, probes deeper into the

detrimental effects of aggregate volatility. The high volatility of world prices of natural resources causes severe volatility of output per capita growth in countries that depend heavily on them. This has a robust negative effect on long-run growth itself and presents a new explanation to the natural resource curse. Volatility can fortunately be substantially reduced provided that countries have a sound financial system to cope with large and sudden fluctuations in resource income. The curse can even be turned into a blessing because we find evidence for a positive direct effect of natural resource dependence on growth after controlling for volatility. However, the *indirect negative* effect of resource dependence on growth, via volatility, is much larger than any *direct positive* effect.

Acknowledgements

The quote on the inner side of the title page is from his novel *Nooit meer slapen* (Beyond sleep). It translates freely as:

"*...All intellectual professions are based on continuously doing things which, by themselves, are very simple, after a gigantic preparation. To fry an egg on the top of Mount Everest, that is what it is.*
– You think so? The inventor of the telescope held two magnifying glasses behind each other, one close to his eye and the other with outstretched arm in front. What a colossal invention that was!
– But if you wanted to have such a magnifying glass in that time, you could not go to an optician to buy one. In that case you could go and grind it yourself. And there's the difficulty."

That I would never sleep again is probably how I felt during the first year of coursework, and starting a seemingly futile journey is how the following year felt. Luckily for the reader, most of the toil behind this thesis is invisible. It is the result that counts, and hopefully the fun remains visible! For overcoming the difficulties I owe much gratitude to everyone around me, everyone supporting me.

Hilde joined me in Florence, she let me do the work when I had to, but more importantly made sure that I did not when I didn't really have to! Without such wisdom and her loving support it would never have been finished. Also my parents were a steady source of support through the years, for both of us.

I thank my supervisor, Rick, for his inspiration, motivation, for his lighthearted and easy-going way of keeping up the pressure, teaching me about presenting and writing, the importance of coffee and *dolce*, making me see the fun of economics, and interest in our general wellbeing.

I thank all my colleagues in the economics and other departments during the years: Marcello in particular for making sure I skippered on our sailing trips, Decio especially for sharing his knowledge (always a few steps ahead of us), Matthias, Amber, Rik, Simon, Henk, Itai, Patrick, Joana, Sebastian, Christoph, Carolina, Mayssun, Riham, Javier, Bastiaan, Aurora, Renato, Sanne, Markus, Joel, Tim, Graham, Rory for the language correction, and everyone I had the honor to meet.

Academically I owe much to the discussions and advice of my second reader Giancarlo Corsetti. For their help and suggestions on different parts of this dissertation I also thank Bas Jacobs, Anindya Banerjee, Gilles Duranton, William Strange, Marcus Berliant, Harry Garretsen, Helmut Lütkepohl, Jan Willem Gunning, Fabio Schiantarelli, Rob Alessie, Pieter Gautier, Martin Zagler, Saverio Simonelli, Christian Bayer, Frank van Oort, Marko Köthenbürger, Hosni Zoabi, Michela Redoano, Matthias Türck, Marc Schramm, Nils Drews, Rupert Kawka, the Tinbergen Institute and Utrecht School of Economics for their hospitality, seminar participants at the EUI, Kiel Institute, Università di Catania and NARSC 2006 participants.

Furthermore I want to mention the EUI staff, especially Jessica, Lucia, Marcia, Julia, Martin and Thomas from the Villa San Paolo, Laetitia and Laura from the Robert Schuman Centre, Loredana and Natasia.

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Chapter 1

Introduction

1.1 The rise and fall of cities

The human talent for organization and cooperation is physically reflected in the creation of cities. Throughout history, the density of cities has allowed people to interact frequently to organize defence, religion, politics, order and justice. These institutional improvements have always served to maximize welfare for their inhabitants or at least their rulers. They allowed individual specialization and trade, but also had the downside of war and slavery. However, not every city has become as large, wealthy or powerful as other cities, and each may have only had a temporary period of relative importance, growth and prosperity. The city of Rome for example, became the world's largest metropolis by being the center of politics and trade within a vast empire, only to decline as its supporting empire vanished. For the centers of political power, success and demise was often interlinked with their civilization or nation.

From the viewpoint of an economist it is intriguing why *within* one and the same country cities can also surpass each other, even though the national institutional and political arena in which they exist is the same. Why did Boston climb out of the downward spiral experienced by many former heavy industry cities during the last century? Why was San Francisco able to place itself at the forefront of the modern technology and services sectors and not Cleveland? Detroit's specialization in car manufacturing gave it economic might in the first half of the 20th century, but the same dependence on the car sector brought decline in the second half. Why was Detroit unable to attract new sectors? The 'Ruhrgebied' in Germany around Essen used to be the flourishing industrial heart. Now, Munich in the South of Germany is by far the wealthiest region. Why does city size change over time and what determines present-day urban growth, both in economically successful and less developed countries?

Such questions form the leading thread through this thesis. The aim is not to give a single definite answer, but all four chapters provide steps in that direction. They are written as individual articles which can be read independently. The next sections introduce the main chapters and relate each of them to the main theme. The last chapter will summarize the arguments.

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1.2 Do modern cities need unskilled workers?

A popular view on urban growth and rejuvenation held by many city councils is due to Richard Florida (2002 and 2004). In his view cities need to attract the 'creative class', consisting of architects, artists, doctors, musicians, editors, designers, and other skilled professionals. Tolerance and creativity attract skilled workers and foster invention and new ideas. Mainstream economists such as Edward Glaeser (see his review, 2002) claim that cities that score high on the creative class are, at least statistically, undistinguishable from cities with a high share of college graduates. The latter is arguably a more objective measure and a robust cause of urban success. Data on all US metropolitan areas reveal moreover that the average share of high skilled labor in the total work force has steadily increased over time but much more in some cities than in others. Figure 1.1 shows the correlation between skills and growth. Cities with a higher share of skilled labor were likely to experience higher population growth in the subsequent two decades. It is therefore important to find out why some cities attract more skilled workers, and others do not.

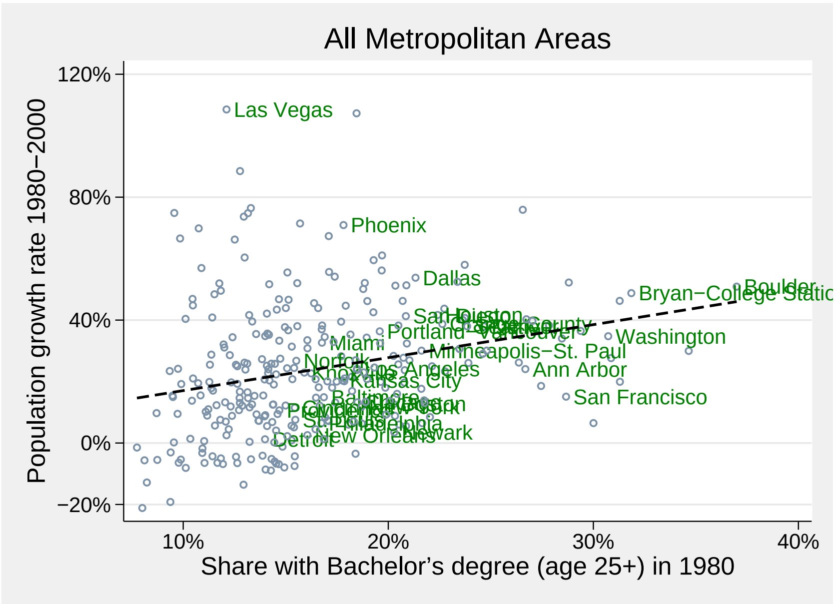

Figure 1.1: *Skilled Cities Grow Faster in the Next 20 Years (Selected MSAs Labeled)*

Among several possible explanations there is one which asks whether there is a role left for unskilled workers in modern fast growing cities. Amenities such as a low-priced and low-skilled personal service sector might make some cities more attractive. The supply of amenities, public or private, may be larger in some cities and may be a reason why they attract more people. The amenity effect is often estimated indirectly by assuming that amenities are capitalized in housing rents. If these rise faster than wages, then quality of life matters. However, if there was a boom in housing prices, then it would appear as if there was a boom in the appreciation of quality of life. The usual direct estimates of quality of life include crime, the number of bars & restaurants, high school drop-outs, and environmental variables, and are likely relevant to the whole population, and not in particular to the highly skilled. I will look at cultural diversity, owner-occupied housing, union coverage, and the low-skilled services sector. A low-skilled service sector is especially important. Human capital is attracted to places with an abundance of personal services which improve quality of life for highly payed workers who can afford them, yet who do not want to spend time on 'home production'. The argument is reinforced by data on German metropolitan areas which show a similar effect of the personal service sector on the growth of the number of highly skilled workers.

It has also been argued that skilled workers attract more skilled workers through a self-reinforcing effect that makes skilled workers concentrate in larger and more skilled cities. It could be that new firms hire predominantly skilled workers, which relates to the increased wage premium for skilled workers. However, the self-reinforcing effect has been estimated with an upward bias due to the inclusion of a lagged dependent variable. Fixed effect regressions will actually show a mean reversion of the share of skilled workers, but this is biased downwards for the same reason. An Arellano-Bond-type estimator solves this issue. Chapter 2 concludes that the coefficient in question is not larger than one, leaving more room for other explanations for the skill divergence.

A third explanation is that the structure of industry is a possible attractor of a skilled workforce. Because skilled workers are the carriers and creators of (tacit) knowledge they should especially benefit from any externalities generated by the local industry structure. This is based on three industry composition structures that maximize externalities: regional specialization (Marshall-Arrow-Romer), local competition (Porter), and urban diversity (Jacobs). Significant effects of these factors have been found on firm location, employment, and total factor productivity growth. All three may matter. The chapter tries to add to that literature by focusing, not on total employment effects, but on the subset of skilled workers.

1.3 Can German data support the urban skills growth connection?

The link between urban growth and the local share of skilled workers is mostly based on US data. It is generally believed that the US has a more flexible labor market and a geographically mobile population, much more so than most European countries, such as Germany. If some cities grow faster only because they are able to attract more skilled workers, then cities have to compete for them. Immobility due to cultural or other reasons may in effect isolate cities from such competition. This form of transportation costs might limit agglomeration of skilled workers and therefore limit the effect of skills on urban growth. It would be interesting if German skilled metropolitan areas also grow much faster than German cities that are less skilled. This would reinforce the belief that a concentration of skilled workers causes growth.

The data show that German metropolitan areas have also been diverging in terms of local human capital concentration. Cities that were very skilled in 1975, such as Munich, have seen the share of skilled workers increase much more than initially less skilled cities such as Bremen. Figure 1.2 shows this pattern for West German metropolitan areas between 1975 and 2001. This observation and the estimated effect on city employment growth are both remarkably similar to well known findings for American metropolitan areas and, at a glance, confirm the robustness of the skills growth connection in cities.

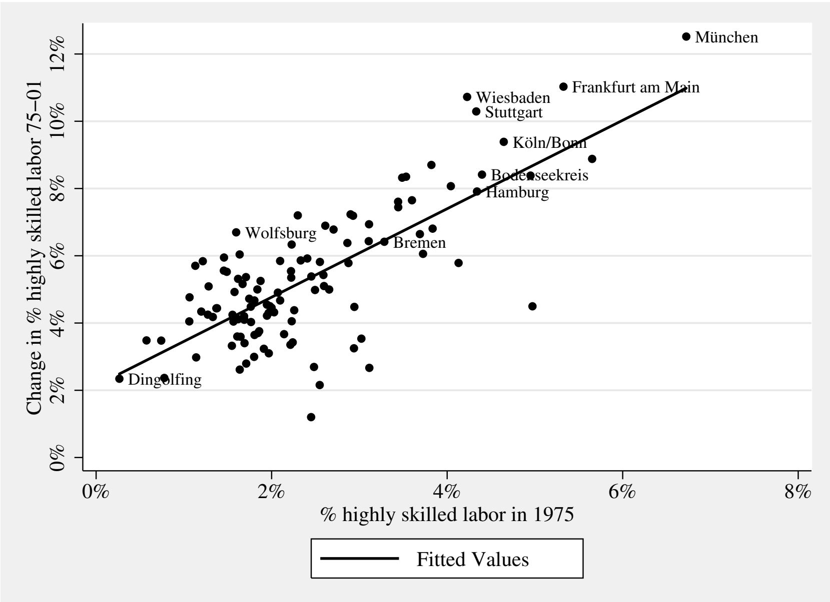

FIGURE 1.2: *Change in % Highly Skilled Labor*

Chapter 3 will go into more technical detail and question commonly accepted estimates of the *magnitude* of the effect of skills on growth. The size of the skill-growth effect for American cities lies around 0.8% for every 10% increase in the share of college educated workers. We find the same for West and East German metropolitan areas (agglomeration of counties based on commuting time). However, regressions in which time-invariant unobserved characteristics affect both growth and initial levels (i.e. initial employment size) lead again to an downward bias in the within-estimate of the initial employment size coefficient, and an upward bias in the OLS estimate. The true value should lie in between. Using recently developed GMM-IV techniques we show that the effect is at least 30% smaller for each of two German data sets.

In addition, the chapter questions whether the concentration of college graduates is the only growth enhancing type of human capital although it is commonly used as a measure of average local productivity. Also other skilled workers, such as those with vocational training, may contribute significantly to agglomerations' employment growth. There is evidence that cognitive skills rather than motor skills are productivity enhancing, something which many workers with vocational training may also possess in a significant amount. It is therefore not a foregone conclusion that the share of college graduates is the best indicator of local productivity. Apart from asking *how much* human capital is good for growth, the additional question of which *combination* of skills is beneficial is asked. The evidence shows a positive interaction between workers with vocational training and graduates from technical colleges. The productivity enhancing effect of non-technical college graduates is increasing over time, but their presence was of lesser influence to the size of the productivity effect of workers with vocational skills.

1.4 Why do cities in developing countries grow fast, even when the economic engine has stalled? Aggregate risk provides an answer.

So far I have assumed that cities only grow if they create employment, in particular through their skilled workers. If we take a global perspective and compare countries, then we see that outside the US, Germany and the rest of the highly skilled industrialized world cities grow unrelentingly fast. The level of urbanization (the share of total population living in cities) has increased by over 5 percentage points per decade outside the developed world since 1960. As a result, since 2007 the world will have more urban inhabitants than rural dwellers. In most parts of the world, rapid urbanization is accompanied by fast economic growth, however, notably Africa (and Latin America after 1980) has a different experience as shown in Figure 1.3. While growth in GDP per capita slowed significantly or even reversed, the rate of urbanization continued its normal fast pace. Without growth to create jobs or higher wages in cities (such as in East Asia) it seems puzzling that so many rural dwellers choose to become urban dwellers. Most people end up in slums which do not necessarily offer better living conditions than

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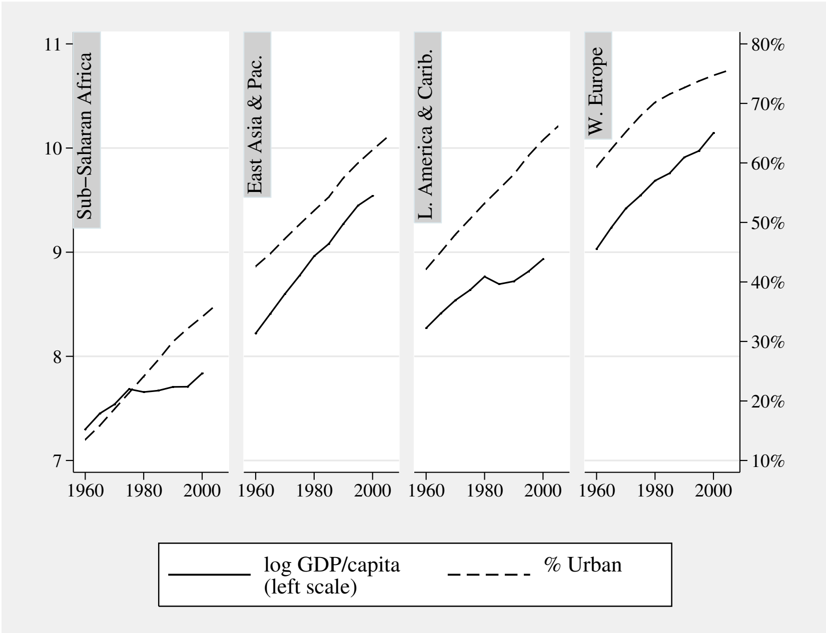

FIGURE 1.3: *Growth and Urbanization*

rural areas for a given income, and the long time period and crowding of public services should lower the expectations about any income gain from moving to the city. Big city lights are not always bright. It seems that the continued migration flows in some parts of the world are larger and more persistent than the classic Harris-Todaro model can explain. An (extreme) illustration is given by Equatorial Guinea, a Sub-Saharan African country. Between 1990 and 1995 its urban population grew 12% faster than the national population, yet GDP per capita and manufacturing value added declined by respectively -9% and -7% per year on average.

Apart from being *pulled* to the city by a high wage promise people may also be *pushed* from the rural area. If living conditions worsen in the countryside because sources of income decline (by natural causes such as rainfall or conflicts for example) then people will move to cities even if urban economic growth is absent, because it is the only place to go with at least some chance of improvement. Even if rural life exhibits good as well as bad years then people are still pushed off the land and to the city in bad years, unless they have the financial means to smooth consumption and 'ride out the bad times'. The more volatile aggregate income shocks are, the more likely it is that sufficiently bad years occur, wiping out savings. Natural resource production and the exogenous prices they fetch on the world market show very volatile behavior and financial services to insure against shocks are relatively absent in rural areas. Even local informal insurance will not work because everyone is hit by a similar (aggregate) shock.

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Sub-Saharan Africa was the most volatile region during the past 45 years and is also very resource dependent. Our example of Equatorial Guinea did not suffer from war or conflict in the 1990s, but output growth volatility in the agricultural sector (62% of all value added) was a worrying 27% and the standard deviation of yearly GDP per capita growth rates a similarly high 24%! The negative agricultural growth shock of -29% in 1993 (while world food export prices had been declining for three years) may well have pushed farmers to cities to find alternative income sources if they could not use financial instruments to wait for next year's positive shock of +44%.

Risk was evidently high. Chapter 4 will try to explain urbanization even under negative growth by including another feature of many developing countries: their dependence on natural resource production (including agriculture) and consequent shocks to GDP growth.

1.5 Why is resource wealth a curse? Volatility is again to blame.

The link between urbanization and macroeconomic volatility leads to an additional hypothesis, albeit farther away from why some cities perform better than others. Chapter 5 explores within the global cross-country perspective whether volatility may also have an effect on *economic* growth in the long run. The curse of being endowed with many natural resources could be that volatility tends to come with it when financial markets are underdeveloped. Could it be that volatility is an explanation for rapid urbanization and slow long-run growth at the same time?

The key determinants of economic growth highlighted in the empirical literature - institutions, geography and culture - show far more persistence than the growth rates they are supposed to explain. One candidate to explain the volatility of growth in income per capita is the volatility of commodity prices. This includes not only oil, but also for example grain and coffee prices. What commodity prices lack in trend, they make up for in volatility. Countries that specialize in commodities with substantial price volatility have more volatility in their terms of trade, enjoy less foreign direct investment and experience lower growth rates than countries that specialize in commodities with more stable prices or countries that are industrial leaders. Countries in the periphery with volatile commodity prices and undiversified economies fall behind in economic development. Also, the long-run volatility of the real exchange rate of developing countries is approximately three times bigger than that of industrialized countries. The adverse effect of exchange rate volatility on growth is weaker for countries with well developed

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financial systems.

Earlier work has estimated the effect of volatility of output per capita growth on long run growth by including it in a standard cross-country growth regression. Volatility is based on the errors in a regression that controls for investment, human capital, initial income, amongst others. The chapter extends this set-up by allowing for the direct effect of natural resource abundance on growth and, more importantly, the indirect effect of natural resources on growth performance via volatility, by letting the standard deviation of the errors simultaneously depend on resource dependence. Also financial development, openness, and distance from waterways, are included as the underlying determinants of volatility. The objective is to test whether any adverse *indirect* effect of natural resources on growth performance via volatility of unanticipated output growth dominates any adverse *direct* effect of natural resource abundance on economic growth.

Figures 1.4 and 1.5 motivate the hypothesis. The figures show that volatile countries have lower annual GDP per capita growth rates on average, and that resource-rich countries are more volatile.

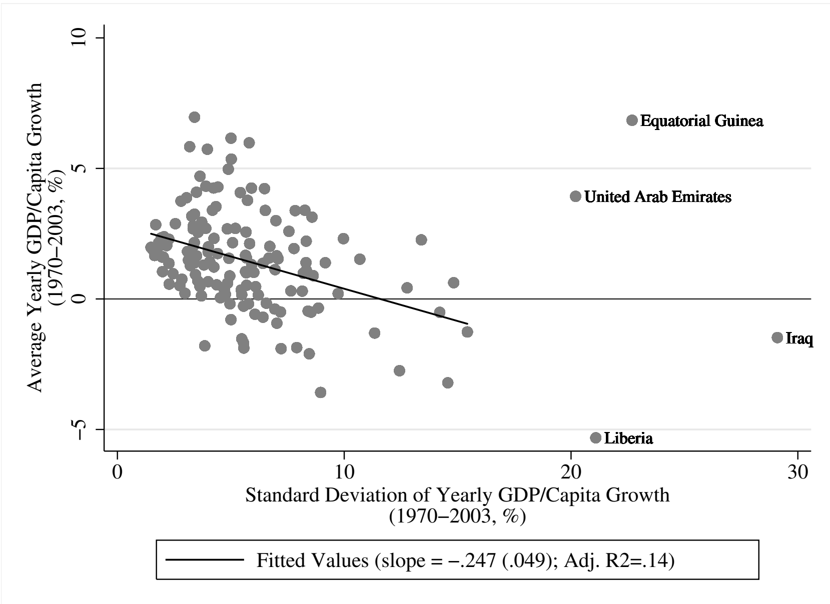

FIGURE 1.4: *Volatile Countries Have Lower Annual Growth in GDP per Capita*

The chapter also provides evidence that economic restrictions and ethnic tensions play a role. Countries with a large dependence on natural resources and that are land-locked are typically not very diversified and are vulnerable to highly volatile world commodity prices. Natural resource revenues tend to be very volatile (much more so than GDP), because the supply of natural resources exhibits low price elasticities of supply.

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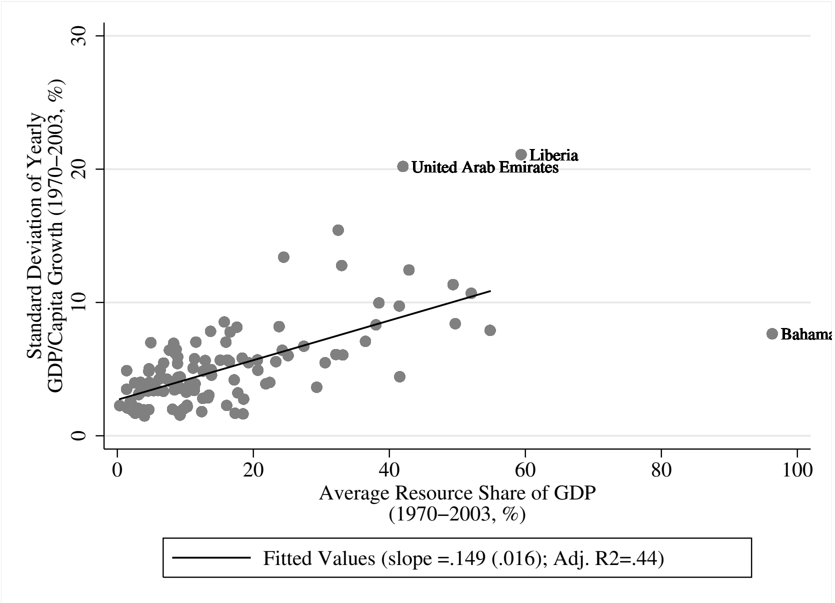

FIGURE 1.5: *Resource-Rich Economies are More Volatile*

Furthermore, Sub-Saharan Africa is most vulnerable to volatility of commodity prices as it depends so much on natural resources. Dutch Disease effects may also induce real exchange rate volatility and thus a fall in investment in physical capital and learning, and further contraction of the traded sector and lower productivity growth. Volatile resource revenues are disliked by risk-averse households. The welfare losses induced by consumption risk are tiny compared with those resulting from imperfect financial markets. However, a recent dynamic stochastic general equilibrium study of Zimbabwe highlights the incompleteness of financial markets and suggests that the observed volatility in commodity prices depresses capital accumulation and output by about 40 percent.

The chapter gives a prominent role to the quality of financial markets in understanding how the volatility of commodity prices and natural resource export revenues might depress growth. Effectively, larger natural resource revenues make it easier to overcome negative liquidity shocks. We thus show that more volatile commodity prices will harm innovation and growth.

1.6 Outline

The following chapters explore the agglomeration of human capital and its effect on urban growth in modern economies. I will ask whether spillovers are large enough to induce self-reinforcing agglomeration of skilled workers, or whether certain amenities which improve quality of life are needed to sustain agglomeration. In Chapter three data on German cities is used instead and detail on the size of the effect of skills on growth is given. In Chapter four risk as a determinant of urban growth in developing economies is looked at, even when cities do not create new jobs. In Chapter five the long run macroeconomic effects of aggregate risk are looked at. In both cases aggregate risk finds its origins in countries' dependence on natural resource production.

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CHAPTER 2

High-Skilled Metropolitan Growth, Low-Skilled Services, Amenities and Diversity

Synopsis

Since 1970 the share of skilled workers in urban populations has steadily increased in US metropolitan areas, but more so in some cities than in others. A higher concentration of skills affects population growth positively, even when the initial share is instrumented with historical land-grant colleges. Skilled cities may attract more skilled workers, but not because they are more skilled initially: increasing returns are rejected when controlling for fixed effects and bias from inclusion of a lagged dependent variable. Several amenities such as a low-skilled personal service sector do affect the concentration of skills positively, both in the US and in Germany. There is no convincing case for an effect of industry structure (specialization/diversity) on the concentration of college graduates in a city.

2.1 Introduction

From rustbelt to shiny and confident, The Economist celebrated the city of Chicago's successful deindustrialization and revival, mentioning among others the move to finance, the right infrastructure, and a growing entertainment sector.[1] With the latter they follow a popular view held by many city councils. However, they do not mention that more than 30% of the adult population has at least a bachelor's degree. The growth of Chicago's population is in a large part caused by this fact. Data on all US metropolitan areas show that the average share of high skilled labor in the total work force has steadily

[1]A Survey of Chicago, March 18th, 2006.

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increased over time[2], but this increase is unequally distributed across cities. Figure 1 in appendix 2.B repeats the correlation between skills[3] and growth also found in Glaeser and Saiz (2004). Cities with a higher share of skilled labor were likely to experience higher population growth in the subsequent two decades.

This paper shows that skilled cities have faster population growth by using land-grant institutions as a strong and valid instrument for the initial share of skilled labor. Skill divergence can thus help to understand the success and demise of cities. But what makes some cities attract ever more highly skilled workers while others have trouble retaining them? We aim to explain the divergence of human capital shares by looking at three possible explanations.

First, it has been argued that skilled workers attract more skilled workers. Berry and Glaeser (2005), and Wheeler (2006) argue that there is a self-reinforcing effect that makes skilled workers concentrate in larger and more skilled cities. The former paper attributes this to a tendency of new firms to hire predominantly skilled workers, which relates to the increased wage premium for skilled workers. However, the self-reinforcing effect is estimated with an upward bias due to the inclusion of a lagged dependent variable. Fixed effect regressions will actually show a mean reversion of the share of skilled workers, but this is biased downwards for the same reason, as shown by Nickell (1981). An Arellano-Bond-type estimator addresses this issue. We conclude that the coefficient in question is not larger than one, leaving more room for other explanations for the skill divergence.

Second, amenities such as a low-skilled personal service sector might make some cities more attractive. The supply of amenities, public or private, may be larger in cities and may be a reason to migrate to certain cities as proposed, among others, by Glaeser, Kolko, and Saiz (2001), Glaeser and Saiz (2004), and Shapiro (2006). Figure 2 shows for example that MSAs with an average January temperature of less then 39.2 degrees Fahrenheit (4 °C) have a stronger skill-growth connection. The amenity effect is often estimated indirectly by assuming that amenities are capitalized in housing rents. If these rise faster than wages, then quality of life matters. However, if there was a boom in housing prices in the US, then it would appear as if there was a boom in the appreciation of quality of life. The usual direct estimates of quality of life include crime, bars & restaurants, high school drop-outs, and environmental variables, and are likely appealing to the whole population, and not specifically to the highly skilled. This

[2]From 1970 to 2000 by an average growth rate of 38% per decade.

[3]Persons of age 25 and over with a Bachelor's degree or higher as a share of the urban population aged 25 and over.

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paper will add cultural diversity, owner-occupied housing, union coverage, and the low-skilled services sector, and show that a low-skilled service sector especially matters. This result runs contrary to the popular view by Richard Florida (2002 and 2004) who claims that "creative people power regional economic growth, and these people prefer places that are innovative, diverse, and tolerant" (Florida, 2004, p.34). This chapter claims that human capital is attracted to places with an abundance of personal services which improve quality of life for highly payed workers who can afford them, yet whom do not want to spend time on 'home production'.[4] Our argument is reinforced by data on German metropolitan areas which show a similar effect of the personal service sector on growth of the number of highly skilled workers, even when instrumented for with lagged values.

Third, the structure of industry is a possible attractor of a skilled workforce. Because skilled workers are the carriers and creators of (tacit) knowledge they should benefit particularly from any externalities that local industry structure generates. This is based on three industry composition structures that possibly maximize externalities: regional specialization (Marshall-Arrow-Romer), local competition (Porter), and urban diversity (Jacobs). This chapter will build on the work of various authors (Glaeser et al. (1992), Henderson (1997), Combes et al. (2003), and Cingano, Schivardi (2004)) who find significant effects of these on firm location, employment, and total factor productivity growth. The survey of Combes and Overman (2004) shows that all three may matter. This paper attempts to add to that literature by not focusing on total employment effects, but on the subset of skilled workers.

The next section will discuss the strategy to isolate a causal effect of skills on urban growth. Section three challenges the view that skilled cities become ever more skilled by themselves and proposes two new explanations for skill-divergence. Section four reports the estimation results, after which section five highlights the characteristics of several successful cities. Section six concludes.

2.2 Urban population growth and highly skilled labor

Growth of agglomerations is more and more dependent on knowledge intensive industries and less on transportation costs which have fallen considerably over time (Glaeser and Saiz, 2004). The concentration of human capital and its induced productivity effect through spillovers (see Moretti, 2004a for an overview) is more important for overall

[4]The provision of these services might actually be decreasing in the value of houses if low-skilled workers in this sector cannot afford to life in the area.

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city growth than the second, broad, explanation of quality of life. Shapiro (2006) finds that a 10 percent increase in an MSA's concentration of college-educated residents is directly associated with a 0.8 percent increase in subsequent employment growth, but that two-thirds is due to productivity effects, and one-third due to quality of life. Wage growth is also higher in skilled cities. Moretti (2004c) and Glaeser and Saiz (2004) documented a positive effect on population growth in US MSAs using a proxy (number of colleges per capita in 1940) for the initial share of skilled workers. Shapiro (2006) and Moretti (2004c) have used 'land-grant' colleges as an instrument for the share of skilled workers and isolate a causal effect on employment and wage growth. We will show that also total population growth is causally explained by the initial concentration of skilled workers.

Our basic specification is given by:

$$y_{i,t+10} - y_{i,t} = S_{i,t}\beta_1 + X_{i,t}\beta_2 + \tau_t + \eta_{i,t} \tag{2.1}$$

where $y_{i,t}$ is (ln) total population, $S_{i,t}$ is the share of skilled workers in the total population, $X_{i,t}$ are control variables such as the initial total population and the shares of workers in manufacturing. τ_t and $\eta_{i,t}$ are respectively common shocks to cities and an error term. In Glaeser and Saiz (2004) β_1 is estimated to be of the order 0.5. Even though observations are observed every 10 years[5], it might be that more college graduates settle in cities that are expected to enjoy faster population growth in the next decade which would make inference on the direction of causality problematic. Furthermore, it is reasonable to believe that quality of life is important enough to attract both skilled workers and other types of workers. Quality of life is hard to define and might partly be contained in the error term. In that case, our estimate of β_1 will be inconsistent, because S and η are correlated. Even time invariant climate variables may not be able to capture quality of life in its entirety. Using a good predictor of the share of graduates which is clearly exogenous to the outcome and any non-negliable unobserved characteristics should solve this problem and establish causality. We will show that the effect may be much larger than Glaeser and Saiz (2004) reported.

We will have to make a case for the validity and strength of the instrument to prove this claim. The instrument has to satisfy several assumptions to be useful for a consistent estimate of the effect of the concentration of graduates on population growth rates. First of all, the presence of a land-grant college should be randomly assigned to cities, and cities with a land-grant should not be systematically different from cities without a land-grant. The land-grant colleges were founded shortly after 1862 when

[5]See section 2.A for data sources.

the US Congress passed the Morrill Act to support higher education (Nevins, 1962). Every state that had remained in the Union (in 1880 this was expanded to southern states) received a grant to establish colleges in engineering, agriculture and military science: 73 land-grant colleges and universities were founded, with each state having at least one. Almost one-fifth of all college students were educated through the universities and colleges that evolved out of the originally technical and agricultural institutions (Moretti, 2004c). Virtually all the MSA's have colleges and universities, but only 49 of them have one founded by a land-grant.[6] If colleges and universities tend to be located in wealthy areas, densely populated areas, or political centers, the instrument is not exogenous. Although not directly testable, the act that founded the colleges was federal, and assured that at least one college was founded in each state, irrespective of characteristics. Among 288 metropolitan areas the four main Census regions West, Northeast, South and Midwest have respectively 19.6%, 20.93%, 17.09%, and 11.43%[7] of cities with a land-grant institution. Given the agricultural and technical nature of the colleges, rural areas were just as likely to be awarded the grant as were cities. Small towns in underpopulated states were just as likely to receive a grant as the more developed parts of the early settled New England states. Cities that received a grant include Boston, Massachusetts (MIT); Madison, Wisconsin; Prairie View, Texas; Fairbanks, Arkansas; Reno, Nevada; Tallahassee, Florida; and Albany, New York.[8] Moretti (2004c) shows that cities with a land-grant and cities without have similar racial and demographic structures, and workers in these cities have virtually identical (measured by AFQT scores) ability for similar educational attainment. The strength of the instrument can be tested, which we will do in section 4, along with the estimation results.

[6]The state of Wyoming is missing: Laramie (University of Wyoming) is too small to appear in the sample.

[7]The share in the Midwest is somewhat smaller due to the fact that many land-grant cities have populations of less than 100,000 and are excluded from the sample, such as Brookings, SD. Shapiro (2006) concludes that land-grant institutions are distributed independently from the Census regions using a Pearson's chi-squared test.

[8]The following metro-areas have at least one land-grant institution: Albany, NY; Athens, GA; Baton Rouge, LA; Boston, MA; Champaign-Urbana, IL; Columbia, MO; Columbia, SC; Columbus, OH; Des Moines, IA; Fargo-Moorhead, ND-MN; Fayetteville-Springdale, AR; Fort Collins, CO; Gainesville, FL; Greensboro, NC; Hartford, CT; Honolulu, HI; Knoxville, TN; Lafayette, IN; Lansing-East Lansing, MI; Lexington, KY; Lincoln, NE; Macon, GA; Madison, WI; Minneapolis-St. Paul, MN-WI; Nashville, TN; Pine Bluff, AR; Portsmouth-Dover-Rochester, NH-ME; Providence, RI; Raleigh-Durham, NC; Reno, NV; Richmond, VA; Riverside-San Bernardino, CA; Sacramento, CA; San Francisco, CA; State College, PA; Tallahassee, FL; Tucson, AZ; Washington, DC-MD-VA and Wilmington, DE-MD (Nevins, 1962).

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2.3 Why some cities become ever more highly skilled

The causal effect of skills on urban population growth forms the motivation to look for the determinants of the concentration of skilled workers. This section will discuss three possible reasons for skilled workers to cluster in certain cities: a self-reinforcing process, amenities that appeal to skilled workers, and externalities generated by industrial diversity or specialization.

2.3.1 Bias in the self-reinforcement hypothesis

Based on work by Rauch (1993), Moretti (2004c) finds evidence that wages are higher in cities with a high concentration of skilled labor controlling for worker's characteristics, even for college graduates themselves. The negative relative supply effect on the wage of graduates from an increase in college graduates in a city is actually smaller than the positive spillover effect (given imperfect substitutability between high and low skill workers). This finding leads Berry and Gleaser (2005) and Wheeler (2006) to estimate the effect of the initial concentration of skilled workers on changes in this share from decade to decade. They find coefficients larger than 1 suggesting a self-reinforcing process.

However, the inclusion of a lagged dependent variable will cause OLS estimates of the coefficient on the lagged dependent variable to be biased upwards if the regressors are correlated with unobserved fixed effects, while within estimators are biased downwards even when the cross-section dimension is large because the correlation between $S_{i,t}$ and $\eta_{i,t}$ does not go to zero in the limit (Nickel, 1981). The bias is larger in shorter panels. Unobserved fixed effects are important explanatory variables as cities are very heterogeneous with respect to time invariant characteristics such as natural resources, climate, aesthetics and (state) laws. The fixed effects can be taken into account by using the within transformation. This yields the following baseline specification to be estimated:

$$S_{i,t+10} = S_{i,t}\beta_1 + X_{i,t}\beta_2 + \tau_t + \mu_i + \epsilon_{i,t} \quad (OLS) \tag{2.2}$$

$$S_{i,t+10} - \overline{S}_i = \left(S_{i,t} - \overline{S}_i\right)\beta_1' + \left(X_{i,t} - \overline{X}_i\right)\beta_2' + \tau_t + \epsilon_{i,t} - \overline{\epsilon}_i \quad (FE) \tag{2.3}$$

where upper bars denote variable means over time. In Berry and Glaeser (2005) β_1 is estimated to be larger than one, but the bias in the coefficient is not addressed. If the bias is large then β_1 might actually be smaller than one, while β_1' would be too small. To consistently estimate β_1', the methodology by Arellano and Bond (1991) is adopted.[9] A twostep differenced-GMM estimator which includes a correction for finite sample bias and is robust to heteroskedasticity in the errors should solve this issue. It is however not possible to do this for all regressions because we need a minimum of three panels. County-level indstrial data (see section 2.A) could not be collected for 1970 in a comparable manner to the decades 1980 and 1990.[10] It will be shown however that the bias introduced by the lagged dependent variable is modest in those regressions. Results where this bias could not be corrected for will be interpreted as a lower bound where the true value is likely close to the estimated value.[11] Furthermore, Philips and Sul (2004) prove that inclusion of more exogenous regressors decreases inconsistency in the estimate of the lagged dependent coefficient as long as they have a non-zero effect on the dependent variable.

The results in section 4 will show that β_1 is not larger than 1, leaving more room for other explanations for skill concentration, such as amenities.

2.3.2 Some new amenities which appeal mostly to skilled workers

Amenities make a location attractive for people. The consumer city view (Glaeser, Kolko, Saiz, 2001) links the attractiveness in consumer amenities directly to population growth. Estimates of particular amenities (such as bars, restaurants, climate) have found some positive effects on the location of total population as shown by Glaeser and Saiz (2004) and Shapiro (2006). However, they have not before been tested on the location of highly educated workers. The cost of moving people has not declined much (for example in terms of opportunity costs of valuable time given higher real earnings) and productivity shifted to knowledge and people intensive services. Growth of agglomerations is therfore more determined by the preferences of people (Glaeser, Kohlhase, 2004). We introduce four amenities that should predominantly appeal to skilled workers: a low-skill personal service sector, the share of owner-occupied housing units, labor market flexibility and cultural diversity.

A *low-skill personal service sector*[12] consisting of services from laundry, day care,

[9] See also Bond (2002).

[10] County Business Patterns (CBP) data for 1969 exists on ICPSR but is not yet consistent with CBPs 1980 and 1990. See section 2.A for more details.

[11] The regressions that confirm the link between skill concentration and population growth also contain a lagged dependent variable, but this is not a variable of main interest. The exact direction and size of any bias in the other regressors is unclear so it is best to view the results as qualitative, rather than as the true parameter size.

[12] Defined as Standard Industrial Codes (SIC codes) 7200 (personal services), 7500 (auto repair services), and 7600 (miscellaneous repair services); The percentage of college graduates working in this

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beauty shops, and parking, to car repair and electrical repair services, are the services that make living in a city more convenient, especially when skill intensive jobs are demanding. The higher earnings are, the higher is the opportunity cost of not working, and in a workforce with a high concentration of similar highly educated workers competition for jobs may also be higher (Rosenthal and Strange, 2004). Having few of these services around (note for example day care) makes it more difficult for working couples to manage work and leisure. A city will likely also need less educated workers to perform tasks that are equally important for maintaining a productive city. We measure the personal service sector by the number of establishments and employment size. We provide additional results using German data based on employment size.

The *share of owner-occupied housing units* may matter because home-ownership has two features distinct from rented houses. The high skilled share of the population will find it easier to buy a house, because they earn more on average and will find it easier to get a mortgage. A second feature addresses mobility. It is more costly to move to another location from an owned unit relative to moving between rented units[13] in terms of transaction cost such as notary and real estate agent fees, and search costs. Agents become pickier if they know they commit a large part of their wealth to a home in a location they cannot easily move out of again. These characteristics do not hold for renting. The correlations between the share of owner-occupied housing and both the murder rate and the share of the population that did not move between 1995 and 2000 (which was 52% of the population) are respectively -0.33 and 0.56. Additionally, this correlation suggests that cities with more owner-occupied houses have generally somewhat less crime. Having more such units available in a city makes it less likely that skilled workers move out of a city in response to a negative employment shock.

A *flexible labor market* is attractive to skilled labor as they benefit in terms of spillovers from moving between jobs (see next section below), and they are presumably more prone to adapt to changing environments and need less protection by labor laws and unions. Glaeser and Alesina (2005) describe evidence that regulation negatively affects private investment. If unions represent vested interests in keeping an incumbent employer in business as long as possible without shedding labor, then this might deter investment[14] in new start-ups. Saxenian (1994) attributes the success of Silicon Valley to job flexibility and openness. Skilled workers are more likely to start up a company and

sector was 4% in 1980, and 5% in 1990.

[13]Assuming there is no difference in the housing supply elasticity between units for sale and units for rent.

[14]There is too little data available on venture capital.

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benefit from flexible labor markets. High skill sectors such as software have relatively low union density rates. We proxy labor market flexibility by the number of labor organization establishments per 1000 residents.[15]

There is some evidence (described in Alesina and La Ferrara (2004)) that *cultural diversity* based on language, life style, and attitudes are positively associated with higher productivity. Florida (2004) describes positive correlations between measures of tolerance and creativity. Glaeser and Alesina (2005) note that immigrants are often more risk taking than natives but also that public goods provision such as welfare spending is lower in ethnically more diverse areas. These measures are not perfect as both ethnicity and language based diversity may over or under estimate cultural diversity. Ottaviano and Peri (2004) use a different measure of cultural diversity based on immigrants' country of birth. They show it has economic value and is positively associated with both urban wages for natives and the rental price of housing. To see if there is any effect of cultural diversity on the location of highly educated individuals we proxy for culture by ethnical diversity: the inverse of the sum of squared race shares of the population, where races are: White, African-American, Hispanic, and an 'other' group, which includes people from Asian origin, as defined by the US Census. Diversity based on country of birth is included as a robustness check.

2.3.3 Are skilled workers attracted by externalities generated by industrial structure?

Externalities originating from the composition of industry provide a theoretical explanation for city growth. While the literature of this branch has looked mainly at the location of firms and the benefits of externalities for total employment (Combes et al., 2004) and total factor productivity (Cingano, Schivardi, 2004), it should also be interesting to look at the effects on the location of highly educated workers. As carriers and creators of knowledge, skilled labor should be able to benefit from externalities created by the composition of industry. For example, diverse and larger cities may offer more work opportunities for highly specialized knowledge (Duranton and Jayet, 2005).

The first theory described in Glaeser et al (1992) is due to Marshall (1890), Arrow (1962), and Romer (1986) (called MAR-externalities, or localization economies) where externalities occur between firms in the same industry. Firms can learn from each other by being in close geographical and technological proximity helping growth in that industry. This theory predicts that local monopoly is better for growth than competition

[15]Corresponding to SIC code 8630: labor organizations.

because the flow of ideas through imitation, movement, and interaction of highly skilled labor is internalized fully by the innovator. In contrast, Porter (1990) argues that innovation is induced by local competition. Although highest in specialized, geographically concentrated industries, competition among firms within their industry induces innovations, because the alternative to innovating is the demise of the company. Externalities are then maximized in specialized, but competitive, industries. A third branch, by Jacobs (1969), emphasizes that externalities are maximized when industries learn from technologically close industries outside their own industry. Geographic proximity and diversity (urbanization economies) increase the opportunities of learning and adopting new ideas from other industries. The adoption of new ideas will then be faster if local competition is higher. Moreover, a larger and more diverse pool of firms and labor lowers risk in the event of negative shocks (Duranton, Puga, 2004) and works thus as a form of portfolio diversification (Frenken et al, 2004). A greater variety of firms and workers in close interaction also speeds up the search and matching process between firms and workers, increasing efficiency and productivity.

To test this we include indices that should capture the features of MAR, Porter, and Jacobs-externalities.[16] In addition, following Katz and Murphy (1992) and Moretti (2004c) we control for national exogenous shocks that shift relative demand of skilled workers predicted purely by the city industry mix.

2.4 Estimation results

We start with estimation the effect of skills on population growth, before turning to the determinants of skill concentration in the following subsections.

The firsth and second columns of Table 1 in Appendix C show the highly significant effect of skills on population growth with various standard control variables. Independent variables are timed at $t-10$ so that the coefficients measure their effect on future population growth.[17] Column 2 also confirms that climate variables have an effect on population growth.

[16]See section 2.A for definitions.

[17]$\Delta \ln(\text{population})$ equals:

$$\ln\left(\frac{\text{Population}_t}{\text{Population}_{t-10}}\right)$$

where i is a MSA subscript and t a time index.

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2.4.1 Causality

Our instrument has one drawback, which is that it is a dummy and cannot be used in a specification including fixed MSA effects, because the within transformation would absorb the instrument. For this reason the regressions in Table 1 use OLS and 2SLS, including the *observed* fixed effects: region and time dummies, and the climate variables. The fifth column shows the instrumented effect of the concentration of people with a bachelor's degree or higher in a city on future population growth: the effect is highly significant and actually larger than the uninstrumented case in column 1. There appears to be no reverse causality and human capital is a strong predictor of city population growth rates. The standard errors in the equation tend to be somewhat larger than those of the OLS estimate. A Hausman test cannot reject the null that the estimates are not systematically different from the OLS equation as a group. Note that without MSA dummies, immigration is actually bad for city growth possibly reflecting the fact that many (at least recent) immigrants work in agriculture and manufacturing or other lower wage jobs, which were not high growth industries between 1970 and 2000.

The third column looks at relevance of the instrument: it significantly predicts the share of college graduates and explains a large part of the variance in the share of college graduates.[18] Column four reports the significant first stage of 2SLS[19], where an F-test on the instrument is included: the relatively high F-statistic rejects the presence of weak-instrument bias (Stock and Yogo, 2002). This is reassuring, because even if there is some correlation with the error through unobserved fixed effects, the strength of the instrument increases consistency of the IV-estimator, and decreases bias due to any violation of the exclusion restriction. This is important as it is not possible to control for MSA-fixed effects in this setting which might be correlated with the instrument. A formal Sargan-test of over-identifying restrictions is not possible because the model is just identified. College graduates significantly and causally predict future population growth.

2.4.2 Dynamic panel bias and constant returns

Table 2 reports regressions where we include all the important determinants of the concentration of skilled workers for which we have at least three time periods.[20] In this

[18] Excluding year dummies and a constant the instrument explains 20% of the variation.

[19] Included in the first stage are also the climate variables: although they are found to be positive determinants of population growth in column 2, they are actually significantly negatively associated with the concentration of skills.

[20] We therefore do not include industry structure indices.

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section we focus on the lagged dependent variable, the initial share of skilled workers.

The first column reports the OLS estimates with region fixed effects, but no MSA fixed effects. The coefficient on the lagged share of college graduates is significantly positive but has an upward bias. The second column includes MSA fixed effects and employs the within transformation to eliminate unobserved fixed city characteristics. The coefficient is significantly smaller than one, but this estimate is biased downward. A F-test rejects the hypothesis that the coefficient on college graduates is equal to one in columns 1 and 2.

The last column uses the two-step differenced GMM Arellano-Bond estimator which corrects for finite sample bias (Windmeijer, 2005) and eliminates the unobserved fixed effects through first-differencing. It uses lagged level values of the explanatory variables to instrument for variable changes: they are all allowed to be endogenous, except for the time dummies.[21] There are too few time periods for the Arellano-Bond test to test for autoregression of order 2 in the error term (the error term is AR(1) by construction). Although we cannot test for this source of correlation between the errors and the lagged instruments, in regression 2 the estimate of the magnitude of AR(1) in the error of the within estimator is quite small (0.04) so it is less likely that any AR(2) in the error is a big problem. Furthermore, as these test are based on so few time periods they have low power and less interpretive value. Because periods have 10 year intervals any problematic autocorrelation is unlikely. A Hansen's J-statistic of over-identifying restrictions (robust to heteroskedasticity and autocorellation) cannot reject that the instruments are valid so we conclude that the GMM instrument set is well specified. As expected, the two-step differenced GMM estimator finds a coefficient in-between the OLS and within estimates. The difference between the within estimate and the two-step GMM estimate is statistically small which indicates that the downward bias in the within estimator is likewise small.

Table 2 finds no evidence for increasing returns in the share of college graduates: controlling for unobserved time invariant city characteristics there is no evidence that skilled workers go where skilled workers are. Since the two-step GMM estimate is below but close to one, there is a better case for constant returns: a F-test cannot reject

[21]Persistence in the lagged dependent variable actually warrants use of the system-GMM version (Blundell and Bond, 1998) which also uses lagged first differenced equation to instrument the equation in levels. High persistence may also bias the difference-GMM estimator downwards, even below the FE estimate. Unfortunately, these additional instruments did not pass the Hansen test. Nevertheless, it yielded a coefficient of 0.987 (not reported) and the difference-GMM estimate is well-behaved: it is not below the FE estimate.

equality to one (p-value = 0.20).

2.4.3 A low skilled service sector matters

Table 3 uses observations on the years 1980, 1990, and 2000 for all the proposed amenities and indices. All regressions include a lagged dependent variable, which makes OLS estimate biased upward, and within-estimates biased downward for this coefficient. Table 2 shows that the bias downward in the within estimates is probably not very large. Therefore, within-estimates should be viewed as lower bounds to the true effect, where in columns 2, 4, 5, and 6, the true coefficient is likely to be close to or below one. The coefficients on the other variables should be interpreted preferably as qualitative rather than an exact measure of the size of the effect since the literature is not clear on the size and direction of any bias in the other regressors.

The third and fourth columns include seven amenities and the ethnical diversity index. Clearly insignificant are traditional amenities such as restaurants, museums, health institutions, and crime (disamenity). There are significant effects of the other four variables, which actually become more pronounced when unobserved time invariant city specific characteristics are included. The concentration of skilled workers in a city responds positively to a low-skilled service sector, and home ownership. As expected, labor organizations (proxy for stringent labor markets) affect concentration of skills negatively, yet ethnical diversity enters the equation negatively also. Ethnical diversity may be a poor substitute for *cultural* diversity. Ottaviano and Peri (2004) found positive cultural diversity effects on wages and rents. To see if our negative result is due to the wrong proxy used for cultural diversity, we include also their measure based on country of birth of foreign urban citizens, which changes results very little (not reported). An explanation could be that the average level of education of immigrants is lower than the average education of natives, which does not necessarily conflict with the positive effect on wages for natives as found by Ottaviano and Peri (2004).

The results of Table 3 are robust to including other significant controls: unemployment, housing value (negative), and high school drop-outs.[22]

Column 6 and panel B investigates the interaction between the low-skill service sector and the lagged dependent variable. Panel B evaluates the marginal effects at the means and maximum values of the two variables:

[22] Other controls as the share of workers in manufacturing or foreign born residents did not change the results in any way (except for the diversity index based on country of origin, which becomes insignificant once the share of foreign born is included, as they are highly collinear).

$$\begin{aligned}\text{collegeshare}_{i,t} &= \alpha(\text{collegeshare})_{i,t-10} + \beta(\text{low-skillservices})_{i,t-10} + \\ &+ \gamma(\text{collegeshare} * \text{low-skillservices})_{i,t-10} + \ldots + \varepsilon_{i,t} \end{aligned} \quad (2.4)$$

such that:

$$\frac{\partial \text{college share}}{\partial \text{low-skill services}} = \widehat{\beta} + \widehat{\gamma}(\text{college share}) \quad (2.5)$$

and the corresponding standard error depends on the concentration of college graduates and is given by (analogues for the marginal effect of the share of college graduates on itself):

$$s.e. = \sqrt{\text{Var}(\widehat{\beta}) + (\text{college share})^2\text{Var}(\widehat{\gamma}) + 2(\text{college share})\text{Cov}(\widehat{\beta}, \widehat{\gamma})} \quad (2.6)$$

Increasing the low-skilled service sector affects the persistence over time of the concentration of college graduates positively and significantly. The direct effect on the concentration of skilled workers becomes higher, the higher the initial concentration of skills. Figure 3 plots this relationship. The marginal effect of 1 more low-skill service establishment per 1000 residents on the future concentration of skills becomes significant as the initial concentration of college graduates in a city exceeds 19.2%, which is very close to the median concentration in 1990. For the upper skilled half of cities an increase of 1 establishment per 1000 residents affects the future concentration of skills significantly and more so as the initial concentration is higher. Moreover, this effect decreases any mean reversion in the concentration of skills by 0.05 percentage points per extra establishment and brings the coefficient closer to constant returns: at the maximum thickness of this service industry in 1990 the effect of lagged concentration of skills on itself is close to one. Still, increasing returns are not likely.

Evidence from German cities

Table 4 shows additional evidence of the positive effect of low-skilled services on employment growth of highly skilled workers in 150 German metropolitan areas. Since we only have data on employed workers we estimate the slightly different equation:

$$s_{i,t+10} - s_{i,t} = s_{i,t}\gamma_1 + p_{i,t}\gamma_2 + X_{i,t}\gamma_3 + \tau_t + \mu_i + \epsilon_{i,t} \quad (2.7)$$

where $s_{i,t}$ is (ln) total highly skilled employment, $X_{i,t}$ are control variables such as the initial total employment, the shares of workers in manufacturing, the average wage per

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worker, and a dummy for former East Germany. $p_{i,t}$ is the initial share of workers in the personal service sector. τ_t, μ_i and $\epsilon_{i,t}$ are respectively common shocks to cities, unobserved city characteristics and an error term. Our main variable of interest is γ_2.

OLS and FE estimations in columns 1 and 2 show mixed results. Only when we control for the μ_i do we find a positive and significant effect of the personal service sector. However, the effect is not robust to controlling for the wage rate and the share of manufacturing in column 3. Since we also have a lagged dependent variable in this specification we will use the GMM estimators to correct for this bias to find out if doing so also affects the other results.[23]

Column 4 is able to improve the estimate on the lagged dependent variable: also for Germany we find conditional convergence of highly skilled employment. The Hansen test for the overall instrument set is passed, and the difference-Sargan test for the additional instrument set is also passed, showing that all our instruments are uncorrelated with the errors. Most interesting is that we now find a significant and large effect of the initial share of workers in the personal service sector on growth of the number of highly skilled workers in German metropolitan areas. Column 5 additionally adds year dummies to the instrument set to improve efficiency. The drawback is that this weakens the power of the overidentification tests. Even so, we improve the standard errors somewhat.

A low-skilled personal service sector is an important amenity for highly skilled workers, both in the US and in Germany.

2.4.4 Industrial structure does not attract skilled workers

Table 3 also included variables which capture industry composition. The indices on related variety (Jacobs-externalities) and competition (Porter/Jacobs-externalities) are positive, but small and not significant.[24] Only unrelated variety (MAR-externalities; portfolio effect) shows a significant positive sign, robust to MSA fixed effects shown in the second column, but when including other important controls as in the fifth column, the significance disappears. Unexpectedly, none of the externality indices on industrial structure appeal to highly skilled workers in particular. Trying different measures for the related variety index such as using the lower bound in the range given where data was suppressed on employment only increased standard errors, and using an index based on 3-digit data changed the coefficients very little. Another problem is that the main

[23]The data is observed yearly from 1975 to 2001, which means that persistence may be a larger problem in this case. We therefore use the system-GMM variety (see Bond, 2002).

[24]All regressions include the Katz & Murphy exogenous relative demand shock for skilled labor as a control.

industry groups are constructed without an input-output matrix that should measure industry relations more precisely, and are probably too arbitrary: the indices are sensitive to which industries are classified as being unrelated to others. The means of the unrelated and related densities decline for unrelated diversity both in the 80s and 90s[25]. However, related diversity decreases from 1980 to 1990 (means of 1.19 and 1.13 respectively), but increases much more in the 90s.[26] This could bias the effect of related variety, because a rapid increase in diversity between 1990 and 2000 (with means of respectively 1.13 and 1.45) is not picked up by the regressions. Also changing the industry main groups to a set of nine, consisting broadly of 1-digit classifications only moderately improves things as cities with higher related diversity attract more skilled people but this is not robust to within-estimation (Tables available on request). Including MSA fixed effects shows that cities which increased competition relative to their mean levels attracted more college graduates. The coefficients on the other variables do not change. This shows how sensitive the indices are to the definition of which industries are considered unrelated, but also that the indices are not sensitive to measurement error originating from data suppression due to confidentiality. Combes, Duranton, and Gobillion (2006) find that wages are determined by individual skills, and by a far smaller amount due to industry interactions or local endowments. Their benefits may accrue mostly to firm profits and not to wages. If skilled workers hardly see the benefits of local interactions in their wage, then it consistently will also play a small role in their decision to live in a certain city.

2.5 What do successful cities look like?

The previous section has attempted to uncover the effects of city characteristics on the future concentration of college graduates. The starting point is the importance of having a large concentration of skills for future population growth. How did Chicago, IL, and the most educated cities of Boulder, Colorado, and San Francisco, California, score on the amenities, and what was their relative importance?

The 15 most educated and seven most populous cities are listed in Table 6 in appendix C together with the sample mean and median. The first column reports the skill level as measured by their share of the population with a bachelor's degree or higher

[25]1980: 1.00; 1990: 0.94; 2000: 0.86

[26]2000 figures are from NAICS classification of industries, but using the same 24 main industry groups: SIC and NAICS do not compare readily, so 2000 numbers may not be consistent with 1980 and 1990 numbers. In the regressions only 1980 and 1990 were used.

in 2000, and in the even numbered columns thereafter their 1990 characteristics: levels of important determinants of the concentration of skills. The levels are multiplied with the coefficient found in the regression analysis to calculate their aggregate effect on next decade's concentration of skills.[27]

Chicago does better than average in terms of its skill level. It gained 5.6% compared to 3.8% sample average, while the 15 most educated cities expanded their skill concentration on average by 6.1%, the latter translating to a population growth rate difference of at least 8.0% over the next decade[28] (instead of 6.9% if the most educated cities had attracted only 3.8% extra college graduates). The most educated cities had a 16% larger than average low-skilled service sector which more than compensates in magnitude for the relatively high number of labor organizations (less flexible labor market) in Boulder.

Chicago scores quite well across the board, although it has quite a strong presence of labor organizations, but also a good low-skill service sector. The city seems set to attract more highly educated workers, which will be a rich source of future growth.

2.6 Conclusion

A higher concentration of skilled workers leads to faster population growth also if the initial share is instrumented for. The diverging concentration of skilled workers is not a self-reinforcing process in contrast to Berry and Glaeser (2005) and Wheeler (2006). There is a better case for constant returns and a stable process. Cities with more amenities and in particular a low-skilled personal services sector do tend to gain more skilled workers, both in the US and in Germany. Other amenities also matter, such as the owner-occupied housing share (positive), and weakly cultural diversity measured by both ethnicity and country of birth of immigrants (negative), and labor organizations (negative). Industry externalities as captures by unrelated diversity (MAR), competition (Porter), or related diversity (Jacobs) did not work very well.

Skilled workers are important for a city's future growth. They will not come by themselves to a city, even if a city already has a significant concentration. City councils

[27]Note however that the coefficients of the regressions cannot be taken as the true effect because they could not be estimated in the most appropriate way (taking account of the lagged dependent variable), but if we are willing to believe they are approximately near the true effect, it can at least say something about the relative performance between cities. Still, it is best not to take the magnitudes too literally. Furthermore, the regression coefficients were obtained through fixed effect estimations. This means that there can still be city-specific characteristics of cities that explain their concentration of skills, and those characteristics listed in Table 6 are not exhaustive.

[28]$(0.407 - 0.236) * 0.466 = 0.080$, using table 2(1).

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can do well if they focus on amenities, including those provided by the lower skilled workforce.

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APPENDICIES

2.A Data sources and variable definitions

The main data used are observations on metropolitan statistical areas (MSA) from the HUD State of The Cities Data System, which offers a sample of 1970, 1980, 1990 and 2000 Census data. We use metropolitan statistical areas as units of observation from the 1999 Census definition.[29] Except in New England states (New England Central Metropolitan Area (NECMA) is used there) the definition of Primary MSA (PMSA) along county-based boundaries should capture the standard assumption that a MSA is a labor pool as it is unclear if the externality effects arise where people work or where they live. Central MSA's are however considered to be too large and capture more than a labor region. We only consider MSAs with a population of more than 100,000 in 1999, which leads to a sample of 288 cities with an average of 650,000 people per city.

The Census data provides a measure of **human capital** in the form of persons aged 25 and over with at least a Bachelor's diploma, and the number of high school drop-outs, but unfortunately no further precise measures such as average years of schooling are available. The County and City Data Books (1994) are used for **climate variables**, the County Business Patterns Database for constructing the **amenities**, and the FBI National Archive of Criminal Justice Data for murder rates (negative amenity). For these data, the MSA level figures were obtained by aggregating from county level, using the Census Bureau 1999 definition. From these sources, almost complete datasets could be obtained for 1980 and 1990.[30] The **related diversity index** is based on 4-digit industry level data on employment (or 3-digit if 4-digit was not reported). Unfortunately, public CBP data requires that no single company's activity level should ever be identifiable. Therefore, if an industry in a county consists of only a few establishment, then data on employment is suppressed and is replaced by a range: i.e. 0-19, 20-99, or 100-249, etc, employees. In these cases the range was replaced by the middle of the range: i.e. 10, 60, 175, etc. It was also tried to use the lower bound of the range, and a separate index was constructed on 3-digit data, which suffers much less from this problem. IPUMS 1% samples were used to construct the national **skilled worker demand shocks**, also using college graduates or higher as a measure of the skilled labor force, and to construct the **cultural diversity** index based on country of birth.

[29] Definitions by the Office of Management and Budget, US Census Bureau, 1999: to avoid the endogeneity of current definitions to growth.

[30] The panel dataset is balanced, except for the precipitation variable where data was only missing for Honolulu, HI.

2.A.1 Diversity Indices

The most commonly used diversity index is the Herfindahl-Hirschman index which sums the squared labor shares of each industry. However, this is not sufficient to distinguish between diversity at an aggregate level (1 or 2 digit industry codes) and diversity at a lower level (3 or 4 digit industry codes) *within* each aggregate industry group and measure them simultaneously in one regression. Jacobs-externalities are, for example, highest if all workers are equally distributed over related industries, which means specialization on the 1- or 2-digit level and simultaneously diversity within this group at the 3- or 4-digit level. A different index, Theil's entropy, provides the right framework to achieve this.[31] The useful feature of this index for diversity is that including both measures in one regression does not introduce additional collinearity to the regression, because they are independent. They can therefore be measured simultaneously for their effect on the location of college graduates.

Theil's (1972) measure of entropy corresponds to the expected information content of a probability distribution: in this application the distribution of employment in industries across cities and major industry groups, where the θs stand for the probability to find a number of workers in a certain city-industry.

Define $S_g, g = 1, \ldots, 24$ the major industry groups in city $S = 1, \ldots, 288$ broadly based on 1- and 2-digit SIC industry classifications[32], which represents unrelated diversity, that is industries which are technologically dissimilar. Industries i belonging to these groups that are defined as technologically similar and are related to diversity because they belong to only one of the groups S_g. The appendix Table 5 describes in detail which major industries are included. Each group S_g consists of i industries belonging to this group at the lowest reported classification level (mostly 4-digit; in some cases 3-digit).

Define:

$$\Theta_{sg} = \sum_{i \in S_g} \theta_{si} \tag{2.8}$$

where

$$\theta_{si} = \frac{\text{workers employed in industry } i\text{, city } s}{\text{all workers (all industries, all cities)}} \tag{2.9}$$

is the probability of finding a number of workers in industry i, in city s,

[31] See Frenken et al. (2004) for a recent similar application of this measure.

[32] Standard Industrial Classification (SIC) based on the 1980 and 1990 definitions from the County Business Pattern data (Census, 1980, 1990).

and:

$$\theta_{s.} = \sum_i \theta_{si} \tag{2.10}$$

Between group entropy (*unrelated* diversity: MAR-externalities) is defined as:

$$H_{so} = \sum_g \frac{\Theta_{sg}}{\theta_{s.}} \log \frac{\theta_{s.}}{\Theta_{sg}} \tag{2.11}$$

and measures the city specific dispersion of workers across major industry groups. H_{so} takes its maximum value $\log(g) = \log(24) \approx 1.380$ if all workers are distributed equally across all the major industry groups that exist in the city, and its minimum value if all workers in city s are found in only one industry group g: $\log(1/1) = 0$. This index corresponds to unrelated diversity. A *low* value of this index represents specialization of a city in a few industries corresponding to a *high* level of MAR-externalities.

An analogues index can be defined at the lowest industry level:

$$H_s = \sum_i \frac{\theta_{si}}{\theta_{s.}} \log \frac{\theta_{s.}}{\theta_{si}} \tag{2.12}$$

which measures between industry entropy at the lowest digit level, which takes on its maximum value if all workers in a city are distributed equally across all 4-digit industries that exist in the city, and its minimum value if all employment in a city is concentrated in only one 4-digit industry.

Both measures are additive in the following way (see Theil, 1972, for a derivation):

$$H_s = H_{so} + \sum_g \frac{\Theta_{sg}}{\theta_{s.}} H_{sg} \tag{2.13}$$

where:

$$H_{sg} = \sum_{i \in S_g} \frac{\theta_{si}}{\Theta_{sg}} \log \frac{\Theta_{sg}}{\theta_{si}} \tag{2.14}$$

defines the industrial diversity of the s^{th} MSA within industry group g by employment distribution across all $i \in S_g$.

Finally, $H_s - H_{so}$ is the average within group entropy, and measures the average diversity within industries groups in a city s. H_{so} will be used as an index of unrelated diversity (MAR-externalities), and $H_s - H_{so}$ as an index of related diversity corresponding to Jacobs-externalities: a higher value corresponds to a higher level of Jacobs-externalities. This index is always larger or equal to zero because both Θ_{sg}/θ_s

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and H_{sg} are non-negative: there can never be more dividedness after grouping than there was before grouping.

2.A.2 Competition

Following Glaeser et al. (1992) the index of competition is defined as follows:

$$\text{competition} = \frac{\text{establishment in city-industry/employment in city-industry}}{\text{establishments in national industry/employment in national industry}}$$

The more firms there are in an industry per worker, the higher is the level of competition relative to the national level of competition. If this value is greater than one it means that an industry is locally more competitive than the national average.[33]

2.A.3 Exogenous labor demand shock for skilled workers

The index captures exogenous shifts in the relative demand for workers with a bachelor's degree or higher that is predicted by the mix of industries in a city. The index is based on nationwide employment growth for college graduates in industries weighted by the share of industries in a MSA:

$$\text{shock}_{jtc} = \sum_s \eta_{sct} \Delta E_{js} \tag{2.15}$$

where s indexes the major industry groups, j is the type of worker (here workers with a college degree or higher), c indexes the MSA, and t stands for the decade after which the shock takes place (from t to $t+10$). η equals the number of employees in industry s, city c at time t, and the last term measures the log change in employment of type j workers in national industry s from t to $t+10$. The employment shares of skilled labor in each industry group is estimated from the IPUMS database[34], which reports the educational attainment of workers in each industry in a sample of about one million individuals per decade.

[33]Unfortunately, without firm level output figures it is hard to distinguish between more competitive firms and smaller firms and the number of firms per worker as such might not reflect competition. However, since we average the industry major groups instead of 4-digit levels of competition this should not be of great concern as it is likely that aggregate groups of industries do not consist of only large or only small firms. In their article, a higher value of this measure is significantly associated with higher employment growth in two digit industries in support of both Porter's and Jacob's theories, and as negative evidence of MAR externalities.

[34]Integrated Public Use Microdata Series, 1% samples: 1980, 1990, and 2000.

2.A.4 Data sources for German metropolitan areas

This study uses the factually anonymous IAB Employment Sample (IABS) (Years 1975 - 2001). Data access was provided via a Scientific Use File supplied by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) (see Drews et al., 2006). It comprises a 2% random sample of employees subject to social security payments from 1975 to 2001 at the county ('Kreise') level. We group the counties into labor regions or agglomerations. German labor market regions are defined by Eckey, Kosfeld, and Türck (2006) on the basis of commuting patterns (maximum commuting time of 45 to 60 minutes depending on the attractiveness of the center) and have a size of at least 50,000 inhabitants and are comparable to the US MSAs. This leads to 150 regions consisting of one or more counties that capture the area where people both work and live. We define highly skilled workers as those with educational attainment levels 5 and 6: university degree ('Hochschule') and technical college degree ('Fachhochschule'). The personal services sector includes, using the variable 'beruf' (profession), categories 3 (gardener), 105 (porter), 106 (servant), 110 (naturopath, masseur, remedial gymnast), 117 (child care), 121 (hairdresser, other personal care), 125 (domestic services) and 127 (domestic cleaner).

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2.B Figures

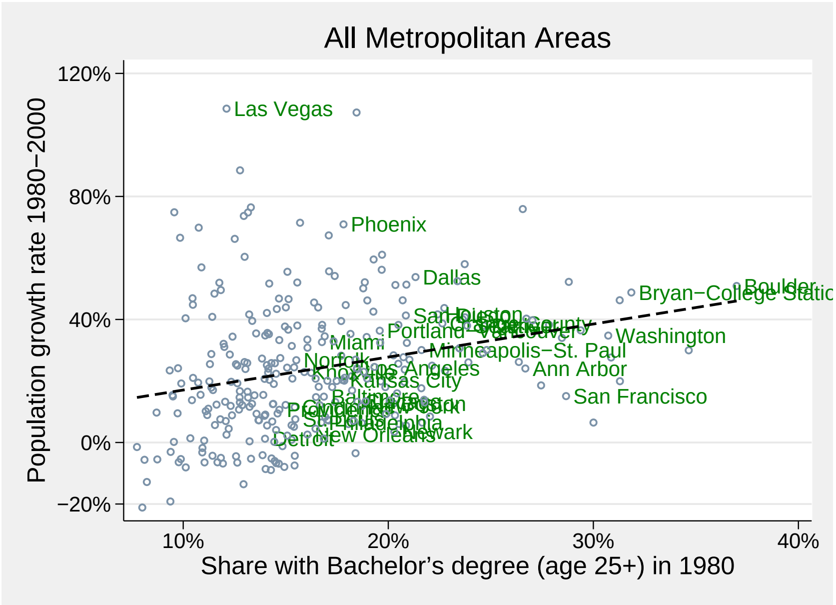

FIGURE 2.1: *Skilled Cities Grow Faster During the Next 20 Years (Selected MSAs Labeled)*

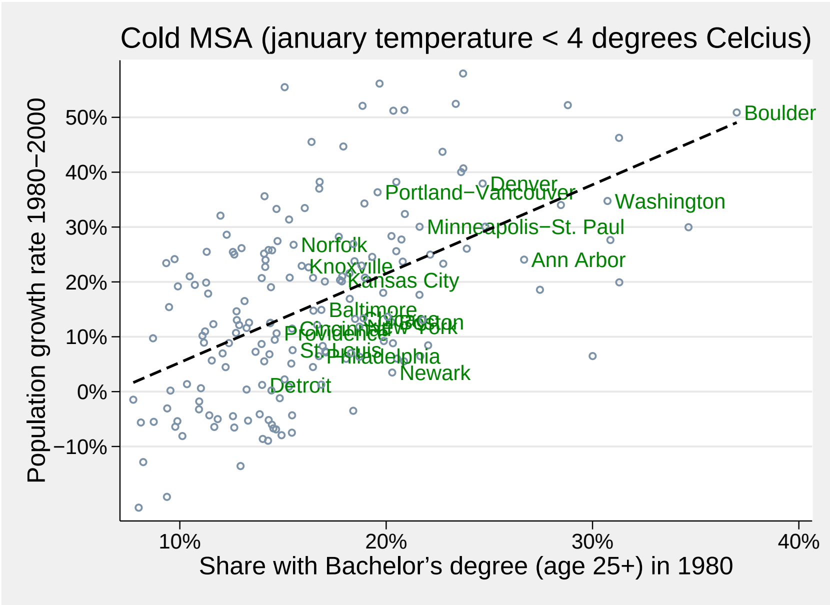

FIGURE 2.2: *Skills Matter More for Growth in Colder Climates*

FIGURE 2.3: *Low-Skill Services More Important Predictor if Initial Concentration Is Higher*

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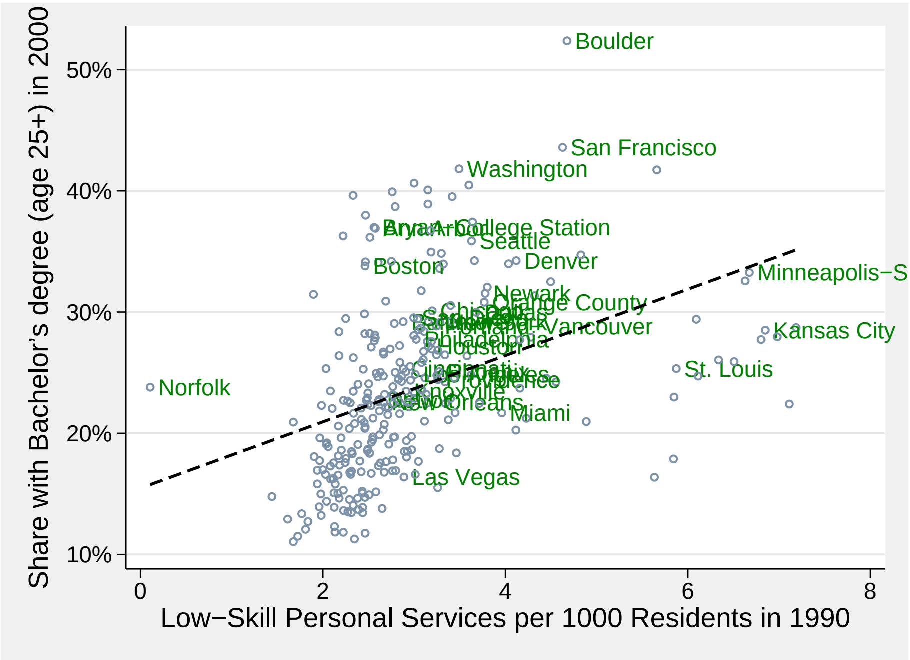

FIGURE 2.4: *Low-Skill Personal Services and Future Skill Concentration*

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2.C Regression Tables

TABLE 2.1: *A Robust Effect: Instrumenting Using Land-Grant Institutions*

	Δlog(Population)		Share Bachelors		Δlog(Pop)
	Within	OLS	*OLS*	1st Stage	2SLS
at t-10	(1)	(2)	*(3)*	(4)	(5)
Share with Bachelor's degree (age 25+)	.466	.924			1.867
	(.165)***	(.100)***			(.507)***
Land-grant Institution (dummy)			*.059*	.020	
			*(.005)****	(.004)***	
ln(population)	-.337	-.030		.013	-.040
	(.025)***	(.004)***		(.001)***	(.008)***
Average heating degree days '61-'90 (coldness)		-.002		.014	-.042
		(.0004)***		(.003)***	(.0150)***
Average precipitation '61-'90		-.00003		.009	-.110
		(2.04e-06)***		(.003)***	(.011)***
Share workers in manufacturing	.279	-.247		-.125	.023
	(.091)***	(.052)***		(.019)***	(.083)
Share workers in professional services	.076	-.680		.638	-1.208
	(.171)	(.118)***		(.033)***	(.366)***
Share workers in trade	.597	.962		-.210	.981
	(.220)***	(.169)***		(.047)***	(.213)***
Share of Foreign Born Population	.487	.059		.083	-.397
	(.140)***	(.081)		(.039)**	(.131)***
Year f.e.	yes	yes	*yes*	yes	yes
Region f.e.	no	yes	*no*	yes	yes
MSA f.e.	yes	no	*no*	no	no
F-test on excl. IV (F<10 => weak IV)				30.10	
Correlation with Share Bachelor's degree			*0.355****		
Correlation with population growth rate			*0.074*		
Hausman-test, p-value					0.98
H0: OLS more efficient: no endogeneity					*not rjctd*
Obs.	864	861	*861*	861	861
Number of MSA	288	287	*287*	287	287
Adj. R-squared	.500	.487	*.446*	.732	.494

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.2: *Bias in the Lagged Dependent Variable*

	Share with Bachelor's degree (age 25+)		
	OLS	Within	2step diff-GMM†
L.=lag (at t-10)	(1)	(2)	(3)
Share with Bachelor's degree (age 25+)	1.080	.763	.919
	(.024)***	(.035)***	(.063)***
ln(population)	.004	.005	.029
	(.0006)***	(.005)	(.011)***
Share workers in Personal Services	-.026	.106	.314
	(.024)	(.065)	(.185)*
Share Workers in Business and Repair Services	.034	.127	.344
	(.061)	(.082)	(.110)***
Share workers in manufacturing	.018	-.065	-.131
	(.009)**	(.022)***	(.039)***
Share workers in professional services	.050	.058	.438
	(.018)***	(.047)	(.130)***
Share workers in trade	.098	.082	.028
	(.024)***	(.046)*	(.088)
Share of Foreign Born Population	-.049	-.026	.002
	(.014)***	(.041)	(.088)
Unemployment rate	-.097	-.085	-.110
	(.028)***	(.034)**	(.060)*
Share High School drop-outs (age 25+)	-.019	.022	.095
	(.009)**	(.025)	(.038)**
Owner occupied housing share	-.029	.068	.068
	(.014)**	(.024)***	(.056)
ln Median Family Income (real; 2000$)	.007	.013	.050
	(.007)	(.011)	(.028)*
ln Median House Value (real; 2000$)	.003	-.018	-.045
	(.003)	(.004)***	(.011)***
dummy 1980	-.113		
	(.050)**		
dummy 1990	-.139		
	(.049)***		
dummy 2000	-.144		
	(.049)***		
Year f.e.	yes	yes	yes
Region f.e.	yes	no	yes
MSA f.e.	no	yes	yes
Estimate of ρ in error term (AR1)		0.04	
Hansen's test (p-value)			0.364
Arellano-Bond AR(1) test (p-value)			0.000
Obs.	864	864	576
Number of MSA	288	288	288
Adj. R-squared	.996	.942	

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

† All regressors were allowed to be predetermined and endogenous, and finite sample bias is corrected for.

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Table 2.3: *Explaining Change in the Concentration of Skills: Amenities and Diversity*

(a)

	Share with a Bachelor's degree (age 25+) *at t+10*					
	OLS	Within	OLS	Within	Within	Within
at t	(1)	(2)	(3)	(4)	(5)	(6)
Share with Bachelor's degree	1.148 (.014)***	.652 (.057)***	1.135 (.016)***	.533 (.053)***	.685 (.068)***	.447 (.079)***
ln(population)	.004 (.0007)***	-.006 (.006)	.005 (.0006)***	-.005 (.007)	.0003 (.008)	.0007 (.006)
Unrelated Diversity Index	.021 (.009)**	.047 (.022)**			.026 (.021)	
Related Diversity index	.005 (.007)	.014 (.012)			.008 (.012)	
Competition Index	.003 (.002)	.004 (.003)			.002 (.003)	
Low-Skill Service * % Bachelor						.051 (.012)***
Low-Skill Service Estab. /1000			.003 (.001)**	.009 (.003)***	.005 (.002)***	-.007 (.003)**
Labor organizations /1000			-.005 (.010)	-.088 (.035)**	-.085 (.033)***	-.066 (.031)**
Owner occupied housing share			.004 (.019)	.085 (.030)***	.091 (.033)***	.084 (.030)***
Murder rate per 100,000 pop			-.00006 (.0001)	.0004 (.0002)*	.0004 (.0002)*	.0004 (.0002)*
Ethnical Diversity Index			-.007 (.002)***	-.027 (.010)***	-.017 (.012)	-.024 (.010)**
Eating and Drinking Estab. /1000			.001 (.002)	-.002 (.005)		
Museum /1000 pop			-.013 (.069)	.004 (.089)		
Health Institutions /1000 pop			-.001 (.002)	-.003 (.004)		
ln Median House Val. (real; '00$)					-.016 (.005)***	-.013 (.004)***
Unemployment Rate					-.074 (.047)	-.139 (.036)***
Share High School drop-outs (25+)					.021 (.036)	
% Population below Poverty Line					-.037 (.059)	
Year f.e.	yes	yes	yes	yes	yes	yes
Region f.e.	yes	no	yes	no	no	no
MSA f.e.	no	yes	no	yes	yes	yes
Katz & Murphy Index	yes	yes	yes	yes	yes	yes
Obs.	576	576	575	575	576	576
Number of MSA		288		288	288	288
Adj. R-squared	.966	.892	.968	.908	.914	.92

Robust standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.

(b) Marginal Effects Corresponding to Regression (6) Above

	Share with a Bachelor's degree (age 25+)			
using:	*the mean values*		*the maximum values*	
L.=lag (at t-10)	mean	(6): FE	maximum	(6): FE
L.Share with a Bachelor's degree (age 25+)	0.18	0.573 (0.064)***	0.43	0.813 (0.070)***
L.Low-Skill Service * Share Bachelor's		0.050 (0.012)***		0.050 (0.012)***
L.Low-Skill Service Establishments / 1000	2.47	0.0023 (0.0015)*	7.19	0.015 (0.003)***

Table 2.4: *Low-Skilled Personal Service Labor, German Cities*

	Growth Rate Highly Skilled Labor				
	OLS	Within	Within	2step system-GMM†	2step system-GMM†
	(1)	(2)	(3)	(4)	(5)
ln total highly skilled labor	-0.073***	-0.353***	-0.347***	-0.146***	-0.135***
	(0.012)	(0.036)	(0.035)	(0.046)	(0.043)
ln % personal service labor	0.004	0.043**	0.031	0.153**	0.129**
	(0.009)	(0.020)	(0.022)	(0.073)	(0.057)
ln total labor	0.090***	0.227***	0.180**	0.161***	0.154***
	(0.016)	(0.068)	(0.081)	(0.060)	(0.056)
average wage			-0.002***	0.003**	0.003***
			(0.001)	(0.001)	(0.001)
ln % manufacturing labor			0.067	0.056	0.027
			(0.053)	(0.047)	(0.045)
constant	-0.273***	-0.163	0.280	-0.127	-0.332
	(0.067)	(0.571)	(0.720)	(0.402)	(0.309)
Observations	3252	3252	3252	3252	3252
Adj. R2	0.18	0.30	0.30		
cities	150	150	150	150	150
East Germany dummy	yes	yes	yes	yes	yes
AR(1) test p-value				0.000	0.000
AR(2) test p-value				0.691	0.711
Hansen overid. test p-value				0.1140	0.6613
Diff-Sargan overid. test p-value				0.1060	0.9880

Robust standard errors in parentheses. Year dummies included. * significant at 10%; ** significant at 5%; *** significant at 1%.

† All regressors were allowed to be predetermined and endogenous. Standard errors are corrected for finite sample bias.

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TABLE 2.5: *Major Industry Groups and SIC Industry Content (1980 and 1990)*

Major Industry Groups	SIC code	Description
1	07–	AGRICULTURAL SERVICES,FORESTRY,FISHERIES
2	10–	MINING
3	15–	CONTRACT CONSTRUCTION
4	2000	FOOD AND KINDRED PRODUCTS
5	2100	TOBACCO MANUFACTURES
6	2200;	TEXTILE MILL PRODUCTS;
	2300	APPAREL AND OTHER TEXTILE PRODUCTS
7	2400;	LUMBER AND WOOD PRODUCTS;
	2500	FURNITURE AND FIXTURES
8	2600;	PAPER AND ALLIED PRODUCTS;
	2700	PRINTING AND PUBLISHING
9	2800;	CHEMICALS AND ALLIED PRODUCTS;
	2900;	PETROLEUM AND COAL PRODUCTS;
	3000	RUBBER AND MISC. PLASTICS PRODUCTS
10	3200	STONE, CLAY, AND GLASS PRODUCTS
11	3300	PRIMARY METAL INDUSTRIES
12	3400	FABRICATED METAL PRODUCTS
13	3500	MACHINERY, EXCEPT ELECTRICAL
14	3600	ELECTRIC AND ELECTRONIC EQUIPMENT
15	3700	TRANSPORTATION EQUIPMENT
16	3800	INSTRUMENTS AND RELATED PRODUCTS
17	3900	MISCELLANEOUS MANUFACTURING INDUSTRIES
18	40– less 4800	TRANSPORTATION AND OTHER PUBLIC UTILITIES
19	4800	COMMUNICATION
20	50–	WHOLESALE TRADE
21	52–	RETAIL TRADE
22	60–	FINANCE, INSURANCE, AND REAL ESTATE
23	70–	SERVICES
24	99–	UNCLASSIFIED ESTABLISHMENTS

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Table 2.6: *Characteristics of the 15 Most Educated Cities, and the 7 Most Populous Cities*

	Dependent variable is the % of the urban population with a Bachelors degree or higher in 2000, explained by urban characteristics in 1990.	(1) **2000 level**	(2) 1990 level	(3) Effect on 2000 level	(4) 1990 level	(5) Effect on 2000 level	(6) 1990 level	(7) Effect on 2000 level	(8) 1990 level	(9) Effect on 2000 level	(10) 1990 level	(11) Effect on 2000 level	(12) 1990	(13) Effect on 2000 level	(14) Total Effect	(15) % of true 2000 level
		% with Bachelors degree			**% Owner-Occupied**		**Ethnical Div. Ind.**		**# Labor Org.**		**Low-Skill Services**		**% Unemployed**			
			Coef. Table 2 (3)	*0.919 (0.063) ****	*Coef. Table 3 (5)*	*0.091 (0.033) ****	*Coef. Table 3 (5)*	*-0.017 -0.012*	*Coef. Table 3 (5)*	*-0.085 -0.033 ***	*Coef. Table 3 (5)*	*0.005 (0.002) ****	*Coef. Table 3 (5)*	*-0.074 -0.047*		
A	**Most Educated Cities**						(insignificant)						(insignificant)			
1	**Boulder-Longmont, CO PMSA**	**0.524**	**0.428**	**0.394**	**0.578**	**0.053**	**1.242**	**-0.021**	**0.029**	**-0.002**	**4.676**	**0.023**	**0.048**	**-0.004**	**0.443**	**84.5**
2	**San Francisco, CA PMSA**	**0.436**	**0.349**	**0.321**	**0.459**	**0.042**	**2.482**	**-0.042**	**0.105**	**-0.009**	**4.627**	**0.023**	**0.05**	**-0.004**	**0.331**	**75.9**
3	Washington, DC-MD-VA-WV PMSA	**0.418**	0.37	0.340	0.577	0.053	2.064	-0.035	0.07	-0.006	3.493	0.017	0.036	-0.003	0.366	87.6
4	Columbia, MO MSA	**0.417**	0.365	0.335	0.517	0.047	1.268	-0.022	0.142	-0.012	5.659	0.028	0.046	-0.003	0.374	89.6
5	Madison, WI MSA	**0.406**	0.342	0.314	0.536	0.049	1.154	-0.02	0.202	-0.017	2.999	0.015	0.032	-0.002	0.339	83.3
6	San Jose, CA PMSA	**0.405**	0.326	0.299	0.57	0.052	2.41	-0.041	0.053	-0.005	3.6	0.018	0.047	-0.003	0.320	79.1
7	Charlottesville, VA MSA	**0.401**	0.333	0.306	0.564	0.051	1.429	-0.024	0.061	-0.005	3.15	0.016	0.032	-0.002	0.341	85.1
8	Santa Fe, NM MSA	**0.399**	0.357	0.328	0.643	0.059	2.119	-0.036	0.034	-0.003	2.76	0.014	0.044	-0.003	0.358	89.7
9	Bloomington, IN MSA	**0.396**	0.329	0.303	0.522	0.047	1.142	-0.019	0.101	-0.009	2.331	0.012	0.056	-0.004	0.330	83.2
10	Fort Collins-Loveland, CO MSA	**0.395**	0.323	0.297	0.594	0.054	1.198	-0.02	0.016	-0.001	3.417	0.017	0.053	-0.004	0.342	86.6
11	Raleigh-Durham-Chapel Hill, NC MSA	**0.389**	0.317	0.291	0.568	0.052	1.698	-0.029	0.036	-0.003	3.151	0.016	0.037	-0.003	0.324	83.3
12	Gainesville, FL MSA	**0.387**	0.346	0.318	0.492	0.045	1.675	-0.028	0.055	-0.005	2.792	0.014	0.056	-0.004	0.340	87.7
13	Champaign-Urbana, IL MSA	**0.38**	0.341	0.313	0.511	0.047	1.404	-0.024	0.121	-0.01	2.468	0.012	0.041	-0.003	0.335	88.1
14	Middlesex-Somerset-Hunterdon, NJ PMSA	**0.374**	0.302	0.278	0.676	0.062	1.496	-0.025	0.107	-0.009	3.64	0.018	0.044	-0.003	0.320	85.4
15	Bryan-College Station, TX MSA	**0.37**	0.358	0.329	0.378	0.034	1.836	-0.031	0.008	-0.001	2.56	0.013	0.057	-0.004	0.340	92.0
B	**average of the above 15**	0.407	**0.346**	**0.318**	**0.546**	**0.05**	**1.641**	**-0.028**	**0.076**	**-0.006**	**3.422**	**0.017**	**0.045**	**-0.003**	**0.347**	**85.4**
	average city, overall	**0.236**	**0.198**	**0.182**	**0.604**	**0.055**	**1.521**	**-0.026**	**0.1**	**-0.008**	**2.955**	**0.015**	**0.062**	**-0.005**	**0.213**	**90.4**
	median city, overall	**0.227**	**0.188**	**0.188**	**0.61**	**0.056**	**1.415**	**-0.024**	**0.082**	**-0.007**	**2.69**	**0.013**	**0.059**	**-0.004**	**0.206**	**90.8**
		% with Bachelors degree			**% Owner-Occupied**		**Ethnical Div. Ind.**		**# Labor Org.**		**Low-Skill Services**		**% Unemployed**			
C	Most Populous Cities						(insignificant)						(insignificant)			
1	Los Angeles-Long Beach, CA PMSA	**0.249**	0.223	0.205	0.456	0.042	3.023	-0.051	0.043	-0.004	3.012	0.015	0.073	-0.005	0.201	81.0
2	New York, NY PMSA	**0.292**	0.246	0.226	0.316	0.029	2.957	-0.05	0.071	-0.006	3.284	0.016	0.083	-0.006	0.209	71.7
3	**Chicago, IL PMSA**	**0.301**	**0.245**	**0.225**	**0.573**	**0.052**	**2.042**	**-0.035**	**0.081**	**-0.007**	**3.197**	**0.016**	**0.067**	**-0.005**	**0.246**	**81.8**
4	Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH NECMA	**0.338**	0.278	0.256	0.559	0.051	1.262	-0.021	0.058	-0.005	2.462	0.012	0.066	-0.005	0.288	85.1
5	Philadelphia, PA-NJ PMSA	**0.277**	0.226	0.208	0.651	0.059	1.648	-0.028	0.086	-0.007	3.023	0.015	0.057	-0.004	0.243	87.4
6†	Washington, DC-MD-VA-WV PMSA	**0.418**	0.37	0.340	0.577	0.053	2.064	-0.035	0.07	-0.006	3.493	0.017	0.036	-0.003	0.366	87.6
7	Detroit, MI PMSA	**0.228**	0.177	0.163	0.659	0.06	1.658	-0.028	0.082	-0.007	2.614	0.013	0.089	-0.007	0.194	85.2

Note: For each variable the regression coefficient's value is listed from the given table, and column number between brackets. Robust standard errors in parenthesis, and significance level denoted by stars: ** significant at 5%; *** significant at 1%.

†: Washington DC also appears among the 15 most educated cities.

Chapter 3

The Effect of Skills on Employment Growth: Adjusting Bias and Weak IVs with New Evidence from German Metropolitan Areas

Synopsis

German metropolitan areas with large shares of highly skilled workers have increased this share more than initially less educated cities between 1975 and 2003, and this has strong implications for urban employment growth. Conventional estimates show that the share of college graduates affects growth by the same magnitude as it does in American MSAs. However, we show that this figure is biased upwards because of endogeneity of initial employment. Corrected estimates using lagged values as instruments are closer to 0.5% employment growth for a 10% increase in the concentration of graduates. The effect is robust to various controls across two data sets. We additionally question that aggregate productivity growth is solely caused by college graduates. After distinguishing between 6 different skill levels we find positive growth effects of high school graduates with vocational training, especially if the local concentration of technical professionals is high. The concentration of non-technical university graduates becomes more important over time, but has less bearing on the marginal growth effects of other skill groups. City success may thus depend on the 'right' combination of skills rather than college graduates in itself.

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3.1 Introduction

German metropolitan areas with large shares of highly skilled workers have increased this share more than initially less educated cities between 1975 and 2003. Cities that were very skilled in 1975, such as Munich, have seen the share of skilled workers increase much more than initially less skilled cities such as Bremen. Figure 3.1 graphs this pattern for West German metropolitan areas between 1975 and 2001. This observation, which we call divergence, and the estimated effect on city employment growth are both remarkably similar to well known findings for American metropolitan areas (see for example Berry and Glaeser, 2005) and confirms the robustness of the skills-growth connection in cities.

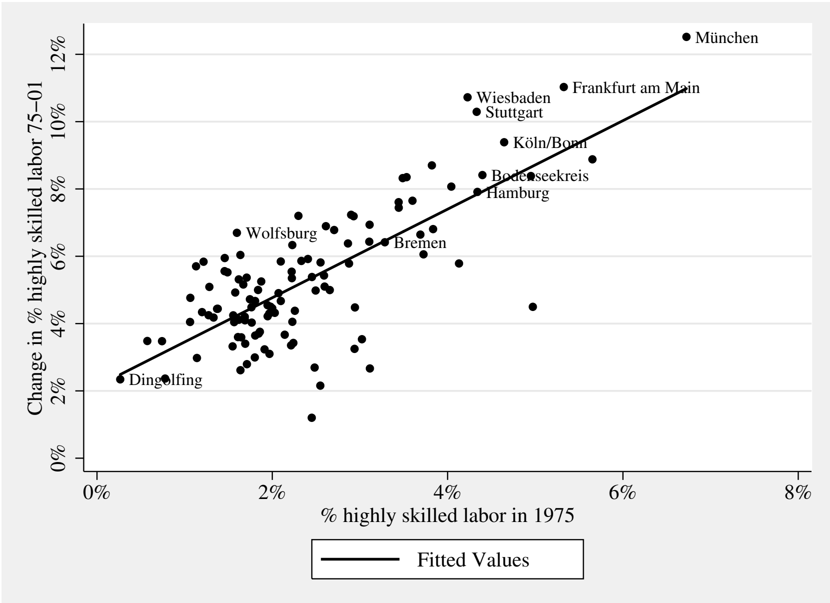

FIGURE 3.1: *Change in % Highly Skilled Labor (IAB Sample)*

This chapter argues that the *magnitude* of the effect is however biased upwards, because common estimators cannot properly control for the initial employment-size effect when fixed effects such as city characteristics correlate with both growth and initial size. Recently developed GMM-IV techniques reveal that the effect is at least 30% smaller for each of the two data sets. The chapter further argues that other skilled workers, such as those with vocational training, also contribute significantly to agglomerations' employment growth. We also find evidence of positive interaction between workers with vocational training and graduates from technical colleges. The productivity enhancing effect of non-technical college graduates is increasing over time, but their presence was

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of lesser influence to the productivity effect of workers with vocational skills.[1]

The size of the skill-growth effect for American cities is about 0.8% for every 10% increase in the share of college educated workers as shown recently by Shapiro (2006). Südekum (2006) moreover finds the same magnitude for West German *counties*. It it therefore less surprising that we find the same for West and East German metropolitan areas (agglomeration of counties based on commuting time). However, Nickell (1981) proved that regressions in which time-invariant unobserved characteristics affect both growth and initial levels (i.e. initial employment size) lead to an downward bias in the within-estimate of the initial employment size coefficient, and an upward bias in the OLS estimate. The true value should lie in between. Not correcting for this endogeneity bias puts too much weight on the initial size effect and therefore also affects the estimation of other controls, such as human capital. The bias is especially severe if the time dimension of the panel is small as is typically the case with city employment data. GMM estimators (Blundell and Bond, 1998) using lagged differenced equations as additional instruments can improve estimation and lead to different results. Recent versions of these estimators can solve the weak instrument problem of high persistence in the lagged dependent variable (see Bond (2002) and Windmeijer (2005)), as is the case with yearly and even 10-yearly urban employment panel data.[2]

We furthermore question whether college education is the only growth enhancing type of human capital although it is commonly used as a measure of average local productivity.[3] A city with many college graduates and also a lot of unskilled labor is not necessarily more skilled than a city with mostly workers with post-high school vocational training. Bacolod, Blum and Strange (2007) moreover find evidence that cognitive skills rather than motor skills are enhanced by urbanization, something which many workers with vocational training may also possess in a significant amount. It is therefore not a foregone conclusion that the share of college graduates is the best indication of local productivity. Many cities focus on how to attract as many college

[1] For Germany it is not undisputed whether skill levels diverge or converge between cities (Südekum, 2006) and it seems to depend on what the definition of divergence is. We come back to this issue in section 4.

[2] This has for example significantly improved estimates of the effect of education on democracy (Bobba, Coviello, 2007).

[3] Usually the productivity effect of skilled workers is looked upon from the viewpoint of wages (Rauch, 1993; Moretti, 2004) or whether or not workers receive higher wages if they are employed in a city (i.e. Glaeser, Maré, 2001). We will focus on the aggregate city productivity effect on city *employment*. Employment has been persistently low compared to the labor force in Germany (high unemployment) for some time.

graduates as possible although a different mix of skills could also be a successful strategy. In particular we hypothesize that workers with vocational training are more productive among technical college graduates than among non-technical graduates because their tasks are more similar. This facilitates better learning than from colleagues with the same skill levels. The cognitive skills that are more typically found among technical professionals can have beneficial effects on other workers if companies employ them both. Using average years of schooling would not pick up any skill interaction effects. Apart from asking *how much* human capital is good for growth we want to ask the additional question of which *combination* of skills is beneficial. Our data set allows us to differentiate between 6 different levels of human capital ranging from no schooling to university graduates.

The rest of the paper is organized as follows. Section two adapts an illustrative model. Section three discusses the econometric challenges and solutions after which section four describes the data. Sections five present our results on the size of the skill-growth connection and section six expands the college graduate productivity measure to include other skills and interactions. Section seven concludes.

3.2 An estimation framework

This section will briefly derive the main question of how human capital affects employment growth. We consider a setting similar to the work by Glaeser et al. (1992) and Simon (1998) in which each metropolitan area i is a separate small open economy. They produce one good, which is freely traded nationally under perfect competition, using labor L_{it}, and technology A_{it} at time t, using a production function $A_{it}(L_{it})^{1-\alpha}$, where $0 < \alpha < 1$. Firms sell the good for a numéraire price of 1. Following Glaeser et al. (1992) we abstract from capital or land input because we cannot measure different types of technological process with our data. Firms maximize profits taking technology, prices, and wages w_{it} as given. The wage rate (nominal and real) will thus equal its marginal product:

$$w_{it} = (1-\alpha)A_{it}(L_{it})^{-\alpha}, \tag{3.1}$$

which in terms of growth rates becomes:

$$\ln\left(\frac{w_{it}}{w_{i,t-1}}\right) = \ln\left(\frac{A_{it}}{A_{i,t-1}}\right) - \alpha \ln\left(\frac{L_{it}}{L_{i,t-1}}\right). \tag{3.2}$$

As in Combes et al. (2004) we assume that labor is imperfectly mobile such that labor growth reacts to wage growth with a strictly positive supply elasticity σ:

$$\ln\left(\frac{L_{i,t}}{L_{i,t-1}}\right) = \sigma \ln\left(\frac{w_{it}}{w_{i,t-1}}\right). \tag{3.3}$$

Perfect labor mobility would require wage growth to be a constant across cities, while perfectly immobile labor would disconnect productivity from employment growth and lead to wage growth instead.[4] We could expand this framework to include quality of life as in Shapiro (2006) and Glaeser et al. (1995). We do not observe quality of life however and assume implicitly that most of it is captured by the fixed effects, which include important quality of life indicators such as climate and geography. The technology A_{it} can have both national (δ_t) and local components, where local components in turn depend on city characteristics that may be both permanent (η_i) and time-varying in nature. We assume that the local time-varying characteristics depend on human capital H_{it} and other characteristics included in X_{it} such as total initial employment to capture urbanization economies (local demand, labor pooling, interactions). Unobserved shocks are given by v_{it}.

$$\ln\left(\frac{A_{it}}{A_{i,t-1}}\right) = \beta_1 H_{i,t-1} + \beta_2 X_{i,t-1} + \eta_i + \delta_t + \epsilon_{i,t} \tag{3.4}$$

Combining equations 3.2, 3.3 and 3.4 leads to the main relationship of interest:

$$\ln\left(\frac{L_{it}}{L_{i,t-1}}\right) = \frac{\sigma}{1+\alpha\sigma}\left(\beta_1 H_{i,t-1} + \beta_2 X_{i,t-1} + \eta_i + \delta_t + v_{i,t}\right), \tag{3.5}$$

where $\sigma/(1+\alpha\sigma)$ is a positive parameter. The functional form of human capital H_{it} is commonly a single variable such as the average or median schooling or the share of workers with a college degree or higher.[5] We will experiment also by including other skill groups in H as well as interactions between skill groups.

3.3 Bias, endogeneity, weak instruments, and solutions

The common specification for estimating the skill-growth relation is given as follows (reformulating eq. 3.5):

$$y_{i,t} = (\lambda+1)y_{i,t-1} + \beta H_{i,t-1} + \eta_i + \delta_t + v_{i,t} \quad i = 1,...,N;\; t = 1,...,T \tag{3.6}$$

where $y_{i,t}$ is $\ln L_{i,t}$, the natural logarithm of total employment in city i and year t.[6] The η_i are (unobserved) city characteristics that do not change over time, such as for

[4] Imperfect mobility is supported by the finding that regional labor demand shocks trigger much less migration in Germany than in the US between 1960 and 1987 (Decressin and Fatás, 1995). Moreover, the gross migration rate between NUTS 2 regions has declined between 1983 and 1990, down to one percent of the population, below rates for the UK. Also, 60% of migration is between neighboring regions (Huber, 2004).

[5] As for example in Glaeser, Scheinkman, Shleifer (1995).

[6] We could have written $\Delta y_{i,t} = \lambda y_{i,t-1} + ...$ instead.

example access to a river (geography) or the existence of an airport. These may correlate strongly with employment growth. $v_{i,t}$ is an error term which captures i.i.d. shocks to employment growth. We further assume $|\lambda| < 1$ to rule out an explosive process.

Fixed effects such as whether or not a city has a port or if it used to be a mining town have an effect on employment each year during the sample period. These effects can also include institutions, culture and even climate. This means that employment is not strictly exogenous: $E[y_{i,t-1}, \eta_i] > 0$, and for the same reason: $E[y_{i,t-1}, v_{i,t-1}] > 0$. Even if current shocks are not correlated with previous period employment size we will still estimate a positively biased (OLS) coefficient α because of the positive correlation between the fixed effects and initial employment. Moreover, this bias does not vanish if the sample size increases in the time dimension. Nickell (1981) showed that also the within transformation to get rid of the fixed effects does not solve this problem. If we define $\tilde{y}_{i,t-1} = y_{i,t-1} - \frac{1}{T-1}(y_{i1} + ... + y_{i,T-1})$ and $\tilde{v}_{it} = v_{it} - \frac{1}{T-1}(v_{i2} + ... + v_{i,T-1})$ and we regress the transformed employment growth variables on employment and other controls we will still have a positive correlation between the lagged dependent variable and the disturbances. This is because the negative correlations between $\frac{-y_{it}}{T-1}$ and v_{it} and $\frac{-v_{i,t-1}}{T-1}$ and $y_{i,t-1}$ dominate other positive correlations (Nickell, 1981).

$$Corr(y_{i,t-1}, \frac{-1}{T-1}v_{i,t-1}) < 0 \Rightarrow \tag{3.7}$$

$$E[\tilde{y}_{i,t-1}, \tilde{v}_{it}] < 0 \tag{3.8}$$

$$\text{unless } t \to \infty$$

and therefor $p\lim_{N\to\infty} \tilde{\lambda}_{Within} < \lambda$ and we estimate λ with an downward bias. This problem has not been addressed in the papers by Shapiro (2006) and Simon and Nardinelli (2002), nor by Berry and Glaeser (2005) and Wheeler (2006) in the context of employment growth of highly skilled labor in a panel setting.

A commonly used solution is to use first-differences of the system of equations to get rid of the η_i and use lagged equation as instruments as in Arellano and Bond (1991).[7] To do this the errors should not be serially correlated ($E[v_{is}v_{it}] = 0$ for $s \neq t$), we need predetermined initial conditions ($E[y_{i1}v_{it}] = 0$ for $t = 2, ..., T$) and $E[\eta_i] = E[v_{it}] = E[\eta_i v_{it}] = 0$.[8] A serious problem with this method is that λ might be close to zero. In our case this means that a city's employment size does not change much from year to year and is thus very persistent. λ then contains little predictive information about next

[7]We refer to this method as difference-GMM (DGMM).

[8]AR(1) is introduced by construction. Note also that we do not require the initial conditions to be strictly exogenous which would require $E[y_{i1}v_{it}] = 0\ \forall t$. Strict exogeneity of all variables would result in a consistent within estimate for large N and T.

year's employment size and is too weak as an instruments for employment growth, even if it is exogenous. In finite samples this problem is even more severe and may bias the estimate of the lagged dependent variable's coefficient downward and even below the Within estimate as we will demonstrate empirically further down. This important issue is not always acknowledged in the context of urban employment growth. See for example the similar difference-GMM approach taken by Blien, Südekum and Wolf (2006), on local sector employment growth, and Combes, Magnac, Robin (2004), on France, whom both use very persistent yearly employment data. Blundell and Bond (1998) proposed to expand the instrument set by including additional moment conditions by using lagged first-differenced equations.[9] With time dummies this additionally assumes that mean employment evolves in a common way over time for all cities in the sample.

$$E[\Delta y_{i,t-1}, (\eta_i + v_{it})] = 0 \text{ for } t = 3, ..., T \tag{3.9}$$

All these assumptions can be tested with common Sargan over-identification tests. Windmeijer (2005) provides corrected standard errors for the twostep version of System-GMM, which are otherwise too small.[10]

A further attractive feature of this method is that we have many instruments. Strong and valid instruments are rare which makes solving the endogeneity issue difficult in general. Our dynamic panel approach is to assume that lagged levels and lagged first differenced equations are not correlated with the current period disturbances. This means that the past concentration of skilled workers has no influence on the current shock to employment growth after controlling for fixed effects and other controls including the current concentration of skills. Since the time length of our sample is long enough (> 3 periods) we have many instruments and the system is over-identified. Common Sargan tests can tell us if the assumption of predetermined initial conditions is valid. There is one pit-fall with having many instruments. If the set of instruments is much larger than the number of cities (the N dimension) there is a risk of 'over-fitting' the data which decreases the power of the Sargan tests. On the other hand, using more instruments makes more efficient use of the available data. In general, if increasing the number of instruments does not move the lagged dependent's estimatied coefficient towards the Within-estimate, then over-fitting should not be a problem. See for example Bowsher

[9] We refer to this method as system-GMM (SGMM).

[10] Both DGMM and SGMM have one- and two-step versions which refers to the method of estimating the weight matrix for GMM. One-step requires the assumption of homeskedastic v_{it} disturbances, but two-step estimation tends to deflate the standard errors. We use the identity matrix as an initial guess for the covariance matrix of idiosyncratic errors as in Blundell and Bond (1998). See Bond (2002) for an overview.

(2002).

3.4 German employment data

We need employment data on the very disaggregated level of counties.[11] Two sources provide such data: the German Statistical Agency (DESTATIS), publishes a 'Statistik Regional' (SR) database (2005), which provides consistent data on all 439 (East and West) German counties from 1995 to 2003. These include all employed workers, excluding civil servants and the self-employed, subject to social security payments. This data set is supplemented with educational attainment data of workers counted at place of work from the Federal Office for Building and Regional Planning ('Bundesamtes für Bauwesen und Raumordnung', BBR) as well as local unemployment rates. These data come from their DUVA database and follow the same definition as the DESTATIS data. It distinguishes three levels of human capital. Employment of highly skilled labor is defined as those with a degree of a specialized upper secondary school, specialized college of higher education, or institution of higher education. Middle skilled workers are those with apprenticeship or training on the job, qualification at a full-time vocational school or at a trade or technical school. Lowest skilled workers are those without occupational qualification. The highly skilled resemble the widely used measure of those with a bachelor degree or higher for US studies, but are likely slightly higher educated than the US highly skilled and form a smaller share of employment.

A second source is the factually anonymous IAB Employment Sample (IABS) (Years 1975 - 2001). Data access was provided via a Scientific Use File supplied by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) (see Drews et al., 2006). It comprises a 2% random sample of employees subject to social security payments.[12] Although it has the drawback that it is only a sample, it provides a long time series from 1975 to 2001 and distinguishes between more distinct levels of human capital. In both data sets we observe that the share of skilled workers has increased the most in those cities that were already ranked as highly skilled at the start of the sample period: both from 1975-2001 and from 1995-

[11] These 'Kreise' and 'Kreisfreiestädte' (NUTS III regions) measure on average a quarter of the surface size of US counties.

[12] We select a cross-section of individuals at date June 30th of each year, which corresponds to the cross-section date of the SR sample, and aggregate (or average) variables within counties, which are then aggregated (or averaged if applicable, with a weight by employment size) to metropolitan areas. Other details: employment is counted as those with main employment (to prevent double counting), with regional observations and those who are not apprentices.

2003. However, we find that the coefficient of variation (=standard deviation/mean) decreases over time as also reported in Südekum (2006) at the level of German counties. The average skill level increases faster than the standard deviation rises across cities. He labels this patterns as *convergence*. We define *divergence* as an increase in the standard deviation to stay close to Berry and Glaeser (2005) and because the share of skilled workers in a city ultimately matters for its employment growth, rather than its relative share to the country mean.[13]

Several German employment studies have used administrative boundaries rather than economic agglomerations because statistical offices do not readily provide data on the level of agglomerations.[14] Since we want to measure urban human capital and estimate its effect on urban employment growth we need to group the counties into labor regions or agglomerations. By doing so we stay close to the commonly used US statistical metropolitan area definition and circumvent bias arising from possible spatial dependence. German labor market regions are defined by Eckey, Kosfeld and Türck (2006) on the basis of commuting patterns (maximum commuting time of 45 to 60 minutes depending on the attractiveness of the center) and have a size of at least 50,000 inhabitants. This leads to 150 regions consisting of one or more counties that capture the area where people both work and live.

TABLE 3.1: *Number of Counties Versus Labor Regions*

	Labor Regions	Counties
Germany	150	439
West	112	326
East	38	113

The mean and standard deviation of the ratio of employed workers counted at place of work over place of residence is 0.98 and 0.34 for the German counties, while only 0.96 and 0.07 for the labor regions, which is clearly an improvement in precision if we rely on *employed* workers to measure a city's human capital.[15]

[13]Own calculations using data from the US Census reveals that the coefficient of variation for skill shares (bachelor's degree or higher) among US metropolitan areas has also decreased over time, from .36 in 1970 to .30 in 2000 (the respective means (standard deviations) being 11% (4%) in 1970 and 24% (7%) in 2000).

[14]See for example Südekum (2006) and Blien, Südekum and Wolf (2006).

[15]The city of Munich for example becomes a labor region of 12 counties. Similarly, the cities of Cologne and Bonn really form only one agglomeration. Single county labor regions are mostly low density rural areas. The labor regions are smaller than the NUTS II ('Bezirke') and NUTS I ('Länder': states) regions:

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Tables 2 to 5 provide descriptive statistics for the two data samples and the definition for 6 skill groups in the IAB sample, where the units of observation are metropolitan areas. Employment growth since 1995 has been distinctly lower than before and even negative on average. The tables also show that there are important differences in the data between the former East and the former Western agglomerations. For example, the East reports higher formal education levels yet worse growth performance. However, the focus of this paper is not on differences between East and West, but the statistics are provided because the Eastern agglomerations enter the data in 1991 (IAB sample) and 1995 (SR sample) and thus show their relative weight in the data. The tables also show that manufacturing has continued to be an important employer and has even expanded as a share of employment in the former East. A competition index (see the next section) larger than one means that there is more competition than on average nationally. The diversity index (see also the next section) reaches its minimum at 0 and its maximum at 2.77 ($= -\ln(1/16)$, 16 industry groups).

TABLE 3.2: *Sample Employment Growth Rates*

	West		East	
	mean	sd	mean	sd
IAB Employment Growth (75-01)	1.5%	4.1%	-1.1%	3.9%
SR Employment Growth (95-03)	-0.1%	1.6%	-2.7%	2.0%

We start the analysis with the Statistik Regional (SR) sample with population data on all German counties from 1995 to 2003. Figure 3.2 shows that divergence of human capital levels is also clear from this data source although only in West Germany. East German skill levels are high compared to the West. Before unification it was standard to acquire at least medium skills in the former East. Unemployment did not exist because each worker was assigned a job. The resulting over-employment and closure of inefficient plants led to sudden unemployment of many workers, while party members also lost their job: many of which were highly skilled.[16] The latter presumably had an easier time to find new employment (in the private sector) while medium skilled workers likely moved West or waited for new employment opportunities. If the out-migration of mainly medium skilled workers had been going on for some time prior to 1995, then that might explain the relatively high share of high skilled workers in the East. We will therefor include an East Germany dummy and experiment with an interaction term

these areas are administrative rather than economic in nature.

[16]Thanks to Matthias Hertweck for pointing this out to me.

TABLE 3.3: *SR Sample Descriptive Statistics*

SR Sample	1995 (West)		2003 (West)		1995 (East)		2003 (East)	
	mean	sd	mean	sd	mean	sd	mean	sd
% highly skilled	5.4%	2.1%	7.3%	2.8%	9.9%	2.8%	10.6%	3.0%
% medium skilled	69.9%	3.3%	71.0%	3.6%	79.4%	3.0%	78.2%	3.5%
% lowest skilled	24.6%	3.5%	21.6%	3.0%	10.7%	1.4%	11.2%	1.4%
Total employment	195599	239145	195167	242877	164019	256398	134645	219147
% Manufacturing	30.2%	8.5%	28.4%	9.2%	11.7%	3.5%	15.2%	5.6%
Competition	1.34	0.46	1.26	0.44	0.79	0.27	1.10	0.39
Rel. % Pop. 25-35	1.03	0.05	1.02	0.07	0.92	0.05	0.93	0.07
Rel. % Pop. 35-45	0.98	0.04	1.01	0.04	1.07	0.04	0.98	0.05
Rel. % Pop. 45-60	0.99	0.06	0.98	0.03	1.03	0.04	1.07	0.03

Note: Manufacturing includes WZWG C to D ('Wirtschaftszweig', Industrial classification): manufacturing and mining (no reliable separate series were available). Age distributions are relative to the national average.

TABLE 3.4: *IAB 2% Sample Descriptive Statistics*

	1975 (West)		2001 (West)		2001 (East)	
	mean	sd	mean	sd	mean	sd
% level 6	1.2%	0.8%	4.6%	2.2%	7.1%	2.3%
% level 5	1.2%	0.5%	3.1%	0.9%	4.7%	0.9%
% level 4	0.6%	0.3%	5.5%	1.9%	4.5%	0.9%
% level 3	0.3%	0.2%	1.3%	0.7%	1.0%	0.5%
% level 2	57.0%	5.1%	69.4%	4.8%	75.5%	4.3%
% level 1	39.7%	5.8%	16.1%	2.8%	7.2%	1.2%
Total employment	3183	4056	4378	5261	3414	4586
% Manufacturing	46.2%	10.4%	32.9%	9.0%	19.9%	6.2%
Diversity	2.36	0.27	2.45	0.14	2.51	0.10
Average Age	34.1	1.1	39.2	0.5	40.0	0.4

Note: Manufacturing includes WZWG 2 to 6 ('Wirtschaftszweig', Industrial classification): (consumer) goods manufacturing, steel, machines, metal, transportation manufacturing, processed foods. Total employment is a sample of individuals. Age is averaged over metropolitan areas.

between Eastern agglomerations and the effect of skills on growth. Table 3.6 estimates the effect of the concentration of highly skilled labor on total employment growth with controls for initial employment (the lagged dependent variable), a dummy for the former

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TABLE 3.5: *Skill definitions (IAB Sample)*

Level	Definition
6	University Degree ('Hochschule')
5	Technical college degree ('Fachhochschule')
4	High school degree and vocational training ('Abitur mit Berufsausbildung')
3	High school degree ('Abitur')
2	Vocational training ('Volks-,Haupt-,Realschule mit Berufsausbildung')
1	no degree ('ohne Berufsausbildung')

Note: A high school degree of the 'Abitur' level qualifies for university and technical college, while a high school degree from the 'Volks-,Haupt-,Realschule' does not.

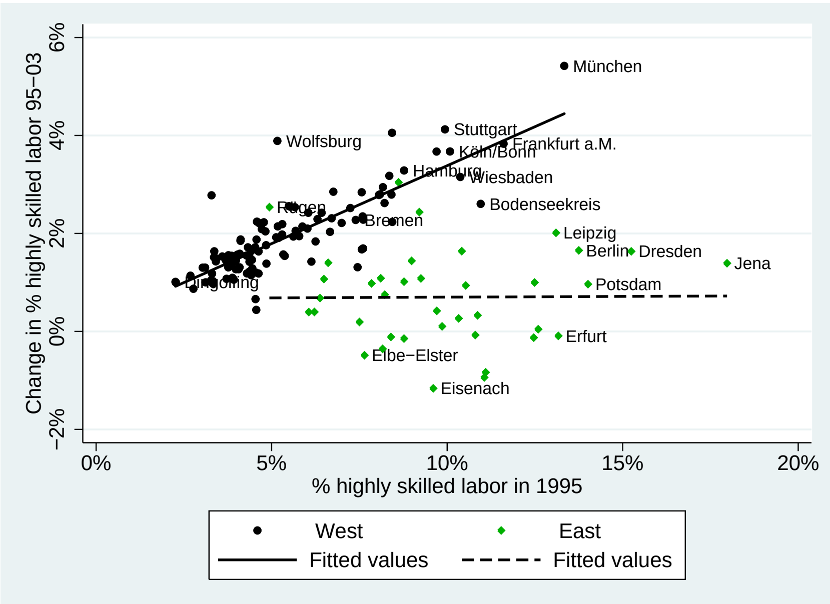

FIGURE 3.2: *Change in % Highly Skilled Labor (SR Sample)*

Eastern agglomerations, and time dummies, as in equation (5).[17] OLS estimates λ to be close to zero which means that employment is very persistent, although the within transformation which accounts for city fixed effects finds a rate of convergence of 8.2% per year. The latter is biased downward and seems implausibly large in magnitude. We do confirm that a 10% increase in the share of skilled labor leads to 0.8% more employment growth, consistent with Shapiro (2006), while keeping in mind that initial

[17]Fixed effects regression furthermore control implicitly for density, because the initial employment size coefficient can be interpreted as the effect of a change in employment size relative to its period city average for a constant city surface area. This change is perfectly correlated to a change in density.

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TABLE 3.6: *SR Sample, 1995-2003*

	Yearly % total employment growth						
	OLS	Within	DGMM1	DGMM2	SGMM1	SGMM2	SGMM2r
At *t-1*	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln % highly skilled labor	.006	.084	.239	.223	.160	.175	.175
	(.003)*	(.015)***	(.065)***	(.020)***	(.050)***	(.018)***	(.071)**
ln total employment	-.0009	-.082	-.283	-.269	-.065	-.077	-.077
	(.001)	(.017)***	(.085)***	(.021)***	(.022)***	(.009)***	(.032)**
East Germany Dummy	-.029				-.126	-.130	-.130
	(.002)***				(.032)***	(.012)***	(.044)***
Obs.	1200	1200	1050	1050	1200	1200	1200
AR(1) test, p-value			.0007	3.85e-07	.001	2.05e-07	3.25e-07
AR(2) test, p-value			.506	.748	.194	.043	.067
AR(3) test, p-value			.489	.366	.592	.228	.235
Sargan over-id. test, p-val.			.84	.0008	.999	.0001	.0001
Diff-Sargan test, p-value					.386	.213	.213
Adj. R2	.561	.503					

Robust and clustered standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Time dummies included. Column 7 uses the Windmeijer (2005) robust standard errors and the last digit in the column names refers to 1- and 2-step estimation.

employment size is endogenous. The third column uses lagged level equations as instruments and assumes homoskedasticity (Difference-GMM, one-step). Also allowing for heteroskedastic errors (two-step) does not perform well as λ is now even much smaller, while the true value should lie in between the OLS and Within estimate. We clearly have a weak instrument problem. the fifth and sixth columns therefore employ also lagged differenced equations. These perform much better. The errors in column 6 are too small but correcting them in column 7 still yields significant estimates. The Difference-Sargan (D-Sargan) test for exogeneity of the additional System GMM moment conditions (see equation 3) is passed with confidence. However, the overall Sargan test fails and we cannot properly identify λ. This means that also the coefficient on highly skilled labor may be biased. Moreover, this regression does not capture other possible determinants of employment growth, such as the industrial mix. Next, we control for such omitted variable bias.

Table 3.7 adds more controls (and hence also more instruments). Centers of manufacturing may have had a different growth experience while possibly attracting less

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TABLE 3.7: *Robustness SR Sample, 1995-2003*

	Yearly % total employment growth		
	OLS	Within	SGMM2r
At *t-1*	(1)	(2)	(3)
ln % highly skilled labor	.005	.088	.043
	(.002)*	(.018)***	(.013)***
ln % Highly skilled ∗ East Dummy	.001		.006
	(.005)		(.024)
ln % medium skilled labor	.008	-.038	-.040
	(.015)	(.062)	(.093)
ln total employment	.0004	-.186	-.018
	(.001)	(.020)***	(.006)***
ln % manufacturing	.0003	.002	.019
	(.002)	(.0007)***	(.010)**
Competition Index			-.017
			(.014)
% pop. age 25-35			.010
			(.041)
% pop. age 35-45			-.057
			(.066)
% pop. age 45-60			-.137
			(.061)**
East Germany Dummy	-.016		-.011
	(.012)		(.057)
Obs.	1039	1039	1187
AR(1) test, p-value			.0002
AR(2) test, p-value			.09
AR(3) test, p-value			.104
Sargan over-id. test, p-val.			.301
Diff-Sargan test, p-value			.882
Adj. R2	.624	.558	

Robust and clustered standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Time dummies included. Column 3 uses the Windmeijer (2005) robust standard errors and 2-step estimation.

highly skilled labor. Competition is added to capture the effect of local industry structure. There is a long-standing debate fueled by Glaeser et al. (1992) and Henderson et al. (1995) as to whether an industry grows faster if the local environment is competitive, diverse, specialized, or a combination of those three.[18] We do not observe enough industry information in the SR sample to include diversity or specialization save for the share of manufacturing. We measure competition as the local average number of employees per firm divided by the national average number of employees per firm. The age distribution of employees (relative to the national average) might be relevant because the education level reported is based on the highest acquired degree. With progressive

[18]See Duranton, Puga (2004) for an extensive overview of this literature.

advancement of technology it might be that a worker with a recent degree is actually more skilled than a worker with a degree from 30 years earlier. Young employees might thus be more productive. Medium skilled workers contain workers with a level of education that could be considered of equivalent to college level in the US (trade and technical schooling). These controls improve identification as column 3 shows. We find a plausible rate of conditional employment convergence of 1.8%, and a positive effect of highly skilled labor, which is however now smaller at 0.4% for a 10% increase in the concentration skilled workers (which is not different in the former East). The Sargan and difference-Sargan tests are passed at standard confidence levels. Since we find some weak evidence for AR(2) we only use lags 3 and up as instruments. The competition variable did not affect our results. Cities with a higher share of persons between 45 and 60 years of age do tend to grow slower. Omitting the age variables would have given us a high skilled workers effect of 0.36%, which is only slightly smaller.

Table 3.8 repeats the exercise for the longer IAB sample, covering the years 1975-2001. S5+6 refers to skill levels 5 and 6 (see Table 3.5 in the previous section) which is equivalent to highly skilled labor in the SR sample. S2+3+4 refers to middle skilled labor. The IAB sample allows us to add a measure of local industry diversity as a control to account for the possibility of diversity or specialization being beneficial to growth. We define diversity as minus the natural logarithm of the sum of 16 squared industry shares in each city.

$$\text{diversity} = -ln\left[\sum_{s=1}^{S}\left(\frac{L_{ist}}{L_{it}}\right)^2\right] \tag{3.10}$$

where $S = 1, ..., 16$ is our set of 16 industries in city i at time t. This Herfindahl-type index is very similar to the diversity indices used in Glaeser et al. (1992) and Combes, Magnac and Robin (2004), except that we focus on city employment growth rather than industry employment growth. The IAB sample unfortunately does not contain representative information at the county level on the number of firms. We include the average age of employees within a city to account for the possibly negative age effect.

The same basic patterns holds. After correcting for endogeneity of initial employment in columns 3 and 6 (with more controls) we conclude that the effect of highly skilled labor on employment growth is smaller than previously reported. A 10% higher share of skilled labor leads to 0.43% more employment growth. The initial employment size variable now lies between the OLS and Within estimates and the Sargan tests are passed meaning that the GMM estimator is well specified. Diversity enters with a negative sign, which means that less diverse cities tend to grow faster in Germany, as do

Table 3.8: *IAB Sample, 1975-2001*

	Yearly % total employment growth						
	OLS	Within	SGMM2r	OLS	Within	SGMM2r	SGMM2r
At *t-1*	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln S5+6	-.0008	.003	.059	.002	.006	.043	.025
	(.002)	(.004)	(.017)***	(.001)	(.004)	(.018)**	(.013)**
ln total employment	-.003	-.035	-.030	-.0009	-.042	-.003	-.019
	(.0007)***	(.008)***	(.007)***	(.0005)	(.008)***	(.006)	(.017)
ln S2+3+4				.008	.036	.236	.106
				(.008)	(.020)*	(.061)***	(.051)**
ln % manufacturing				.004	-.012	.033	.008
				(.002)**	(.012)	(.013)**	(.031)
Diversity index				-.0007	-.027	-.076	-.012
				(.002)	(.008)***	(.024)***	(.017)
Average worker age				-.005	.002	-.016	.0003
				(.0005)***	(.001)	(.004)***	(.004)
East Germany Dummy	-.028		-.061	-.024		-.030	-.045
	(.002)***		(.011)***	(.002)***		(.013)**	(.025)*
Obs.	3252	3252	3252	3252	3252	3252	3252
AR(1) test, p-value			3.61e-20			1.42e-19	1.24e-19
AR(2) test, p-value			.415			.773	.69
Sargan over-id. test, p-val.			.419			.593	-
Diff-Sargan test, p-value			1.000			1.000	-
Adj. R2	.721	.729		.729	.731		

Robust and clustered standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Time dummies included. Columns 3 and 6 use the Windmeijer (2005) robust standard errors and 2-step estimation. Column 7 uses all available instruments.

cities with an increasing share of manufacturing.[19] As in the SR sample we find that an older work force tends to lead to less employment growth. Recently acquired degrees seem to be more important than experience. We also find evidence that middle skilled workers affect employment growth positively and strongly, which warrants further investigation in the next section. Lastly, we include column 7 where we appeal to the efficiency argument and use all the information available. We include all lags of the variables in the instrument set so that we have 1975 instruments for 150 agglomerations. At the downside, the Sargan tests are now unavailable due to over-fitting (the lagged dependent variable's coefficient has moved in the direction of the within estimate), so we cannot test the validity of the instruments. The skill effects are still there but are

[19]Blien, Südekum and Wolf (2006) find a positive effect of diversity on *industry* employment, and a lagged negative effect. Our negative effect is robust to using their diversity measure (the measures correlate by 0.81; coefficient of -0.12*** in that case, available on request). It appears that employment in metropolitan areas benefits from overall specialization, even though industries may benefit from surrounding diversity on a smaller geographical scale. Since we use metropolitan areas as observations instead of counties and industries these results should be seen as complementary.

slightly smaller.

3.5 Growth and skill interactions

This section explores whether or not the share of college graduates is the most appropriate skill definition to capture education's aggregate productivity effect. Figure 3.3 graphs the average share of skilled workers across all agglomerations over time, for 6 different skill groups.[20] The technical colleges (level five) are engineering schools which

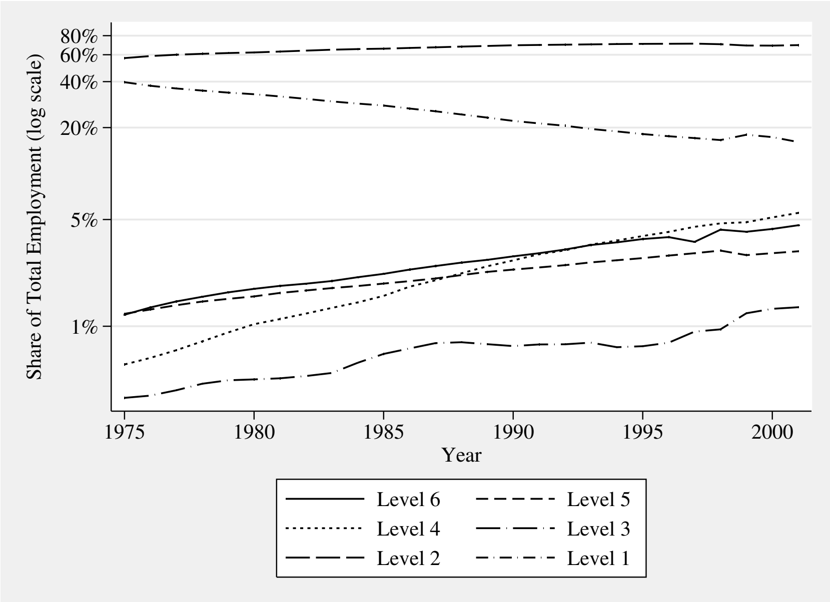

Figure 3.3: *Change in Skill Concentration Over Time (IAB Sample, West Germany)*

also issue Master's degrees. The difference with a university (which provides other disciplines) is that they do not award PhDs. There is furthermore no clear difference in educational level between levels one and three, except that 'Abitur' allows a student to enter schools of levels five and six. By far the largest shares are taken up by the lowest two schooling levels (upper two lines in the graph), of which the share of workers without a degree is steadily decreasing over time. The left scale is in logs, so the fastest relative increase in education was among level four: high school + vocational training (dotted line).

Table 3.9 differentiates between more than two skill levels. Unskilled labor is the

[20]Because reporting of skill levels about their workers is done by companies themselves there are some inconsistencies. We used imputation method IP3 as described in Fitzenberger, Osikominu and Völter (2005) to make sure that the highest attained degree did not *decrease* over time for the same worker. This may overreport the skill level but it yielded more similar skill levels compared to the SR sample for the years 1995-2001 than other imputation methods or the raw data.

TABLE 3.9: *Skill Interactions (IAB Sample, 1975-2001)*

	Yearly % total employment growth (SGMM2r estimator)					
interactions with:		S5+6	S5	S6	S5+6 & time trend	
At *t-1*	(1)	(2)	(3)	(4)	(5)	(6)
ln S5+6	.063 (.014)***	.160 (.042)***			-.025 (.019)	.013 (.038)
ln S5			.060 (.045)	.013 (.010)		
ln S6			.017 (.008)**	.077 (.032)**		
ln S2+4	.073 (.048)	1.008 (.235)***	1.119 (.284)***	.928 (.219)***	.143 (.064)**	-.015 (.308)
ln S3	-.017 (.005)***	-.018 (.020)	-.046 (.030)	-.027 (.019)	.037 (.007)***	.038 (.007)***
ln total employment	-.023 (.006)***	-.025 (.005)***	-.014 (.005)***	-.015 (.005)***	-.038 (.009)***	-.037 (.009)***
ln S5+6 * ln S2+4		.250 (.060)***				.007 (.080)
ln S5+6 * ln S3		-.001 (.007)				
ln S5 * ln S2+4			.240 (.063)***			
ln S5 * ln S3			-.009 (.007)			
ln S6 * ln S2+4				.190 (.048)***		
ln S6 * ln S3				-.003 (.005)		
ln S56 * time trend					.003 (.0007)***	
ln S5+6 * ln S2+4 * time trend						-.003 (.0009)***
time trend					.007 (.002)***	.0003 (.001)
Obs.	3207	3207	3204	3204	3207	3207
AR(1) test, p-value	5.19e-19	9.84e-18	4.59e-19	1.30e-18	2.82e-18	3.35e-18
AR(2) test, p-value	.72	.666	.839	.791	.063	.055
Sargan over-id. test, p-val.	.407	.332	.34	.361	.227	.215
Diff-Sargan test, p-value	1.000	1.000	1.000	1.000	1.000	1.000

ln Sx denotes the ln of the share of workers of skill level(s) x. Windmeijer (2005) robust standard errors in parentheses (two-step estimation). * significant at 10%; ** significant at 5%; *** significant at 1%. East Germany dummy included, and time dummies in columns 1 to 4..

reference skill level as it is the only level that has decreased over time. All other shares have increased but unequally so across cities, leading to various growth experiences. We group levels two and four together because both list vocational training as tertiary education. Column 2 finds a positive interaction effect between high skilled labor and

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workers with vocational training (ln S5+6 * ln S2+4) and no interaction effect with high school graduates. The marginal effect of vocationally trained workers on employment growth depends on the share of skilled workers in a city:[21]

$$\frac{\partial \Delta y_{it}}{\partial \text{ln S2+4}} = \beta_1 + \beta_2 * \text{ln S5+6} \tag{3.11}$$

The standard errors follow as:

$$\text{s.e.} = \sqrt{Var(\hat{\beta}_1) + (\text{ln S5+6})^2 + Var(\hat{\beta}_2) + 2(\text{ln S5+6})Cov(\hat{\beta}_1, \hat{\beta}_2)} \tag{3.12}$$

where we estimate $\Delta y_{it} = \alpha y_{i,t-1} + \beta_1 \text{ln S2+4}_{i,t-1} + \beta_2 \text{ln S5+6 * ln S2+4}_{i,t-1} + \text{controls} + \eta_i + v_{it}$ and $\hat{\beta}_1 = 1.008$ and $\hat{\beta}_2 = .25$. Using this calculation for all the sample values of ln S5+6 we find that the effect of workers with vocational training is significant across all observed values of the share of highly skilled workers, although it nears insignificance as the share of skilled workers becomes high in the sample. Columns 3 and 4 show that the positive interaction between the highly skilled and workers with vocational training is stronger for graduates of technical colleges than for university graduates. Presumably the former two are closer in terms of knowledge which facilitates better learning and hence larger productivity effects on employment growth. Columns 5 and 6 show that the effect of highly skilled labor interacts positively with a time trend, indicating that the effect of highly skilled labor is increasing over time. Moreover, the interaction between the trend and the ln S5+6 ln S2+4 interaction term shows that the spillovers on workers with vocational training decreases over time. This is consistent with our finding that the productivity effect of these workers nears insignificance as the share of skilled workers becomes high. These effect are robust to including controls for the local industry structure and age of the work force (see Table 3.10 in the appendix). As a second robustness test we exclude those workers that are in training. Many of the vocational training school include ‘on the job’ training which might increase the measured share of this human capital group while their effect on productivity might be lower in reality. Comparing Table 3.5 and Table 3.11 shows that some workers without formal education (level 1) and those with only high school (level 3) were in training while at their job. However, Table 3.12 in the appendix does not find qualitatively different results.

[21]By the same reasoning the marginal effect of ln S5+6 will now depend on the sample values of the other skill groups and cannot be interpreted directly.

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3.6 Conclusion

This paper has shown that well known estimates of the size of the skills-growth effect are biased because endogeneity of the initial employment size is not sufficiently accounted for when fixed effects matter for both growth and initial city characteristics. Adjusting the estimates using two data-sets on German metropolitan areas and recently improved dynamic panel GMM techniques shows that the effect is significant but 30% smaller. We have also demonstrated that other skill groups matter for growth, namely those with vocational training. We find robust evidence that technical college graduates such as engineers interact positively with workers with vocational training and reinforce the latter's positive effect on employment growth. This effect is slightly decreasing over time however, while non-technical university graduates are becoming more important. City success may depend on the right combination of skills and not only on the percentage of college graduates. Micro-data at the firm level may shed more light on this link in the future.

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APPENDICIES

3.A Robustness

TABLE 3.10: *Skill Interactions with Additional Controls (IAB Sample, 1975-2001)*

	Yearly % total employment growth (SGMM2r estimator)			
interactions with:	S5	S6	S5+6 & time trend	
At *t-1*	(3)	(4)	(5)	(6)
ln S5	.043 (.055)	.025 (.013)*		
ln S6	.023 (.010)**	.072 (.039)*		
ln S2+4	1.932 (.398)***	1.418 (.300)***	.323 (.075)***	-.466 (.355)
ln S3	-.096 (.033)***	-.048 (.025)*	.038 (.007)***	.036 (.006)***
ln total employment	-.013 (.007)*	-.017 (.006)***	-.031 (.009)***	-.030 (.009)***
ln S5 * ln S2+4	.390 (.086)***			
ln S5 * ln S3	-.025 (.008)***			
ln S6 * ln S2+4		.265 (.059)***		
ln S6 * ln S3		-.012 (.007)*		
ln S5+6 * time trend			.006 (.001)***	
time trend			.015 (.002)***	.005 (.002)***
ln S5+6 * S2+4 * time trend				-.007 (.001)***
ln S5+6 * ln S2+4				-.124 (.092)
ln % manufacturing	-.010 (.023)	.012 (.023)	.087 (.026)***	.074 (.022)***
Diversity index	-.106 (.030)***	-.082 (.027)***	-.032 (.030)	-.049 (.030)*
Average worker age	-.015 (.005)***	-.010 (.004)***	.0005 (.003)	-.0005 (.003)
Obs.	3204	3204	3207	3207
AR(1) test, p-value	5.86e-19	3.87e-18	1.58e-17	1.46e-17
AR(2) test, p-value	.739	.819	.075	.068
Sargan over-id. test, p-val.	.374	.371	.176	.169
Diff-Sargan test, p-value	1.000	1.000	1.000	1.000

ln Sx denotes the ln of the share of workers of skill level(s) x. Windmeijer (2005) robust standard errors in parentheses (two-step estimation). * significant at 10%; ** significant at 5%; *** significant at 1%. East Germany dummy included, and time dummies in columns 1 and 2.

Table 3.11: *Skill Shares Without Workers in Training (IAB Sample)*

Level	Av. share in 1975	Av. share in 2001
6	1.3%	5.4%
5	1.3%	3.6%
4	0.6%	5.4%
3	0.3%	0.8%
2	60.1%	74.0%
1	36.4%	10.7%

Note: 2001 includes East Germany.

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TABLE 3.12: *Without Workers in Training (IAB Sample, 1975-2001)*

	Yearly % total employment growth (SGMM2r estimator)				
	(1)	(2)	(3)	(4)	(5)
ln S5+6	.052 (.017)***			-.057 (.024)**	.043 (.048)
ln S5		.374 (.071)***	.046 (.019)**		
ln S6		.040 (.016)**	.227 (.045)***		
ln S2+3+4	.202 (.073)***				
ln S2+4		1.815 (.456)***	1.118 (.288)***	.521 (.102)***	.572 (.407)
ln S3		.144 (.035)***	.094 (.024)***	.064 (.007)***	.070 (.008)***
ln total employment	-.005 (.006)	-.025 (.009)***	-.025 (.008)***	-.035 (.012)***	-.041 (.012)***
ln S5+6 * ln S2+4					.092 (.106)
ln S5 * ln S2+4		.353 (.100)***			
ln S5 * ln S3		.034 (.009)***			
ln S6 * ln S2+4			.193 (.058)***		
ln S6 * ln S3			.022 (.006)***		
ln S5+6 * time trend				.006 (.001)***	
time trend				.013 (.003)***	.0007 (.002)
ln S5+6 * S2+4 * time trend					-.006 (.002)***
ln % manufacturing	.033 (.014)**	.037 (.024)	.055 (.022)**	.091 (.026)***	.089 (.025)***
Diversity index	-.072 (.026)***	-.077 (.041)*	-.056 (.036)	-.045 (.035)	-.060 (.040)
Average worker age	-.016 (.003)***	-.012 (.007)*	-.009 (.007)	-.006 (.004)	-.005 (.004)
Obs.	3250	3115	3115	3117	3117
AR(1) test, p-value	3.43e-15	1.57e-16	5.32e-07	1.53e-15	7.20e-15
AR(2) test, p-value	.670	.943	.671	.077	.068
Sargan over-id. test, p-val.	.605	.481	.695	.186	.165
Diff-Sargan test, p-value	1.000	1.000	1.000	1.000	1.000

ln Sx denotes the ln of the share of workers of skill level(s) x. Windmeijer (2005) robust standard errors in parentheses (two-step estimation). * significant at 10%; ** significant at 5%; *** significant at 1%. East Germany dummy included, and also time dummies in column 1.

Chapter 4

Urban Growth, Uninsured Risk, and the Rural Origins of Aggregate Volatility

Synopsis

The proportion of the population living in urban areas has increased by over five percentage points per decade outside the developed world since 1960. Rapid urbanization was accompanied by fast economic growth and job creation in most parts of the world. However, Africa (and Latin America after 1980) has had a notably different experience: while growth in GDP per capita slowed significantly or even reversed, the rate of urbanization continued its fast pace. This paper aims to explain this by introducing an aggregate risk differential between the countryside and the city. Uninsurable expected risk will lead to rural-urban migration as a form of ex-ante insurance if households are liquidity constrained in incomplete markets and cannot overcome adverse shocks. Macroeconomic volatility finds its origins in risk-prone natural resource production including agriculture and has a robust positive effect on urban growth, especially when economic growth is slow. The effect exists in addition to the transitional view on urbanization of economies shifting from an agricultural to an industrial base.

4.1 Introduction

The level of urbanization has increased by over five percentage points per decade outside the developed world since 1960. As a result, sometime this year the world will have more urban inhabitants than rural dwellers. Rapid urbanization was accompanied by fast economic growth in most parts of the world. However, Africa (and Latin America after 1980) has had a notably different experience (Fay, Opal, 2000) as is shown in Figure 4.1. While growth in GDP per capita slowed significantly or even reversed, the rate of urbanization continued its normal fast pace. Table 4.1 ranks regions by the growth differential between national and urban population. Given the low GDP per capita

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growth in Sub-Saharan Africa, it is surprising that it comes on top in terms of the pace of urbanization. Without growth to create jobs or higher wages in cities (such as in East Asia) it seems puzzling that so many rural dweller choose to become urban dwellers. Most people end up in slums which do not necessarily offer better living conditions than rural areas for a given income (UN-Habitat, 2006). The long time period and crowding should lower the expected income gain from moving to the city. Big city lights are not always bright. It seems that the continued migration flows in some parts of the world are larger and more persistent than the classic Harris-Todaro (1970) model can explain. An illustration is given by Equatorial Guinea, a Sub-Saharan African country. Between 1990 and 1995 its urban population grew 12 percent faster than the national population, yet GDP per capita and manufacturing value added were *declining* on average by 9 percent and 7 percent per year respectively.

Apart from being pulled to the city by a higher income promise, people may also be pushed from the rural area. If living conditions worsen in the countryside because sources of income decline (for example by natural causes such as rainfall or conflicts) then people will move to cities even if urban economic growth is absent, because it is the only place to go with at least some chance of improvement. Even if rural life exhibits good as well as bad years then people are still pushed off the land and to the city in bad years, unless they have the financial means to smooth consumption and 'ride out the bad times'. The more volatile shocks are, the more likely it is that sufficiently bad years occur that wipe out savings. Natural resource production and the exogenous prices they fetch on the world market show very volatile behavior (Deaton, 1999). Financial services to insure against shocks are relatively absent in rural areas (Collier, Gunning, 1999). Return migration in good years is limited by population growth, but also because good years offer more urban employment. Sub-Saharan Africa was the most volatile region during the past 45 years and also very resource dependent, as Table 4.1 shows.[1] Our example of Equatorial Guinea did not suffer from war or conflict in the 1990s, but output growth volatility in the agricultural sector (62% of all value added) was a worrying 27 percent and the standard deviation of yearly GDP per capita growth rates a similarly high 24 percent! The *negative* agricultural growth shock of 29 percent in 1993 (while world food export prices had been declining for three years) may well have pushed farmers to cities to find alternative income sources, if they could not use financial instruments to wait for next year's positive shock of 44 percent. Risk was evidently high.

This paper will try to explain urbanization occurring even under negative growth, by including another feature of many developing countries: their dependence on natu-

[1]See appendix section 4.A for data sources.

ral resource production and consequent shocks to GDP growth. Figure 4.2 shows the dependence of four regions on resource exports over time. Notably Africa and Latin America are very resource dependent.

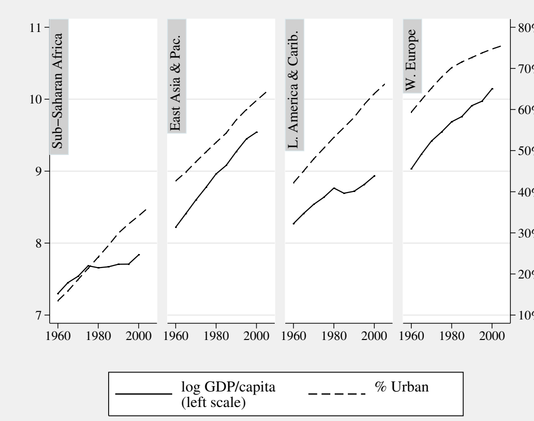

Figure 4.1: *Growth and Urbanization*

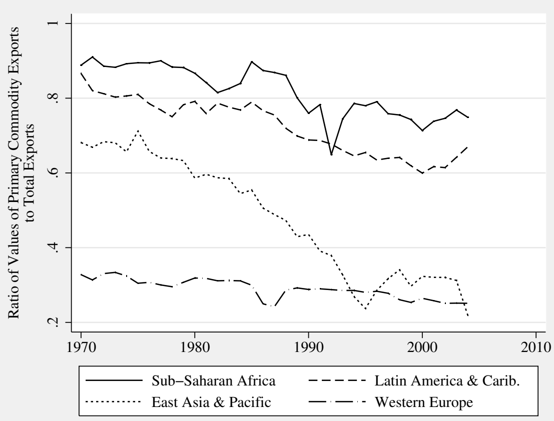

Figure 4.2: *Resource Dependence*

Table 4.1: *Economic and Urban Growth by Region (yearly %, 1960-2005)*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP/capita growth		% Population growth			Nat. resource exp. value/GDP	% Urban	
	mean	sd	urban	total	(3)-(4)	mean	1960	2005
Sub-Saharan Africa	0.85	6.93	5.25	2.54	2.71	17.37	13.50	36.25
South Asia	2.40	2.70	3.97	2.12	1.85	5.05	13.00	23.92
Eastern Europe & Central Asia	2.98	4.54	2.84	1.30	1.53	3.83	32.85	60.50
East Asia & Pacific	3.39	4.13	3.31	1.84	1.48	16.04	42.62	64.31
Middle East & North Africa	1.78	5.75	3.96	2.84	1.12	11.48	42.27	65.17
Latin America & Caribbean	1.44	4.11	3.10	2.00	1.10	13.96	42.16	66.10
Western Europe	2.78	2.52	1.22	0.57	0.65	7.54	59.35	75.53
North America	2.28	1.88	1.53	1.17	0.36	5.82	69.55	80.45

Note: Ordered on column 5. Means (or standard deviations) are calculated as the within-region cross-country unweighed average (or standard deviation) of country-time-period average growth rates (or standard deviations).

Recent work has explained the different African experience by using rainfall data (Barrios et al., 2006) and shown that low rain fall (low agricultural productivity) is associated with a higher contemporary level of urbanization. Fay and Opal (2000) and Davis and Henderson (2003) identify government policy resulting in 'urban bias' and artificially high urban wages as an important cause for high levels of urbanization, in combination with urban poverty. Other explanations are ethnic tensions, democracy (more regional autonomy, so less urban bias), less than average agricultural yield (which is related to rainfall), and changes in the five-year average ratio of producer prices of wheat, rice, and maize to the country's CPI (which is often used as a proxy for rural to urban terms of trade), and to the world prices. We will add to this literature by focusing on volatility in output (standard deviation of GDP per capita growth), and volatility in the value of natural resources. We believe that the uncertainty associated with shocks around five-year means is more important than average changes themselves. We will show that these shocks originate mostly from rural (resource) sectors rather than urban (manufacturing) sectors and that the resource sector tends to be more risky. Figure 4.3 shows cumulative density functions for four resources, and general price indices for industrial countries and the world. The x-axis shows the size of yearly standard deviations in percentage monthly price index changes. It is clear for example that a country with a high dependence on food products faces much more volatile prices than the average industrial country which typically trades in manufactures. Moreover, food prices are almost as volatile as oil prices. This prompted large price stabilization schemes in the 1970s which had many pitfalls and adverse side effects as studied in Newbery and Stiglitz (1981). Figure 4.4 plots the same resource price indices over time in levels. There are clearly very volatile periods and periods in which the price is much more stable. The volatility of output shocks is primarily caused by volatility in non-urban sectors, such as the natural resource sector. We will furthermore primarily focus on the speed of urbanization rather than the level and hypothesize that urban growth is faster in more volatile periods, especially if average growth is low. Shocks around a low or negative growth rate are probably worse than shocks around a high and positive growth rate.

Stark and Levhari (1982) first noted the role of uncertainty and risk as a motive to migrate (for some family members). Daveri and Faini (1999) have estimated this motive for Italian migrants within Italy and internationally, and conclude that risk is a significant determinant, driven by risk aversion. Dustmann (1997) similarly models the *duration* of migration as it is determined by risk at home and abroad, and the (intertemporal) covariance of labor market shocks in addition to a wage differential. For example, a temporary migrant may diversify risk if the covariance of shocks is negative. We will try to link this motive to a country's natural resource dependence and income risk in rural and urban sectors to explain fast rates of urban growth.

The next section describes the means by which households may cope with risk and how successful they are. Section three models households' migration behavior in response to shocks and section four discusses the estimation strategy. Sections five and six describe the results and assess their robustness, after which section seven concludes.

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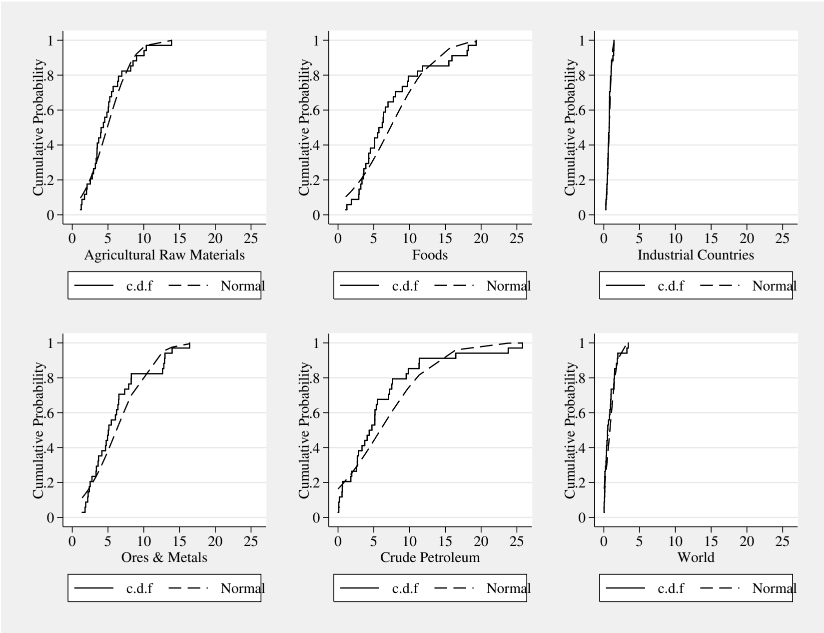

FIGURE 4.3: *Densities of Yearly Standard Deviation of Monthly Price Index Changes, 1970-2003*

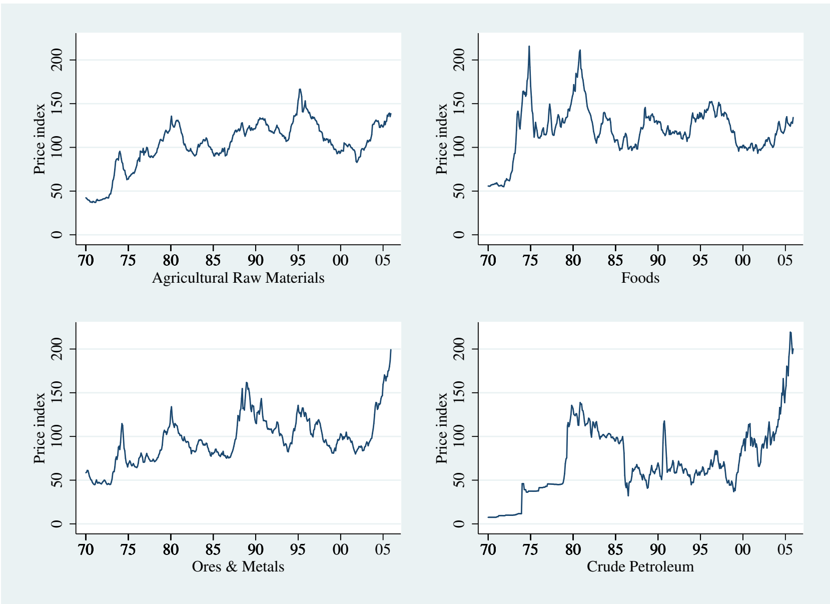

FIGURE 4.4: *Price Index Plots (Monthly, Labels at January of Each Year)*

4.2 Households and risk insurance

In industrialized countries households can deal with risk by buying financial services such as a savings and checking accounts, (unemployment) insurance, pensions, bonds, and loans, allowing them to smooth consumption over time. Most of these services are however beyond the reach of most people in developing countries, especially outside the urban environment where few if any of these services are provided. Even inside cities a dual economy exists, the formal and the informal one, both in terms of labor and in terms of housing (see i.e. Temple, 2005). Slum dwellers will find it much harder to smooth consumption because they cannot provide collateral or a credit history. We are therefore in a situation of incomplete markets which affect not only households' (ex post) income, but also their (ex ante) behavior.

Insurance may partly be obtained by various informal means, as described in Besley (1995). We distinguish ex post risk sharing which usually happens at the village level among households. It takes the form of (cross-sectional) transfers which pool risk and income and provide insurance against idiosyncratic shocks but requires strong information and enforcement institutions within the community (Udry, 1990). However, the larger the covariance of shocks among households, the less scope there is for this form of insurance. Aggregate community shocks can not be insured against. Townsend (1994) and others[2] find that Pareto efficient risk pooling is often not achieved. Transfers across time may provide additional insurance, but Rosenzweig and Binswanger (1993) find that this is also limited because of credit constraints. Moreover, it leads households to choose less risky investment projects with a lower return, which has an adverse effect on productive efficiency.[3] Accumulation of buffer stocks, often in the form of bullocks, may also be used to smooth consumption (Deaton, 1991), but this may also affect production if these assets are used in production (Rosenzweig and Wolpin, 1993) and is thus a sub-optimal insurance method.

Households can also cope with risk by changing their behavior in such a way that they minimize the chance of bad shocks hitting them in anticipation of risk. This is referred to as ex ante insurance and takes the form of conservative investment decisions, such as postponing adoption of new risky technology, crop diversification, crops of lower yields but faster growth cycles, diversifying family members among different income activities, or sharecropping. It is also related to remittances and risk diversification by means of assigning family members to work in a different area, country or sector such as in Stark and Lucas (1988), although we do not believe that this alone can account for the high speed of urbanization. The relative importance of ex ante risk insurance is

[2]See Bardhan and Udry, 1999.

[3]Risk usually commands a higher return because otherwise the project would never be started, but in a rural development country setting risk might be high even with low return if social and financial constraints limit the ability to change predetermined investments, such as being born on a family (subsistence) farm.

shown by Elbers et al. (2005). They use micro data to quantify the ex post and ex ante effects of risk on capital accumulation and find that two-thirds of the detrimental effect of risk is due to the ex ante type which influences households behavioral decisions.

Since we focus on aggregate shocks which are uninsurable by the local informal ex post methods we assume that ex ante risk insurance is an important response to, for example, world resource price shocks. We hypothesize that migration is the link between risk and urban growth because it is the ex ante response to aggregate rural income risk.

4.3 Model of ex-ante risk insurance

The theoretical reason to look at volatility as an explanation for urbanization is derived as follows. Representative workers are either employed in an urban manufacturing sector M, the urban informal sector I or in the rural resource sector R.[4] The resource sector may produce agriculture, mining or plantation products such as coffee, and is assumed to be the only source of income and employment outside the city. The national composition of output in these sectors is also translated into output growth volatility (its standard deviation). We will show that output volatility originates to an important extend from shocks to the exogenous world prices for exports including manufactures and natural resources, the latter of which are more volatile. The more total GDP depends on resource export earnings, the higher will be the covariance between GDP growth shocks and resource prices. Shocks are larger and more frequent in the rural resource sector than in the urban manufacturing sector.[5] Furthermore, the urban sector typically has better access to financial services to insure against shocks, while the rural agricultural sector is additionally affected by weather shocks. It is therefore reasonable to assume that production and employment in the rural sector is inherently more risky than employment in the urban manufacturing sector even though its return is not necessarily higher. Some periods are more volatile than others and a country's development over time may change the dependence on resources and its ability to cope with external shocks. A time dimension is therefore also important. The goal of this model is to analyze the effect of a risk differential on workers' location choice.

A representative worker[6] faces a migration choice every period and simultaneously a

[4]The 'sector' of subsistence farming is not explicitly modeled because it is affected mostly by weather shocks, rather than by price shocks.

[5]Unfortunately, we will not be able to distinguish between urban and rural GDP growth and shocks, we only observe changes in aggregate GDP. We assume instead that manufactures are produced exclusively in cities and agriculture and resources outside cities.

[6]We will not distinguish between migration of a single worker or of a household since we rely on aggregate data.

choice between sectors.[7] Household face a liquidity constraint every period because we assume that financial markets are underdeveloped, especially in the rural and informal urban sectors. Lack of collateral or a credit history (and incomplete markets) prohibits borrowing such that in every period the value of assets A_t plus expected income y_t should be larger than consumption c_t and the optional cost of migration κ (which is positive only if a household decides to move, zero otherwise).

$$A_t + y_t - c_t - \kappa_t \geq 0 \tag{4.1}$$

Income y_t depends on the previous period's 'portfolio' choice ($z_{t-1} \in \{0, 1\}$) of the household which corresponds to a choice of sector and hence of location.[8] We call $z = 1$ rural and $z = 0$ urban. Because each location has a perfectly competitive sector people can always find either formal or informal employment in the city.[9] We assume additionally that each sector faces a different degree of aggregate (multiplicative) income risk. Income is therefore a function of exogenous shocks taking place in the rural sector $\epsilon_t \sim N(1, \sigma_\epsilon^2)$ with unit mean and variance σ_ϵ^2 and in the urban sector $\eta_t \sim N(1, \sigma_\eta^2)$, with known joint density function $f(\epsilon, \eta)$. Income thus also depends on the previous-period location choice z_{t-1}: $y_t = y(z_{t-1}, \epsilon_t, \eta_t)$. Income is increasing in the size of the shocks: $\partial y_t / \partial \epsilon_t > 0$ if $z_{t-1} = 1$ and, 0 otherwise; and $\partial y_t / \partial \eta_t > 0$ if $z_{t-1} = 0$, and 0 otherwise.[10] Income is increasing in the choice of the rural sector when rural times are good ($\partial^2 y_t / \partial \epsilon_t \partial z_{t-1} > 0$), but decreasing if the urban sector enjoys good times ($\partial^2 y_t / \partial \eta_t \partial z_{t-1} < 0$). It is therefore crucial to form expectations on the relative riskiness of both sectors to make a choice of location. We assume that the urban sector is less risky such that $\sigma_\eta^2 < \sigma_\epsilon^2$.

Households maximize a discounted flow of expected utility from consumption subject to their budget constraint, where r_t is the rate of return on assets:

$$\max_{c_t, z_{t+1}} E_t \sum_{\tau - t}^{T} \beta^{\tau - t} u(c_\tau) \tag{4.2}$$

$$s.t. \qquad A_{t+1} = (1 + r_t)(A_t + y_t - c_t - \kappa) \tag{4.3}$$

[7]This section builds heavily on a standard risk and insurance model with a precautionary savings motive (as in Mirrlees, 1965; Deaton, 1991), see Bardhan and Udry (1999). In these models households make choices between different investments with different risk and return. Here we add the possibility that location is a choice and that each location promises a different stream of income.

[8]We could also make this choice continuous. In that case the household chooses its distance to the nearest city and thus access to an external market with means of diversification, but this would not change our main results. See for example Brueckner and Zenou (1999) for an urbanization model with a land market.

[9]We abstract from any unemployment benefits.

[10]This is only if rural and urban shocks are uncorrelated. If they are imperfectly positively correlated then a rural shock might also affect urban income, but less so than an urban shock of equal magnitude.

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Households are risk averse so $u' > 0$, $u'' < 0$ and $\lim_{x \to 0} u'(x) = +\infty$. Households therefore aim to smooth consumption over time. The corresponding period t value function is given by:

$$\begin{aligned} V_t(A_t + y_t) = \max_{c_t}\{u(c_t) &+ \beta E_t V_{t+1}[(1+r_t)(A_t + y_t - c_t - \kappa) \\ &+ y(z_t, \epsilon_{t+1}, \eta_{t+1})] + \lambda_t(A_t + y_t - c_t - \kappa)\} \end{aligned} \tag{4.4}$$

where λ_t is the multiplier associated with the liquidity constraint. The current value of assets and income equals the maximum of current utility from consumption plus the discounted value of future assets and income. Maximization yields:

$$u'(c_t) = \beta E_t V'_{t+1}[(1+r_t)(A_t + y_t - c_t - \kappa) + y(z_t, \epsilon_{t+1}, \eta_{t+1})] + \lambda_t \tag{4.5}$$

The household also chooses the location one period before as a form of ex-ante risk insurance. Using the envelop theorem we have:

$$E_{t-1}\frac{dV'_t(\cdot)}{dz_{t-1}} = E_{t-1}u'(c_t)\frac{\partial y}{\partial z_{t-1}} = 0 \tag{4.6}$$

$$\iff E_{t-1}[\beta(1+r)V'_{t+1}(\cdot) + \lambda_t]\frac{\partial y}{\partial z_{t-1}} = 0 \tag{4.7}$$

If the liquidity constraint 4.1 never binds ($\lambda_t = 0$), the location is chosen such that there is no incentive to move

$$E_{t-1}V'_{t+1}(\cdot)\frac{\partial y}{\partial z_{t-1}} = 0 \tag{4.8}$$

but if it does bind and $\lambda_t > 0$ households chose z_{t-1} such that (rewriting eq. 4.7)

$$E_{t-1}\beta(1+r)V'_{t+1}(\cdot)\frac{\partial y}{\partial z_{t-1}} = -E_{t-1}\lambda_t\frac{\partial y}{\partial z_{t-1}} \gtreqless 0 \tag{4.9}$$

The last inequality holds only when the liquidity constraint binds, which is when either shock is negative (meaning smaller than 1) but not equal to each other. We look at the short run effects of large shocks rather than the long run effects when shocks are expected to be at their mean of 1. Volatility is then interpreted as a higher chance of receiving a shock that is so large that all savings are diminished. Households will want to avoid being put in that situation. If the household lives and works in the city ($z_{t-1} = 0$) and the shock is sufficiently bad ($\eta_t << 1$) such that the liquidity constraint binds we have that $\partial y/\partial z_{t-1} > 0$. Households could improve utility by moving to the countryside if they expect the constraint to bind, which is where $-E_{t-1}\lambda_t\frac{\partial y}{\partial z_{t-1}} < 0$. Conversely, if $z_{t-1} = 1$ (rural) and $\epsilon_t << 1$ (bad rural year) we have that $\partial y/\partial z_{t-1} < 0$ and thus that $-E_{t-1}\lambda_t\frac{\partial y}{\partial z_{t-1}} > 0$. In that case the urban sector would be better if households expect the constraint to bind. If both shocks are of equal size they cancel, and we are back in the situation of equation 4.8 where there is no incentive to move.

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Three insights arise: the more likely it is that the liquidity constraint binds, the more likely households will be able to improve consumption and utility by migrating to the area where they expect shocks to be smaller. Second, since the variance of shocks to the rural sector was assumed to be larger than the variance of shocks to the urban sector, we have that rural households are more likely to suffer an adverse shock that is large enough to hit the liquidity constraint. They will migrate to the urban area. Without modern sector job growth this leads to an increase in the informal sector (for given wages) and a lower expected urban wage which is the balancing force. Third, if both shocks are equal in size we have that $\partial y/\partial z_{t-1} = 0$. Then no improvement can be gained from migrating, even if households hit a liquidity constraint. This is the case if the covariance of both shocks equals one.

In our three sector model we can write household income y_t as:

$$y_t(z_{t-1}, \epsilon_t, \eta_t) = z_{t-1} w_{R,t} \epsilon_t + (1 - z_{t-1})(e_t w_{M,t} + (1 - e_t) w_{I,t}) \eta_t \tag{4.10}$$

where the w_j $(j = R, M, I)$ are sectoral wage rates and e_t is the share of urban labor employed in the modern sector, which are all taken as given by the household. The wage rate in the modern sector is higher than the wage in the informal sector. This may be due to for example minimum wage legislation, trade unions, efficiency wage or the need for specific human capital in the modern sector, but is not modeled explicitly.[11] Excess labor supply in the urban area is absorbed by the informal sector. The expected urban wage (second element in equation 4.10) is therefore the probability-weighted income of the informal and the modern sector.

With a non-binding liquidity constraint (4.8) becomes:

$$E_{t-1} V'_{t+1}(\cdot)(w_{R,t}\epsilon_t - (e_t w_{M,t} + (1 - e_t) w_{I,t})\eta_t) = 0 \tag{4.11}$$

which is satisfied if the expected rural wage equals the expected urban wage and corresponds to a classic Harris-Todaro (1970) equilibrium migration equation. If however shocks are adverse enough to exhaust all assets such that the liquidity constraint binds, we have that:

$$\begin{aligned} E_{t-1} V'_{t+1}(\cdot)(w_{R,t}\epsilon_t &- (e_t w_{M,t} + (1 - e_t) w_{I,t})\eta_t) = \\ &- E_{t-1}\lambda_t (w_{R,t}\epsilon_t - (e_t w_{M,t} + (1 - e_t) w_{I,t})\eta_t) \gtreqless 0 \text{ if } \epsilon_t \lesseqgtr \eta_t \end{aligned} \tag{4.12}$$

If $\epsilon_t < \eta_t$ and smaller than 1 it follows that the rural wage is smaller than the expected urban wage, corresponding to a negative marginal income to the location choice. The

[11]See for example Temple (2005) for an overview.

household could have improved income by decreasing z_{t-1}: that is, moving to the urban sector. If however $\epsilon_t > \eta_t$ and $\eta_t < 1$, the reverse holds, and if both shocks are equally adverse we are back in the equilibrium setting. Within our assumption that the rural sector is more risky ($\sigma_\eta^2 < \sigma_\epsilon^2$), it follows that rural households are expected to face more severe shocks than urban households. Rural households can expect the liquidity constraint to bind in such volatile periods. The net direction of migration should therefore be from rural to urban areas. A crucial reason for this is the lack of financial instruments to insure against aggregate shocks (except some saving in the form of livestock for example). If such markets are available at all they will be more prevalent in urban areas (Collier, Gunning, 1999). Urban households will thus be better equipped to face downturns than their rural counterparts which reinforces the hypothesized direction of migration and hence urbanization. Urban growth due to migration should thus be positively influenced by volatility. Furthermore, the larger the urban informal sector, the lower urban growth because it depresses the expected urban wage. Positive wage growth in the urban modern sector will still induce faster urban growth.

The role of migration costs lies in the fact that risk aversion would induce a household to move independently from liquidity constraints. The premium a household would be willing to pay to get rid of risk depends on the functional form of utility, but is positive for risk averse households. Lower migration costs should induce more migration independently of shocks if they fall below the utility costs of risk. In long-run equilibrium when shocks are of mean size and no one has an incentive to move this means that the cost of migration is equal to the risk premium. We therefore include proxies such as the density of the road network, a decolonization dummy, and the polity index to capture changes in costs and migration restrictions in the regressions. Furthermore, if households have to sell off assets such as land to afford migration, they may be locked in when they arrive in cities (or slums) until they have accumulated enough assets again.

4.4 Estimating the effect of risk on urban growth

Our work builds on Brueckner (1990) who specifies a monocentric-city model with rural-urban migration. He finds an important positive effect of the urban to rural income ratio on both urban population levels and growth rates but is limited to a cross-section of 24 developing countries, as are Becker and Morrison (1988). Moomaw and Shatter (1996) estimate a larger panel sample of countries. The most robust finding is that countries with a higher share of industrial labor are more urbanized, supporting that view that urbanization takes place as a country transitions from an agricultural to an industrial base. If technological progress drives city growth through the industrial

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sector as simulated in Kelley and Williamson (1984), then urban income may continue to outpace rural income. Davis and Henderson (2003) estimate a five year panel from 1960 to 1995 and find that a shift from agriculture to industry, and the policies that affect this, lead to urbanization. For example, planned economies such as China tend to restrict migration, and policy may affect the sectoral composition through, for example, import substitution programs.

The above mechanisms form plausible explanations for city growth but rely implicitly on economic growth of the urban manufacturing sector to generate a rural-urban income gap and sectoral transition. Why would some countries still urbanize if growth is absent? We add to the literature by focusing on risk and the hypothesized migration reaction of rural households and include macroeconomic volatility as an explanatory variable. We also extend the panel to 2005 and update the estimation techniques (see section 6).

As a starting point we take the specification in Davis and Henderson (2003) based on Brueckner (1990). In equilibrium the national urban population L^u_{it} for country i and year t (5-year intervals) is given by:

$$\ln L^u_{it} = \delta_0 \ln L_{it} + \delta_1 X_{it} + \gamma_i + e_{it} \tag{4.13}$$

where L is total population. The X_{it} include measures that should capture the country's state of development, rural-urban differences in public service provision, democracy and infrastructure, which may affect migration costs; urban cost of living which is affected by local population and level of development; and ideally measures of the expected urban and rural wages. The γ_i capture fixed unobserved country characteristics and the e_{it} is the error term which may be autocorrelated within countries due to the high persistence of our variables.

However, we will not assume that countries are in equilibrium every five years and rather focus on changes. Our core message is that volatility is a strong destabilizing force which influences the speed of urbanization rather than the level. Volatile countries are not necessarily more or less urbanized, but volatile periods will induce more rural-urban migration. Our main specification is therefore given by:

$$\ln L^u_{i,t+1} - \ln L^u_{i,t} = \beta_0(\ln L_{i,t+1} - \ln L_{it}) + \beta_1 Z_{it} + \beta_3 \sigma_{it} + \gamma_i + e_{it} \tag{4.14}$$

where the Z_{it} contain the (ln) initial urbanization rate as a measure of the state of development (which is also highly collinear with initial (ln) GDP per capita), plus allows urbanization to influence itself if migration leads to more migration. $\beta_3\sigma_{it}$ denotes the effect of output per capita growth volatility and is our core variable of interest. We assume that households form expectations at the beginning of every period t on the volatility between t and t+1, and decide to move or not at time t. Average GDP per capita growth is included to capture the effects of economic development and the transition process (including changes to the urban-rural wage gap if growth, as is often assumed, originates in cities). An interaction term between volatility and average growth is added to see if the effects of risk are higher when growth is negative. Negative growth should make shocks worse for credit constrained households. In robustness tests we will also include an index of democracy and authoritarian rule (polity index), the state of infrastructure (road density), a dummy for independence because colonialism also limited migration, and change in average rainfall as a proxy for changes in agricultural productivity. Financial development (as proxied by domestic credit as a percentage of GDP) captures the extend to which markets are complete and the degree to which households have access to financial services: the higher this number, the less likely it is that credit constraints ever bind, and the less volatility should affect urban growth. The panel structure of our data allows us to let all variables change over time and moreover to control for country fixed effects. We observe the level of urbanization and thus urban population growth only every 5 years, but are able to regress this on level country characteristics at the start of the period, and changes which happen during the 5 year period. See the appendix for detailed variable definitions and their sources.

A caveat is that we introduce a lagged dependent variable by regressing urban population growth on the initial level of urbanization.[12] Equation 4.2 can be rewritten as $\ln L^u_{t+1} = 1 * \ln L^u_t + \beta_1 \ln L^u - (\beta_1 + \beta_2) \ln L + \beta_2 \ln L_{t+1} + ... + \gamma_i + e_{it}$. Nickell (1981) showed that the coefficient β_1 is in this case measured with bias in both OLS and FE regressions if initial urban population is correlated with the country fixed effects. Estimators such as Arellano and Bond (1991) and Blundell and Bond (1998) should be able to solve for this bias by first differencing the system to get rid of the fixed effects and using lags as instruments. Davis and Henderson (2003) used these methods as a form of IV. Recent developments have made the estimators more reliable, see for example Windmeijer (2005) and Roodman (2006).

4.5 Estimating the effect of resource production on aggregate volatility

The drawback is that we have to rely on aggregate data to estimate the effect of volatility on urban growth. Although we would have liked to use shocks to rural versus urban GDP, no such data exists, so we have to extend the estimation with aggregate explanatory variables for aggregate output per capita shocks. We will show that volatility originates

[12]This also occurs in Brueckner (1990) and Fay and Opal (2000) but is not addressed.

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mostly in rural activities such as export of natural resources, including food, and in shocks to value added in the agricultural sector. We estimate the following equation where we assume that resource production is a rural activity:

$$\sigma_{it}^{GDP/cap.} = \sigma_{it}^{resources} + R_{it} + \tilde{e}_{it} \tag{4.15}$$

where $\sigma_{it}^{GDP/cap.}$ is the five-year standard deviation of output per capita growth rate regressed on $\sigma_{it}^{resources}$, the five-year standard deviation of growth rates in natural resource export values; and R_{it}, a control matrix with initial dependence of GDP on resource exports at time t and possible other correlates with $\sigma_{it}^{GDP/cap.}$ such as rainfall shocks, financial development, a civil war dummy which happened all too often in many African countries, a measure of remoteness and openness to trade which allows export diversification to absorb sectoral shocks. Rainfall volatility allows us to distinguish between value added and export value shocks which incorporate price shocks, and nature shocks.

We can never use the world price indices for resource exports directly because they consist of a basket of export products. The weights of each product does not correspond to the composition of our export variables for every country. We assume instead that supply is very inelastic and changes slowly because mines or plantations cannot be expanded in the short run. Shocks to changes in export value should then be interpreted as price shocks rather than quantity shocks.

Because resource exports are exported through ports (through cities), one could object and question whether much of the price movement actually affects the non-urban sector. Alternatively, we estimate the similar equation:

$$\sigma_{it}^{GDP/cap.} = \sigma_{it}^{sector\ growth} + R_{it} + \tilde{e}_{it} \tag{4.16}$$

where $\sigma_{it}^{sector\ growth}$ is the five-year standard deviation of growth rates in various sectors. We assume that the manufacturing sector is a purely urban activity, while the agricultural sector (and the mining sector) are purely rural activities. We will show that shocks to the agricultural sector do affect aggregate volatility, while shocks to manufacturing have much less effect.

4.6 Panel evidence from 1960 to 2005

4.6.1 Urban growth and volatility

We start our estimation by performing simple OLS and FE regressions on our baseline equation 4.14 presented in Table 4.2. For a sample of 108 countries from 1960 to 2005 we find that volatility significantly affects urban population growth, even after controlling for fixed (country) unobservable covariates, and the level of development as captured by

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initial urbanization[13], average growth rate of GDP per capita, and population growth during the same period. The errors are robust to heteroskedasticity and clustered by country because we find significant autocorrelation in the errors.[14]

In the third column we test for an interaction term between volatility and average GDP/capita growth. The size and significance of the resulting marginal effect of volatility cannot be read from the table because it depends on average growth and covariances. We represent the effect graphically in Figure 4.5, which clearly shows that the marginal effect of volatility on urban growth is significant for negative average economic growth rates. This confirms our hypothesis that shocks to income have an important effect on rural-urban migration, especially when economic growth is slow or negative which is when liquidity constraints bind more often. A country such as Brazil for example, with average GDP per capita growth rate of only -0.5% per year between 1980 and 1985, could have had negative urban growth rate as jobs disappear. However, volatility during this period was 4.8% leading to fast urban growth of 5.6% over the period. In Niger during the same period urban growth was even 7.9%, although GDP per capita growth was declining at 3.4% per year! Volatility in this case was also 7.9%. This may explain continued urbanization even without economic growth.

4.6.2 Volatility, agriculture and natural resources

Next we explore the source of macroeconomic volatility by looking at natural resource exports and fluctuations in sectoral value added growth rates. Note that this constrains our sample size and, for example, excludes the 1960s. The first two columns in Table 4.3 regress five yearly observations of volatility on the standard deviation of resource export value growth rates, and in column two with controls for initial dependence. The agricultural effect seems much weaker than the effect of fuels and ores. However, when we add interactions between initial dependence and subsequent five-year volatility we see that there is a strong effect of agricultural products. Countries with high volatility in food and agricultural materials export values have also more aggregate volatility if their GDP depends on these export earnings, making them more risky.

Columns four and five instead focus on three sectors: manufacturing, which we assumed is an urban activity, and agriculture (including plantations) and mining, which

[13]We experimented also with initial ln GDP/capita instead but this gave worse fits and was often insignificant in addition to being highly collinear with the initial level of urbanization.

[14]We deleted 4 outliers which had average GDP/capita growth rates of a staggering 18% *per year* or more during a 5 year interval (Haiti '65-'70, Ghana '65-'70, Equatorial Guinea '95-'05). The sample of countries included is listed in Table 4.4. Small island nations did not introduce bias into the results.

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are large employers outside cities.[15] The last column shows that countries with relatively large agriculture and mining sectors are more volatile. Controlling for the relative importance of each sector in the economy we find that mainly fluctuation in the growth rate of value added of agriculture leads to aggregate shocks. The effect is twice as large as a shock to manufacturing sector growth. This confirms that rural sectors are more risky than urban sectors. It may well be that risk from rural production leads to aggregate risk which is positively associated with rural-urban migration. The export data explains less of the variation in aggregate volatility. It is likely the case that most natural resources are exported through ports in cities and exporting firms may have more access to external finance. Fluctuation in the value added of sectors may better reflect the inherent risk of these sectors and have larger effects on aggregate risk because it also includes producers for the local market.

The next section will test the robustness of these results and try to tackle the bias in the lagged dependent variable and endogeneity issues.

4.7 Endogeneity and robustness

4.7.1 Robustness: volatility and urban growth

There are strong reasons to believe that the regressions in Table 4.2 suffer from omitted variable bias. First of all it might be that volatility really consists of shocks around a positive growth rate instead of reflecting positive as well as large negative shocks. One large positive shock might cause urban growth by itself and have less to do with risk. We therefore replace the volatility measure with one that is based on only those yearly periods where average growth was positive.[16] The higher this measure, the larger were the positive growth rates. It has no effect, while its converse, based on negative growth rates has a strong negative effect as expected.[17]

In the second column we add changes in average rainfall. Barrios et al (2006) found a strong correlation between rainfall and levels of urbanization, but we cannot confirm that it has any effect on urban growth. The polity index which is increasing in democratization and decreasing in authoritarian rule has no impact, although Davis and Henderson (2003) did find political effects on primacy (the degree to which urban pop-

[15]We also observe sector data for the categories transport, construction, retail, and 'other' which includes many services. However, only for the three used can we make a plausible distinction between urban and rural activities. The mining variable never works well, probably because it also includes utilities, which are urban rather than rural.

[16]This requires a minimum of two positive growth rates within each 5 year period.

[17]We reported only the positive measure because the negative measure is a much smaller sample requiring at least two negative growth rates within each 5 year period.

ulation is concentrated in one city). Infrastructure investments, which also decrease migration costs by unlocking remote areas, as captured by the length of the road network as a share of country surface area, have a positive but insignificant effect. The independence dummy is significant: independence from colonial powers lifted old bans on migration and led to urban growth (Barrios et al., 2006). Including financial development improves the precision with which we measure the effect of volatility on urban growth but has no direct effect. Our main result that volatility affects urban growth is significant, even in this smaller sample and with all our robustness checks.[18]

Columns three to six explore heterogeneity in the effect of volatility on urban growth by dividing countries along the lines of their 1965 level of development, fuel and mining dependence, and 1965 level of financial development. As expected, urban growth in OECD countries is not affected by volatility: they are too developed, even though the standard error reflects some heterogeneity within the OECD.[19] The 1965 level of development (as measured by quartile of GDP per capita) does not change the significant effect of volatility on urban growth. Fuel exporting countries also do not urbanize more than other countries in response to volatility, but mining dependent countries urbanize much faster than non-fuel and non-mining dependent countries in volatile times (measured by top decile of average dependence). Households in countries such as Zambia, where up to half of GDP consists of copper exports, appear to be much more vulnerable to risk outside cities: they migrate to urban centers. Finally, the least financially developed countries urbanize much faster than other countries in volatile periods, which, for instance, is also consistent with lack of financial instruments for insurance. We always find an effect of volatility on urban growth, even after dividing countries along these lines.

Endogeneity and lagged dependent variable bias

Table B.5 aims to tackle two problems at once. First we have to deal with the lagged dependent variable bias in the initial level of urbanization, by first differencing the equation to get rid of the fixed effect and using lagged levels as instruments. Table 4.2 already predicted that the true value should be in between the OLS estimate which is biased upwards and the FE estimate which is biased downwards. This yields a range of -0.063 to -0.117 (Nickell, 1981). Secondly, we follow Davis and Henderson (2003) and use the difference GMM estimators (see further down) as an IV strategy.

[18]We did not include time dummies because this would assume shocks to urban growth common to all one-hundred countries which we consider to be unlikely.

[19]For example, an interaction between Mexico and volatility yields a positive but insignificant interaction term.

There are several assumptions that have to be met before we can use lagged equations as valid instruments for current differenced equations. According to Arellano and Bond (1991)[20] the errors should not be serially correlated of order two or more ($E[e_{is}e_{it}] = 0$ for $s \neq t$), and we need predetermined initial conditions ($E[\ln L^u_{i1} e_{it}] = 0$ for $t = 2, ..., T$) and $E[\gamma_i] = E[e_{it}] = E[\gamma_i e_{it}] = 0$.[21] We use lagged initial urbanization as an instrument for current urbanization while assuming that passed levels have no direct effect on current growth rates. In effect we will use lags of order three or more meaning that variables dated 15 years earlier are used as instruments. A serious problem with this method is that β_0 might be close to zero. This means that the urban population changes relatively slowly from year to year and is thus very persistent. β_0 then contains little predictive information about next year's urban size and is too weak as an instruments for urbanization, even if it is exogenous. In finite samples this problem is even more severe and may bias the estimate of the lagged dependent variable's coefficient downward and even below the FE estimate. Blundell and Bond (1998) proposed to expand the instrument set by including additional moment conditions, that is, lagged first-differenced equations with the following additional assumption:[22]

$$E[\Delta \ln L^u_{i,t-1}, (\gamma_i + e_{it})] = 0 \text{ for } t = 3, ..., T. \tag{4.17}$$

All these assumptions can be tested with common Hansen/Sargan over-identification tests. Windmeijer (2005) provides corrected standard errors for the twostep version of system-GMM, which are otherwise too small.[23]

Columns two and three use difference GMM and show that both one and two step versions perform poorly: the lagged dependent coefficient is close or even below the FE estimate, although the two-step version improves precision of the volatility affect.[24] Column four is more successful in treating the weak instrument problem by expanding the instrument set. Both the Hansen and the Sargan tests are passed: one for the overall instrument set and one for the additional assumptions of SGMM. Since we found AR(2) in the errors we used the third and fourth lags as instruments. These may

[20]We refer to this method as difference-GMM (DGMM).

[21]We do not require the initial conditions to be strictly exogenous which would require $E[\ln L^u_{i1} e_{it}] = 0$ $\forall t$. Strict exogeneity of all variables would result in a consistent within estimate for a large N and T.

[22]We refer to this method as system-GMM (SGMM).

[23]Both DGMM and SGMM have one- and two-step versions which refers to the method of estimating the weight matrix for GMM. One-step requires the assumption of homeskedastic e_{it} disturbances, but two-step estimation tends to deflate the standard errors. We use the identity matrix as an initial guess for the covariance matrix of idiosyncratic errors as in Blundell and Bond (1998). We always cluster the errors by country to allow for autocorrelation within countries and perform a small sample correction. See Bond (2002) for an overview.

[24]All estimations treat all regressors as endogenous but predetermined, except for changes in rainfall and the independence dummy.

be weaker instruments and have more trouble with predicting current volatility. Even so, the effect of volatility has become stronger and remains significant. Column five replaces the average aggregate growth rate with average growth rates in value added of agriculture and manufacturing as a control to test for the sector shift out of agriculture which is often the explanation for urbanization as in Davis and Henderson (2003). They both have the expected sign: growth of the manufacturing sector leads to urban growth and rural growth to urban decline, but they only slightly affect the volatility variable. Since these are unfortunately imperfect substitutes for rural and urban GDP they do predict urban growth imprecisely, in addition to restricting the sample which explains why many standard errors have increased.

Volatility has a significant and robust positive effect on urban growth even when instrumented with lagged values. An economy with more risk seems to induce larger flows of migration towards cities. It is in cities that there lies hope of improving living conditions because they offer a more diverse demand for labor. More importantly, risk and large shocks may force households leave the countryside if such shocks exhaust their buffer savings. In the next section we show that aggregate shocks originate mostly from the agriculture sector and non-urban natural resource exports.

4.7.2 Robustness: explaining volatility

We turn to the origins of volatility and use a similar strategy as above except that we do not have to worry about a lagged dependent variable. We first look at natural resource export value and shocks therein. In Table 4.7 we split resource exports into four categories and look at both dependence and shocks to (ln) changes in export receipts. Furthermore, we control for other likely determinants of volatility, such as financial development. More financially developed countries have more means to deal with shocks such as through insurance or futures contracts, and liquidity constraints bind less often. Openness and access to waterways[25] allows diversification into less volatile sectors, cushioning the aggregate effect. Civil war and rainfall shocks are added as other suitable and exogenous candidates to explain aggregate volatility in income. The results are that shocks to fuel prices are most significantly important, but shocks to export receipts of food products have a much larger effect. Among the controls only openness matters in this short-run panel. There might be too little time variation in the other variables to yield significant effects. These variables however allow for a smaller sample and we explain less variance in volatility than with sectoral data, which we use next.

[25]The average distance in a country to the nearest coast or waterway is the most robust geographical determinant of aggregate per capita output volatility in Malik and Temple (2005).

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The first column in Table 4.8 provides a better fit of the variation in volatility (where R2 is adjusted for the number of variables). We find a significant effect of shocks to value added growth in agriculture, even while controlling for initial agriculture dependence, the average growth rate and natural rain shocks. Column two furthermore controls for fixed unobserved country effects which do not affect the results much. We have also added shocks to changes in government spending, as this may be heavily influenced by export earning through taxation, even though it is essentially a choice variable. It has a large impact on aggregate volatility, but the direction of causality may be the other way around. Also shocks to the terms-of-trade exert a significant effect. Adding the mining sector in column three does not matter: it is mostly risk in agriculture, most clearly a rural activity, that leads to aggregate volatility. We now do find some evidence of civil war leading to aggregate volatility in this case. Columns 4 and 5 perform one and two-step versions of the difference-GMM estimator (Arellano-Bond, 1991) where the two-step version's standard errors are corrected for finite sample bias.[26] One-step assumes homoskedasticity of the errors and yields almost identical results compared to relaxing this assumption in column five. Using a set of lagged level instruments for the equation in first differences shows the robustness of the effects of the shocks to government spending volatility, terms-of-trade shocks and agricultural value added growth shocks. The Hansen tests confirm exogeneity of the instruments. Unfortunately, this IV strategy limits the sample we can work with and as a consequence the standard errors have increased somewhat. System-GMM can use more information which indeed yields a better estimate in column six.

We can conclude that the determinants of aggregate volatility originate in the agricultural sector even after controlling for a broad set of possible covariates. Shocks to the manufacturing sector have little effect on aggregate volatility. This shows that the rural sector is much more risky than the urban sector, lending support to our explanation that such a risk differential induces rural-urban migration.

4.8 Conclusion

This paper addresses the fact that many countries urbanize surprisingly fast even though economic growth is slow or negative. Negative growth is unlikely to create urban jobs, it does not raise urban wages nor does it increase earlier migrants' flow of remittances, which could all be powerful urban-pull factors from the perspective of poor rural house-

[26]Using system-GMM would not give us an advantage in this case because we do not have to deal with a lagged dependent variable. In both estimations all regressors are treated as endogenous and predetermined except rainfall volatility and the civil war dummy.

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holds. We solve this puzzle by acknowledging that push factors are at least as important, especially when the economic circumstances are such that households cannot cope with negative shocks to income. Periods of aggregate volatility turn out to be strong predictors of urban growth, especially when GDP per capita growth is negative. The source of volatility lies in rural activities such as agriculture and natural resource production which are much more risky sectors than urban manufacturing. World resource prices are highly volatile (which is more important than rainfall), and financial instruments such as credit to deal with aggregate risk are all but absent in the countryside. Aggregate risk may be more important than a sectoral shift from agriculture to manufacturing and the parallel transition to urbanization for countries with poor economic performance. Unable to save or insure effectively, households are forced to migrate to cities to avoid being hit by large negative shocks as an ex-ante response to expected risk, because large shocks may easily wipe out any buffer savings.

We realize that many countries with very large cities, and slums, view urbanization as a problem. If that is justified in itself then rural development of credit institutions could decrease migration pressure on cities. On the other hand, it might also be that agglomeration economies can bring opportunities to fast urbanizing countries if these centers can be made attractive enough for start-ups and foreign investment. Future research using micro data should shed more light on these issues.

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APPENDICIES

4.A Data Sources

Category	Variable	Definition	Source
Population	urban population growth	5 year (ln) change in total urban population, national definition	UN (2005)
	ln urban population share	ln (total urban population / total population)	idem
	av. national population growth rate	5 year average of yearly total population growth rates	WDI (2006)
GDP	volatility GDP/cap. growth	5 year standard deviation of yearly GDP per capita growth rates (PPP, 2000 USD)	PWT 6.2 from Heston et al. (2006)
	volatility of positive shocks	idem, for those periods with at least 2 positive growth rates and positive average growth (PPP, 2000 USD)	idem
	average GDP/capita growth	5 year average of yearly GDP per capita growth rates (PPP, 2000 USD, Laspeyres)	idem
Resources	% export value/GDP	F.o.b. value of exports as a percentage of GDP. **Fuels** corresponds to SITC section 3 (mineral fuels). **Ores and Metals**: SITC divisions 27, 28, and 68 (nonferrous metals). **Agricultural Raw Materials**: SITC section: 2 (crude materials except fuels) excluding divisions 22, 27 (crude fertilizers and minerals excluding coal, petroleum, and precious stones), and 28 (metalliferous ores and scrap). **Foods**: SITC sections: 0 (food and live animals), 1 (beverages and tobacco), and 4 (animal and vegetable oils and fats) and SITC division 22 (oil seeds, oil nuts, and oil kernels). (constant USD)	WDI (2006)
	export growth volatility	5 year standard deviation of yearly (ln) changes by export group.	idem
	volatility of exp. growth	idem	idem
	exp. av. growth	5-year average yearly (ln) changes by export group	idem
	price indices	yearly standard deviation of monthly price changes	UNCTAD (2007)
Sectors	sector % total va	Value added (value of output less the value of intermediate consumption) of sector as a % of total value added. **Manufacturing**: section D Manufacturing. **Agriculture**: Section A Agriculture, hunting and forestry and Section B Fishing. **Mining**: Section C Mining and quarrying, Section E Electricity, gas and water supply. (all ISIC Rev 3.1)	United Nations Statistics Devision, (2007)
	av. growth sector va	5 year average of yearly growth rate of total value added per sector,	idem
	volatility of sector va growth	5 year volatility of yearly growth rate of total value added per sector.	idem
Geography	% change in average rainfall	Change in ln average 5 year rainfall from last 5 year period.	Mitchell et al. (2002)
	volatility of rainfall	5 year standard deviation of yearly rainfall data.	idem
	road density	Roads (km) / land (km2)	International Road Federation and WDI (2006)
	distance to coast or waterway (100km)	minimum distance in km, fixed effect	CID, General Measures of Geography, (1999)

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Institutions	polity index	Index of autocracy (-10) to democracy (+10)	Marshall et al. (2007)
	independence index	dummy = 1 if a country is independent	CIA World Factbook (2007)
	financial development	Domestic credit to private sector (% of GDP)	WDI (2006)
	openness dummy	open to trade = 1	Wacziarg and Welch (2003)
Other	civil war dummy next 5 years	dummy =1 if a country is in civil war during any year of the 5 year period	Sambanis (2000)
	volatility of government spending	5 year standard deviation of yearly (ln) changes in government spending	PWT 6.2 from Heston et al. (2006)
	volatility in terms-of-trade	5 year standard deviation of yearly imports share of exports	WDI (2006)

4.B Regression tables

TABLE 4.2: *Urban Growth and Volatility, 1960-2005*

Dependent variable:	(1: OLS)	(2: FE)	(3: FE)	sample means
5-year urban population growth				18.15%
volatility GDP/cap. growth	0.317**	0.254**	0.221*	3.93%
	(0.126)	(0.125)	(0.121)	
log urban population share	-0.063***	-0.117***	-0.117***	-1.08 = log(.34)
	(0.007)	(0.018)	(0.018)	
Average GDP/capita growth	0.309**	0.160	0.536***	1.76%
	(0.151)	(0.118)	(0.165)	
av. national population growth rate	1.168***	1.029***	1.031***	9.96%
	(0.074)	(0.083)	(0.078)	
constant	-0.021**	-0.061***	-0.064***	
	(0.009)	(0.021)	(0.020)	
volatility * average GDP/cap. growth			-5.308**	
			(2.318)	
Observations	861	861	861	
Adj. R2	0.64	0.43	0.45	
countries	108	108	108	

Robust and country-clustered standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

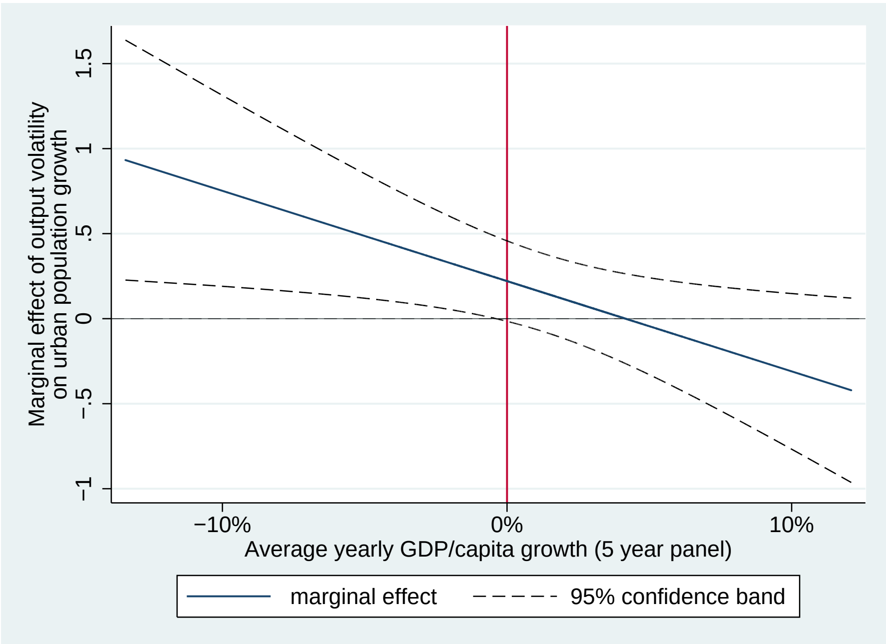

Figure 4.5: *Marginal Effect of Volatility on Urban Population Growth for Given Average Growth Rates, 1960-2005*

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TABLE 4.3: *Volatility and Natural Resources (Exports and National Value Added)*

Dependent variable:	(1: OLS)	(2: OLS)	(3: OLS)	(4: OLS)	(5: OLS)
5-year volatility of GDP/capita growth		(exports)		(sectors)	
volatility of fuel and ores exp. growth	0.094*	0.107*	0.110*		
	(0.055)	(0.054)	(0.056)		
volatility of food and agr. exp. growth	0.496**	0.295	0.161		
	(0.217)	(0.206)	(0.156)		
% fuel and ore export value/GPD		0.063***	0.079***		
		(0.017)	(0.028)		
% food and agr. export value/GPD		0.034	-0.023		
		(0.024)	(0.027)		
fuel and ore volatility * dependence			-1.066		
			(1.339)		
food and agr. volatility * dependence			6.180***		
			(2.292)		
volatility of agri. va growth				0.073***	0.082***
				(0.020)	(0.019)
volatility of mining va growth				0.016	0.009
				(0.010)	(0.008)
volatility of manuf. va growth				0.073***	0.041**
				(0.026)	(0.020)
agriculture % total va					0.062***
					(0.013)
mining % total va					0.086***
					(0.018)
manuf. % total va					-0.004
					(0.016)
constant	0.025***	0.019***	0.021***	0.014***	0.000
	(0.003)	(0.002)	(0.002)	(0.003)	(0.005)
Observations	632	593	593	731	731
Adj. R2	0.05	0.09	0.10	0.17	0.27
countries	99	99	99	105	105

Robust and country-clustered standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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TABLE 4.4: *Countries Included in the Sample of Table 4.2*

Algeria	Congo, Dem. Rep.	Haiti	Mauritius	Senegal
Argentina	Congo, Rep.	Honduras	Mexico	Singapore
Australia	Costa Rica	Hong Kong, China	Morocco	South Africa
Austria	Cote d'Ivoire	Iceland	Mozambique	Spain
Bangladesh	Cyprus	India	Namibia	Sri Lanka
Barbados	Denmark	Indonesia	Nepal	Sweden
Belgium	Dominican Republic	Iran, Islamic Rep.	Netherlands	Switzerland
Benin	Ecuador	Ireland	New Zealand	Syrian Arab Republic
Bolivia	Egypt, Arab Rep.	Israel	Nicaragua	Tanzania
Botswana	El Salvador	Italy	Niger	Thailand
Brazil	Equatorial Guinea	Jamaica	Nigeria	Togo
Burkina Faso	Ethiopia	Japan	Norway	Trinidad and Tobago
Burundi	Fiji	Jordan	Pakistan	Turkey
Cameroon	Finland	Kenya	Panama	Uganda
Canada	France	Korea, Rep.	Papua New Guinea	United Kingdom
Cape Verde	Gabon	Lesotho	Paraguay	United States
Central African Republic	Gambia, The	Luxembourg	Peru	Uruguay
Chad	Ghana	Madagascar	Philippines	Venezuela, RB
Chile	Greece	Malawi	Portugal	Zambia
China	Guatemala	Malaysia	Puerto Rico	Zimbabwe
Colombia	Guinea	Mali	Romania	
Comoros	Guinea-Bissau	Mauritania	Rwanda	

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TABLE 4.5: *Robustness, Urban Growth, Volatility and Heterogeneous Effects*

Dependent variable: **5-year urban pop. growth**	(1: FE)	(2: FE)	(3: FE)	(4: FE)	(5: FE)	(6: FE)
volatility of positive shocks	0.159					
	(0.192)					
volatility GDP/cap. growth		0.477**	0.512**	0.287**	0.246**	0.344***
		(0.206)	(0.211)	(0.125)	(0.122)	(0.115)
OECD countries * volatility			-0.600**			
			(0.266)			
min 1965 quart. GDP/cap. * volatility				0.364		
				(0.323)		
top 1965 quart. GDP/cap. * volatility				0.142		
				(0.123)		
top dec. av. fuel exp. * volatility					-0.241	
					(0.256)	
top dec. av. ores exp. * volatility					0.730***	
					(0.262)	
min 1965 quart. fin.dev. * volatility						0.681**
						(0.334)
top 1965 quart. fin.dev. * volatility						-0.317
						(0.198)
log urban population share	-0.117***	-0.150***	-0.148***	-0.150***	-0.151***	-0.145***
	(0.019)	(0.028)	(0.029)	(0.028)	(0.028)	(0.029)
Average GDP/capita growth	0.022	0.428***	0.423***	0.417***	0.399***	0.432***
	(0.123)	(0.138)	(0.137)	(0.136)	(0.133)	(0.132)
av. national population growth rate	1.037***	1.146***	1.151***	1.195***	1.193***	1.284***
	(0.091)	(0.082)	(0.084)	(0.117)	(0.114)	(0.150)
financial development		0.008	0.006	0.010	0.008	0.007
		(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
% change average rainfall		-0.006	-0.008	-0.008	-0.003	-0.003
		(0.014)	(0.014)	(0.015)	(0.016)	(0.015)
polity index		0.000	0.000	0.000	0.000	0.000
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
road density		0.022	0.019	0.022	0.019	0.022
		(0.024)	(0.023)	(0.023)	(0.023)	(0.022)
independence index		0.026***	0.027***	0.027***	0.028***	0.028***
		(0.007)	(0.007)	(0.007)	(0.006)	(0.007)
constant	-0.052**	-0.148***	-0.143***	-0.153***	-0.151***	-0.158***
	(0.020)	(0.027)	(0.027)	(0.026)	(0.023)	(0.025)
Observations	796	522	522	522	522	522
countries	108	100	100	100	100	100
Adj. R2	0.41	0.55	0.55	0.55	0.56	0.56

Robust and country-clustered standard errors in parentheses. *'65 quart.* = quartile range in 1965; *dec. av.* = decile range in 1965 of variable's long term average export share of GDP.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4.6: *Robustness, Urban Growth and Volatility*

Dependent variable:	(1: FE)	(2: DGMM)	(3: DGMM)	(4: SGMM)	(5: SGMM)
5-year urban pop. growth		one-step	two-step	two-step	two-step
volatility GDP/cap. growth	0.477**	0.441**	0.400**	0.529**	0.549*
	(0.206)	(0.220)	(0.200)	(0.209)	(0.284)
log urban population share	-0.150***	-0.165***	-0.144***	-0.075***	-0.101***
	(0.028)	(0.039)	(0.043)	(0.024)	(0.025)
Average GDP/capita growth	0.428***	0.223	0.238	0.246*	
	(0.138)	(0.158)	(0.168)	(0.134)	
av. national population growth rate	1.146***	1.088***	1.168***	1.266***	1.233***
	(0.082)	(0.177)	(0.129)	(0.202)	(0.155)
financial development	0.008	-0.016	-0.010	-0.011	0.003
	(0.011)	(0.023)	(0.028)	(0.020)	(0.016)
% change average rainfall	-0.006	0.008	0.001	0.002	0.011
	(0.014)	(0.011)	(0.010)	(0.011)	(0.012)
polity index	0.000	0.001	0.001	0.001	0.002
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
road density	0.022	0.056	0.024	0.011	0.015
	(0.024)	(0.054)	(0.051)	(0.014)	(0.009)
independence index	0.026***	0.001	-0.003	0.009	0.014
	(0.007)	(0.011)	(0.011)	(0.007)	(0.009)
av. growth agriculture va					-0.023
					(0.071)
av. growth manuf. va					0.047
					(0.074)
constant	-0.148***			-0.062*	-0.095**
	(0.027)			(0.037)	(0.038)
Observations	522	419	419	522	462
countries	100	92	92	100	98
Adj. R2	0.55				
Hansen overid. test p-value		0.7643	0.7643	0.5193	0.6356
Diff-Sargan overid. test p-value				0.306	0.370

Robust and country-clustered standard errors in parentheses.
Two-step GMM regressions include Windmeijer (2005) corrected s.e.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

TABLE 4.7: *Robustness, Volatility and Natural Resource Exports (Value Share of GDP)*

5-year volatility of GDP/capita growth	(1: OLS)	(2: OLS)	(3: OLS)
volatility of food and agr. exp. growth	0.348		
	(0.217)		
food export growth volatility		0.489**	0.776*
		(0.238)	(0.400)
agr. r.m. export growth volatility		-0.103	-0.075
		(0.086)	(0.126)
volatility of fuel and ores exp. growth	0.071		
	(0.065)		
fuel export growth volatility		0.060***	0.065**
		(0.021)	(0.027)
ores export growth volatility		0.036	-0.046
		(0.045)	(0.063)
% fuel and ore export value/GPD	0.063***		
	(0.020)		
% fuel export value/GDP		0.060***	0.058***
		(0.015)	(0.012)
% ore and metal export value/GDP		0.087*	0.066
		(0.046)	(0.057)
% food and agr. export value/GPD	0.032		
	(0.023)		
% food export value/GDP		0.064**	0.047
		(0.031)	(0.035)
% agricultural r.m. export value/GDP		-0.055*	-0.008
		(0.029)	(0.031)
financial development	-0.007*		-0.004
	(0.003)		(0.004)
openness dummy	-0.010***		-0.009***
	(0.003)		(0.003)
distance to coast or waterway (100km)	0.000		0.000
	(0.000)		(0.000)
civil war dummy next 5 years	-0.000		-0.000
	(0.004)		(0.004)
volatility of rainfall	-0.000		-0.000
	(0.000)		(0.000)
constant	0.029***	0.017***	0.025***
	(0.004)	(0.002)	(0.005)
Observations	470	581	461
Adj. R2	0.17	0.13	0.21
countries	88	99	88

Robust and country-clustered standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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TABLE 4.8: *Robustness, Volatility and Natural Resources (National Value Added)*

Dependent variable:	(1: OLS)	(2: FE)	(3: FE)	(4: DGMM)	(5: DGMM)	(6: SGMM)
5-year volatility GDP/cap. growth				one-step	two-step	two-step
agriculture % total va	-0.023	-0.048	-0.045	0.060	0.057	0.028
	(0.015)	(0.029)	(0.036)	(0.062)	(0.073)	(0.034)
volatility of agri. va growth	0.042**	0.046**	0.050**	0.051*	0.046*	0.080**
	(0.020)	(0.021)	(0.021)	(0.026)	(0.027)	(0.033)
av. growth agriculture va	0.003	-0.014	-0.027	0.052	0.039	-0.020
	(0.023)	(0.023)	(0.024)	(0.059)	(0.064)	(0.048)
manuf. % total va	-0.038*	0.038	0.053	-0.025	-0.020	-0.002
	(0.020)	(0.030)	(0.035)	(0.095)	(0.111)	(0.050)
volatility of manuf. va growth	0.021	0.007	0.008	0.015	0.024	0.014
	(0.019)	(0.020)	(0.020)	(0.024)	(0.020)	(0.026)
av. growth manuf. va	0.014	0.046*	0.038	-0.044	-0.029	0.045
	(0.023)	(0.023)	(0.026)	(0.059)	(0.058)	(0.047)
financial development	-0.001	0.003	0.006	0.015	0.013	0.011
	(0.003)	(0.005)	(0.006)	(0.017)	(0.018)	(0.011)
openness dummy	-0.001	0.001	0.001	-0.001	-0.001	-0.003
	(0.003)	(0.004)	(0.004)	(0.008)	(0.009)	(0.005)
civil war dummy next 5 years	0.005	0.009	0.009*	0.005	0.004	0.005
	(0.004)	(0.005)	(0.005)	(0.007)	(0.009)	(0.010)
volatility of rainfall	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
volatility of government spending	0.208***	0.196***	0.197***	0.194***	0.195***	0.212***
	(0.039)	(0.048)	(0.048)	(0.057)	(0.063)	(0.047)
volatility in terms of trade	0.035**	0.050***	0.051***	0.049**	0.051**	0.016
	(0.015)	(0.014)	(0.014)	(0.021)	(0.021)	(0.023)
distance to coast or waterway	0.001*	0.000	0.000			0.000
	(0.000)	(0.000)	(0.000)			(0.001)
constant	0.016**	0.007	-0.002			-0.006
	(0.007)	(0.010)	(0.015)			(0.015)
mining % total va			0.060			
			(0.040)			
volatility of mining va growth			-0.006			
			(0.008)			
av. growth mining va			0.026			
			(0.021)			
Observations	538	538	528	442	442	538
Adj. R2	0.47	0.38	0.39			
countries	95	95	93	94	94	95
Hansen overid. test p-value				0.4668	0.4668	0.5782
Diff-Sargan overid. test p-value						0.201

Robust and country-clustered standard errors in parentheses in all regressions.
Two-step D-GMM includes Windmeijer (2005) corrected s.e.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Chapter 5

Volatility, Financial Development and the Natural Resource Curse

With Frederick van der Ploeg

Synopsis

Cross-country evidence is presented on resource dependence and the link between volatility and growth. First, growth depends negatively on volatility of unanticipated output growth independent of initial income per capita, the initial investment share, initial human capital stock, trade openness, the national income share of natural resource exports, and population growth. Second, the adverse effect of resources on growth operates primarily through higher volatility. The direct effect of resources on growth is positive, but can be swamped by the indirect negative effect through volatility. Third, with well developed financial sectors, the resource curse is less pronounced. Fourth, landlocked countries with ethnic tensions have higher volatility and lower growth. Fifth, restrictions on the current account lead to higher volatility and lower growth, but capital account restrictions lower volatility and boost growth. These effects are especially strong in resource-rich countries. We also present IV-estimates to correct for the endogenous nature of investment rates and panel estimates to allow for possible changes in explanatory variables over time. Our key message is that volatility is a quintessential feature of the resource curse.

5.1 Introduction

The key determinants of economic growth highlighted in the empirical literature - institutions, geography and culture - show far more persistence than the growth rates they are supposed to explain (Easterly, et al, 1993). One candidate to explain the volatility of growth in income per capita is the volatility of commodity prices. This includes not only oil, but also for example grain and coffee prices. What commodity prices lack in trend, they make up for in volatility (Deaton, 1999). A recent detailed examination of

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the growth performance of 35 countries during the historical period 1870-1939 led to the following conclusions (Blattman, Hwang and Williamson, 2007). Countries that specialize in commodities with substantial price volatility have more volatility in their terms of trade, enjoy less foreign direct investment, and experience lower growth rates than countries that specialize in commodities with more stable prices or countries that are industrial leaders. Countries in the periphery with volatile commodity prices and undiversified economies fall behind in economic development. Also, the long-run volatility of the real exchange rate of developing countries is approximately three times bigger than that of industrialized countries (Haussmann, et al, 2004). Another study employs data for 83 countries over the period 1960-2000 and also finds robust evidence for a strong and negative link between real exchange rate volatility and growth performance after correcting for initial output per worker, enrolment in secondary education, trade openness, government consumption, inflation, and even banking or currency crises (Aghion, et al, 2006). Furthermore, the adverse effect of exchange rate volatility on growth is weaker for countries with well developed financial systems.

The pioneering work of Ramey and Ramey (1995) takes a different approach. It investigates the link between volatility of unanticipated output growth (rather than volatility of the terms of trade) and growth performance. It uses the Heston-Summers data to provide cross-country evidence for a negative link between volatility and mean growth rates controlling for initial income, population growth, human capital, and physical capital. Interestingly, this study finds evidence for this negative link regardless of whether one includes the share of investment in national income or not. It also estimates the relationship between volatility and growth in a panel model that controls for both time and country fixed effects. To allow for the time-varying nature of volatility, a measure of government spending volatility is used that is correlated with volatility of output across both time and countries. The negative link between volatility and growth seems robust to a large set of conceivable controls that vary with time period or country.[1] Another study shows that, for a cross-section of 91 countries, policy variability in inflation and government spending exerts a strong and negative impact on growth (Fatás and Mihov, 2005).

Our main objective is to extend Ramey and Ramey (1995) by allowing for the direct effect of natural resource abundance on growth and, more importantly, the indirect effect of natural resources on growth performance via volatility. We thus follow Blattman,

[1] However, Imbs (2006) shows that growth and volatility correlate positively across sectors. Within the context of a mean-variance portfolio setup, it is understandable that volatile sectors command higher investment rates and thus higher growth rates.

Hwang and Williamson (2007) and allow for the role of natural resources on macroeconomic volatility. We allow natural resources, financial development, openness and distance from waterways to be the underlying determinants of volatility. They may be viewed as exogenous proxies for the volatility of the real exchange rate and thus of GDP growth. We also shed new light on the evidence for the resource curse given by Sachs and Warner (1997) and many others.[2] Our objective is to test whether any adverse *indirect* effect of natural resources on growth performance via volatility of unanticipated output growth dominates any adverse *direct* effect of natural resource abundance on economic growth. Inspired by Aghion, et al (2006), we test whether the adverse effect of natural resources on volatility and growth is weakened if there are well developed financial institutions. We also test whether being landlocked, ethnic tensions, or restrictions on the current account boost volatility and curb growth and whether restrictions on the capital account or exchange controls reduce volatility and boost growth. To avoid omitted variable bias, we control for initial income per capita, population growth, investment rates, and primary schooling on growth.

Our econometric tests on the importance of volatility for the paradox of plenty are motivated by Figures 1-3 and by the data on average yearly growth and its standard deviation by country groups for the period 1970-2003 presented in Table 1. These data suggest five stylized facts that are essential for a new and improved understanding of the natural resource curse.

- First, volatile countries with a high standard deviation of yearly growth in GDP per capita have on average lower growth in GDP per capita. Figure 1 illustrates this partial correlation while Ramey and Ramey (1995) show that this relationship holds even after controlling for initial income per capita, population growth, human capital and physical capital.

- Second, developing countries suffer much more from volatility in output growth than developed countries. Whereas Western Europe and North America have a standard deviation of, respectively, 2.33 and 1.90 percentage-points of yearly growth in GDP per capita, the figures for Asia are 4.4 to 5 percentage-points and for Latin America & Caribbean 4.54percentage-point. Most striking is that Sub-Saharan Africa and the Middle East & North Africa have the highest volatility. Their standard deviations of average growth in GDP per capita are, respectively,

[2]The windfall resource revenues lead to appreciation of the real exchange rate and a decline of the nonresource export sectors. If there is substantial loss in learning by doing in the non-resource export sectors, there will be a fall in total factor productivity growth as in Sachs and Warner (1995). Natural resources may also invite rapacious rent seeking and thus hamper growth.

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6.52 and 8.12 percentage-points.

- Third, countries with poorly developed financial systems are much more volatile. Countries in the bottom quartile of financial development have a standard deviation of annual growth in GDP per capita two percentage-point higher than those in the top quartile. North America and Western Europe have well developed financial systems while Eastern Europe & Central Asia, and especially South Asia and Middle East & North Africa, have poorly functioning financial systems. Resource-rich and landlocked economies have less developed financial systems than resource-poor countries.

- Fourth, countries that depend a lot on natural resources are much more volatile than countries without natural resources. Countries with a share of natural resource exports in GDP greater than 19 percent (the top quartile) have a staggeringly high standard deviation of output growth of 7.37 percentage-point. For countries with a natural resource exports share of less than five percent of GDP (the bottom quartile), the figure is only 2.83 percentage-point. Figure 2 also indicates that resource-rich countries have bigger macroeconomic volatility than resource-poor countries. Figure 3 shows that world commodity prices are extremely volatile and are the main reason why natural resource export revenues are so volatile. Crude petroleum prices are more volatile than food prices and ores and metals prices. The volatility of raw agricultural product prices is less, but still substantial. Monthly price deviations of ten percentage-points from their base level (year 2000) are quite normal.

- Fifth, landlocked countries suffer much more from volatility than countries with easy access to waterways. Indeed, countries that are less than 49 kilometres from the nearest waterway have a standard deviation of growth in GDP per capita that is 1.6 percentage-point lower than countries that are more than 359 kilometres from the nearest waterway. Empirical work also finds that remote countries have less access to markets, less diversified exports, and greater volatility of output growth (Malik and Temple, 2006).

Although these stylized facts are suggestive, they are merely partial correlations and do not permit any causal evidence. Hence, we perform a proper multivariate econometric analysis and control for all potential factors affecting the rate of economic growth. We also face the thorny issue of the endogenous nature of explanatory variables.

The sophisticated statistical decomposition analysis performed in Koren and Tenreyro (2007) suggests four possible reasons why poor countries are so much more volatile than rich countries: poor countries specialize in more volatile sectors; poor countries specialize in fewer sectors; poor countries experience more frequent and more severe aggregate shocks (such as from macroeconomic policy); and macroeconomic fluctuations in poor countries are more highly correlated with the shocks of the sectors they specialize in. The evidence suggests that, as countries develop their economies, their productive structure shifts from more to less volatile sectors. Also, the degree of specialization declines in early stages of development and increases a little in later stages of development. Furthermore, the volatility of country-specific macroeconomic shocks falls with development. This decomposition analysis sheds interesting light on why poor economies are more volatile than rich economies. Our multivariate econometric analysis provides complimentary evidence on the factors affecting volatility.

We argue that crucial and strongly related sources of macroeconomic volatility and poor growth performance include a lack of a sophisticated financial system, natural resource dependence, and whether a country is landlocked or not. We also provide evidence that economic restrictions and ethnic tensions play a role. Countries with a large dependence on natural resources and that are landlocked are typically not very diversified and vulnerable to highly volatile world commodity prices. Natural resource revenues tend to be very volatile (much more so than GDP), because the supply of natural resources exhibits low price elasticities of supply. Furthermore, as documented in Bloom and Sachs (1998) and indicated by Figure 4, Sub-Saharan Africa is most vulnerable to volatility of commodity prices as it depends so much on natural resources. Dutch Disease effects may also induce real exchange rate volatility, and thus a fall in investment in physical capital and learning; and further contraction of the traded sector and lower productivity growth (e.g., Gylfason, et al, 1999; Herbertsson, et al, 2000). Volatile resource revenues are disliked by risk-averse households. The welfare losses induced by consumption risk are tiny compared with those resulting from imperfect financial markets. However, a recent dynamic stochastic general equilibrium study of Zimbabwe highlights the incompleteness of financial markets and suggests that the observed volatility in commodity prices depresses capital accumulation and output by about 40 percent (Elbers, et al, 2007).

Our paper gives a prominent role to the quality of financial markets in understanding how the volatility of commodity prices and natural resource export revenues might depress growth. We adapt the liquidity shock arguments put forward by Aghion, et al (2006). Effectively, larger natural resource revenues make it easier to overcome negative liquidity shocks. We thus show that more volatile commodity prices will harm innovation and growth.

In section two we discuss why volatility may harm output growth, especially in countries with poor financial systems. Since there are also reasons for volatility to boost growth, the issue needs to be settled empirically. In section three we discuss our econometric methodology. In section four we present our cross-country estimates and test their robustness in section five to a sample with OECD countries and a panel specification. In section six we use our preferred estimates to perform a counterfactual experiment comparing resource-rich and landlocked Africa with the Asian Tigers. Section seven concludes.

5.2 Why volatility of natural resource revenues might hamper growth

5.2.1 Economic arguments

Aghion, et al (2006) shows that macroeconomic volatility driven by nominal exchange rate movements may stunt innovations and thus depress growth in economies with poorly developed financial institutions and with nominal wages which do not react immediately to changes in prices. We adopt this argument to show that volatility in natural resource revenues, induced by volatility in primary commodity prices, curbs growth in economies with badly functioning financial systems. We assume the law of one price holds, so that the price level P_t simply tracks the nominal exchange rate S_t. In other words, $P_t = S_t P_t*$ where the foreign price level P_t* is normalized to unity. Nominal wages are pre-set not knowing the realization of the price level, that is $W_t = \phi A_t E[P_t] = \phi A_t E[S_t]$, where A_t denotes productivity and $\phi < 1$ is a constant. Output follows from the production function $Y_t = A_t \sqrt{l_t}$, where l_t denotes employment. Profits are $\pi_t \equiv A_t S_t \sqrt{l_t} - \phi A_t E[S_t] l_t$. The value of innovations the next period is $V_{t+1} = V P_{t+1} A_{t+1}$, where next period's productivity is given by $A_{t+1} = \gamma A_t$ with $\gamma > 1$ if entrepreneurs have sufficient funds to innovate and $A_{t+1} = A_t$ otherwise. Firms have sufficient funds (profits plus resource revenues Q_t) to innovate if they have enough cash flow to cope with adverse liquidity shocks, i.e., $\mu(\pi_t + S_t Q_t) > z P_t A_t$ where μ is a measure of financial development and z is a random liquidity shock. If liquidity shocks z are i.i.d. across firms with cumulative density function $F(z)$, the probability of innovation is given by:

$$\rho_t = F\left(\frac{\mu(\pi_t + S_t Q_t)}{S_t A_t}\right). \tag{5.1}$$

Higher profits or natural resource revenues and a more developed financial system imply that more firms are able to overcome liquidity shocks and thus that the probability of innovation is higher. Profit maximization leads to the following levels of employment and profits:

$$l_t = \left(\frac{S_t}{2\phi E[S_t]}\right) \quad \text{and} \quad \pi_t = \left(\frac{A_t S_t^2}{4\phi E[S_t]}\right), \tag{5.2}$$

so that higher productivity, a lower expected price level (i.e., a lower wage), and a higher realized price level, boost profits. The probability of innovation is thus given by:

$$\rho_t = F\left(\mu\left[\left(\frac{S_t}{4\phi E[S_t]}\right) + \left(\frac{Q_t}{A_t}\right)\right]\right). \tag{5.3}$$

The rate of economic growth increases with the expected probability of innovation:

$$g_t \equiv \frac{E[A_{t+1}] - A_t}{A_t} = (\gamma - 1)E[\rho_t] = (\gamma - 1)E\left[F\left(\mu\left[\left(\frac{S_t}{4\phi E[S_t]}\right) + \left(\frac{Q_t}{A_t}\right)\right]\right)\right]. \tag{5.4}$$

Aghion, et al (2006) make the assumption that the cumulative density function $F(.)$ is concave, so that $E[F(c)] \leq F(E[c])$. The cumulative density functions of standard deviations of commodity prices given in Figure 3 are indeed concave (and close to the normal cumulative density functions). It follows that more exchange rate volatility stunts innovations and curbs growth, especially if the degree of financial development is weak. Moving from a peg to a float thus leads to a lower rate of economic growth. Here we are more interested in the effect of commodity prices on growth performance. *A high and stable level of resource revenues eases liquidity constraints and thus boosts innovations and economic growth. However, for a given expected level of natural resource revenues, more volatility in commodity prices and resource revenues harms innovation and growth, especially if financial development is weak.*

IMF data on 44 commodities and national commodity export shares, and monthly indices on national commodity export prices for 58 countries during 1980-2002 indicate that real commodity prices affect real exchange rate volatility (Cashin, et al, 2002). Since we have seen that real exchange rate uncertainty exacerbates the negative effects of domestic credit market constraints, this gives another reason why volatility of commodity prices curbs economic growth. Also, many resource-rich countries suffer from poorly developed financial systems and financial remoteness, and thus suffer from bigger macroeconomic volatility (Aghion, et al, 2006; Rose and Spiegel, 2007). Given the high volatility of primary commodity prices and resource revenues and thus of the real exchange rate of many resource-rich countries, we expect resource-rich countries with poorly developed financial systems to have poor growth performance.

With complete financial markets, long-term investment is counter-cyclical and mitigates volatility. However, if firms face tight credit constraints, investment is pro-cyclical and amplifies volatility. Of course, there may be other reasons why volatility may depress economic growth (Aghion, et al, 2005). Learning by doing and human capital accumulation is increasing and concave in the cyclical component of production (Martin and Rogers, 2000). In that case, long-run growth should be negatively related to the am-

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plitude of the business cycle.[3] This explanation does not require uncertainty and holds for predictable shocks as well. With irreversible investment, increased volatility holds back investment and thus depresses growth (Bernanke, 1983; Pindyck, 1991; Aizenman and Marion, 1991). The costs of volatility come from firms making uncertainty-induced planning errors (Ramey and Ramey, 1991). These costs arise if it is costly to switch factors of production between sectors (Bertola, 1994; Dixit and Rob, 1994). However, if firms choose to use technologies with a higher variance and a higher expected return (Black, 1987), or if higher volatility induces more precautionary saving and thus more investment (Mirman, 1971), there may be a *positive* link between volatility and growth. If the activity that generates productivity growth is a substitute to production, the opportunity cost of productivity enhancing activities is lower in recessions and thus volatility may boost growth (Aghion and Saint Paul, 1998). Ultimately, the question of whether anticipated or unanticipated volatility harms or boosts growth thus needs to be settled empirically.

In economies where only debt contracts are available and bankruptcy is costly, the real exchange rate becomes much more volatile if there is specialization in traded goods and services and the non-resource traded sector is small (Hausmann and Ribogon, 2002). Shocks to the demand for non-traded goods and services - associated with shocks to natural resource income - are then not accommodated by movements in the allocation of labour but by expenditure switching. This demands much higher relative price movements. Due to bankruptcy costs, interest rates increase with relative price volatility. This causes the economy to specialize away from non-resource traded goods and services, which is inefficient. The less it produces of these goods and services, the more volatile the economy becomes and the higher the interest rate has to be. This causes the sector to shrink further until it vanishes. Others stress that resource revenues are used as collateral and encourage countries to engage in 'excessive' borrowing at the expense of future generations, which can harm the economy in both the short and long run (Mansoorian, 1991).

Volatility is bad for growth, investment, income distribution, poverty, and educational attainment (e.g., Ramey and Ramey, 1995; Aizenman and Marion, 1999; Flug et al, 1999). To get around such natural resource curses, the government could resort to stabilization and saving policies and improve the efficiency of financial markets. It also helps to have a fully diversified economy, as then shocks to demand in the non-traded sector can be accommodated through changes in the structure of production rather

[3] They find that for industrialized countries and European regions a higher standard deviation of growth and of unemployment tends to depress growth rates.

than expenditure switching. This is relevant for inefficiently specialized countries such as Nigeria and Venezuela, but less so for diversified countries like Mexico or Indonesia, or naturally specialized countries such as some Gulf States. Unfortunately, resource-rich economies are often specialized in production and thus tend to be more volatile.

5.2.2 Political arguments

Natural resource bonanzas reduce the critical faculties of politicians and induce a false sense of security. This can lead to investment in 'white elephant' projects, bad policies (e.g., import substitution or unsustainable budgetary policies), and favours to political clientele, which cannot be financed once resource revenues dry up. Politicians loose sight of growth-promoting policies, free trade and 'value for money' management. During commodity booms countries often engage in exuberant public spending as if resource revenues last forever. This carries the danger of unsustainable spending programmes, which need to be reversed when global commodity prices collapse and revenues dry up. Encouraged by the Prebisch hypothesis (i.e., the secular decline of world prices of primary exports), many developing countries have made the mistake of trying in vain to promote state-led industrialization through prolonged import substitution using tariffs, import quota and subsidies for manufacturing in an attempt to avoid resource dependency. These policies may have been a reaction to the appreciation of the real exchange rate and the decline of the traded manufacturing sectors caused by natural resource dependence. The natural resource wealth may thus have prolonged bad policies, which eventually had to be reversed. The resulting policy-induced volatility harms growth and welfare. Table 1 indicates that resource-rich countries indeed have a relatively high volatility in the national income share of government.

Political scientists have also argued that states adopt and maintain sub-optimal policies (Ross, 1999). Cognitive theories blame policy failures on short-sightedness of state actors who ignore the adverse effects of their actions on the generations that come after the natural resource is exhausted, thus leading to myopic sloth and exuberance. These cognitive theories highlight a get-quick-rich mentality among businessmen, a boom-and-bust psychology among policy makers, and abuse of resource wealth by privileged classes, sectors, client networks and interest groups.

5.3 Estimation methodology

Consider a dataset with N countries and a sample period of T years. Ramey and Ramey (1995) specify the following econometric model for growth in GDP per capita:

$$\Delta \log(y_{it}) = \lambda\sigma_i + \mathbf{X}_{i70}\theta + \epsilon_{it}, \quad \epsilon_{it} \sim N(0, \sigma_i^2), \quad i = 1, ..., N, \quad t = 1, ...T, \qquad (5.5)$$

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where y_{it} is GDP per capita in country i for year t, σ_i is the standard deviation for country i of the residuals ϵ_{it}, $\mathbf{X}_{i70}$ is a vector of control variables for country i and the year 1970, and θ is a vector of coefficients assumed to be constant across countries. The residuals ϵ_{it} are the deviations of growth from the predicted values based on the controls. The variances of these residuals do not depend on time, but do vary for each country. The standard controls included in $\mathbf{X}_{i70}$ are initial log of GDP per capita, average share of investment in GDP, initial human capital (proxied by average years of schooling for those older than 25 years in 1970 taken from Barro and Lee (1993)) and the average annual rate of population growth over the sample period. Ramey and Ramey (1995) then find statistically significant estimates for λ of -0.211 for a sample of 92 countries and -0.385 for the OECD countries. There is thus a negative relationship between volatility and conditional growth performance. In terms of the magnitude of the economic impact, volatility ranks third after the investment share and initial income per capita in the sample of 92 countries, and second after initial income per capita for the OECD sample. We will also test whether natural resource dependence, openness, and financial development exert additional effects on growth.

We also probe into the black box of (5) and try to explain volatility (that is, the standard deviation of the yearly error in the growth equation) in terms of degree of financial development, resource dependence, and the distance from the nearest navigable river or the coast. We collect these variables affecting volatility in the vector $\mathbf{Z}_{i70}$ and estimate the cross-country regressions:

$$\begin{aligned} \Delta \log(y_{it}) &= \lambda\sigma_i + \mathbf{X}_{i70}\theta + \mathbf{Z}_{i70}\beta + \epsilon_{it}, \quad \sigma_i^2 = exp(\mathbf{Z}_{i70}\gamma + c) \quad \text{and} \\ \epsilon_{it} &\sim N(0, \sigma_i^2), \quad i = 1, ..., N, \quad t = 1, ...T. \end{aligned} \tag{5.6}$$

Average volatility σ_i is assumed constant over time, but different for each country depending on the initial country characteristics captured in $\mathbf{Z}_{i70}$. If countries are similar in terms of the $\mathbf{Z}_{i70}$, they are also predicted to have similar volatility. The vector of parameters γ measures the average across-country effect of factors like resource dependence, financial development and distance from waterways on volatility. We also allow for *direct* effects of these variables on growth (β).

We estimate parameters λ,θ,γ,c and β of (6) by maximizing the likelihood function:

$$L = -\frac{NT}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\log(\mathbf{\Sigma}_t) - \frac{1}{2}\sum_{t=1}^{T}\epsilon_t\mathbf{\Sigma}_t^{-1}\epsilon_t, \tag{5.7}$$

where the covariance matrix is defined by $\mathbf{\Sigma}_{t,ii} = \sigma_i^2 = \exp(\mathbf{Z}_{i70}\gamma + c)$, $i = 1, ..., N$, $t = 1, ..., T$, and $\mathbf{\Sigma_{t,ij}} = \mathbf{0}$, $i \neq j$, $t = 1, ..., N$ and $\epsilon_t \equiv (\epsilon_{1t}, ..., \epsilon_{Nt})'$ with $\epsilon_{it} \equiv \Delta\log(y_{it}) - \gamma\sigma_i - \mathbf{X}_{i70}\theta - \mathbf{Z}_{i70}\beta$, $t = 1, ..., T$. The method of econometric estimation is analogous to

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that of an autoregressive conditional-heteroskedasticity in mean (ARCH-M) estimation (Engle, Lilien, Robins, 1987). The variances are conditional, but time invariant. The error terms are uncorrelated across countries.[4]

5.4 Is volatility the quintessential feature of the natural resource curse?

The stylized facts discussed in the introduction suggest that natural resources play a key role in understanding macroeconomic volatility and growth prospects. Once account is taken of the *negative* effect of cross-country variations in volatility on the rate of economic growth, the level of resource dependence may exert a *positive* effect on growth.[5] From a policy perspective, it is important to know whether any adverse *negative indirect* effect of natural resources on growth performance via volatility of unanticipated output growth dominates any adverse *positive direct* effect of resource dependence on growth and whether the adverse effects are weakened if there are well developed financial institutions. Furthermore, we test whether landlocked countries experience higher volatility and lower growth. To get meaningful results, we control for initial income per capita, population growth, investment rates, and primary schooling on growth.

5.4.1 Explaining volatility by country and regional dummies

Table 2 provides cross-country empirical evidence on how much volatility of unanticipated output per capita growth depresses average annual growth in GDP per capita. The appendix gives the definition of all the variables and their source of origin. The positive coefficients on the average investment share and initial human capital suggest countries that invest a lot in physical and human capital enjoy a higher growth rate in income per capita, albeit that the coefficient on human capital is not very significant. Similarly, countries with very high population growth rates tend to have worse growth performance. Also, of course, the significant negative coefficient on initial GDP per capita indicates that poor countries which start off with a low level of income per capita catch up and grow faster ceteris paribus (that is, *conditional* convergence). Regression one is our benchmark regression, which indicates that volatility of unanticipated output

[4]Allowing for non-zero covariances as in Cermeño and Grier (2005) would increase the number of parameters to be estimated too much to be identified for the large country panel we work with.

[5]In fact, if the explanatory variable is natural resource *abundance* (proxied by natural resource wealth including the net-present value of subsoil assets, forest resources, protected areas and agricultural land) rather than natural resource *dependence*, there appears to be a positive effect on growth performance (e.g., Ding and Field, 2005; Alexeev and Conrad, 2005; Brunnschweiler and Bulte, 2007). From our point of view, this does not seem surprising as natural resource wealth is much less volatile than natural resource export revenues and more likely to boost the rate of economic growth.

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growth negatively affects growth in GDP per capita. This confirms for our sample the results of Ramey and Ramey (1995). However, regression two indicates that there is some evidence for serial correlation in growth in income per capita. Regression three tests whether there is any evidence for a natural resource curse along the lines of Sachs and Warner (1995).[6] We only find support for a negative coefficient for point-source natural resource dependence on economic growth.[7] In contrast to much of the existing empirical literature, financial development, openness to international trade[8] and various interactions terms are insignificant explanatory factors of cross-country variations in growth in GDP per capita. One possible explanation of this is that the effects of these variables are picked up by the effect of volatility on growth performance. We return to that in section 5.4.2.

In order to get an initial understanding of the sources and origins of volatility, regression four explains volatility by regional block dummies instead of country dummies. It is interesting that Sub-Saharan African and to a lesser extent the Middle-East and North Africa are much more volatile and thus suffer much more from bad growth prospects. If Sub-Saharan Africa would have the same volatility as East Asia and the Pacific, its average annual growth rate would be 0.96%-point higher.[9] Regression four also indicates that, controlling for all traditional factors explaining cross-country differences in growth performance, there is no evidence of a traditional resource curse as the share of point-source or diffuse natural resource exports in total exports is insignificant.[10] However, regression five does indicate that point-source natural resource *rents* (i.e., net of exploration costs)[11] exert a negative effect on growth in GDP per capita even after allowing for the effects of volatility on growth. Regression 5 also shows significant interaction terms with openness and financial development at the one percent-level. This suggests that the resource curse is less pronounced for countries open to international trade and with well functioning financial systems. For very open countries with a high degree of financial development, the resource curse can even be turned into a blessing.

[6]To allow for the fact that the errors in our explanation of growth in GDP per capita are not independent within countries, we cluster the standard errors by country in regressions 2 and all further regressions.

[7]These include oil, gas, ores and minerals, which are typically produced in concentrated locations.

[8]We use the openness variable of Sachs and Warner (1997) as expanded by Wacziarg ad Welch (2003). Instead of 'years open to trade' we use initial openness to minimize reverse causality concerns.

[9]$0.96\% = -0.243 * \sqrt{exp(-7.788)} * \{\sqrt{exp(1.010)} - \sqrt{exp(2.557)}\}$

[10]Diffuse natural resources include agricultural raw materials and foods such as livestock, coffee, bananas or tobacco, which typically are produced throughout the country.

[11]The resource rents data are not necessarily superior, since extraction costs are available for much fewer countries than resource revenues and are often proxied by regional/continental rather than local costs.

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Clearly, the regional block dummies leave out information that is in the parsimonious country dummies. The resulting omitted variable bias is why the coefficient on volatility is bigger, since it forces countries within each region to have similar volatility.

5.4.2 Opening the black box: Underlying determinants of volatility and the resource curse

To better understand the effects of natural resource dependence on growth, we need to dig deeper into the determinants of volatility. Regression 6a in Table 3 does exactly that and allows for an autoregressive error structure. It still finds that investment in physical and human capital boost economic growth while population growth depresses growth in income per capita. There is also again evidence for conditional convergence, so that poor countries catch up. Interestingly, there is now evidence of a significant *positive* direct effect of point-source natural resources on economic growth. There is no evidence for a significant effect of openness on growth. There is evidence for a significant direct effect of financial development on economic growth, but unfortunately it is negative. More important, volatility of unanticipated growth exerts a powerful and negative effect on growth of GDP per capita. As expected, volatility itself increases with the GDP share of point-source resources and to a lesser extent with the GDP share of diffuse resources. Volatility also decreases with the degree of financial development and openness of a country to international trade, which supports the hypothesis put forward by Aghion et al (2006) and Rose and Spiegel (2007). In line with Malik and Temple (2006), we find that volatility increases with the distance from navigable coast or rivers, which is their strongest predictor of output volatility.

5.4.3 Dealing with the endogenous nature of investment shares

Growing countries attract more investment, so the direction of causality may go either way. Even though we control for openness and financial development, we probably do not capture enough of the institutional effects on growth and investment. We therefore look for an exogenous variable that strongly predicts the investment share, but does not affect growth or correlate with other important unobserved characteristics. We choose to instrument the investment share with an index of ethno-linguistic fractionalization. This index measures the probability that two randomly selected individuals from a given country will not belong to the same ethnic group (Montalvo and Reynal-Querol, 2005a).[12] The rationale is that trust, ability to communicate and social cohesion are essential pre-

[12] They base their data on the World Christian Encyclopedia. They argue that fractionalization is a poor predictor of civil war compared to ethnic polarization. We are therefore more confident that there is no effect of fractionalization on growth via the link of conflicts.

requisites for successful investment. Fractionalized countries have lower levels of trust, more corruption, less transfers, subsidies and political rights (Alesina et al, 2003). These factors should lower the investment rate, since they increase uncertainty about returns and expropriation.[13] We also assume that ethno-linguistic fractionalization is randomly 'assigned' to countries and mostly historically determined. Countries should also not have systematically different growth rates depending on their degree of ethnic fractionalization. We suspect that this is the case given the very different growth experiences of countries among the top-ten of ethnic fractionalization, i.e., Canada, Senegal, India and Mali. In the bottom-ten of least fractionalized countries are Norway, Japan, Tunisia, and Greece. We also include two geographical variables: whether a country is landlocked or not, and a climate variable. Investment opportunities may be lower if it is more difficult for a country to diversify and export. Alesina et al (2003) also find strong correlations between ethno-linguistic fractionalization and geographical variables. This allows us to isolate the effect of fractionalization on investment and most importantly to conduct a Hansen over-identification test for exogeneity of the instruments. Regressions (6b), (6c), and (6d) of Table 3 report the first and two second stages of this IV exercise and confirm the detrimental effect of volatility on growth. Regression (6c) uses all the instruments in the first stage, while (6d) uses only the ethno-linguistic fractionalization index, for reasons explained below. Although the positive effect of the investment share on growth is now larger, the qualitative results are similar to the ML estimates presented in regression (6a). An interesting feature of the second-stage regressions (6c) and (6d) is that the (weak) evidence for a positive direct effect of natural resources on growth has disappeared. The first stage (6b) of the IV regressions shows a large and significant positive correlation between natural resource dependence and the investment share. We cannot claim that this corresponds to a causal effect, but it further explains the positive (although insignificant) direct effect of natural resource dependence on growth after controlling for volatility.

These conclusions are supported by several statistical tests which measure the quality of the IV-strategy. The first stage (6b) confirms that ethno-linguistic fractionalization has a strong negative effect on the investment share. The F-test on the excluded instruments is unfortunately below 9.08 (5% critical value for three instruments) which

[13]Montalvo and Reynal-Querol (2005b) argue that ethnic polarization affects investment but not growth, while fractionalization affects growth directly as in Easterly and Levine (1997), but not investment. However, these growth regressions do not control for population growth or volatility. If we run regression 6a with ethnic fractionalization and polarization using their ethnicity data, we find no growth effects of these two variables. Adding polarization to the first stage yields no effect of polarization, but still gives a significant negative effect of fractionalization on investment. Taking the effect of volatility into account seems to have important effects on the link between ethnicity and growth, and should be seen as complementary. Regressions available on request.

means that the relative bias of using these instruments is larger than 10 percent of the inconsistency of regression 6a. This means that there is still some bias in the equation (Stock and Yogo, 2002). However, if we repeat the IV regressions with only ethnic fractionalization in column (6d) we achieve an F-test value of 11.85. Ethnic fractionalization is therefore a strong predictor of investment. Using only this instrument improves the precision of several important estimates (first-stage not reported). On the other hand, using all three instruments allows us to test for their exogeneity because in this case the equation is over-identified. The Hansen test[14] is passed with confidence in column (6b) and implies that our instruments are exogenous.[15]

Figure 5 shows, on the basis of regression 6a, the marginal effect of resource dependence on growth.[16] This effect depends on the volatility of unanticipated output growth because the standard deviation of unanticipated output growth impacts the mean equation while the variance equation explains the logarithm of the variance of unanticipated output growth.[17] Natural resource dependence is thus a curse for very volatile countries, but a boon for countries with relatively stable unanticipated output growth. In fact (based on regression 6a), if σ exceeds 0.071 (i.e., 2*0.050/(0.871*1.621), resource dependence curbs growth and otherwise it boosts growth. However, after correcting for the endogeneity of the initial investment share in regression 6c we do not find a positive resource effect anymore and σ only has to exceed 0.046 (=2*0.036/(0.937*1.657)) to decrease growth.[18] We see from Figure 5 that for the less volatile OECD (including Norway) and Asian Tigers, resource dependence is a boon for growth, while for volatile landlocked Africa (especially Zambia) it is a curse. For resource-rich Africa the positive direct effect of resource dependence is more or less canceled out by the indirect effect through volatility. In later regressions we find a *negative* direct effect of resource dependence on growth, in which case the line in Figure 5 lies below the horizontal axis. The

[14] Robust to heteroskedasticity and autocorrelation.

[15] A complicating factor is that the predicted investment share in regression 6c is a generated regressor (Pagan, 1984), which causes standard errors to be too small (although coefficients are consistently estimated). A common solution is to block bootstrap the standard errors, which resamples every replication from within each cluster (each country) to allow errors to be correlated within countries, but independent between countries. Since it is very difficult to achieve convergence of the log likelihood function for every replication, we use the fact that block bootstrapping is asymptotically equivalent to panel robust sandwich standard errors (Cameron and Trivedi, 2005). The latter correction of the standard errors is what we use in all regressions, including 6c, to allow for within-country correlation of the errors. We can therefore directly interpret the results.

[16] Note: RR. Africa = resource-rich Africa; LL. Africa = Landlocked Africa; Asian T. = Asian Tigers, corresponding to Table 8.

[17] Ramey and Ramey (1995) have used the same specification. We also tried the logarithm of the variance in the mean equation, but this gave a much worse fit.

[18] If we take the t-test literally the direct effect is not different from zero and therefore only the indirect effect matters, which is always negative. In that case resources are a curse for any level of volatility.

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resource curse is always more severe for more volatile countries.

5.4.4 Natural resource rents, volatility and growth

Our regressions 6 quantify the effects of the GDP share of natural resource exports on volatility and growth, but it seems relevant to also take account of production costs of extracting natural resources. Regressions 7 therefore present the corresponding ML and IV estimates with the GDP share of natural resource rents as an explanatory variable. Again, growth performance is negatively affected by volatility of unanticipated output growth even after allowing for the positive effect of investment shares and the negative effect of population growth and initial income per capita on growth performance. Also, the direct effects of natural resource rents on growth are statistically significant and negative (but insignificant once we allow for the endogeneity of investments). The interaction terms with financial development and openness are significant and positive (also once we allow for endogenous investments) while financial development and openness now have a negative direct effect on growth. This indicates that financial development and openness are especially growth enhancing for resource-rich economies and that natural resource rents boost growth provided countries are open and financially developed. Figure 6 shows that for already moderate degrees of financial development the marginal effect of the rent share on growth is positive rather than negative. Resource dependence has a positive effect on growth in open economies and a negative effect for closed economies.[19] Hence, countries that are open to international trade and have a high degree of financial development turn the resource curse into a blessing.

Turning to the determinants of volatility, we see that the GDP share of point-source resource rents and the distance from the navigable coast or rivers have a significant positive effect on volatility and thus a negative effect on growth. Rents on diffuse resources do not seem to impact volatility and growth. Still, there is a significant negative effect of openness and financial development on volatility of unanticipated output growth and thus a positive effect on growth.

Unfortunately, our set of instruments does not perform as well when we use resource rents which is reflected in large standard errors in regression 7c and an insignificant effect of the ethno-linguistic fractionalization index in the first stage regression 7b, even though the Hansen test supports our claim that the instruments are exogenous. The F-test in the first-stage is also very small and remains small in regression 7d where only the investment share is used. However, qualitatively the estimates are very similar in

[19]The line shifts to the left for full openness and more to the right the less open a country was to trade in 1970.

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nature to the regressions where resource export revenues were used.

Summing up and probing deeper into the determinants of volatility, we find that countries that are closed to international trade, have badly functioning financial markets, are landlocked and have a high share of natural resource rents have higher volatility in unanticipated growth in output per capita and therefore worse growth prospects. These results suggest, in contrast to the previous literature, that volatility of commodity prices is a key feature of the resource curse.

5.4.5 Impact of volatility of various commodity export shares on macroeconomic volatility

With regression 6a as the benchmark, regression 6e in Table 4 tries to see if marginal effect of initial resource dependence on volatility is weaker if a country starts off from a higher level of financial development as well. This seems not to be the case. However, it is more likely that financial services give countries the means to deal with the large world price shocks and will reduce the effect of resource wealth fluctuations on output volatility. Financial development may limit the pass-through of volatile resource income into general output volatility through insurance and easing of borrowing constraints. The second half of Table 5 therefore focuses on ML estimates of regressions with fluctuations in the GDP shares of resource exports as an additional explanatory variable in the variance equation. Since resource quantities are relatively inelastic, most of the revenue movement will originate in world prices. Regression 9a indicates that adding the volatility of the GDP share of both point-source and diffuse resources to the variance equation significantly helps to explain the volatility of unanticipated output growth. Regression 9b indicates that, inspired by Fatás and Mihov (2005), adding the volatility of the GDP share of government spending (capturing policy shocks and spending bonanzas following windfall revenues) also significantly improves our estimate of the volatility of unanticipated growth. Furthermore, regression 9c shows that especially the volatility of food export share, the volatility of fuel export share and the volatility of ores & metals export share contribute to the volatility of unanticipated output growth. The volatility effect of natural resources is thus not limited to oil-producing countries, but also includes for example copper, coffee, banana and tobacco exporters. The qualitative results of the estimated equation for annual growth are not much affected, except that the estimated negative effect of volatility of unanticipated output growth on mean annual growth is almost three times smaller and closer to the black-box estimate with individual country dummies (despite being much more parsimonious). Although we did not find evidence for a significant interaction term between financial development and initial point-source resource dependence in the variance equation, we find in regression

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9d that well-functioning capital markets greatly reduce the effect that shocks in the resource share have on volatility. Consistent with the model of section 2, a stable share of natural resources in GDP does not increase volatility by itself, but rapid fluctuations in the share through prices create liquidity constraints and harm growth. Financial development gives a country the means to deal with sudden changes in resource revenues. This holds even after we control for terms-of-trade shocks.

5.4.6 Impact of ethnic tensions and economic restrictions on volatility and growth

Table 5 presents some further refinements and robustness tests of our results. Since ethnic polarization as defined by Montalvo and Reynal-Querol (2005b) is a good predictor of civil conflict, it may also be a good predictor of volatility. We want to check whether resources still have an independent effect on volatility when we allow for an effect of ethnic polarization. Furthermore, this measure takes its highest value if a country is equally divided into two groups. Such a situation may increase instability if natural resources are present as well. Regression 10a indicates indeed that ethnic polarization significantly improves the estimate of the volatility of unanticipated output growth, but does not have an independent direct effect on growth. The interaction term shows that there is also a significant positive interaction with resource dependence: the more polarized a country, the more resources lead to volatile economies through conflict and rent-seeking government policy. Regression 10b shows that ethnic polarization is no longer important once the volatility of the export shares of point-source and diffuse resources, and the volatility of the GDP share of government spending are used as explanatory variables of volatility. Resources are not necessarily bad, but anything that magnifies already volatile prices, such as public spending booms and busts (possibly related to civil tensions), seems to harm long-run growth prospects.

Table 5 also tests for the impact of economic restrictions to examine whether financial and trade liberalization boosts or depresses growth. We replace the single openness dummy with four measures of restrictions from the Annual Report on Exchange Arrangements and Restrictions (IMF, 2006). Regression 11a indicates that capital account restrictions have a somewhat negative direct impact on growth. However, this is swamped by the negative effect of capital account restrictions on volatility and thus the positive effect on growth, especially for countries with a high degree of natural resource dependence. Capital account restrictions may thus help to curb volatility and increase growth performance, especially in resource-rich countries.[20] Access to international

[20]Kose et al (2003) find that increased gross financial flows and absence of capital account restrictions

capital markets may have a pro-cyclical element, which tends to generate higher output volatility especially in resource-rich, developing economies. Current account restrictions have no significant direct effect on growth, but do contribute to volatility especially in resource-rich countries and thus hamper growth. Regression 11a also indicates that the surrender of export receipts is associated with higher volatility and lower growth. Multiple exchange practices lower volatility and increase growth, since they are a form of exchange control and curb volatile capital in- and outflows. Regression 11b drops the interaction terms and includes the fluctuations in revenues and government spending as well as terms-of-trade shocks. The effect of the four restrictions is qualitatively unchanged.

5.5 Robustness of Results

5.5.1 Detrimental effect of volatility greater in OECD sample?

Ramey and Ramey (1995) found evidence that the detrimental effect of volatility on growth was actually slightly larger in OECD countries. This is surprising, because OECD countries have a much higher level of development of institutions and financial markets. Table 6 explores how our results hold for the much smaller OECD sample. The first column repeats regression 6a with the full sample of countries but summarizes the resources into one variable. The third column shows that we also find a somewhat stronger effect of volatility on growth in OECD countries. This does not mean, however, that volatility is a bigger problem in these developed countries. The standard error has also increased by enough to make both results indistinguishable from each other, and the predicted sample volatility for OECD countries is at least half that of the full sample. The net effect on growth is thus close to half what it is for the full set of countries, and much higher for the non-OECD countries. Regression 12d OECD indicates that the significance of this difference actually disappears when we further condition volatility on government spending volatility, ethnic tensions, and volatility of the terms of trade as is done for the full sample in 12b. In fact, for the developed OECD countries there appear to be no negative effect of output volatility. They are sufficiently open to international trade and financially developed to balance the adverse effects of government spending booms and busts and fluctuations in the terms of trade.

An interesting finding is that resource dependence does not increase volatility, but rather decreases it in OECD countries. Countries such as Norway and The Netherlands with significant resource exports have very stable institutions which may be able to turn

lead to an increase in the relative volatility of consumption.

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around any resource curse into a blessing. This is further supported by the positive direct effect of resources on growth in the mean equation of regression 12c of Table 6. Consistent with the result that financial development can alleviate the resource curse, natural resources can be a blessing for countries with the institutional means to spend the proceeds wisely.

5.5.2 Robustness: short-run panel perspective and fixed-effects estimation

We allow volatility to be time dependent by building a five-year panel. Instead of using 1970 values of explanatory variables, we use values for 1970, 1975, 1980, and so on, in regressions 13, and non-overlapping five-year means in regressions 14-16, for each year within the respective 5-year period. However, for both the dependent variable and its lag, we still use yearly observations to yield five errors for each five-year period over which to calculate the volatility. For example, the ten growth rates between 1970 and 1980 are regressed on five repeated initial values of 1970 and five initial values of 1975, or regressed on five repeated means calculated over the years 1970-75, and five means calculated over the years 1975-1980. In both cases σ_{it} is the standard deviation over the errors of period t to $t+5$. It is true that this is a short time period for a standard deviation, but on the other hand it allows institutions and other determinants of growth and volatility to change over time. We estimate the following panel data specification:

$$\begin{aligned} \Delta log(y_{it}) &= \lambda\sigma_{it} + \mathbf{X}_{it}\theta + \mathbf{Z}_{it}\beta + d_t + \epsilon_{it}, \quad \sigma_{it}^2 = exp(\mathbf{Z}_{it}\gamma + c_t) \quad \text{and} \qquad (5.8) \\ \epsilon_{it} &\sim N(0, \sigma_{it}^2), \quad i = 1, ..., N. \quad t = 1, ..., T. \end{aligned}$$

$\mathbf{Z}_{it}$ now includes time-varying data on financial development, resource dependence, and so on, which also allows volatility to vary over time. As various countries become more open to the world economy over the years, this allows us to address the question whether countries as a consequence become less volatile. This allows for a richer story than the hypothesis tested so far, namely that countries which were open in 1970 were less volatile in the 33 years thereafter. Furthermore, we can factor out the effect of unobserved fixed effects on growth. To do this, we apply the within-transformation (subtracting the mean of each variable over the period 1970-2003 per country from itself) on all variables and re-estimate the panel with maximum likelihood. The coefficients can then be interpreted as the effect of a change in the variable relative to its country-mean over time. σ_{it} is not de-meaned itself, but represents the volatility of de-meaned growth shocks. One possible drawback is that fixed-effects estimation also factors out important long-run characteristics of countries such as average financial development and natural resource abundance. This is why fixed-effects regressions are not our preferred specification. Table 7 reports the panel estimates of the effects of volatility, natural resource dependence, financial development and openness (as well as investment rates, schooling, population growth and initial income per capita) on growth in GDP per capita. We find significant negative effects of volatility on growth in all cases, although short-run volatility over and above long-run volatility (which is absorbed by the fixed effects) is somewhat less significant. We see the most notable differences between the pooled regressions 13a and 14a, and the fixed-effects regressions 13b and 14b in the variance equation.[21] Most of the effects from the previous tables are still present in the pooled regressions. After controlling for country fixed effects (e.g., a country's average level of financial development), we see that an increase in financial development does not significantly decrease volatility over a short run period of five years. The strongest remaining effect is that of volatility of changes in the terms of trade. This also affects short-run increases in volatility. The difference between regressions 15, 12b and 12d OECD of Table 5 is remarkable. Countries that were financially developed in 1970 could dampen the effect of long-run terms of trade volatility on volatility of unanticipated output growth, but the effect works the other way around in a short-run, fixed-effects regression both in the full sample and in the OECD sample. Short-run terms of trade volatility may coincide with credit booms, such as during the Asian crisis. In any case, the sample means for these variables (at the bottom of Table 7) are very small which shows that these short-run effects are less important than they appear. The effect of a short-run increase in the value of natural resource exports has on the other hand no direct effect on volatility, but still interacts negatively with financial development.

5.6 Accounting for growth performance: Africa versus the Asian Tigers

To get a feeling for what our estimates of the determinants of growth in GDP per capita imply in practice, it is interesting to perform some counterfactual exercises. We perform these exercises based on our preferred equation 6a of Table 3. It is insightful to compare the African countries with the Asian Tigers[22], since they have similar starting positions (in 1970). We therefore compare in Table 8 resource-rich and landlocked Africa with the Asian Tigers. Resource-rich countries are those in the global top 25 and natural

[21] The observed fixed effects of distance to the nearest navigable river or coast and long run government spending volatility are factored out by the within transformation. Government spending did not vary enough across 5-year periods to be able to include it in regressions 14b, and 15b-17. We also left out ethno-linguistic polarization as it limits the sample and would also be absorbed by fixed effects.

[22] The Asian Tigers in our sample are: South Korea, Malaysia, Philippines and Thailand.

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resource exports valuing on average more than 17.31% of GDP during 1970-2003. Since the resource-rich countries of Africa were poorer in 1970 than the Asian Tigers, they grow faster and catch up, everything else equal. We see from the top panel of Table 7 that this growth differential amounts to 0.87%-point per year (the difference in initial GDP per capita times the coefficient). Allowing for the positive direct growth effects of higher natural resource dependence in Africa, we see that the growth differential with the Tigers becomes 1.31%-point. Now if those African countries would invest as much in physical and human capital as the Asian Tigers, they would add a further 0.65%- and 0.46%-points, respectively to their annual growth rate. If resource-rich Africa's population growth rate were to be reduced in line with the Tigers, Africa would gain yet another 0.43%-point annual growth. These three factors combined yield an extra bonus to potential growth of 1.54%-point. However, the key message is how much potential growth is lost due to the high volatility of unanticipated output growth in resource-rich Africa compared with the Asian Tigers: a whopping 2.98%-point extra growth per annum! The main reasons for the high volatility of these resource-rich countries in Africa compared with the Asian Tigers are their heavy dependence on natural resources (increasing volatility by 0.41%-point, translating into a 0.52%-point loss in growth, their lack of openness (1.71%-point), their badly developed financial markets (0.58%-point) and their distance from navigable waterways (1.07%-point).[23]

The bottom panel of Table 8 compares landlocked Africa with the Tigers. The results are similar, although the prospects of these countries are perhaps even more miserable. Still, as landlocked Africa starts off from a worse starting position than resource-rich Africa, it catches up more quickly and thus grows 1.41%-point faster than the Tigers. Accounting for landlocked Africa being more dependent on resources than the Tigers, would raise this growth differential to 1.74%-point. Now bringing mainly investment in physical and human capital but also population growth in line with the Tigers would add an extra 1.47%-point growth per annum. This offers some hope. However, if landlocked Africa were to be able to bring down its volatility of unanticipated output in line with that of the Tigers, it would boost growth by a further 1.97%-point per annum. The potential growth bonus is thus 3.44%-point. If this were feasible, landlocked Africa's negative growth differential with the Tigers of -3.82%-points could have been reduced to a little as -0.38%-points. The countries Malawi and Zambia are resource rich and landlocked. They also have relatively high volatility and poorly developed financial

[23] Each number is obtained by keeping all other variables constant and using the Asian Tiger's number for the respective variable. The effect on growth is then calculated using the coefficient on volatility in the mean equation. They therefore reflect the growth effect of changing only one variable to the Asian Tiger's 1970 level.

systems. Not surprisingly, they have a lot to gain.

We conclude that a big push to economic growth occurs if the volatility of unanticipated output growth in Africa is brought down to the level of the Asian Tigers. The big contributing factors to Africa's volatility are its volatile stream of mainly point-source natural resource revenues, its lack of fully developed financial markets and openness to international trade, and its disadvantages of being relatively more landlocked than the Asian Tigers.

5.7 Conclusion

We have shown that the curse of natural resources is foremost a problem of volatility. The high volatility of world prices of natural resources causes severe volatility of output per capita growth in countries that depend heavily on them. The resulting volatility of unanticipated output growth has a robust negative effect on long-run growth itself and can therefore rightly be termed a curse. This is not limited to oil-producing countries, but also applies to exporters of copper, coffee, foods, amongst others. which include many of the world's worst performing countries. Also, ethnic tensions, which are often fueled by resource wealth, and current account restrictions increase volatility. The latter effect is especially strong in resource-rich countries. Government spending bonanzas after windfall resource revenues also increase volatility to the detriment of growth, because revenue drops inevitably follow.

Volatility can fortunately be substantially reduced provided that countries have a sound financial system to cope with large and sudden fluctuations in resource income. Fewer capital account restrictions, openness, and physical access to world trade also lower volatility. Countries can turn the curse even into a blessing, because we find evidence for a positive direct effect of natural resource dependence on growth after controlling for volatility. The key to a turn-around for many resource-rich countries is financial development, ensuring openness and mitigating the effect of being landlocked, because the *indirect negative* effect of resource dependence on growth, via volatility, is much larger than any *direct positive* effect. While it may be difficult to lower price volatility of resources themselves, it should be feasible to deal with volatility in a more efficient way. Future research should focus on ways to overcome the political temptations of short-run resource wealth to create the financial and political institutions needed to reduce volatility, soften the impact of volatility on growth, and prevent poverty.

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APPENDICIES

5.A Data sources

Variable Name	Definition	Source
GDP/capita growth rate	Ln difference in real GDP per capita, Laspeyres	PWT 6.2 from Heston et al. (2006)
Investment share of GDP	Gross fixed capital formation as % of GDP	PWT 6.2 from Heston et al. (2006)
Average population growth rate	Ln difference in total population	PWT 6.2 from Heston et al. (2006)
log per capita GDP	Ln real GDP per capita	PWT 6.2 from Heston et al. (2006)
Human capital	Average schooling years in the population (age 25+)	Barro & Lee (2000)
Point-source resources	F.o.b. value of exported fuels + ores & metals as a percentage of GDP	WDI (2006)
Diffuse resources	F.o.b. value of exported foods and agricultural raw materials as a percentage of GDP	WDI (2006)
Fuels	F.o.b. value of exports as a percentage of GDP. Corresponds to SITC section 3 (mineral fuels). Volatility refers to standard deviation of the yearly shares of GDP.	WDI (2006)
Ores & Metals	F.o.b. value of exports as a percentage of GDP. Commodities in SITC divisions 27, 28, and 68 (nonferrous metals). Volatility refers to standard deviation of the yearly shares of GDP.	WDI (2006)
Agricultural Raw Materials	F.o.b. value of exports as a percentage of GDP. Corresponds to SITC section: 2 (crude materials except fuels) excluding divisions 22, 27 (crude fertilizers and minerals excluding coal, petroleum, and precious stones), and 28 (metalliferous ores and scrap). Volatility refers to standard deviation of the yearly shares of GDP.	WDI (2006)
Foods	F.o.b. value of exports as a percentage of GDP. Commodities in SITC sections: 0 (food and live animals), 1 (beverages and tobacco), and 4 (animal and vegetable oils and fats) and SITC division 22 (oil seeds, oil nuts, and oil kernels). Volatility refers to standard deviation of the yearly shares of GDP.	WDI (2006)
Resource rents	(total sale value total production costs)/GDP, current US$ for bauxite, copper, nickel, tin, zinc, lead, phosphates, iron ore, silver, gold (ores); brown coal, hard coal, oil, natural gas (fuels)	World Bank (2007) and WDI (2006)
Monthly world commodity prices	Monthly averages of free-market price indices for all food, agricultural raw materials, minerals, ores & metals, crude petroleum (average of Dubai/Brent/Texas equally weighted). Base year 2000 = 100.	UNCTAD, 2007
Financial development	Domestic credit to private sector (% of GDP)	WDI (2006)
Openness dummy	open to trade = 1	Wacziarg & Welch (2003)
Landlocked dummy	=1 if a country has no access to sea	Gallup et al. (1999)
Government spending volatility	standard deviation of yearly share of government expenditure of GDP	PWT 6.2 from heston et al. (2006)
sd ToT index growth	standard deviation of yearly terms-of-trade index growth rate, where the terms-of-trade index is defined as the vaue of total exports over total imports	PWT 6.2 from heston et al. (2006)

% population in temperate climate zone	% 1995 pop in Koeppen-Geiger temperate zones (Cf+Cs+Df+DW)	CID, General Measures of Geography, 2007
Distance to nearest navigable river or coast	minimum distance in km, fixed effect	CID, General Measures of Geography, 2007
Ethnic Polarization	Index of ethno-linguistic polarization (0: many small groups, to 1: two large groups)	Montalvo & Reynal-Querol (2005)
Ethnic Fractionalization	Index of ethno-linguistic fractionalization (0 to 1), the probability that two randomly selected individuals from a given country will not belong to the same ethnic group.	Montalvo & Reynal-Querol (2005)
Multiple Exchange Practices	yes = 1	IMF (2006)
Current Account Restrictions	yes = 1	IMF (2006)
Capital Account Restrictions	yes = 1	IMF (2006)
Surrender of Export receipts	yes = 1	IMF (2006)

5.B Tables

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TABLE 5.1: *Growth, Volatility, Financial Development and Resources in World*

Regional Characteristics (%, 1970-2003, at least 10 observations per country)

Region	Yearly real GDP per capita growth rate		Export Value Share of GDP: Fuels, Ores & Metals		Export Value Share of GDP: Agricultural Raw Materials, Foods		Export Value Share of GDP: All Resources		Rent Share of GDP: Fuels, Ores & Metals		Government Share	Fin. Development
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	sd	mean
Middle East & North Africa	1.18	8.12	22.24	9.30	2.51	1.52	24.75	9.07	26.98	11.20	5.82	41.41
Sub-Saharan Africa	0.47	6.52	9.60	3.97	10.24	3.60	19.65	5.66	5.79	3.76	4.76	17.44
East Asia & Pacific	2.47	5.00	6.81	3.45	10.04	3.11	16.71	5.49	4.44	2.44	2.72	51.77
Latin America & Caribbean	1.47	4.54	4.99	2.64	9.66	3.70	14.59	5.34	6.31	3.26	3.98	34.87
South Asia	2.41	4.41	0.52	0.42	4.25	1.55	4.77	1.83	1.31	0.96	2.98	17.33
Eastern Europe & Central Asia	2.56	4.34	2.07	0.66	3.50	1.03	5.57	1.54	2.23	1.23	2.52	22.70
Western Europe	2.35	2.33	2.71	1.00	5.20	0.95	7.86	1.60	0.55	0.52	1.53	76.08
North America)	2.09	1.90	2.90	0.52	2.99	0.45	5.88	0.85	3.41	1.85	1.60	109.36
1st q. Av. Fin. Dev. (≤16.2)	0.70	6.40	9.71	4.23	7.64	3.00	17.06	5.52	5.14	2.95	4.64	10.38
4th q. Av. Fin. Dev. (≥52.9)	2.32	4.40	4.68	2.29	5.28	1.78	9.89	3.45	4.99	2.62	3.03	80.92
1st q. Av. Resource Dep. (≤6.1)	2.73	2.83	1.17	0.48	2.23	0.64	3.41	0.93	1.65	1.11	2.38	64.96
4th q. Av. Resource Dep. (≥19.3)	1.08	7.37	23.22	10.00	11.62	3.59	34.67	10.85	14.10	6.47	4.72	25.47
1st q. Dist. to waterway (≤49km)	1.76	8.12	6.72	3.41	8.22	2.65	24.75	9.07	6.03	2.50	5.82	41.41
4th q. Dist. to waterway (≥359km)	1.46	6.52	8.22	3.68	8.59	3.43	19.65	5.66	8.99	4.75	4.76	17.44

Note: *Means* are cross-country averages of country average growth rates or variable shares between 1970 and 2003. *Standard deviations* (sd) are the average cross-country standard deviations of country yearly growth rates or variable shares over the corresponding period.

TABLE 5.2: *Natural Resource Curse and Regional Volatility*

Dependent Variable	yearly GDP growth per capita 1970-2003				
(constant 2000 international dollars, PWT 6.2)	1	2	3	4	5
Mean equation	**Resource Export Revenues**				**Rents**
Av. investment share of GDP 70-03	0.108***	0.079***	0.063***	0.053***	0.083***
	(0.012)	(0.012)	(0.013)	(0.017)	(0.020)
Av. population growth rate 70-03	-0.472***	-0.337***	-0.411***	-0.460***	-0.624***
	(0.118)	(0.112)	(0.127)	(0.158)	(0.141)
log per capita GDP 1970	-0.012***	-0.009***	-0.011***	-0.012***	-0.010***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Human capital 1970	0.001*	0.001*	0.001*	0.001**	-0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)
Volatility (σ_i)	-0.110**	-0.089*	-0.126**	-0.243**	-0.240***
	(0.049)	(0.047)	(0.058)	(0.113)	(0.087)
1st lag GDP per capita growth		0.264***	0.264***	0.240***	0.207***
		(0.015)	(0.032)	(0.028)	(0.031)
Point-source resources 1970			-0.071**	-0.035	
			(0.035)	(0.041)	
Point-source rent share 1970					-0.202***
					(0.044)
Diffused resources 1970			-0.000	0.010	0.033**
			(0.018)	(0.020)	(0.014)
Financial development 1970			-0.003	-0.001	-0.007**
			(0.006)	(0.005)	(0.003)
Openness dummy 1970			0.001	0.002	0.002
			(0.003)	(0.004)	(0.002)
Point-source resources * openness 70			0.003	0.012	
			(0.086)	(0.073)	
Point-source rent share * openness 70					0.177**
					(0.085)
Point-source resources * Fin. Dev. 70			0.280	0.181	
			(0.215)	(0.191)	
Point-source rent share * Fin. Dev. 70					0.745***
					(0.182)
Constant	0.110***	0.084***	0.100***	0.117***	0.106***
	(0.011)	(0.011)	(0.012)	(0.014)	(0.011)
Variance equation					
Sub-Saharan Africa				2.557***	2.618***
				(0.207)	(0.224)
Middle-East & North Africa				1.708***	1.675***
				(0.258)	(0.305)
Latin America & Caribbean				1.583***	1.561***
				(0.176)	(0.178)
Eastern Europe & Central Asia				1.410***	1.350***
				(0.036)	(0.050)
East Asia & Pacific				1.010***	0.852***
				(0.195)	(0.221)
South Asia				0.444**	0.356**
				(0.182)	(0.165)
Western Europe				0.192	0.256
				(0.153)	(0.163)
North America				Reference region (least volatile)	
Constant	-3.823***	-3.947***	-6.630***	-7.788***	-7.747***
	(0.118)	(0.121)	(0.024)	(0.033)	(0.041)
Country dummies in variance eq.	yes	yes	yes	no	no
Observations	3448	3437	2185	2185	2014
Log likelihood	5898.5	5997.9	4226.6	4017.1	3759.4
Countries	103	103	65	65	60

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10. Clustered (by country) in regressions 2 to 5.

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TABLE 5.3: *Underlying Determinants of Volatility and the Natural Resource Curse*

Dependent Variable	Δy_{it}	Av. inv/GDP	Δy_{it}	Δy_{it}	Δy_{it}	Av. inv/GDP	Δy_{it}	Δy_{it}
(constant 2000 international dollars, PWT 6.2)	(6a) ML	(6b) 1st stage	(6c) IV-ML	(6d) IV-ML	(7a) ML	(7b) 1st stage	(7c) IV-ML	(7d) IV-ML
Mean equation	Resource Export Revenues				Resource Rents			
Av. investment share of GDP 70-03	0.045*		*0.119***	*0.113**	0.094***		*0.137***	*0.151***
	(0.025)		*(0.056)*	*(0.061)*	(0.019)		*(0.066)*	*(0.071)*
1st lag GDP per capita growth	0.221***	0.053**	0.215***	0.215***	0.205***	0.068***	0.203***	0.201***
	(0.025)	(0.021)	(0.027)	(0.026)	(0.027)	(0.024)	(0.028)	(0.029)
Av. population growth rate 70-03	-0.478***	0.258	-0.457***	-0.460***	-0.692***	-0.236	-0.612***	-0.607***
	(0.144)	(0.832)	(0.162)	(0.157)	(0.105)	(0.964)	(0.142)	(0.142)
log per capita GDP 1970	-0.014***	-0.026**	-0.013***	-0.013***	-0.012***	-0.021	-0.012***	-0.012***
	(0.002)	(0.012)	(0.003)	(0.002)	(0.002)	(0.015)	(0.003)	(0.003)
Human capital 1970	0.002**	0.012***	0.001	0.001	0.000	0.012***	-0.000	-0.000
	(0.001)	(0.003)	(0.001)	(0.001)	(0.000)	(0.004)	(0.001)	(0.001)
Volatility (σ_i)	**-0.971****		**-0.897***	**-0.937****	**-0.843*****		**-1.069***	**-1.055*****
	(0.378)		**(0.508)**	**(0.415)**	**(0.286)**		**(0.584)**	**(0.378)**
Point-source resources 1970	0.050*	0.242***	0.033	0.036				
	(0.030)	(0.039)	(0.041)	(0.027)				
Point-source rent share 1970					-0.188***	0.543**	-0.120	-0.132
					(0.051)	(0.229)	(0.116)	(0.085)
Financial development 1970	-0.018**	0.067*	-0.021**	-0.021***	-0.027***	0.066*	-0.031***	-0.031***
	(0.007)	(0.037)	(0.009)	(0.007)	(0.007)	(0.035)	(0.010)	(0.006)
Point-source rent % * Fin. Dev. 70					0.948***	-0.311	0.572***	0.601***
					(0.144)	(1.691)	(0.207)	(0.179)
Openness dummy 1970	-0.006	0.058***	-0.010	-0.010*	-0.009**	0.052**	-0.014*	-0.015**
	(0.005)	(0.018)	(0.008)	(0.005)	(0.004)	(0.022)	(0.007)	(0.006)
Point-source rent % * openness 70					0.208**	-0.032	0.198*	0.201**
					(0.101)	(0.064)	(0.102)	(0.099)
Constant	0.170***		0.151***	0.157***	0.149***		0.162***	0.158***
	(0.030)		(0.046)	(0.032)	(0.021)		(0.043)	(0.035)
Landlocked dummy		-0.012				-0.007		
		(0.013)				(0.012)		
% Pop. in temperate climate		0.002				0.004		
		(0.026)				(0.032)		
Ethnic fractionalization index		-0.073***				-0.059*		
		(0.026)				(0.035)		
Variance equation								
Point-source resources 1970	1.621***		1.655	1.657**				
	(0.589)		(1.386)	(0.657)				
Point-source rent share 1970					2.449***		2.568	2.575**
					(0.935)		(1.723)	(1.272)
Diffused resources 1970	0.801		0.982	0.980	0.154		0.260	0.261
	(0.514)		(1.952)	(0.711)	(0.783)		(0.626)	(0.649)
Financial development 1970	-1.290***		-1.299***	-1.300***	-1.423***		-1.430***	-1.430***
	(0.072)		(0.457)	(0.184)	(0.209)		(0.092)	(0.167)
Openness dummy 1970	-0.693***		-0.681***	-0.682***	-0.709***		-0.717***	-0.717***
	(0.160)		(0.129)	(0.182)	(0.242)		(0.149)	(0.085)
Distance to navigable river, coast	0.001***		0.001***	0.001***	0.001***		0.001**	0.001***
	(0.000)		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)
Constant	-6.100***	0.313***	-6.118***	-6.117***	-5.974***	0.281**	-5.958***	-5.959***
	(0.062)	(0.090)	(0.278)	(0.070)	(0.054)	(0.116)	(0.059)	(0.073)
F-stat. on excl. instruments		6.46		11.85		2.44		5.65
Hansen overid. J-stat. (p-value)		0.126				0.366		
Observations	2084	2084	2084	2084	1980	1980	1980	1980
R2	.	0.72	.	.	.	0.67	.	.
Log likelihood	3732.3	3927.4	3732.6	3731.9	3584.0	3538.4	3576.2	3576.4
Countries	62	62	62	62	59	59	59	59

Clustered (by country) standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Δy_{it} =yearly GDP growth per capita 1970-2003.

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TABLE 5.4: *Effects of GDP Shares of Natural Resources on Volatility and Growth*

Dependent Variable	yearly GDP growth per capita 1970-2003		yearly GDP growth per capita 1970-2003				
(constant 2000 international $, PWT 6.2)	(6a)	(6e)	(9a)	(9b)	(9c)	(9d)	(9e)
Mean equation							
1st lag GDP per capita growth	0.221***	0.220***	0.232***	0.230***	0.230***	0.226***	0.226***
	(0.025)	(0.025)	(0.026)	(0.027)	(0.027)	(0.027)	(0.028)
Av. investment share of GDP 70-03	0.045*	0.045*	0.063**	0.065**	0.063**	0.065**	0.074***
	(0.025)	(0.025)	(0.025)	(0.026)	(0.026)	(0.026)	(0.026)
Av. population growth rate 70-03	-0.478***	-0.478***	-0.461***	-0.346**	-0.343**	-0.358**	-0.307**
	(0.144)	(0.145)	(0.133)	(0.152)	(0.149)	(0.139)	(0.147)
log per capita GDP 1970	-0.014***	-0.014***	-0.012***	-0.011***	-0.010***	-0.011***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Human capital 1970	0.002**	0.002**	0.001*	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Volatility (σ_i)	**-0.971****	**-1.022*****	**-0.427*****	**-0.350****	**-0.334****	**-0.426*****	**-0.388*****
	(0.378)	**(0.297)**	**(0.129)**	**(0.141)**	**(0.148)**	**(0.148)**	**(0.127)**
Point-source resources 1970	0.050*	0.054*	0.014	0.008	0.005	0.018	0.016
	(0.030)	(0.028)	(0.023)	(0.023)	(0.029)	(0.023)	(0.022)
Financial development 1970	-0.018**	-0.018***	-0.010*	-0.008	-0.008	-0.009	-0.007
	(0.007)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Openness dummy 1970	-0.006	-0.007*	0.001	0.002	0.003	0.001	0.001
	(0.005)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	0.170***	0.174***	0.121***	0.107***	0.106***	0.115***	0.104***
	(0.030)	(0.027)	(0.018)	(0.018)	(0.019)	(0.019)	(0.015)
Variance equation							
Point-source resources 1970	1.621***	2.125***	-0.426	-0.720	-0.493	-0.563	-1.247***
	(0.589)	(0.596)	(0.488)	(0.634)	(0.645)	(0.862)	(0.337)
Diffused resources 1970	0.801	0.807	-0.897***	-0.133	-1.076	0.167	0.483
	(0.514)	(0.497)	(0.323)	(0.638)	(0.974)	(0.430)	(0.378)
Financial development 1970	-1.290***	-1.266***	-1.063***	-0.858***	-0.842***	-0.754***	-0.594***
	(0.072)	(0.121)	(0.136)	(0.096)	(0.226)	(0.166)	(0.153)
Openness dummy	-0.693***	-0.700***	-0.467***	-0.536***	-0.487**	-0.545***	-0.215**
	(0.160)	(0.160)	(0.180)	(0.174)	(0.207)	(0.164)	(0.095)
Distance to navigable river, coast	0.001***	0.001***	0.001***	0.001***	0.001***	0.000**	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Initial point res. * Fin. Dev.		-2.780					
		(2.049)					
Point based export share volatility			9.303***	9.528***		15.837***	14.491***
			(0.774)	(1.286)		(1.141)	(0.588)
Diffused export share volatility			10.907***	3.899*		1.841*	3.737***
			(1.491)	(2.004)		(1.047)	(1.377)
Government share volatility 70-03				10.525***	10.406***	9.786***	8.372***
				(1.179)	(3.260)	(2.709)	(1.510)
Agricultural R.M. res. share vol. 70-03					0.631		
					(3.023)		
Food resource share vol. 70-03					10.916***		
					(1.690)		
Ores & metals res. share vol. 70-03					6.626***		
					(2.543)		
Fuels res. share vol. 70-03					9.513***		
					(1.719)		
Fin. dev. * point-source volatility						-34.343***	-29.620***
						(6.542)	(3.295)
sd ToT growth, 70-03							4.321***
							(0.181)
Constant	-6.100***	-6.093***	-6.517***	-6.751***	-6.826***	-6.711***	-7.401***
	(0.062)	(0.067)	(0.030)	(0.035)	(0.057)	(0.075)	(0.020)
Observations	2084	2084	2084	2084	2084	2084	2084
Log Likelihood	3732.3	3732.5	3792.2	3814.4	3815.2	3819.0	3842.8
Countries	62	62	62	62	62	62	62

Clustered (by country) standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10

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Table 5.5: *Ethnic Tensions, Economic Restrictions and the Resource Curse*

Ethnic tensions	(10a)	(10b)
Mean equation		
1st lag GDP per capita growth	0.219***	0.229***
	(0.028)	(0.027)
Av. investment share of GDP 70-03	0.053**	0.069***
	(0.026)	(0.026)
Av. population growth rate 70-03	-0.451***	-0.244
	(0.153)	(0.160)
log per capita GDP 1970	-0.013***	-0.010***
	(0.002)	(0.002)
Human capital 1970	0.001**	0.001
	(0.001)	(0.001)
Volatility (σ_i)	**-0.686*** **	**-0.320*** **
	(0.212)	**(0.121)**
Initial point-source resources 70	0.019	0.008
	(0.037)	(0.028)
Financial development 1970	-0.014**	-0.007
	(0.005)	(0.005)
Openness dummy 70	-0.002	0.002
	(0.004)	(0.003)
Ethnic Polarization	0.002	-0.003
	(0.004)	(0.004)
Constant	0.143***	0.098***
	(0.023)	(0.014)
Variance equation		
Point-source resources 1970	-4.785***	-1.348**
	(0.395)	(0.542)
Diffuse resources 1970	0.863	0.213
	(0.611)	(0.523)
Financial development 1970	-1.140***	-0.683***
	(0.113)	(0.095)
Openness dummy 1970	-0.624***	-0.187
	(0.097)	(0.139)
Distance to navigable river or coast	0.001***	0.000**
	(0.000)	(0.000)
Ethnic Polarization	0.402***	0.056
	(0.088)	(0.127)
Point-source exp. share vol. 70-03		8.834***
		(1.327)
Diffuse export share vol. 70-03		5.827**
		(2.601)
Government share vol. 70-03		8.725***
		(2.072)
sd TOT index growth		4.537***
		(0.483)
Constant	-6.406***	-7.491***
	(0.043	(0.034)
*Point-source res. 70 * Eth. Pol.*	8.536***	
	(0.369	
Observations	2084	2084
Log likelihood	3748.2	3840.1
Countries	62	62

Economic Restrictions	(11a)	(11b)
Mean equation		
1st lag GDP per capita growth	0.220***	0.228***
	(0.028)	(0.029)
Av. investment share of GDP 70-03	0.077***	0.081***
	(0.018)	(0.019)
Av. population growth rate 70-03	-0.426***	-0.394***
	(0.130)	(0.114)
log per capita GDP 1970	-0.012***	-0.010***
	(0.002)	(0.002)
Human capital 1970	0.002***	0.001*
	(0.001)	(0.001)
Volatility (si)	**-0.490*** **	**-0.337*** **
	(0.153)	**(0.114)**
Initial point-source resources 70	0.064***	0.037**
	(0.021)	(0.019)
Financial development 1970	-0.012**	-0.006
	(0.005)	(0.005)
Current Account Restrictions (yes=1)	0.004*	0.002
	(0.002)	(0.002)
Capital Account restrictions (yes=1)	-0.005*	-0.003
	(0.003)	(0.003)
Constant	0.125***	0.105***
	(0.017)	(0.012)
Variance equation		
Point-source resources 1970	5.314***	0.016
	(0.340)	(0.455)
Diffuse resources 1970	2.082**	0.121
	(0.862)	(0.878)
Financial development 1970	-1.232***	-0.582***
	(0.197)	(0.132)
Distance to navigable river or coast	0.001***	0.001***
	(0.000)	(0.000)
Ethnic Polarization	0.965***	0.296***
	(0.122)	(0.058)
Point-source exp. share vol. 70-03		7.811***
		(0.542)
Diffuse export share vol. 70-03		10.504***
		(1.118)
Government share vol. 70-03		3.752*
		(2.179)
sd TOT index growth		4.166***
		(0.322)
Constant	-7.303***	-7.813***
	(0.027)	(0.048)
Multiple Exchange Practices (yes=1)	-0.759***	-0.438**
	(0.186)	(0.178)
Current Account Restrict. (yes=1)	0.426***	0.511***
	(0.105)	(0.069)
Capital Account restrict. (yes=1)	-0.294***	-0.311***
	(0.045)	(0.070)
Surrender of Export receipts (yes=1)	0.384***	0.242***
	(0.081)	(0.082)
*Cur. Acc. Restrict. * Point Res. 70*	4.877***	
	(1.080)	
*Cap. Acc. Restrict. * Point Res. 70*	-2.508***	
	(0.634)	
Observations	2013	2013
Log likelihood	3622.6	3707.2
Countries	60	60

Clustered (by country) standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10.

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TABLE 5.6: *Robustness: OECD Sample*

Dependent Variable	yearly GDP growth per capita 1970-2003			
(constant 2000 international dollars, PWT 6.2)	(12a)	(12b)	(12c OECD)	(12d OECD)
	Full Sample			
Mean equation				
Av. investment share of GDP 70-03	0.044*	0.064**	-0.015	-0.013
	(0.025)	(0.027)	(0.016)	(0.015)
1st lag GDP per capita growth	0.224***	0.224***	0.284***	0.263***
	(0.027)	(0.031)	(0.045)	(0.047)
Av. population growth rate 70-03	-0.490***	-0.326**	-0.361**	-0.323**
	(0.120)	(0.136)	(0.161)	(0.141)
log per capita GDP	-0.014***	-0.010***	-0.024***	-0.021***
	(0.002)	(0.002)	(0.002)	(0.003)
Human capital 1970	0.002**	0.001	0.002***	0.002***
	(0.001)	(0.001)	(0.000)	(0.000)
Volatility (σ_i)	**-0.841*** **	**-0.320***	**-1.086** **	**0.235**
	(0.266)	**0.129**	**(0.504)**	**(0.256)**
Financial development 1970	-0.016**	-0.006	-0.006	0.008***
	(0.007)	(0.005)	(0.007)	(0.003)
Openness dummy 1970	-0.007	0.001	-0.000	0.010***
	(0.004)	(0.003)	(0.004)	(0.003)
Total resources 1970	0.019	0.009	-0.044	0.036**
	(0.015)	(0.014)	(0.044)	(0.016)
Constant	0.159***	0.101***	0.265***	0.191***
	(0.026)	(0.017)	(0.026)	(0.032)
Variance equation				
Financial development 1970	-1.615***	-1.039***	-1.311***	-0.713***
	(0.086)	(0.103)	(0.076)	(0.067)
Openness dummy 1970	-0.841***	-0.496***	-0.648***	-0.257***
	(0.189)	(0.101)	(0.068)	(0.058)
Distance to nearest navigable river or coast	0.001***	0.000***	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Total resources 1970	1.038***	0.123	-7.787***	-4.356***
	(0.352)	(0.392)	(0.776)	(1.070)
Government spending volatility 70-03		9.674***		20.044***
		(2.250)		(4.775)
Ethnolinguistic Polarization index		0.201***		-0.762***
		(0.050)		(0.105)
sd ToT index growth 70-03		5.963***		8.037***
		(0.265)		(0.543)
Constant	-6.050***	-7.356***	-6.112***	-7.700***
	(0.048)	(0.026)	(0.048)	(0.038)
Volatility within sample	*0.044*		*0.021*	
(s.d.)	*(0.016)*		*(0.006)*	
Year dummies in mean equation	yes	yes	yes	yes
Observations	2024	2024	782	759
Countries	62	62	23	23
Log Likelihood	3723.5	3793.7	1947.2	1914.4

Clustered (by country) standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 5.7: *Robustness: Panel-ML Estimates of Volatility and the Natural Resource Curse*

Dependent Variable	yearly GDP growth per capita 1970-2003						
(constant 2000 international $, PWT 6.2)	(13a)	(13b) Within	(14a)	(14b) Within	(15) Within	(15 OECD) Within	(16) Within
	independent variables are 5-yearly initial values		independent variables are 5-yearly non-overlapping averages				
Mean equation							
Investment share of GDP	0.034*	0.008	0.076***	0.101***	0.103***	0.021	0.100***
	(0.020)	(0.023)	(0.022)	(0.032)	(0.031)	(0.051)	(0.030)
1st lag GDP per capita growth	0.266***	0.101***	0.251***	0.090***	0.097***	0.270***	0.098***
	(0.033)	(0.032)	(0.031)	(0.029)	(0.029)	(0.047)	(0.029)
Population growth rate	-0.356**	0.276	-0.307*	-0.021	-0.085	0.296	-0.107
	(0.167)	(0.229)	(0.161)	(0.262)	(0.252)	(0.307)	(0.252)
log per capita GDP	-0.012***	-0.019**	-0.010***	-0.005	-0.008	-0.012	-0.008
	(0.003)	(0.009)	(0.003)	(0.006)	(0.006)	(0.007)	(0.007)
Human capital	0.001**	-0.000	0.001	-0.000	-0.001	0.001	-0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Volatility (σ_{it})	**-0.269*** **	**-0.747** **	**-0.249** **	**-0.967* **	**-0.994*** **	**-0.434*** **	**-0.823*** **
	(0.098)	**(0.362)**	**(0.110)**	**(0.503)**	**(0.345)**	**(0.161)**	**(0.284)**
Financial development	-0.001	-0.015	-0.002	-0.024	-0.029**	-0.106***	-0.021*
	(0.003)	(0.014)	(0.003)	(0.020)	(0.014)	(0.040)	(0.012)
Openness dummy	0.005	0.006	0.003	0.006	0.007	-0.007*	0.006
	(0.004)	(0.008)	(0.004)	(0.011)	(0.007)	(0.004)	(0.008)
Total resource share	0.015	-0.024	0.019	-0.013	-0.011	0.004	-0.019
	(0.015)	(0.035)	(0.016)	(0.047)	(0.023)	(0.005)	(0.028)
Constant	0.096***	0.047***	0.105***	0.037*	0.052***	-0.008	0.047***
	(0.027)	(0.016)	(0.025)	(0.021)	(0.016)	(0.010)	(0.013)
Variance equation							
Financial development	-0.697***	-0.601	-0.663***	-0.783	-1.408***	-1.251**	-0.064
	(0.059)	(0.510)	(0.084)	(0.640)	(0.380)	(0.506)	(0.543)
Openness dummy	-0.256***	-0.080	-0.380***	-0.264	-0.249	0.600**	-0.270
	(0.098)	(0.319)	(0.124)	(0.267)	(0.230)	(0.287)	(0.241)
Distance to navigable river or coast	0.000	-	0.000	-	-	-	-
	(0.000)		(0.000)				
Total resources	2.436***	0.428	2.550***	0.478	0.561	-3.259	1.401
	(0.239)	(2.632)	(0.479)	(2.921)	(1.384)	(4.565)	(2.014)
5-yearly sd ToT index growth	5.269***	3.586***	4.590***	2.760**	1.774**	3.976**	3.006***
	(0.469)	(1.204)	(0.498)	(1.144)	(0.867)	(2.019)	(1.081)
Government share volatility 70-03	17.166***	-	17.208***	-	-	-	-
	(2.030)		(3.466)				
Fin. Dev. * sd ToT growth					4.578***	15.369***	
					(1.070)	(2.590)	
Fin. Dev. * Total resources							-7.691***
							(2.565)
Constant	-7.615***	-6.369***	-7.487***	-6.282***	-6.301***	-7.833***	-6.302***
	(0.036)	(0.152)	(0.199)	(0.122)	(0.129)	(0.178)	(0.084)
Observations	2261	2261	2497	2497	2591	849	2591
Countries	89	89	90	90	94	27	94
Log likelihood	4329.7	3989.9	4695.3	4301.6	4485.5	2119.1	4488.1
sample mean of Fin. Dev.					*0.001*	*0.001*	
sample mean of sd ToT growth					*-0.0003*	*-0.001*	
*sample mean of Fin.Dev.*sd ToT*					*0.0005*	*0.0002*	

Clustered (by country) standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 Mean equations contain year dummies. Variables in columns 2 and 4 are demeaned by country over time, where variance and standard errors are degrees-of-freedom adjusted. Distance to nearest navigable river or coast and government spending volatility are observed fixed effects.

TABLE 5.8: *Counterfactual Experiments for Resource-Rich and Landlocked Africa*

Resource-Rich Africa versus the Asian Tigers		sample mean	Asian Tigers	Resource-rich Africa	Difference	on volatility	on yearly GDP/capita growth rate
GDP per capita growth		1.49%	4.04%	0.25%	-3.79%		
Mean equation							
1st lag GDP per capita growth	0.221***	1.48%	4.00%	1.07%	-2.94%		0.65%
Av. investment share of GDP 70-03	0.045*	17.26%	24.45%	14.96%	-9.50%		0.43%
Av. population growth rate 70-03	-0.478***	1.72%	1.86%	2.75%	0.89%		0.43%
log per capita GDP 1970	-0.014***	8.362	7.747	7.129	-0.619		-0.87%
Human capital 1970	0.002**	4.14	4.049	1.476	-2.574		0.46%
Volatility (σ_i)	-0.971**	4.04%	3.43%	6.02%	2.59%		2.98%
Point-source resources 1970	0.05*	4.35%	4.32%	13.13%	8.80%		-0.44%
Financial development 1970	-0.018**	29.07%	26.89%	14.43%	-12.47%		-0.22%
Variance equation							
Point-source resources 1970	1.621***	4.35%	4.32%	13.13%	8.80%	-0.41%	0.52%
Diffuse resources 1970	0.801	7.27%	11.08%	10.52%	-0.56%	0.01%	-0.02%
Financial development 1970	-1.29***	29.07%	26.89%	14.43%	-12.47%	-0.47%	0.58%
Openness dummy 1970	-0.693***	0.374	0.746	0	-0.746	-1.37%	1.71%
Distance to navigable river or coast	0.001***	277.763	90.902	552.571	461.669	-0.86%	1.07%
Estimated volatility		4.04%	3.43%	6.02%	2.59%		
Countries		62	4	6			

Note: Resource-rich African counties are: Algeria. Congo. Rep.. Ghana. Malawi. Togo. Zambia. Asian Tigers are: South Korea. Malaysia. Philippines and Thailand.

Landlocked Africa versus the Asian Tigers		sample mean	Asian Tigers	Landlocked Africa	Difference	on volatility	on yearly GDP/capita growth rate
GDP per capita growth		1.49%	4.04%	0.22%	-3.82%		
Mean equation							
1st lag GDP per capita growth	0.221***	1.48%	4.00%	0.50%	-3.51%		0.78%
Av. investment share of GDP 70-03	0.045*	17.26%	24.45%	12.13%	-12.32%		0.56%
Av. population growth rate 70-03	-0.478***	1.72%	1.86%	2.57%	0.71%		0.34%
log per capita GDP 1970	-0.014***	8.362	7.747	6.744	-1.004		-1.41%
Human capital 1970	0.002**	4.14	4.049	0.874	-3.176		0.57%
Volatility (σ_i)	-0.971**	4.04%	3.43%	6.88%	3.45%		1.97%
Point-source resources 1970	0.05*	4.35%	4.32%	10.97%	6.65%		-0.33%
Financial development 1970	-0.018**	29.07%	26.89%	12.05%	-14.84%		-0.27%
Variance equation							
Point-source resources 1970	1.621***	4.35%	4.32%	10.97%	6.65%	-0.36%	0.45%
Diffuse resources 1970	0.801	7.27%	11.08%	7.99%	-3.09%	0.09%	-0.11%
Financial development 1970	-1.29***	29.07%	26.89%	12.05%	-14.84%	-0.63%	0.78%
Openness dummy 1970	-0.693***	0.374	0.746	0	-0.746	-1.56%	1.95%
Distance to navigable river or coast	0.001***	277.763	90.902	979.419	888.516	-1.76%	2.19%
Estimated volatility		4.04%	3.43%	6.88%	3.45%		
Countries		62	4	5			

Note: Landlocked Africa are: Central African Republic. Malawi. Mali. Niger. Zambia. Asian Tigers are: South Korea. Malaysia. Philippines and Thailand.

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5.C Figures

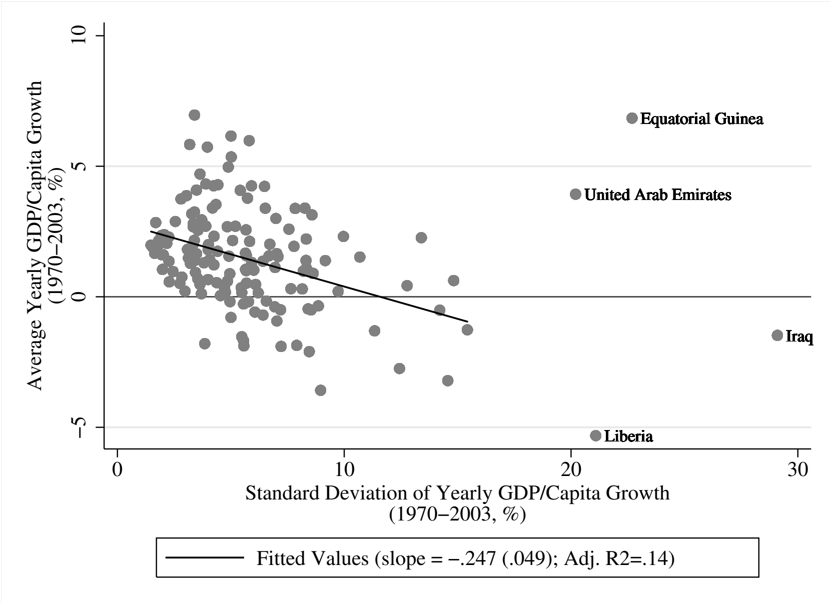

FIGURE 5.1: *Volatile Countries Have Lower Annual Growth in GDP per Capita*

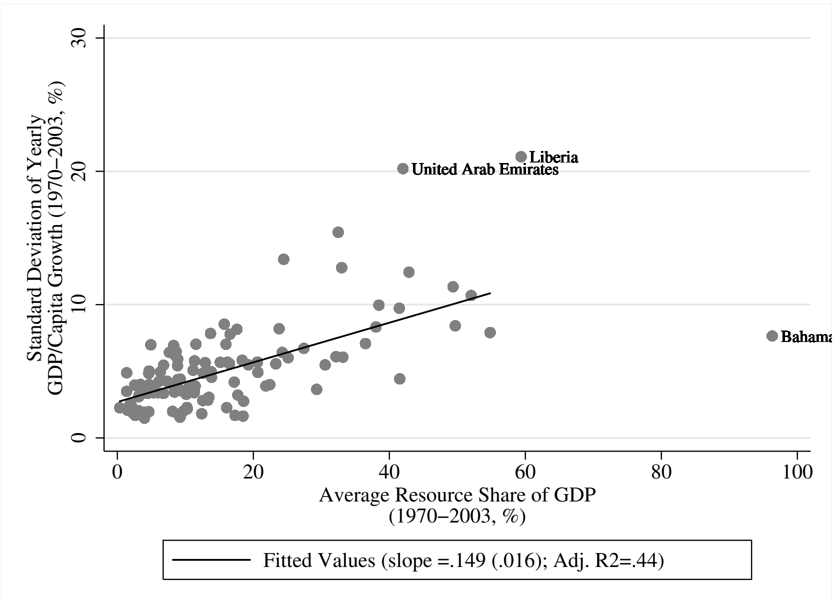

FIGURE 5.2: *Resource-Rich Economies Are More Volatile*

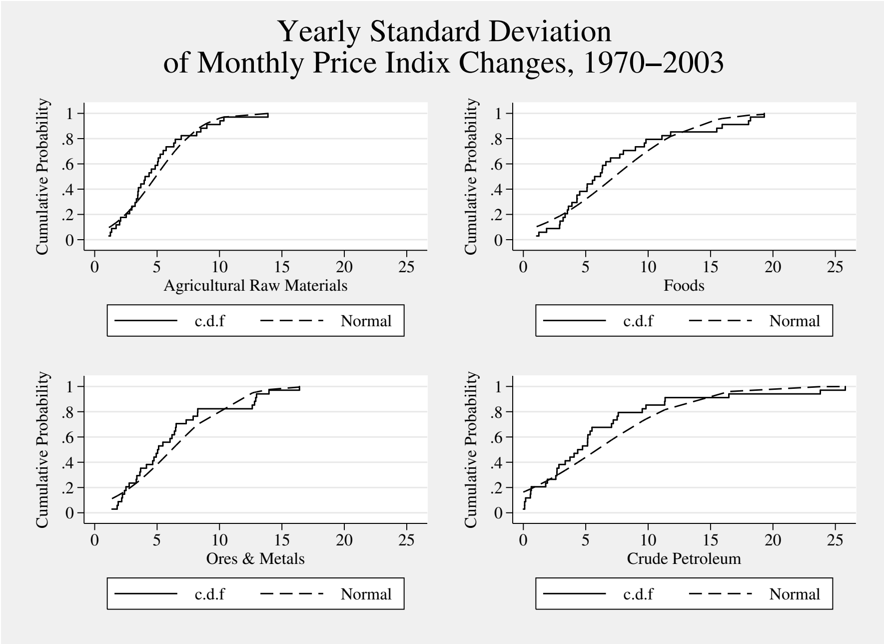

FIGURE 5.3: *Cumulative Density Function of Volatility of Commodity Prices*

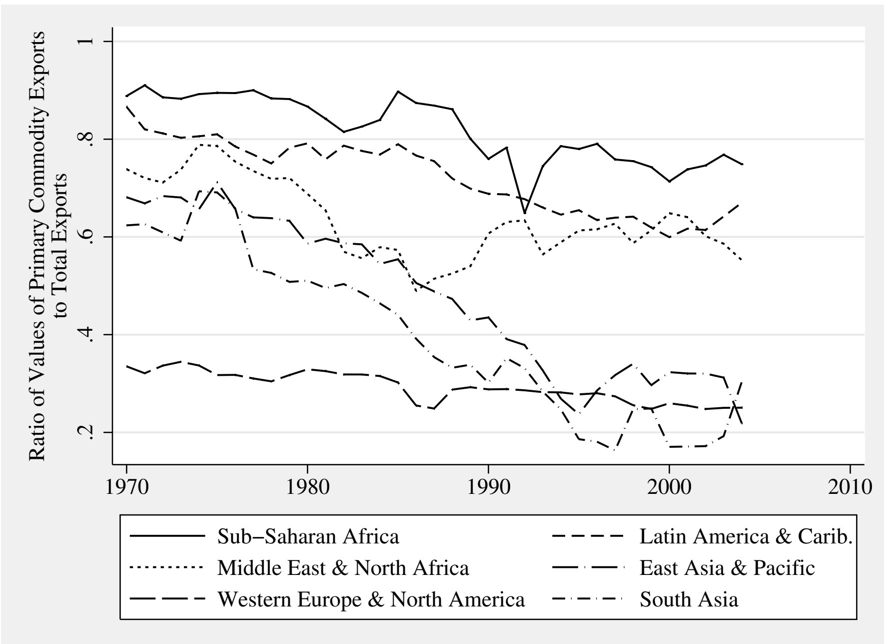

FIGURE 5.4: *Declining Natural Resource Dependence in the Global Economy*

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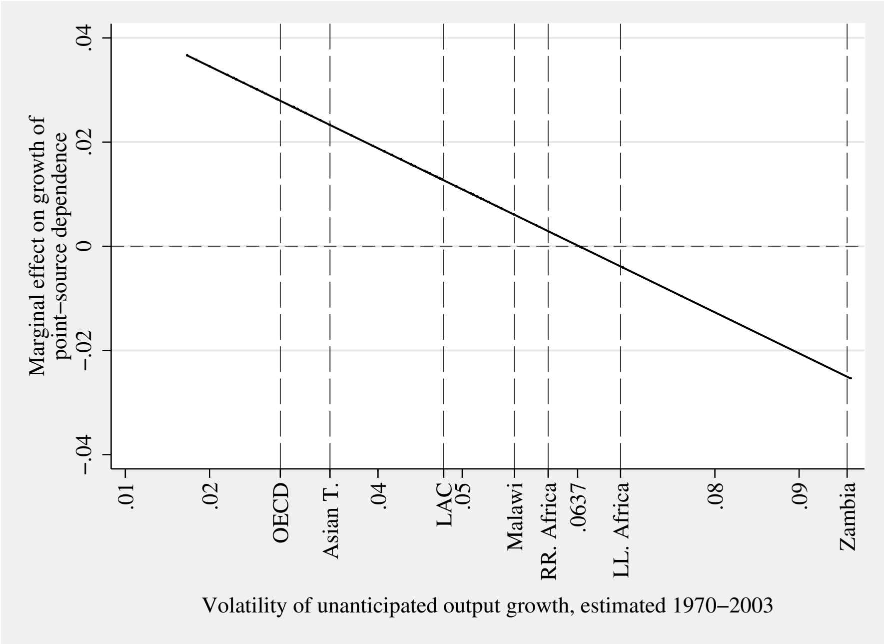

FIGURE 5.5: *Marginal Effect of Point-Source Resource Dependence on Growth*

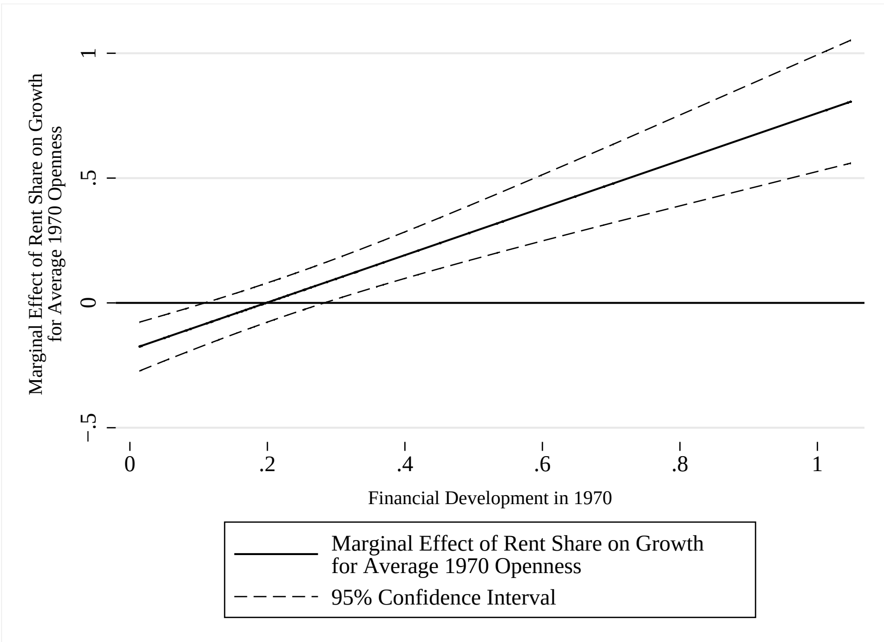

FIGURE 5.6: *Marginal Effect of GDP Share of Resource Rents on Growth*

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Chapter 6

Concluding Remarks

The main aim of this thesis was to take some steps towards a better understanding of how and why cities rise and fall over time.

In developed countries a city's success depends largely on its ability to attract and retain a large concentration of skilled workers. A higher initial concentration of skilled workers tends to result in faster population growth and econometric testing gave strong evidence that the direction of causality runs from skills to growth. The diverging concentration of skilled workers across cities is not a self-reinforcing process. After controlling for unobserved fixed-over-time city characteristics I showed that cities with more amenities and, in particular, a low-skilled personal services sector do tend to gain more skilled workers, both in the US and in Germany. Other amenities also matter, such as the owner-occupied housing share (positive), and cultural diversity measured by both ethnicity and country of birth of immigrants (negative), and labor organizations (negative). Industry externalities as captures by unrelated diversity (MAR), competition (Porter), or related diversity (Jacobs) were not important, suggesting that any such industry externalities are capitalized in profits rather than wages.

Skilled workers are a blessing for a city's future growth. They will not come by themselves to a city, even if a city already has a significant concentration. City councils can do well if they focus on amenities, including those provided by the lower skilled workforce. The latter is an interesting new sound in the popular discussion of how to attract the 'creative class'. Especially in many European countries, there is a tendency that cheap services are unavailable, probably because of a relatively high minimum wage. Future research should also include the housing market because the popular historic centers of many European cities are increasingly expensive places to live in, and are too expensive for less payed, less educated service workers.

Evidence from Germany has shown that well known estimates of the size of the skills-growth effect are biased because endogeneity of the initial employment size is not sufficiently accounted for when fixed effects matter for both growth and initial city characteristics. Adjusting the estimates using two data-sets on German metropolitan areas and recently improved dynamic panel GMM techniques shows that the effect is significant but 30% smaller than previously thought.

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The blessings of skills may also come from other levels of educational attainment, namely those with vocational training. I found robust evidence that technical college graduates such as engineers interact positively with workers with vocational training and reinforce the latter's positive effect on employment growth. This effect is slightly decreasing over time however, while non-technical university graduates are becoming more important. City success may depend on the right combination of skills and not only on the percentage of college graduates. Micro-data at the firm level may shed more light on this link in the future.

In developing countries growth of cities may even occur when job growth is absent. Many countries urbanize surprisingly fast even though economic growth is slow or negative. Negative growth is unlikely to create urban jobs, it does not raise urban wages nor does it increase earlier migrants' flow of remittances, which could all be powerful urban-pull factors from the perspective of poor rural households. This development poses great challenges to poor countries because public services and infrastructure investment lag far behind what is required by a burgeoning urban population. The result is that up to 70% of urban inhabitants live in slums in poor conditions. This is the reason that the cause of rapid urbanization can be seen as a curse.

Push factors are at least as important as pull factors, especially when the economic circumstances are such that households cannot cope with negative shocks to income. Periods of aggregate volatility turn out to be strong predictors of urban growth, especially when GDP per capita growth is negative. The source of volatility lies in rural activities such as agriculture and natural resource production which are much more risky sectors than urban manufacturing. World resource prices are highly volatile (which is more important than rainfall), and financial instruments such as credit to deal with aggregate risk are all but absent in the countryside. Aggregate risk may be more important than a sectoral shift from agriculture to manufacturing and the parallel transition to urbanization for countries with poor economic performance. Unable to save or insure effectively, households are forced to migrate to cities to avoid being hit by large negative shocks as an ex-ante response to expected risk, because large shocks may wipe out any buffer savings entirely.

Rural development of credit institutions could decrease migration pressure on cities. On the other hand, it might also be that agglomeration economies can bring opportunities to fast urbanizing countries if these centers can be made attractive enough for start-ups and foreign investment. Future research using micro data should shed more light on these issues. For now, volatility is a curse for poor countries unless governments can keep up with the influx of migrants.

The curse of volatility reaches further than urbanization alone. The last chapter has

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shown that volatility is also the underlying curse of being endowed with many natural resources. The high volatility of world prices of natural resources causes severe volatility of output per capita growth in countries that depend heavily on them. The resulting volatility of unanticipated output growth has a robust negative effect on long-run growth itself and can therefore rightly be termed a curse. This is not limited to oil-producing countries, but also applies to exporters of copper, coffee, and foods, amongst others, which include many of the world's worst performing countries. Also, ethnic tensions, which are often fueled by resource wealth, and current account restrictions, increase volatility. The latter effect is especially strong in resource-rich countries. Government spending bonanzas after windfall resource revenues also increase volatility to the detriment of growth, because revenue drops inevitably follow.

Volatility can fortunately be substantially reduced provided that countries have a sound financial system to cope with large and sudden fluctuations in resource income. Fewer capital account restrictions, openness, and physical access to world trade also lower volatility. Countries can turn the curse even into a blessing, because we find evidence for a positive direct effect of natural resource dependence on growth after controlling for volatility. The key to a turn-around for many resource-rich countries is financial development, ensuring openness, and mitigating the effect of being landlocked, because the *indirect negative* effect of resource dependence on growth, via volatility, is much larger than any *direct positive* effect. While it may be difficult to lower price volatility of resources themselves, it should be feasible to deal with volatility in a more efficient way. Future research should focus on ways to overcome the political temptations of short-run resource wealth to create the financial and political institutions needed to reduce volatility, soften the impact of volatility on growth, and prevent poverty.

The last two chapters form a consistent story of how countries can experience fast urban growth and slow economic growth at the same time. In both cases aggregate volatility is the curse. In principle poor countries should also be able to investment more in skills and reap its benefits, for example, by using natural resource wealth wisely. There are unfortunately huge challenges ahead to develop financial markets and especially the institutions which make such markets fair and feasible. At the same time, development of institutions may also turn excessively large cities into areas of opportunity. Such concentrations of cheap labor should be appealing to globalizing firms once the cost of doing business is lower.

The blessings of human capital for cities in developed countries are enjoyed by those cities that manage to attract more skilled workers. Such competition between cities need not be efficient if cities lose out after investing public money in amenities. There may be scope for additional research on the aggregate effects of skills-agglomeration.

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