LUISS

Department of Economics and Finance

Chair of Macroeconomic Analysis

Cities, human capital and economic development: from proximate to fundamental sources of differences in economic performance

SUPERVISOR

Prof. Pietro Reichlin

CANDIDATE

Luca Maria Lochi

CO-SUPERVISOR

Prof. Stefano Marzioni

Academic Year 2022-2023

“As long as a branch of science offers an abundance of problems, so long is it alive.”

David Hilbert

To my father, for his unending love and support

Cities, human capital and economic development: from proximate to fundamental sources of differences in economic performance

LUCA MARIA LOCHI

Abstract

This thesis focuses on the role of human capital in explaining cross-country income differences. Traditional accounting is found to be a theoretical lower bound on human capital importance across economies and it explains little of the economic performance gap between countries. I build a human capital aggregator that takes into account the internal and external effects of human capital. The former is defined in terms of accumulation of years of schooling while the latter is captured by the urbanization rate (proxy agglomeration). The usage of the urbanization rate to build my aggregator is twofold: on one hand it represents the human capital externality due to knowledge spillover, on the other it is a way to link proximate to fundamental sources of economic growth. The IV approach I implemented shows that agglomeration economies are mostly exogenous, depending on country-specific geographical characteristics. I provide empirical evidence concerning the success of my aggregator with a growth regression and a development accounting exercise. I demonstrate that human capital may fully account for the large income variation between rich and poor countries.

Keywords: economic growth, development, human capital, urbanization, cities, agglomeration, geography, schooling, income, proximate, fundamentals.

INDEX

1 INTRODUCTION

We live in a world of rich and poor. The striking difference in per capita income between countries is one of the most amazing issues today. Why do some countries produce so much more output per worker than others? These differences are due to the economic growth that has characterized the last two centuries. Today, poor countries still have living standards close to the XIX century while richer countries see their living standards rise steadily. The traditional accepted economic literature on growth finds difficulties to apply on data, in the sense that it only partially explains the differences in terms of GDP per capita around the world.

Development accounting improves our understanding by decomposing these differences into the contribution of factor inputs and total factor productivity. Its objective is to shed only light on the proximate sources of the cross-country income inequalities, which should be a useful guide for theory and policymakers. These proximate sources of growth, such as technology, physical capital and human capital are not satisfactory to explain the process of economic growth and cross-country income differences since there are reasons such factors differ across countries. If these factors are so important in generating cross-country inequalities in economic performance and causing the takeoff into modern economic growth, why do certain societies fail to improve their technology, physical and human capital? The answer is related to the fundamental causes of economic growth, the elements potentially affecting why societies make different technology and accumulation choices. Indeed, North and Thomas (1973) stated that "the factors we have listed (innovation, economies of scale, education, capital accumulation, etc.) are not causes of growth: they are growth".

My central hypothesis is that the primary determinant of a country's long-run economic performance is based on its fundamentals. More specifically, the aim of this thesis is to investigate the broader role of human capital in economic growth and in cross-country income differences, allowing to aggregate both proximate and fundamental sources of growth.

The traditional literature defines *human capital* as the idea that education, training, and other forms of learning are investments that pay off in the future. In particular, the concept of human

capital was first introduced by Adam Smith in 1776, when he defined human capital as consisting "of the acquired and useful abilities of all the inhabitants and members of a society".

The existing literature has shown that measuring human capital is difficult and there are many reasons to want to measure the stock of human capital. The most important one is that failure to recognize the human capital stock could lead to erroneous conclusions about the evolution of a country's productive capacity. Understanding how investments in human capital contribute to cross-country income differences requires a good measure of the resulting human capital stock. The main approaches to measuring human capital focus mostly on the internal effect of it, that comes from the accumulation of years of schooling. However, empirical evidence shows that such measures of human capital explain little of the differences in economic performance across countries. So, there will be an external effect of human capital that matters a lot. Many economists believe that the human capital stock of the workforce creates a direct spillover on the productivity of each worker. The dynamic effects of human capital accumulation and associated spillovers lie at the heart of the endogenous growth theory (Lucas 1988 and Romer 1986). The major insight of the endogenous growth theory is that the law of diminishing returns does not hold for human capital, exactly because of the existence of the knowledge spillovers. Quite the contrary: the productivity of a worker increases if he (or she) is in an environment where he (or she) can interact with other workers. In other words, agglomeration economies produce increasing returns. In "The Economy of Cities" (1969) Jane Jacobs argues for the importance of human capital externalities and suggests that the concentration of economic activity in cities acts as engine of economic growth because it facilitates the exchange of ideas among workers and entrepreneurs.

Following Jane Jacobs (1969), "a city is innovative not only because it solves complex problems but also because it creates complex problems, due to the knowledge spillover. Cities, since the beginning of recorded history, have been centers of artistic creation, drawing in the most talented minds of their times: Athens, Rome, Venice, Vienna and Paris spring to mind. Closer to our epoch, an abundant literature has accumulated suggesting the sensitivity of innovation to agglomeration.

Motivated by these facts, I build a human capital aggregator by investigating both the internal and external effects of human capital in order to explain cross-country income differences between rich and poor countries. To do so, I employ a "generalized approach" developed by Jones (2014) to measuring human capital, that takes into account the fact that skilled and unskilled labor are not perfect substitutes. In the baseline model, the internal effect of human capital is captured by the "unskilled labor equivalents", summing up the country's labor supply with workers weighted by their relative wage with respect to the unskilled. In this context, I aim to investigate whether the positive effects of the urbanization rate (proxy agglomeration) improve the results of the Jones's human capital aggregator in explaining cross-country income differences. Notice that the usage of the urbanization rate to build my aggregator is twofold: on one hand it represents the human capital externality due to knowledge spillover, on the other it is a way to link proximate to fundamental sources of economic growth. Indeed, the IV approach I implemented shows that the country's urbanization level is mostly exogenous, depending on geographical factors such as the distance from the equator and the access to the sea. The latter are exactly the economy-specific fundamentals of economic growth.

I provide empirical evidence concerning the success of my aggregator with a growth regression and a development accounting exercise. I demonstrate that human capital may fully account for the large income variation between rich and poor countries.

The rest of the work is organized as follows. In the next part I discuss the framework for my analysis and then I show the literature to which I refer. Chapter 2 presents the main approaches to measuring the internal effect of human capital. Chapter 3 explains the external effect of human capital, with a focus on the empirical evidence concerning urbanization and economic growth. In Chapter 4 I develop the model and in Chapter 5 I show its empirical results. Finally, the last part of this work addresses the conclusions and caveats of my aggregator.

1.1 A framework for analysis

In this section I present a parable to briefly explain my central hypothesis.
Let consider two countries, Israel and Senegal (15^{th} and 85^{th} percentile of the income distribution). The starting question is the following: why is Senegal so much poorer than Israel?

The GDP per capita in Israel is 12 times that one in Senegal. In both countries, the GDP per capita is produced according to a production function that uses two inputs: labor and capital. Observe that Israel has much more physical capital to work with and it also has a higher educational attainment on average with respect to Senegal. This difference in education level between these countries also explains the technology gap among them.

What is the source of these differences in factor inputs and total factor productivity?
The most trivial answer is that the quantity of investments in physical and human capital is much higher in Israel compared to Senegal. This means that people in Israel save more than in Senegal. This fact is not a mystery since Israel is a much wealthier country. So, differences in capital per worker *per se* and in total factor productivity do not explain much of the total income inequalities across countries. There must be something else that actually makes the difference.

I strongly believe that the quality of people living in a country is the key ingredient to investigate in order to understand the huge income gap across economies. It is the human capital that determines the country's technological level and the country's physical capital accumulation. It is always human capital that characterizes the culture of an economy (trust, openness to new ideas, hard work, forward-looking attitude, etc.), and then the quality of the institutions that govern the country.

However, it is not enough to notice that the system of innate skills and acquired competencies is higher in Israel than in Senegal. The latter is only the internal effect of human capital that the traditional literature has shown to be weakly correlated with income.

What is missing? The traditional literature neglects the external effect of human capital: the fact that workers in Israel are in an environment that facilitates interaction and exchange of ideas. Indeed, Israel has a higher level of urbanization rate (and to some extent, city size) with respect to Senegal. More specifically, the urbanization rate in Israel is equal to 90 percent,

while in Senegal it is below the 40 percent. But what does urbanization rate depend upon? Why people in Israel live more in cities compared to Senegal? Or in other words, what are the fundamentals that make Senegal so much poorer than Israel? The key element here is the role of geography. Indeed, Israel is farther from the equator than Senegal and the former has a higher percentage of population with access to the sea. In particular, the 88 percent of population in Israel lives within 100 km from the sea, while only the 42 percent of Senegalese population lives close to the coast. In terms of latitude, the index that measures the distance from the equator is equal to 0,16 in the case of Senegal and it is 0,345 for Israel. The closer such index is to 1, the farther from the equator is the country.

The human capital aggregator I build with both proximate and fundamentals sources of growth can fully account for these differences between Senegal and Israel or, let say rich and poor economy, explaining the deepest determinants of the gap in economic performance across countries.

1.2 Related literature

This thesis reconsiders the traditional method for measuring human capital. To situate such a work, consider the literature's standard methods and results, which rely on assumptions about (i) the aggregate production function and (ii) the measurement of human capital input.

The traditional production function for cross-country development accounting is Cobb-Douglas. In a seminal paper Mankiw, Romer and Weil (1992) used average schooling duration to measure human capital and showed a strong correlation between years of schooling and per capita output.

In addition to the literature I discussed in the introduction, this work is most closely related to Jones (2014) and Caselli (2005). In particular, the latter estimates human capital stock by using the perfect-substitute assumption between labor types. Jones, instead, builds an aggregator of human capital allowing for imperfect substitutability between worker classes. In addition, as I will explain in Section 3, Jones's aggregator solves the main caveats of the standard measures of internal human capital used extensively in labor and other areas of economics. Abraham and Mallat (2022) summarize the main approaches for measuring human capital: indicator approach, cost approach and income approach. I will further discuss each of them in the next section. Moreover, the standard model of human capital in literature is built by Yoram Ben-Porath (1967) explaining the dynamic of human capital investment.

However, the human capital stock only measured in terms of internal effect, that comes from the accumulation of formal education, seems to be weakly correlated with the economic performance of a country. Therefore, one can argue that there is a significant effect of external human capital that the traditional accounting neglects. As a matter of facts, there is a large literature that cover technological human capital externalities (Lucas 1988 and Jacobs 1969) that enhance the productivity of labor. Another type of human capital externality in literature comes from Nelson and Phelps (1966). They focused on the role of human capital in adapting to change and implementing new technologies.

The role of human capital externality due to agglomeration economies is well described by Mario Polese (2005), which focused on the relationship between cities and national economic growth. As he stated, it is difficult to rigorously test the relationship between agglomeration and growth, even if the positive link between urbanization and per capita

income is irrefutable. Much of the debate focuses on the reverse causality between cities and income: it is difficult to distinguish factors that allow cities to capture a greater share of national economic growth from those that allow cities to add to national economic growth.

However, I will show that the urbanization rate of a country depends on its fundamentals. More specifically, it depends on the country's geographical characteristics: country's distance from the equator and access to the sea. This result help me to show the causal relationship between my human capital aggregator and per capita income.

2 MEASURING HUMAN CAPITAL

In what follows I will be discussing the main approaches used in literature to measuring the internal effect of human capital. By "internal effect" I mean the effects of an individual's human capital on his own productivity, following the definition of Lucas (1988).

Investments in human capital, defined as the skills and experience possessed by an individual or population viewed in terms of their productive value, may take many forms (Abraham and Mallett 2022). The time that parents spend with children during the early childhood can be considered an investment in the development of the children's abilities. Formal education through years of schooling represents a further investment in the individual's capacities. Moreover, after leaving school, individuals may engage in training and less formal learning on the job. However, it is difficult to capture these kinds of investments in human capital since they are less formal with respect to the accumulation of years of schooling. This is the reason why existing literature mainly focus on the investments in formal education.

Three main approaches have been taken to measuring human capital: the indicator approach, the cost approach and the income approach.

Table 1 shows these three approaches, gives examples of studies using each of them, indicates data requirements for implementing the approaches and summarizes pros and cons for each approach. Then I discuss the indicator, the cost and the income approach in turn.

Table 1

Approaches to the Measurement of Human Capital

Approach	*Examples of Relevant Studies*	*Data Requirements*	*Pros and Cons*
Indicator: Measure or measures indicative of a country's investment in or stock of human capital; if multiple measures, weighted to form an index.	Barro and Lee 1993, 2001, 2013, 2021 (average years of schooling) Kraay 2019, World Bank 2020 (World Bank Human Capital Index; considers expected years of schooling, test scores, prevalence of stunted growth, and child and adult survival rates) Samans et al. 2017 (World Economic Forum Global Human Capital Index; considers measures that include school enrollment, educational attainment, literacy, labor force participation, and skill mix of employment)	Survey, census, or administrative data for chosen metric(s) that are consistent across countries and over time	(+) Relatively straightforward to construct and explain (-) Schooling measure(s) may mean different things in different contexts (-) Weights for indicators that combine multiple measures can be arbitrary (-) Not compatible with national accounts or measures of other types of capital
Cost: Current gross investment equals direct spending plus estimated value of unpaid time devoted to human capital development; stock equals sum of appropriately depreciated past investments.	Kendrick 1976 (expanded accounts encompass investments in child rearing, formal education, training, health, and geographic mobility) Eisner 1978, 1985, 1989 (Total Incomes System of Accounts encompasses investments in formal education, training, and health) Gu and Wong 2015 (recent cost-based estimates of investments in formal education in Canada; do not report stock estimates)	School enrollment by age, sex, and type of schooling (e.g., grade level); participant numbers for other human capital investments Direct spending for formal education, training, and other human capital investments Value for time devoted to human capital investment (e.g., student time in formal education, employee time in training)	(+) Monetary measure suitable for integration into national accounts and compatible with measures of other types of capital (-) Relatively demanding data requirements, especially for investments other than in formal education (-) Sensitive to assumptions about value of nominal spending in different periods and rate at which investments depreciate (-) Captures resources devoted to formal schooling and (if applicable) other human capital investments, not necessarily the productive value of that spending
Income: Current gross investment equals year-over-year additions to present value of future labor income; stock equals present value of current population's future labor incomes.	Jorgenson and Fraumeni 1989, 1992a, 1992b (estimates of investment through formal education and additions to population, and of value of stock of human capital) Christian 2010, 2014, 2017; Fraumeni and Christian 2019 (update and extend earlier Jorgenson and Fraumeni work)	School enrollment by age, sex, and type of schooling (e.g., grade level) Population by age, sex, and educational attainment Earnings by age, sex, and educational attainment Mortality rates by age and sex	(+) Monetary measure suitable for integration into national accounts and compatible with measures of other types of capital (-) Relatively demanding data requirements (-) Sensitive to assumptions regarding future growth in earnings, appropriate discount rate for future earnings, and, for formal education, how not completing a year of schooling affects later educational attainment

Source: Abraham and Mallett, "Measuring Human Capital" 2022

The indicator approach attempts to capture a country's investment in human capital using measures such as school enrollment, average years of schooling and adult literacy. Of the three approaches I mentioned, the indicator approach is the most straightforward to build. The best-known indicator dataset has been developed by Barro and Lee (2001), that contains information on educational attainment for 146 countries. It reports the share of the population with each of the seven levels of education: no formal education, incomplete primary, complete primary, incomplete secondary, complete secondary, incomplete tertiary and complete tertiary. Other prominent indicator-based human capital measure is the most recent version of the World Bank's Human Capital Index (2020). The World Bank's Index tries to encompass more than just formal education. It takes into account the probability of survival to age five, expected years of schooling, harmonized test scores, the fraction of children under age five whose growth is not stunted and the adult survival rates.

One challenge in building indexes such as the Human Capital Index is the selection of weights for the various index components.

The main issue of the indicator approach is that it is not compatible with national accounts by definition of an index. This means such measures cannot be used in development accounting exercises.

The cost approach values investments in human capital based on a country's education spending. Tracking changes in nominal education spending is relatively straightforward. Translating a data series for nominal spending on education into a real spending series is more challenging. Indeed, understanding how investments in education capital have evolved over time and producing measures of the current capital stock requires data on real education spending, as opposed to the nominal spending. The standard approach to converting from nominal to real spending is to use an index of output prices to adjust spending amount for the effect of inflation. Because governments do not sell education at market prices, however, this approach will not work in this area. Perhaps for this reason, relatively few researchers have adopted the cost approach to measuring human capital. During the 1970s and 1980s, Kendrick and Eisner developed economic accounts that incorporated human capital investments based on a cost approach.

The main advantage of the cost approach is that since it gives monetary measure, it is suitable for integration into national accounts but with the limitation that it is not obvious to

translate nominal values into real ones and it does not capture the productive value of such a spending.

Finally, the income approach values the investments in human capital by computing the expected present value of future labor earnings. In the existing literature, Jorgenson and Fraumeni (1989) used the income approach to measuring human capital. As a starting point to determining the expected present value of future earnings for people of a given age, sex, and level of education, Jorgenson and Fraumeni begin by calculating the present value of the lifetime earnings of the oldest individual and work backwards. For example, suppose that the oldest working people are age 75. The present value of income for someone in this group is just equal to the market value at age 75. Now consider the present value of lifetime earnings for a person age 74. This equals the current earnings at age 74 plus the expected present value of earnings at age 75. Jorgenson and Fraumeni continue working backwards in the same way to younger age group. The main caveat here is that that the income approach requires strong assumptions in terms of future growth in earnings given uncertainty concerns and then it is difficult to determine the appropriate discount rate.

3 HUMAN CAPITAL EXTERNALITIES

The previous section illustrated how the existing literature measures human capital through the so-called internal effect. This channel is not the only way through which human capital may arise. An important way through which human capital plays a role in economic growth is the area of externalities. An *externality* is an effect of some economic activity for which there is no compensation. In the case of human capital, many economists believe that there are big externalities: the human capital stock of the workforce creates a direct technological spillover on the productivity of each worker.

At this stage is useful to briefly review the existing literature on the extent of human capital externalities.

There are two main approaches to think about human capital externalities.

The first one is followed by Lucas (1988), who shows that human capital externality measured in terms of a country's average level of skills, directly enhances the productivity of labor.

An alternative perspective on human capital externalities is provided by Nelson and Phelps (1966) and Shultz (1975). According to this perspective, the major role of human capital is not to increase the productivity of workers, but instead to enable workers to cope with change, disruption, and especially new technologies.

In the next paragraphs I will discuss these two perspectives of human capital externalities.

3.1 Lucas Model of Human Capital

Lucas (1988) describes "human capital" simply as the general skill level of an individual, so that a worker with human capital h(t) is the productive equivalent of two workers with 1/2 h(t). In his paper "On the mechanics of economic development", Lucas analyses the internal effect of human capital in terms of years of schooling of an individual, and the external effect in terms of average human capital per country.

Lucas considers a close economy with Cobb-Douglas production function given by

$$Y = AK^{\alpha}H^{1-\alpha}h_a^{\gamma}$$

where A is the total factor productivity (TFP), K is the stock of physical capital and H is the stock of human capital. The term h_a^{γ} captures the human capital externality due to the country's average level of skills.

In addition to the law of accumulation of physical capital

$$k_{t+1} = I_t^h + (1-\delta)k_t,$$

Lucas introduces the law of accumulation of human capital (reproducible human capital) as follows:

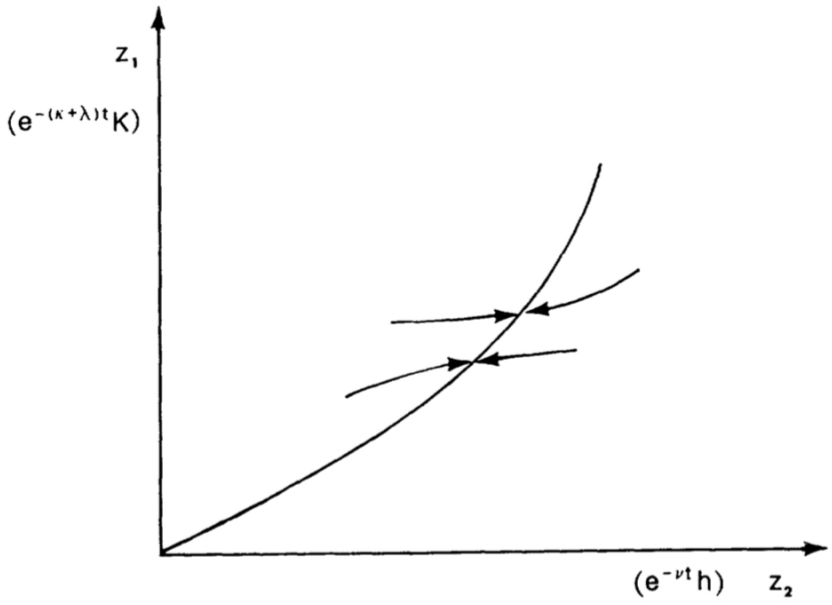
$$h_{t+1} = I_t^h + (1-\delta)h_t$$

where the human capital level at $t+1$ depends on the human capital investment at time t and the level of human capital at time t which is not depreciated.

The main result of this model is that if we introduce reproducible human capital in addition to the standard accumulation of physical capital and Cobb-Douglas production function, the latter is no longer concave but linear, since the Inada conditions do not hold. Human capital is very relevant here. Indeed, the prediction of this model is that capital is not subject to diminishing returns, precisely because of the existence of knowledge spillovers. The marginal productivity of human capital does not fall with the addition of more units, so that countries with different initial conditions will not converge to the same level of output (as it happens in the Ramsey model or in the Solow model with standard assumptions). The productivity of a skilled worker increases if the latter is in an environment that stimulates the interaction between people.

In other words, in a model like this (called AK model) there is no steady state of capital but there is, instead, steady growth rate of capital as we can appreciate from Figure 1.

Figure 1



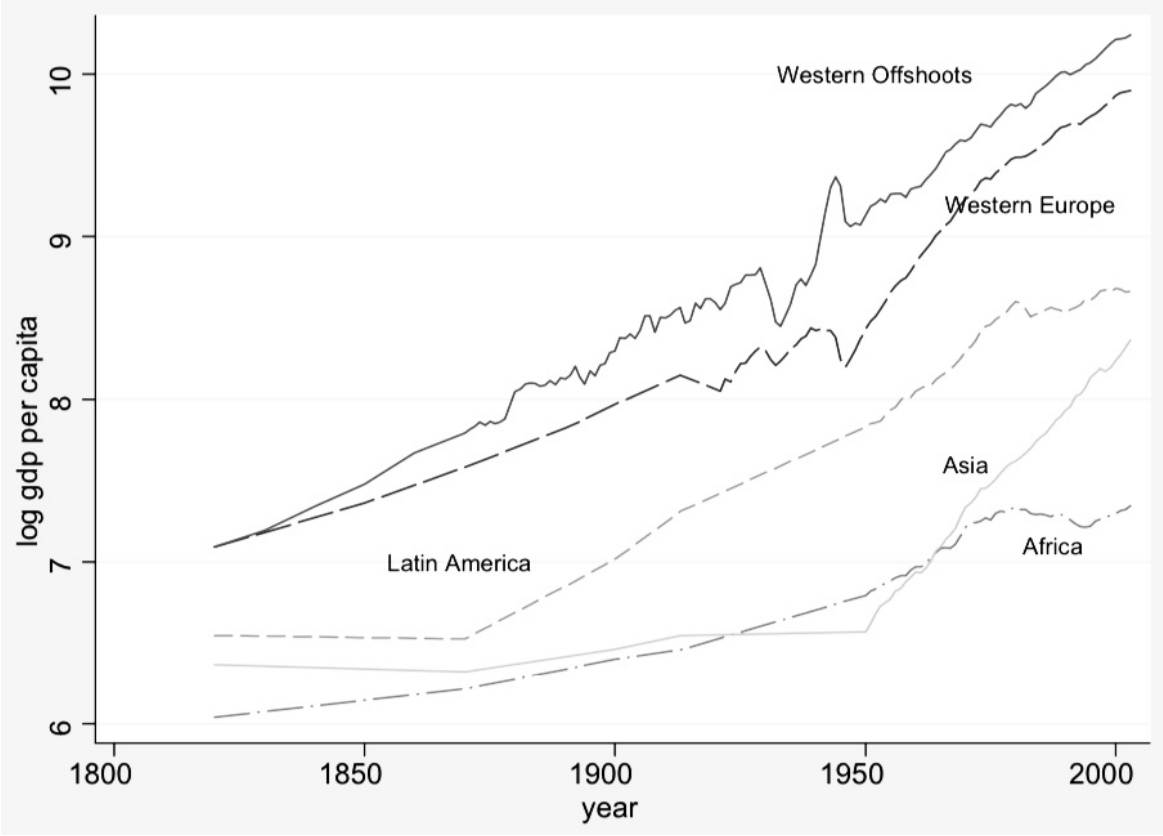
Source: R. Lucas, "On the Mechanics of Economic Development" 1988

With no external effect ($\gamma = 0$) the curve of Figure 1 is a straight line through the origin. Otherwise, ($\gamma > 0$) it is convex.

The intuition is that economies that are initially poor will remain poor compared to wealthier economies, even if the rate of growth between these countries is the same.

The empirical evidence confirms Lucas's hypothesis. In fact, if we look at GDP per capita data for countries divided per continent, there is a trend of income divergence between them: richer continents grow more than poorer continents, as we can see from Figure 2.

Figure 2



Source: D. Acemoglu, "Introduction to modern Economic Growth" 2009

To quote Lucas, he states "I am simply generating new possibilities, in the hope of obtaining a theoretical account for cross-country income differences in levels and growth rates. Since the model just examined is consistent with the permanent maintenance of per capita income differentials of any size some progress toward this objective has been made."

At the end of his paper "On the Mechanics of Economic Development" (1988), Lucas suggests the areas where future research has to look at: the economic role of cities, since group interaction is a key ingredient to individual productivity.

A similar model in literature was presented by Romer (1986). Romer's objective was to model the process of knowledge accumulation, introducing the technological spillover as the engine of growth. The results are very similar to Lucas model, but here spillovers work through physical capital instead of human capital.

3.2 The Nelson-Phelps Model of Human Capital

The alternative perspective of human capital externality was presented by Nelson and Phelps in their short and influential paper in 1966. They modeled human capital externalities as the ability to cope with change and disruptions the frontier technology.

Here I provide a simple presentation of the new dimension human capital may enrich our view and its role in economic growth and development.

Consider the following continuous-time model to illustrate the basic ideas. Suppose that output in the economy is given by

$$Y(t) = A(t)L$$

where L is the constant labor force, supplying its labor inelastically, and A(t) is the technology level of the economy. There is no capital and the only variable that changes over time is technology A(t).

The evolution of the technology level of a country is governed by the following equation:

$$\dot{A(t)} = gA(t) + \phi(h)A_F(t)$$

where g is the growth rate of technology depending on learning-by-doing and $\phi(h)$ is the growth rate of technology depending on the implementation and adoption of frontier technology. Based on this model, the growth rate of technology is faster when $\phi(h)$ is higher. The role of human capital emphasized by Nelson and Phelps is undoubtedly important in several situations. For example, a range of empirical evidence shows that the more educated farmers are more likely to adopt new technologies (Foster and Rosenzweig 1995).

However, this model also presents some caveats. More specifically, workers that contribute to faster technology adoption would be compensated in terms of higher earnings so that the human capital measures previously presented should have already take into account this contribution of more skilled workers. In other words, the risk here is that we are modeling the external effect of human capital when the latter is already considered in the internal measures I discussed in the first section of this thesis.

3.3 Urbanization and Growth

Closely related to the human capital externalities framework is another factor that has recently gained attention as one of the forces behind human capital, that is the urbanization rate of a country. The main reason for this attention is that the presence of cities, captured by the urbanization rate, is associated with economic growth. The idea that cities are sources of growth has gained ground in recent years.

I give some data to understand the size of this phenomenon. Nowadays, more than half of human beings, a total of almost 4 billion, live in urban areas. The population in cities has increased from 746 million in 1950 to 4 billion in 2014. It is expected that in the middle of this century the urban population will be equal to the global one in 2002.

Empirical evidence suggests an important correlation between urbanization and GDP per capita. Naturally, high rates of urbanization do not mean the majority of population lives in prosperity. Neverthless, urbanization is a good proxy for average prosperity and closely corresponds to the GDP per capita measures we are looking at prosperity today.

I strongly believe that cities have to be considered as the engine of growth or at least as complementary to human capital accumulation. One may say that a high level of human capital with a high level of urbanization rate (percentage of people living in urban areas over the total population) generates growth. I will be following the lead of Jane Jacobs, “The Economy of Cities” (1969). Jacobs argues that the long-term growth takes place through innovation, and that the conditions found in large, complex, and diverse urban areas are needed for that innovation to take place. She defines a *true city* as “a settlement that consistently generates its economic growth from its own local economy”.

To illustrate her thesis, Jacobs hypothesized that a fictious settlement *New Obsidian* emerges when hunter-gatherers from various locations with different resource endowments congregate to trade. This peaceful clustering offers a huge gain from trade which in turn attracts new people and increase the size and diversity of the city itself. Then, Jacobs explains how the conditions created by density and diversity of a city creates an ideal environment for innovation due to the existence of the knowledge spillover.

Such conditions are as follows. First, a city must facilitate ordinary people to make important discoveries and to implement them. This is difficult to do in villages or towns that tend to be

more tradition bound and where social contact is rare but is much easier in large settlement like a city. Second, once a discovery is made, it needs to be diffused among a great number of people in order to become widely known and practiced. Again, such a diffusion is more likely to happen in a city rather than in a village or town.

The positive relationship between urbanization (and city size) and per capita incomes is clear. However, the interpretation of such a link between these two variables is still less clear: does urban agglomerations cause incomes to rise or are they a product of economic growth? The evidence of a positive link between cities and economic development is summarized in Figure 3 and Table 2. Notice that I use the 1995 as benchmark since I will use the same year to test my aggregator.

Figure 3

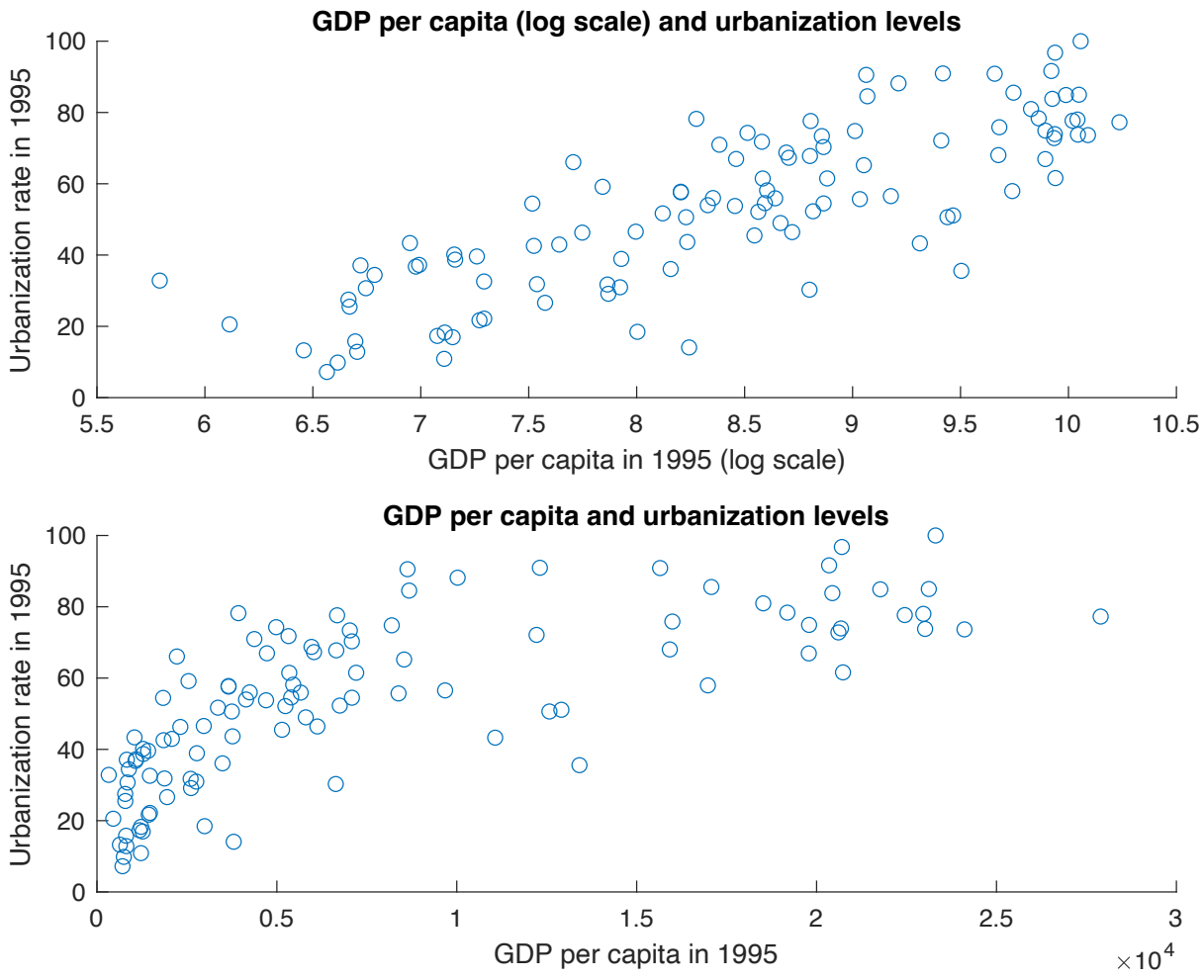


Table 2

Urban area (Agglomeration)	Nation	Percentage share of national total: Population (A)	Percentage share of national total: GNP or Income (B)	Ratio B/A
São Paulo	Brazil	8.6	36.1	4.20
Buenos Aires	Argentina	35.0	53.0	1.51
Santiago de Chile	Chile	35.6	47.4	1.33
Lima	Peru	28.1	43.1	1.53
Guayaquil	Ecuador	13.1	30.1	2.30
Mexico	Mexico	14.2	33.6	2.37
All cities	Mexico	60.1	79.7	1.33
San Salvador	El Salvador	25.8	44.1	1.71
Port au Prince	Haiti	15.1	38.7	2.56
All cities	Haiti	24.2	57.6	2.38
Casablanca	Morocco	12.1	25.1	2.07
Abidjan	Ivory Coast	18.1	33.1	1.83
Nairobi	Kenya	5.2	20.1	3.87
All cities	Kenya	11.9	30.3	2.55
Karachi	Pakistan	6.1	16.1	2.64
All cities	India	19.9	38.9	1.95
Shanghai	China	1.2	12.5	10.42
Manila	Philippines	12.1	25.1	2.07
Bangkok	Thailand	10.9	37.4	3.43
All cities	Turkey	47.1	70.1	1.49
Budapest	Hungary	18.0	35.0	1.98
Moscow	Russia	5.8	10.9	1.88
New York (CMSA)	US	7.5	10.1	1.34
Chicago (CMSA)	US	3.2	3.8	1.17
All MSA's	US	80.0	85.0	1.06
Toronto	Canada	14.2	17.3	1.22
Montreal	Canada	11.4	11.5	1.01

Note: Results are for years within the range 1975–2001, depending on the source.
Sources: Ciccolla (1999), de Mattos, (1999), *The Economist* (1997), PRISMA (1996), Prud'homme (1997), Weiss (2001), World Bank (1991) as well as the author's calculations based on national accounts and census data, specifically for the US and Canada.

Source: M. Polese, "Cities and National Economic Growth: a Reappraisal" 2005

Let us focus on the two scatter plots of Figure 3. The top graph shows that high rates of urbanization are strongly correlated with high level of income per capita, measured in log-scale (R^2 is 0.67). However, if we look at the bottom picture of Figure 3, it shows that relatively high rates of urbanization are not enough to ensure high levels of incomes. Indeed, if we measure income per capita on a normal scale, the relationship takes the form of a lopsided "L". This means that pretty high levels of urbanization are attained at relatively low levels of income. How should one view these results? The interpretation of this result is that the pure gains of agglomeration are diminishing rapidly above a certain threshold. So, once an economy

reaches, let's say the 70 percent of urbanization, it is to be expected that urbanization *per se* will contribute little to income growth. There must be something else that matters. This means that urbanization neglects many factors that play a role in determining the economic performance of a country. I will argue that what is missing is exactly the internal effect of human capital.

Table 2 shows instead the economic importance of cities. Column A indicates the percentage of citizens living in a large urban center with respect to the total population of a country. Column B captures how much of the country's income is explained by the largest urban center of that country. The third column is the ratio between B and A (all ratios are above 1). For example, if we look at the first row of such a Table, San Paulo accounted for 8.6 percent of Brazil's total population, but it generates 36.1 percent of national income. So, cities and in particular bigger cities, mean higher productivity and higher per capita incomes.

The main idea in this section is that the positive relationship between urbanization and growth exists but it is difficult to demonstrate that cities (agglomeration *per se*) cause economic growth. Roads, the telephone and the Internet also facilitate communication, but few would argue that roads cause long-term economic growth, although good roads are essential for growth.

At this stage a final though on the role of urbanization is necessary. We are in an unprecedented period in the history. We have never been so much on the Earth, have never had such a huge disparity between the very few who have so much and the very many who have so little. So, the question an economist of the XXI century must develop is the following: Is urbanization really desirable whatever it takes? On one hand, the positive effect of the exchange of ideas between individuals stimulates growth but on the other the challenging issue today is that high rates of urbanization are not sustainable, given the global changes that humans have caused on nature. The answer key here is on the mechanics of economic growth, that must consider the sustainable development. Today the latter aspect represents the fundamental problem that humanity must face and the search for solutions to get a harmonious relationship between natural and social systems should be the first goal of any modern economist.

4 A NEW HUMAN CAPITAL AGGREGATOR

In this section I develop a static model for measuring human capital stock through three stages: the traditional approach, the generalized approach, and my agglomeration-adjusted human capital aggregator, closely following the Jones's paper "The Human Capital Stock: A Generalized Approach" (2014).

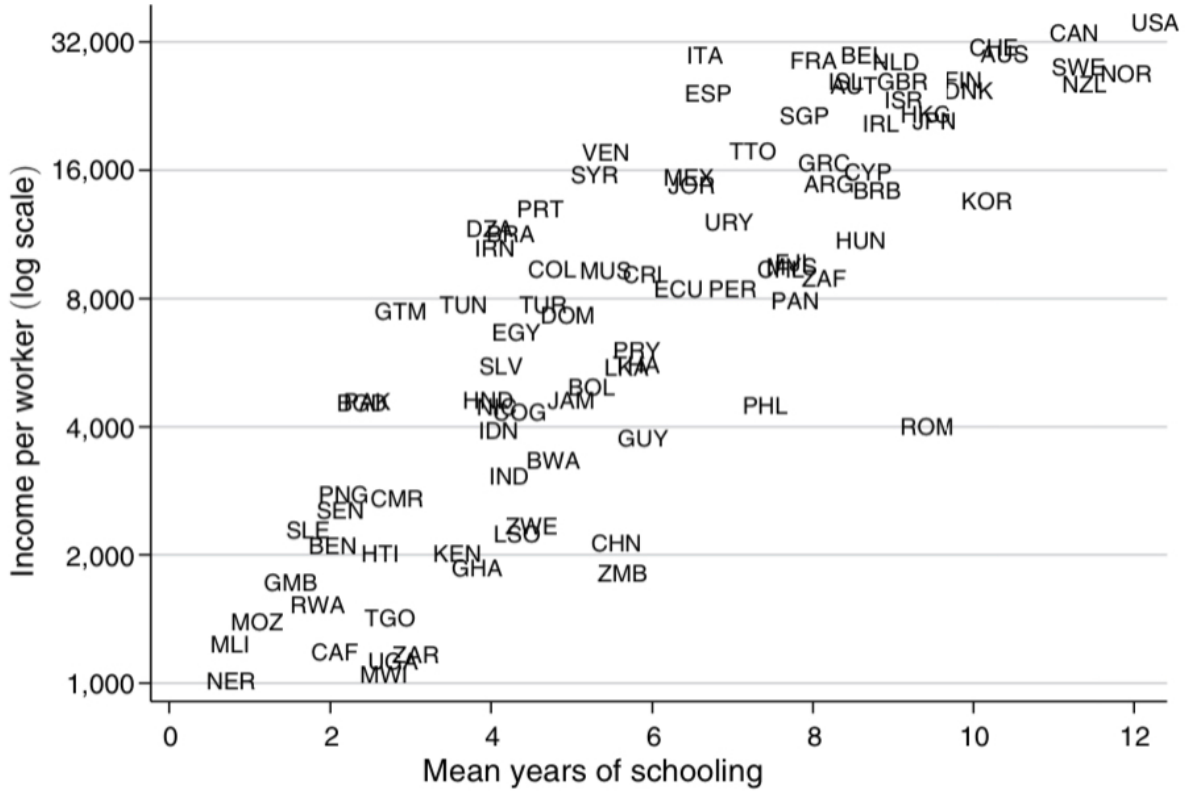
Investigating how differences in human capital contribute to cross-country differences in economic growth requires a measure produced in a comparable way across countries. A good candidate in the literature is the generalized human capital approach developed by Jones (2014), that solves the limitations of the methods I listed in Chapter 2. More specifically, it is an aggregator and then it is compatible with national accounting. In addition, it captures the productive value of human capital through a measure of "service flow". Finally, this approach does not have problems of future earnings or discount rate since it focuses on the current value of human capital.

Following this method, I build a human capital aggregator that considers both the internal and the external effects of human capital. The former is defined by various subgroups of workers (skilled and unskilled) while the latter represents the human capital externalities due to agglomeration economies. Under this framework, human capital variation can account for a much bigger part of cross-country differences in economic performance. Indeed, as I will show in the empirical analysis, the traditional and the generalized methods explains little of the income differences across countries. Moreover, also the correlation with growth appears weak in both cases. Then, human capital externality plays a crucial role in economic growth exactly because agglomeration increases the productivity of workers, and this happens in urban areas. To quote Lucas (1988) again, "what can people be paying Manhattan or downtown Chicago rents for, if not for being near other people?".

4.1 Traditional human capital aggregator

While the correlation between per capita income and average schooling is strong, as we can see from Figure 4, the interpretation of this correlation is not trivial, given the problem of endogeneity between the accumulation of years of schooling and income.

Figure 4



Source: B. Jones, "The Human Capital Stock: A Generalized Approach" 2014

To avoid regression's inference challenges, a key innovation comes in measuring human capital stock, where an economy's worker is translated into "unskilled worker equivalents", summing up the country's labor supply in terms of unskilled workers.

To position the traditional (Jones's terminology) approach, consider the following standard assumptions:

ASSUMPTION 1 (Aggregation): Let there be an aggregate production function

$$Y = F(K, H, A),$$

where Y is value-added output (GDP), K is physical capital and $H_i = h_i L_i$ is the human capital input. Moreover, H $= G\,(H_1, H_2, \ldots H_n)$ is the aggregate human capital where the arguments are the human capital services provided by various subgroups of workers, and A is a scalar.

The basic challenge in accounting for human capital is as follows. While we observe the quantity of each labor type, $\{L_1, L_2, \ldots, L_n\}$, we do not observe their service flow, $\{h_1, h_2, \ldots, h_n\}$. We might observe these qualities from something else we observe: the wage vector, $\{w_1, w_2, \ldots w_n\}$.

ASSUMPTION 2 (Marginal Products): Let factors be paid their marginal products. The marginal product of a capital input X_j is

$$\frac{\partial Y}{\partial X_j} = p_j,$$

where p_j is the price of the input X_j.

More specifically, the marginal product assumption implies

$$w_i = \frac{\partial Y}{\partial H} G_i h_i$$

where w_i is the wage of labor type i.

To proceed, one may write the wage ratio $\frac{w_i}{w_j} = \frac{G_i}{G_j}\frac{h_i}{h_j}$.

So, togheter with Assumption 1 allows us to write the human capital aggregator as

$$H = h_1 G\left(\sum_{i=1}^{n} \frac{w_i}{w_1}\frac{G_1}{G_i} L_i\right).$$

Then, if wages and labor allocations are observed, one could infer the human capital inputs save for two challenges. First, we do not know the ratios of marginal products, $\left\{\frac{G_1}{G_2}, \ldots \frac{G_1}{G_n}\right\}$. Second, we do not know h_1, which represents the "innate" skills of the uneducated worker.

The following analysis shows how traditional development accounting solves these measurements challenges through some strong assumptions. The analysis will then explain how to relax those assumptions.

Human capital is traditionally computed based on the so-called *unskilled labor equivalents.*

DEFINITION 1: Define the unskilled labor equivalents as

$$\widetilde{L_1} = \sum_{i=1}^{n} \frac{w_i}{w_1} L_i,$$

where labor class $i = 1$ represents the uneducated.

The idea behind Definition 1 is to translate each worker type into an equivalent mass of unskilled workers, weighted each type by their relative wage with respect to the unskilled.

ASSUMPTION 3: Skill and unskilled labor are perfect substitutes: G does not vary across different labor types, where G is the marginal increase in total human capital services from an additional unit of a specific human capital service. For example, G_1 is the marginal increase in human capital services from an additional unit of unskilled human capital service. This perfect substitute assumption implies that $G_i = G_j$ for any two types of human capital.

It follows that the Traditional human capital aggregator can be written as $H = h_1\widetilde{L_1}$ and we define the latter $\widetilde{H}$.

To solve the additional problem that we do not know h_1, one must make an assumption about how the quality of such uneducated worker varies across countries. Let two countries we want to compare denoted by R (rich) and P (poor). One common assumption to proceed is as follows.

ASSUMPTION 4: The unskilled worker has the same "innate skills" in all countries, which means that $h_1^R = h_1^P$. This assumption provides a solution to the measurement challenge allowing to compute in a quite simple way the human capital stock of a country.

The following aggregators (generalized and agglomeration adjusted) are built by relaxing the assumptions the traditional aggregator makes. More specifically, the generalized approach

relaxes Assumption 3 about the perfect substitution between labor types, while my agglomeration-adjusted aggregator focuses on Assumption 4, explain how the "innate skills" of unskilled worker can change across countries.

4.2 Generalized human capital aggregator

I now discuss the generalized approach for measuring human capital, which is built by relaxing Assumption 3: skilled and unskilled labor are not perfect substitutes.
Under Assumptions 1 and 2 any human capital aggregator can be written as

$$H = G_1 x\, h_1 x\, \widetilde{L_1}.$$

We see that human capital can be assessed through three essential ingredients.
First, the unskilled labor equivalents. Second, the quality of unskilled labor itself, h_1. Third, the marginal product of unskilled labor services, G_1. As for the latter object, Jones explains that it is more likely that G_1 varies across economies. Moreover, if we consider the ratio $\frac{G_1^R}{G_1^P}$ there is reason to think that such a ratio is greater than 1. Indeed, G_1 is likely to be substantially larger in a rich than a poor country for at least two reasons. First, rich countries have fewer unskilled workers, a scarcity that tends to drive up the marginal product of unskilled human capital. Second, rich countries have more highly educated workers, which will tend to increase the productivity of the unskilled workers.
To implement a feasible generalized accounting for human capital stock, Jones defines the Generalized Division of Labor (GDL) aggregator as

$$H = (H_1^{\frac{\varepsilon-1}{\varepsilon}} + Z(H_1, H_2, \dots, H_n)^{\frac{\varepsilon}{\varepsilon-1}})^{\frac{\varepsilon}{\varepsilon-1}},$$

where $\varepsilon \in [0, \infty]$ is the elasticity of substitution between unskilled human capital and an aggregation of all other human capital types $Z(H_1, H_2, \dots, H_n)$.

For the GDL aggregator,

$$G_1 = \left(\frac{H}{H_1}\right)^{\frac{1}{\varepsilon}}.$$

Thus, we can write the Generalized human capital aggregator as

$$H = H_1^{\frac{1}{1-\varepsilon}} \widetilde{H}^{\frac{\varepsilon}{\varepsilon-1}}.$$

Notice that micro-evidence analyzing the elasticity of substitution between skilled and unskilled labor typically suggests an elasticity in the $[1,2]$, with common estimates toward the center of this range. In fact, in the empirical estimation I will use such a value for the elasticity of substitution.

4.3 Agglomeration-adjusted human capital aggregator

Finally, I build my agglomeration-adjusted human capital aggregator, that attempts to relax Assumption 4 by stating that, *ceteris paribus* the level of education, urbanization rates capture the difference between countries in the innate skills of the uneducated workers, h_1. In fact, it is reasonable that, given the same level of education, citizens that live in urban areas can have a stimulus to innovate and to be more competitive.

The ingredients of my aggregator are the following:

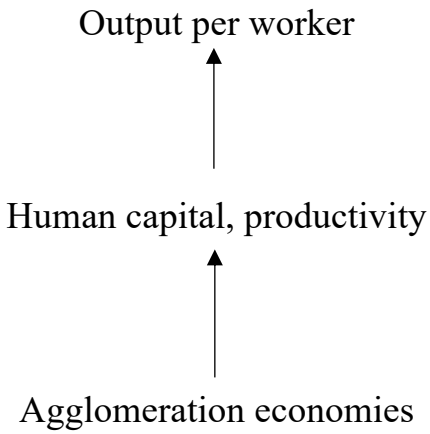
1. Unskilled labor equivalents, which translates different type of labor into a common type (equivalent units of unskilled labor force);
2. Mass of unskilled labor;
3. Elasticity of substitution between skilled and unskilled labor;
4. Urbanization rate, which is my proxy for agglomeration (human capital externality).

Then, the agglomeration-adjusted human capital aggregator is as follows:

$$H = U\ x\ L_1^{\frac{1}{1-\varepsilon}}\ x\ \widetilde{L_1}^{\frac{\varepsilon}{\varepsilon-1}}.$$

In this framework, since the urbanization rate is by definition a percentage, it acts as a weight of the level of human capital stock in a country.

I can summarize my analysis of the determinants of differences in economic performance among countries as



This framework serves for at least two purposes. First, it allows me to distinguish between the proximate cause of economic success which I am focusing (human capital) and the more fundamental determinant of growth. Second, the framework clarifies the contribution of my work. I concentrate on the relation between the existence of agglomeration economies, captured by the urbanization rate, and differences in economic performance.

I am conscious that feedback may occur from output per worker back to agglomeration economies measured in terms of urbanization rate per country. For example, it may be that poor countries lack the resources to build effective agglomeration economies and to some extent to increase city size. I use the geographical characteristics of an economy as instrumental variables. More specifically, I view characteristics such as the latitude of a country and the percentage of a country's population with access to the sea as determinants of the urbanization rate of a country. Indeed, the latitude or the distance from the equator is a good index for the climate conditions of a country and it is related to the urbanization rate.

Moreover, there are many examples of cities built near the sea so that the coastal population should be a suitable proxy to measure the presence of cities in a country. This analysis confirms the directions of the arrows of my framework, from fundamentals to proximate sources of economic growth.

5 EMPIRICAL RESULTS

Given the theoretical result I presented in the previous paragraph, I now show my empirical estimation and its capacity to account for cross-country income variation. Basically, this analysis implements my agglomeration-adjusted human capital aggregator developed in the previous section and makes comparison with both the traditional literature and the Jones's generalized human capital aggregator. More specifically, I will develop a growth accounting exercise and a growth regression analysis to test the success of my aggregator that measures both internal and external effects of human capital.

5.1 Data and measurements

To facilitate comparison with the existing literature, I use the same datasets of Jones (2014), with the only difference that I use data on urbanization rates from the World Bank database. Following the latter database, urbanization rate is defined by the World Bank as the percentage of the total population of a country living in urban areas. The definition of urban areas comes from the national statistical offices. Data are collected and smoothed by United Nations Population Division. Therefore, any differences between the following analysis and the traditional conclusions are driven mainly by human capital aggregation, given some mismatch between observations because I add data on urbanization rates. Data on income per worker are taken from the Penn World Tables v6.1 and data on educational attainment are taken from Barro-Lee (2001). To minimize sources of differences with Jones's assessment, this work also uses the same year for the static analysis, which is the 1995.

The Barro-Lee (2001) dataset provides education attainment for people in seven groups: no schooling, some primary, completed primary, some secondary, completed secondary, some tertiary and completed tertiary. Schooling duration for completed tertiary is assumed to be four years, while schooling duration for primary and secondary are 7 and 6 years respectively.

For wage returns to schooling I use Mincerian coefficient from Jones (2014). Let s be the years of schooling and let relative wage be $w(s) = w(0)e^{\phi s}$. I have considered $\phi = 0.10$ (the global average) for all countries. At this point, I want to spend some words about the Mincer equation,

following the article of David Deming "Four Facts about Human Capital" (2022). He underlines that the Mincer model (1974) is an important building block of human capital theory. Mincer starts from the following equation that models log annual earnings as a linear function of years of schooling and quadratic in years of experience:

$$lny_i = \alpha_i + \beta S_i + \gamma X_i + \delta X_i^2 + \varepsilon_i.$$

The objective of this regression is to measure β, which captures the economic return to an additional year of schooling. Across many different countries and settings, estimates of β yield a coefficient of 0.1, which means that another year of schooling increases earnings by 10 percent.

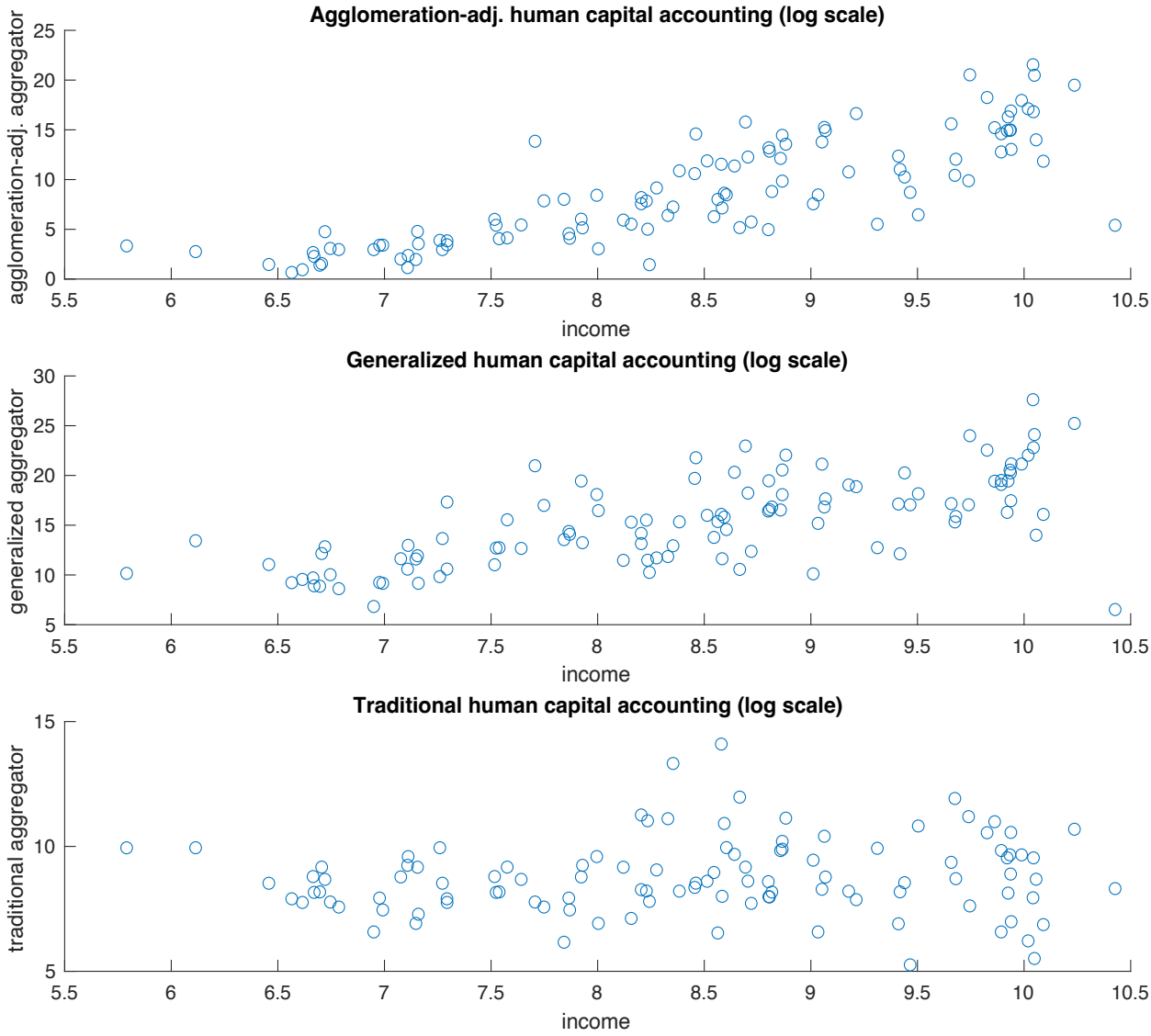
As for the elasticity of substitution, I used the average value of $\varepsilon = 1.5$ that comes from the microfoundation.

5.2 Growth regression

Human capital stock estimations are presented in Figure 5 with a sample of 108 countries based on the availability of data. The regression at the bottom of Figure 5 shows the correlation I developed between the traditional human capital aggregator and the GDP per capita, where each variable is in log scale. Such a regression does not explain a strong link between the two variables. Quite the contrary. Indeed, we can appreciate that the dots do not have a clear shape (the R^2 is lower than 0.5), meaning that the higher traditional measure of human capital stock in a country is not associated with a higher level of per capita income in that country. This result confirms that traditional measurement of human capital explains little of the income variation between countries. If instead we measure human capital stock with the generalized human capital aggregator (regression in the middle of Figure 5), the R^2 is very close to 0.5. Finally, my agglomeration-adjusted aggregator is the best one in terms of correlation with the GDP per capita of a country. Indeed, looking at the regression at the top of Figure 5 there is a strong relationship between the human capital stock broadly measured

(internal and external effects) and per capita income (R^2 above 0.7), improving the previous results.

Figure 5

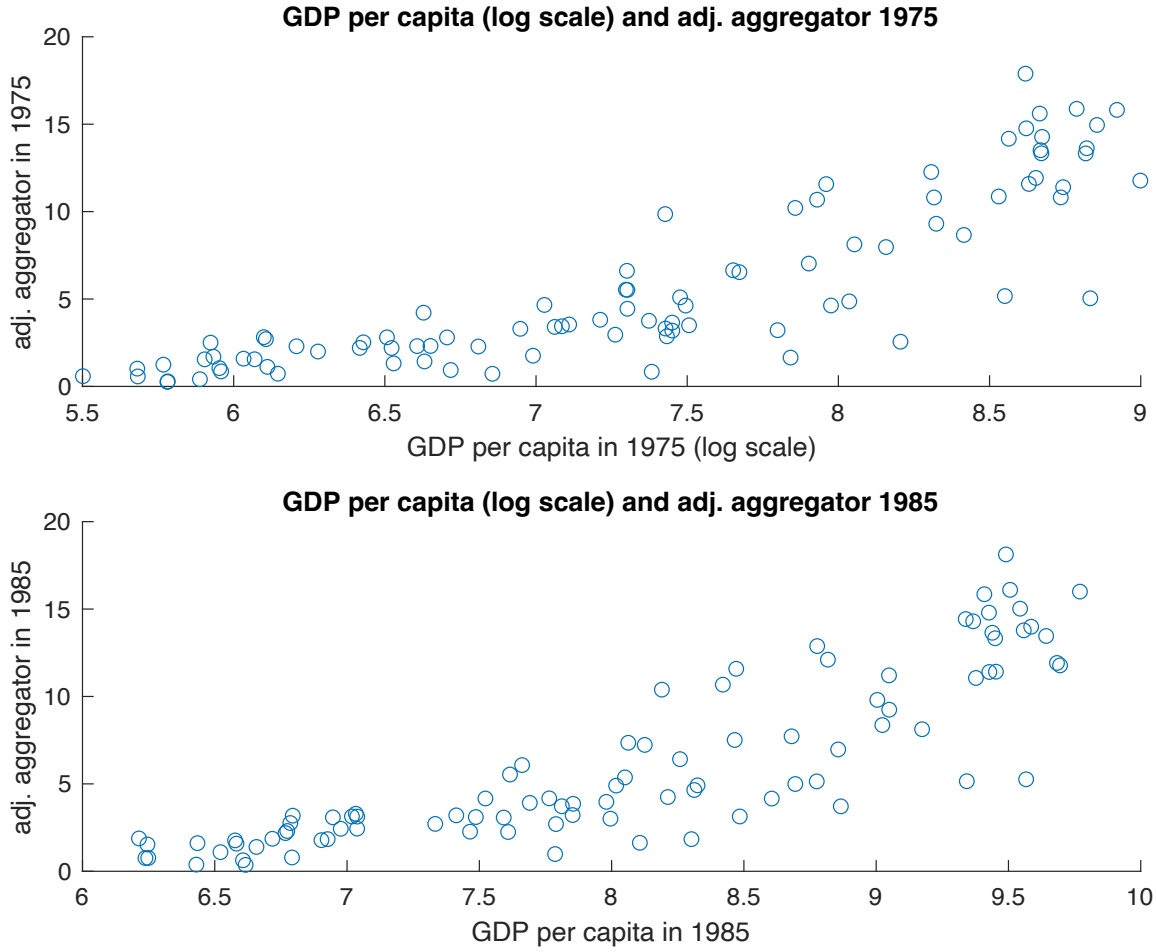


An interesting case is represented by the United States, which is the rightmost dot in the regression at the top of Figure 5. Indeed, United States has a relatively low urbanization rate but the highest per capita income in my sample.

As a robustness check, I have also considered the same relationship between my agglomeration-adjusted aggregator and GDP per capita across different years. Since the last

year available in Jones's dataset is the 2000, In Figure 6 I considered the 1985 and 1975 to verify my analysis. These alternative estimations provide similar results as in the benchmark year (1995).

Figure 6



5.3 Identification and Instruments

To examine the quantitative importance of differences in urbanization rate as determinants of incomes given endogeneity concerns between urbanization rate and per capita output, I hypothesize the following structural model:

$$Y = \alpha + \beta U + \varepsilon$$

and

$$U = \gamma + \delta X + \eta$$

where Y denotes the GDP per capita of a country, U is the urbanization rate of such a country, and X is a vector of two instruments: latitude and access to the sea.

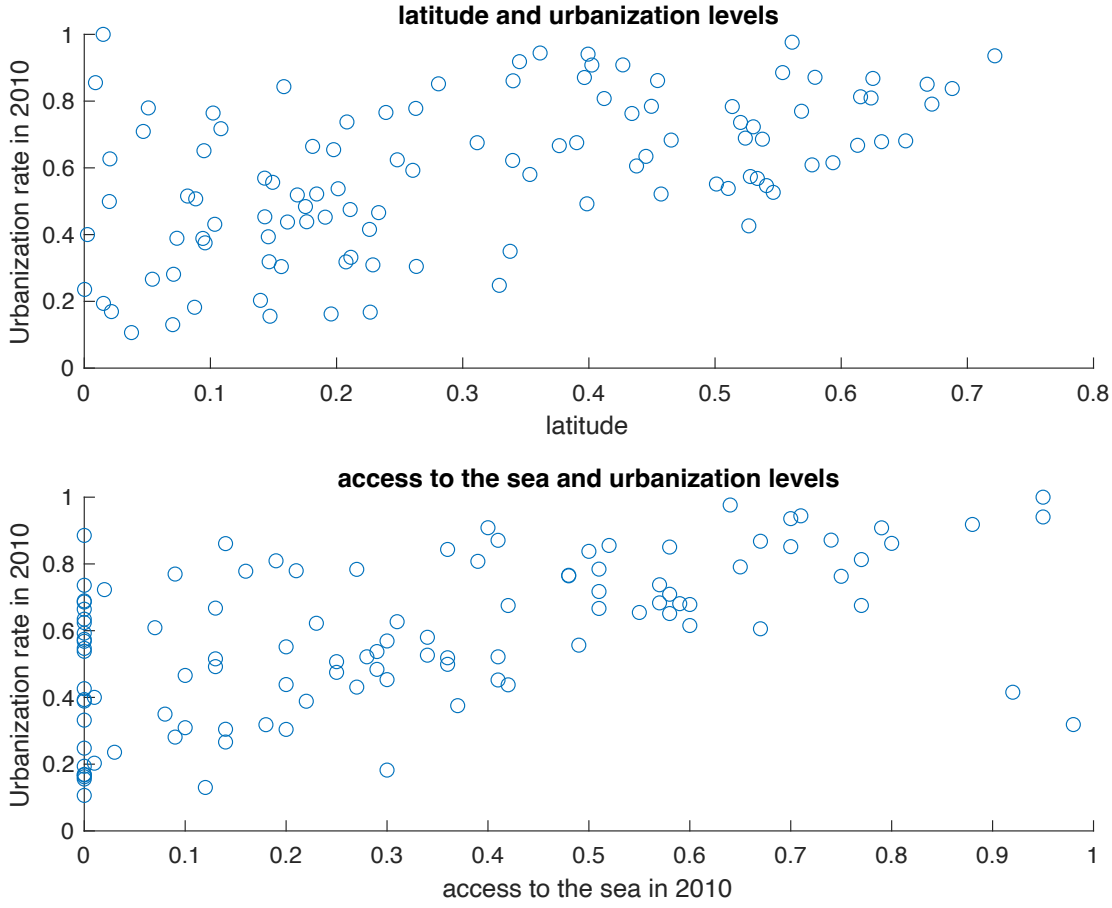
The latter instruments are positively correlated with the urbanization rate using as benchmark year the 2010 because of the availability of data. In fact, most people live in places where conditions are favorable for production and living. Moreover, these instruments are exogenous with respect to the GDP per capita since they are country-specific geographical characteristics. A country cannot affect its distance from the equator (latitude), its endowment of natural resources, its proximity to the sea and so on.

What does geography explain? Here I want to spend a few words about the book of J. Diamond "Guns, Germs and Steel" 1997. Diamond, which is not an economist but a biologist, shows how geography can help in explaining the development of entire continents. In particular, his question is the following: why the Eurasian landmass developed before the rest of the world (America, Africa and Oceania)? According to Diamond (1997) it can that Eurasia was endowed with much more numerous species of both plants and domesticable animals. Moreover, the east-west geographical orientation of Eurasia, as compared to the north-south orientation of America and Africa, facilitated the diffusion of agricultural techniques because of the similar climate conditions in Eurasia. Finally, over time denser and wealthier population in Eurasia developed partial immunity to a great variety of diseases.

Geography today matters much less than it used in the past. However, some geographical patterns seem to be present even nowadays. For example, we observe at least two relevant facts today.

First, the farther a country is from the equator, the more is urbanized because of the advantage of favorable climate condition. Second, a better access to the sea is associated with higher urbanization rate. Such stylized facts are described by Figure 7: the top graph shows the correlation between urbanization levels in 2010 and latitude, while the bottom one shows the relationship between urbanization levels in 2010 and access to the sea.

Figure 7



I measure distance from the equator following the paper of R. Hall and C. Jones “Why Do Some Countries Produce So Much More Output Per Worker Than Others?”, as the absolute

value of latitude in degrees divided by 90 to place it on a 0 to 1 scale. It is widely known that economies farther from the equator are more successful in terms of per capita income.

As for the access to the sea, I use the percentage of a country's population within 100 km from the sea and such data comes from the NASA database.

Geographers divide the Earth's climate into twelve zones. In particular, the temperate zones contain circa 35 percent of world population and have per capita income almost twice as much as the world average. Table 3 shows this pattern more in detail. The temperate zones are denoted by Cf, Cs, Df, Dw and they also contain some of the most important cities in terms of size: New York, Paris, Shanghai, Sydney, San Francisco, Rome, Santiago, Chicago and Moscow.

Table 3

Climate Zone	Description	Representative Cities	Percentage of World Landmass	Percentage of World Population	GDP per Capita Relative to World Average
Af	Tropical Rain Forest	Jakarta, Indonesia Manaus, Brazil	4.0	4.4	0.64
Am	Tropical Rain Forest with Seasonal Monsoon	Manila, Philippines Cochin, India Belém, Brazil	0.8	2.4	0.41
Aw	Tropical Savannah	Dhaka, Bangladesh Kinshasa, Congo Havana, Cuba	10.8	17.5	0.38
Cw	Subtropical: MildHumid with Dry Winter	Hanoi, Vietnam Kanpur, India Lilongwe, Malawi	4.3	16.0	0.44
Cf	Mild Humid Climate with No Dry Season	New York, USA Paris, France Shanghai, China Sydney, Australia	7.7	19.5	2.24
Cs	Mediterranean Climate: Mild, Humid with Dry Summer	San Francisco, USA Rome, Italy Santiago, Chile	2.2	4.3	2.10
Df	Snowy-Forest Climate with No Dry Season	Chicago, USA Moscow, Russia	23.0	5.8	1.90
Dw	Snowy-Forest Climate with Dry Winter	Seoul, South Korea Vladivostok, Russia	6.2	5.3	0.64
BS	Semi-arid Steppe	San Diego, USA Odessa, Ukraine	12.3	11.8	0.55
BW	Desert: Annual Precipitation Less than 15 in. (38 cm)	Cairo, Egypt Karachi, Pakistan	17.3	6.2	0.58
H	Highlands	Mexico City, Mexico	7.3	6.8	0.78
E	Ice Climates: Average Temperature in Warmest Month Less Than 50°F (10°C)	Nuuk, Greenland	4.0	<0.1	—

Source: D. Weil, Economic Growth 2013

With respect to 2010, the correlation between urbanization and GDP per capita is strong (R^2 close to 0,63). Table 4 shows the results of a TSLS approach to understand the causality of the previous relationship between the urbanization rate and economic growth.

Table 4

	Parameter	Standard error
Intercept	5,209	0,2933
Urbanization (exogenous)	5,547	0,4828

The main specification in Table 4 reports the results from instrumental variables estimation of the effect of a change in urbanization rate on the log of output per worker. The estimation shows that a difference of 1 percent in GDP per capita is associated with a difference in urbanization rate of 5,547 percent. With standard error of 0,4828 this coefficient is estimated with considerable precision. Moreover, the relative F-test is equal to 52,63 and this confirms the goodness of the estimation. I also develop a Cragg-Donald test for weak instruments to figure out the relationship between the variables I used as proxy and the urbanization rate. The Cragg-Donald's regression is as follows:

$$Urbanization = \alpha + \beta * latitude + \gamma * access\ to\ the\ sea + \varepsilon$$

Table 5 reports the results for this test.

Table 5

	Parameter	Standard error
Intercept	30,98	3,158
Latitude	49,41	7,823
Access to the sea	38,85	5,671

The point estimate indicates that a difference of 1 percent in the urbanization rate is associated with a difference in latitude (distance from the equator) of 49,41 percent. As for my measure of the proximity to the sea, the results show that a difference in 1 percent in the urbanization

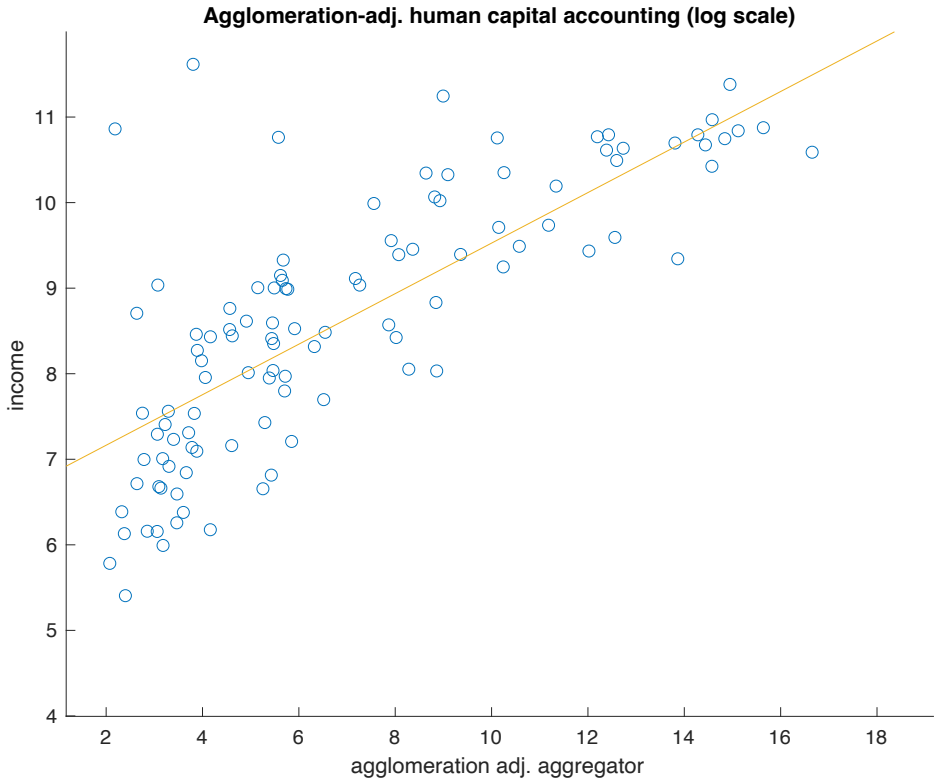
rate is associated with 38,85 percent variation in the access to the sea measured in terms of total country's population within 100 km from the sea.

To sum up this IV analysis, my objective is to capture the idea that the urbanization rate can be considered mostly exogenous with respect to the per capita income of a country. Indeed, my estimation shows with significance that urbanization is determined by the geography of a country: climate conditions and proximity to the coast facilitate cities to rise and to improve the economic performance of a country.

To conclude, these results demonstrate that the link between my human capital aggregator and per capita income can be interpreted as a causal relationship. In other words, the agglomeration-adjusted human capital aggregator causes income to rise, given the measure of human capital through unskilled labor equivalents and the urbanization rate as a product of the country's geography.

More specifically, Figure 8 shows this causal relationship between the agglomeration-adjusted human capital aggregator and the GDP per capita with respect to the 2010. To do so, I use as dependent variable the Jones's human capital aggregator multiplied by the first stage fitted values I computed before. In this way the urbanization rate is now exogenous with respect to income given the country's specific characteristics (latitude and access to the sea). The relative R^2 is close to 0,6 and I conclude that my results indicate that differences in the agglomeration-adjusted human capital aggregator account for much of the differences in the long-run economic performance throughout the world, as measured by output per worker.

Figure 8



5.4 Development accounting

The objective of development accounting is to compare two economies and assess the relative role of variation in inputs and total factor productivity in explaining variation in income.

Following standard literature, I will use Cobb-Douglas production function, $Y = AK^{\alpha}H^{1-\alpha}$ and take the capital share as $\alpha = 1/3$. Writing $Y_H = H^{1-\alpha}$ to account for the component of income explained by my human capital aggregator. Following Jones's procedure, I can define the success of a factor-only explanation as

$$success = \frac{Y_H^R/Y_H^P}{Y^R/Y^P},$$

where R is a "rich" country and P is a "poor" country.

Table 6 summarizes data for development accounting using the Traditional human capital aggregator. Comparing the richest and the poorest country in Jones's data (the United States and Congo Zaire), the observed ratio of income per worker is 91 but the ratio of the unskilled labor equivalents (traditional measure of human capital differences) appears modest, at 1.7. Comparing the 85^{th} to 15^{th} percentile (Israel and Kenya) and the 75^{th} to 25^{th} percentile (S. Korea/India), we see that the ratio of the measures of human capital is again too modest with respect to the income per capita ratio between countries.

Moreover, using the traditional approach, the success of factors-only explanation is very low. For example, in the case of USA/Congo $success = 9$ percent. The same trend holds for the success in the case of Israel/Kenya, $success = 25$ percent, and S. Korea/India with $success = 45$ percent. These results implies that we need a large total factor productivity value to account for the differences in economic performance between rich and poor countries. This happens because the unskilled labor equivalents vary little and then human capital appears to add little in accounting for cross-country income differences.

Table 6

Measure	Rich versus poor		
	99th/1st percentile (USA/Zaire)	85th/15th percentile (Israel/Kenya)	75th/25th percentile (S. Korea/India)
Panel A. Traditional accounting measures			
Y^R/Y^P (income)	90.9	16.9	6.3
K^R/K^p (capital stock)	185.3	43.9	17.4
$\tilde{L}_1^R/\tilde{L}_1^P$ (unskilled worker equivalents)	1.70	1.33	1.15
Traditional success (percent)	9	25	45
Panel B. Relative labor allocations			
Labor ratios (rich/poor)			
No education	0.02	0.21	0.23
Some or completed primary	0.23	0.78	1.71
Some or completed high school	11.7	6.7	3.4
Some or completed college	56.2	34.3	3.2

Source: B. Jones, "The Human Capital Stock: A Generalized Approach 2014

In Table 7 I show the development accounting results of my agglomeration-adjusted human capital aggregator. We can see that the success of my aggregator is larger than one for both Israel/Senegal and Uruguay/India comparisons. This means that when we weight the human capital level by the urbanization rate of a country, the measure of the human capital stock fully accounts for the cross-country income differences. As for the ratio between USA and Congo, $success = 0.73$ means that for sure there will be something else than human capital broadly measured that matters, such as the presence of conflicts, the quality of institutions and so on.

Table 7

	USA / Congo (99th/1st)	Israel / Senegal (85th/15th)	Uruguay / India (75th/25th)
Income ratio	90,9	12,7	4,4
Generalized human capital ratio	2,48	1,75	1,24
Agglomeration-adjusted human capital ratio	5,85	4,00	3,33
Success of agglomeration-adjusted human capital aggregator	0,73	1,38	1,60

However, this result could overestimate the true success of my agglomeration-adjusted human capital aggregator exactly because of the endogeneity between the urbanization rate and per capita income. So, a deeper analysis suggests that actually the success of my aggregator is on average 2/3, meaning that the majority of the cross-country income differences is due to differences in human capital broadly considered and the residual 1/3 is due to differences in total factor productivity and physical capital. I got such result by using the first stage estimate of urbanization through geographical characteristics together with the Jones's aggregator. Table 8 presents such results without the endogeneity bias.

Table 8

	USA / Congo (99th/1st)	Israel / Senegal (85th/15th)	Uruguay / India (75th/25th)
Success of agglomeration-adjusted human capital aggregator	0,72	0,68	0,71

In particular, the success of my aggregator in explaining difference between the country at the top and at the bottom of the income distribution does not change from the previous measure, meaning that geographical characteristics play a modest role in such gap because of other relevant fundamental differences. It is interesting to notice instead that the success of the aggregator in explaining the differences between Israel and Senegal drops from 1,38 to 0,68. The same drop occurs in the case Uruguay/India, for which the success is now 0,71 instead of 1,6. This means that for countries in the middle of the income distribution we need the presence of physical capital and total factor productivity to explain the differences in economic performance.

5.5 Discussion

This section considers intuition and interpretations for the results and highlights open issues.

Let us start the discussion from the development accounting exercise. Following the same idea of Jones, it would appear that reducing human capital stocks in the USA to the levels in the Congo will cause a precipitous drop in output. This outcome is very different if we consider the opposite case: increasing the education level in the Congo will not lead to a boom in output because of the issues I listed at the beginning of my thesis: fundamentals matter. The focus on agglomeration is just a point of view from which one may think about the interaction between proximate and fundamental sources of economic growth. The same framework also

has other natural applications at the level of countries, regions, cities and firms that are interesting areas to explore in future studies. Further questions that future works may develop are the following: Can we make a progress in understanding fundamental causes of cross-country income inequalities? Is growth theory useful in such an endeavor?

The growth regression with the first stage fitted values for urbanization rate shows the correlation between the internal and the external measures of human capital and income per capita, and this can be interpreted as causality. Indeed, as for the internal effect of human capital, the existing literature has underlined that the correlation between per capita income and average schooling is strong, as we can see from Figure 4, but the interpretation of this result is not obvious given endogeneity concerns. What about the external effect of human capital captured by the urbanization rate? For sure the positive relationship between urbanization (and to some extent, city size) and per capita income is indisputable. However, the link with growth has to be clarified. Does the presence of urban agglomerations cause incomes to rise or, instead, are they an outcome of economic growth? I discussed a lot about these issues in Chapter 3.

As for the endogeneity between schooling and income, the method of "unskilled labor equivalents" seems to solve such a problem using as common unit of measure the uneducated labor class so that there is no relationship between accumulation of years of schooling and income since each labor type is taken as uneducated. The only element that makes the difference between labor classes is their relative wage with respect to the unskilled.

Here I want to give some intuition to understand where one may look to solve the issue of endogeneity between the presence of cities and growth. The Instrumental Variable (IV) approach is a possibility in order to find a proxy that affects urbanization but is unrelated to the other determinants of income. Such proxies are the country's distance from the equator and the country's access to the sea. They explain the deepest determinants of agglomeration economies allowing to interpret the relationship between my human capital aggregator and per capita income.

To conclude, my analysis suggests that interventions that build human capital broadly considered will be the true engine of economic growth. In fact, Jacobs places great importance on policies that make cities people-friendly so that they may fulfill their role as places where innovations originate and are applied. But, there is still little evidence that agglomeration

causes growth. Does this mean that the existence of cities and the quantity/quality of education are of little importance? Obviously, creating a favorable environment that allows people to develop and exchange ideas is a good thing. Education system, infrastructures, street lightning, and other policies pedestrian-oriented are essential if human capital is properly to fulfil its role in economic growth.

6 CONCLUSIONS AND CAVEATS

Human capital accounting operates under the assumption that the productivity advantage of human capital can be inferred by comparing the productivity of those with more human capital with those with less human capital. In practice, this productivity comparison is traditionally made using relative wage of the skilled workers with respect to the unskilled. The latter method is called “unskilled labor equivalent”: all types of workers of an economy are translated into “unskilled equivalent”, with wage gains associated with higher skill. Using this approach to build human capital stock of a country, the literature finds that human capital accounts for a small portion of the differences in per capita income across economies. This conclusion suggests that human capital investments can play only a modest role in economic development.

However, the traditional result does not take into account the huge human capital externalities that agglomeration economies actually create.

This thesis continues with the broad paradigm of human capital accounting, where the productivity advantage of human capital is inferred by analyzing both the internal and the external effects of human capital. By adjusting the method to a broad class of human capital aggregator, this work reaches four conclusions.

First, as Jones (2014) emphasized, the perfect substitutes accounting will understate the variation in human capital across countries.

Second, the human capital externality due to agglomeration plays a relevant role in measuring human capital.

Third, the ingredient agglomeration is mostly exogenous with respect to income. Indeed, some geographical characteristics such as the distance from the equator and the access to the sea are good proxies for measuring agglomeration economies. The strong correlation between the urbanization level and these geographic factors provides clear evidence has been one of the shaping forces of the current world income distribution.

Finally, empirical evidence shows that my agglomeration-adjusted human capital aggregator accounts (even fully) for the differences in GDP per capita between rich and poor countries.

To conclude, effects of human capital investments are highly heterogeneous across economies. As I underlined in the discussion, differences in human capital investments produce different outcomes based on the country's fundamentals.

Economic growth and development is a crucial topic for an economist of the XXI century because it has such a significant impact on the welfare of so many people. It is also an interesting topic becouse it is an ongoing history. The passage of time brings new data, new events and new policy experiments. Finally, it is a field of active research, in which new ideas are constantly proposed, debated and tested. A successful theory of economic development needs mechanics consistent with both proximate and fundamental sources of economic growth. This was my objective in my work. I know that this is a more complex task because of the difficulty in finding the optimal way that permits more forces to operate, but I think that such a thesis is a promising beginning.

Matlab Codes

Chapter 3

```
%urbanization and growth


figure('Name','Urbanization and Economic Growth')
subplot(2,1,1)
scatter(log(gdp),urbanization)
title('GDP per capita (log scale) and urbanization levels')
xlabel('GDP per capita in 1995 (log scale)')
ylabel('Urbanization rate in 1995')
subplot(2,1,2)
scatter(gdp,urbanization)
title('GDP per capita and urbanization levels')
xlabel('GDP per capita in 1995')
ylabel('Urbanization rate in 1995')
```

Chapter 5

```
%growth regression

y=adj;
N=size(adj,1);
iota=ones(N,1);
X=[iota,log(gdp)];
results=ols_2022(y,X);
figure('Name','Human Capital Stock Variation')
subplot(3,1,1)
 scatter(adj,log(gdp))
 title('Agglomeration-adj. human capital accounting (log
scale)')
    xlabel('agglomeration adj. aggregator')
    ylabel('income')
subplot(3,1,2)
    scatter(aggregator,log(gdp))
    title('Generalized human capital accounting (log scale)')
    xlabel('generalized aggregator')
    ylabel('income')
```

```
subplot(3,1,3)
scatter(log(L_tilde),log(gdp))
title('Traditional human capital accounting (log scale)')
xlabel('traditional aggregator')
ylabel('income')



%robustness check

N=size(adj_75,1);
iota=ones(N,1);
X_75=[iota,log(cgdp_75)];
results_75=ols_2022(adj_75,X_75);
X_85=[iota,log(cgdp_85)];
results_85=ols_2022(adj_85,X_85);
figure('Name','Robustness Check')
subplot(2,1,1)
scatter(log(cgdp_75),adj_75)
title('GDP per capita (log scale) and adj. aggregator 1975')
xlabel('GDP per capita in 1975 (log scale)')
ylabel('adj. aggregator in 1975')
subplot(2,1,2)
scatter(log(cgdp_85),adj_85)
title('GDP per capita (log scale) and adj. aggregator 1985')
xlabel('GDP per capita in 1985')
ylabel('adj. aggregator in 1985')



%determinants of urbanization

figure('Name','determinants of urbanization')
subplot(2,1,1)
scatter(latitude,urbanization_2010./100)
title('latitude and urbanization levels')
xlabel('latitude')
ylabel('Urbanization rate in 2010')
subplot(2,1,2)
scatter(coastal,urbanization_2010./100)
title('access to the sea and urbanization levels')
xlabel('access to the sea in 2010')
ylabel('Urbanization rate in 2010')
```

```
%TSLS

N=size(gdp_2010,1);
iota=ones(N,1);
y=log(gdp_2010);
X=[iota,urbanization_2010./100];
results_ols=ols_2022(y,X);
y_iv=log(gdp);
XX=[iota];
WW=[latitude,coastal];
X_iv=[XX,urbanization_2010./100];
results_TSLS=TSLS(y_iv,XX,urbanization_2010./100,WW);



%Cragg-Donald test for weak instruments

K_exogenous=size(XX,2);
K_W=size(WW,2);
K_Y=size(urbanization,2);
X=[XX,urbanization_2010];
K=size(X,2);
results1stage=ols_2022(urbanization_2010,[XX,WW]);
R=[zeros(K_W,K_exogenous),eye(K_W)];
c=zeros(K_W,1);
F_test=(R*results1stage.beta-
c)'*inv(R*results1stage.Sigma*R')*(R*results1stage.beta-
c)/K_W;
pvalue_Donald=1-fcdf(F_test,K_W,N-K);



%growth regression with first stage fitted values


x=results1stage.yhat./100.*aggregator_2010;
figure('Name','Human Capital Stock Variation')
 scatter(x,log(gdp_2010))
 title('Agglomeration-adj. human capital accounting (log
scale)')
    xlabel('agglomeration adj. aggregator')
    ylabel('income')
```

References

D. Acemoglu, "*Introduction to Modern Economic Growth"* Princeton 2009

D. Weil, *"Economic Growth"* Routledge 2013

D. Acemoglu and D. Autor, *"What Does Human Capital Do?"* Journal of Economic Literature 2012

D. Deming, *"Four Facts About Human Capital"* Journal of Economics Perspective 2022

K. Abraham and J. Mallatt, *"Measuring Human Capital"* Journal of Economic Perspectives 2022

B. Jones, *"The Human Capital Stock: A Generalized Approach"* American Economic Review 2014

M. Polese, *"Cities and National Economic Growth: A Reappraisal"* Urban Studies 2005

P. Romer, *"Increasing Returns and Long Run Growth"* Journal of Political Economy 1986

R. Lucas, *"On The Mechanics of Economic Development"* Journal of Monetary Economics 1988

R. Lucas, *"Ideas and Growth"* Economica 2009

W. Baumol, *"Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show"* The American Economic Review 1986

J. Jacobs, *"The Economy of Cities"* New York: Vintage 1969

S. Ikeda, *"The Economy of Cities: Jane Jacobs's Overlooked Economic Classic"* The Independent Review 2020

H. Hall and C. Jones, *"Why Do Some Countries Produce So Much More Output Than Others?"* The Quarterly Journal of Economics 1999

F. Caselli, *"Accounting for Cross-Country Income Differences"* Handbook of Economic Growth 2005

Hsieh, Chang-Tai and P. Klenow, *"Development Accounting"* American Economic Journal: Macroeconomics 2010

L. Hendricks and T. Schoellman, *"Skilled Labor Productivity and Cross-Country Income Differences"* American Economic Journal: Macroeconomics

Y. Ben-Porath, *"The Production of Human Capital and the Life Cycle of Earnings"* Journal of Political Economy 1967

Nelson, Richard R., and E. Phelps *"Investment in Humans, Technological Diffusion, and Economic Growth"* 1966

P. Reichlin, *"Notes on Macroeconomic Theory"* LUISS University 2022

K. Raworth, *"Doughnut Economics"* Cornerstone 2017

Barro, Robert J., and Jong-Wha Lee, "*International Data on Educational Attainment"* Downloadable dataset 2001

Heston, Alan, R. Summers, and B. Aten, *"Penn World Table Version 6.1"* Downloadable dataset 2002

World Bank, *"United Nations Population Division. World Urbanization Prospects: 2018 Revision"* Downloadable dataset

World Bank *"National accounts data, and OECD National Accounts"* Downloadable dataset

Dataset on a country's latitude available on https://developers.google.com/public-data/docs/canonical/countries_csv

NASA, "*Population, Landscape, And Climate Estimates (PLACE), v3"* Downloadable dataset

World Bank, *"The Human Capital Index"* 2020

G. Mankiw, D. Romer and N. Weil, *"A Contribution to the Empirics of Economic Growth"* Quarterly Journal of Economics 1992

J. Diamond, "*Guns, Germs, and Steel: The Fates of Human Societies"* 1997

Acknowledgements

Last but not least, il mio grazie a quanti, con i loro suggerimenti e i loro consigli mi hanno accompagnato nel percorso di ricerca e nella stesura del presente lavoro.
In particolare, al prof. Pietro Reichlin, per essere stato guida attenta e paziente;
alla prof.ssa Giovanna Vallanti, costante punto di riferimento;
e al dottor Celso Brunetti per l'utile confronto nonostante la distanza "atlantica".