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The Accumulation and Utilization of Human Capital over the Development Spectrum

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Abstract

This paper reviews how human capital is accumulated and used over the process of development. It highlights that differences in worker productivity are the byproducts of a wide variety of investments happening at different stages of the life cycle, all subject to barriers in developing countries. Moreover, the effective use of human talent in the production process is a key mediator of the effect of human capital on development. It is also a driver of human capital accumulation itself. In light of this interplay between accumulation and utilization, the paper discusses the potential role of human capital in facilitating the adaptation to global challenges such as climate change, demographic transitions, and rapid urbanization.

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The Accumulation and Utilization of Human Capital over the Development Spectrum

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1 Introduction

Over the past few decades, human capital has been a central ingredient of the process of economic development. The XXth century has seen unprecedented increases in educational attainment across the world, as well as important improvements in the health and nutrition of the global population. Still, large cross-country gaps persist in several forms of human capital, and a growing literature in macro-development argues that these gaps contribute importantly to differences in the standards of livings between rich and poor countries (Rossi, 2020).

In which ways is human capital accumulated across different countries? Through which channels does human capital contribute to development? How is this contribution likely to change in the future? This paper provides a review of the academic literature relevant to these questions. Our aim is to offer a comprehensive overview of the multifaceted processes of the accumulation and utilization of human capital, highlighting the key challenges that countries at different stages of development face in promoting these processes and the roles of policy in alleviating these challenges. Our work complements and adds to several reviews on human capital and economic development, such as Klenow and Rodríguez-Clare (1997), Caselli (2010), Flabbi and Gatti (2018), and Rossi (2020), which are mostly focused on the measurement of the contribution of skills for cross- and within-country income gaps.

To set the stage for the rest of the paper, it is useful to start from a definition of human capital. Acemoglu and Autor (2011) define human capital as "any stock of knowledge or characteristics the worker has (either innate or acquired) that contributes to his or her productivity." Two aspects of this definition are worth noticing from the onset. First, human capital is a very broad concept, which include cognitive skills but also many other characteristics potentially affecting productivity, such as health and physical traits, personality, socio-emotional skills, tacit and explicit knowledge, culture, and so on. Second, the definition puts no restrictions on how and when these relevant characteristics are acquired. In other words, formal education is by no means the only way to accumulate human capital; on the contrary, human capital accumulation can start in utero and then take place throughout the whole life cycle, from early childhood to late adulthood.

Indeed, Section 2 reviews evidence supporting the idea that human capital gaps, both within and across countries, are due to differences in a variety of forms of investments. Individuals in low-income countries face stronger barriers to human capital accumulation throughout the life cycle, from before birth until old age, and these barriers reinforce each other due to dynamic complementarities between human capital investments. The resulting human capital gaps go well beyond cognitive skills, and include physical health as well as a variety of non-cognitive traits. From a policy perspective, a narrow focus on educational attainment is likely to be ineffective, given the variety of environments and stages of the life cycle (beyond schooling) where human capital is accumulated.

Section 3 argues that the effects of human capital accumulation on economic devel-

opment are crucially mediated by the way human capital is utilized in the production process. We discuss the key forces that shape the allocation of human talent across sectors, jobs, and firms, highlighting how the varying availability of high-skill labor affects the organization of production in rich and poor countries. Several frictions prevent an efficient allocation of talent in poor countries, partially jeopardizing the effectiveness of the accumulation of investments that have been taking place over the past few decades. Moreover, human capital accumulation is itself a function of opportunities for utilization, as new generations have stronger incentives to invest in skills that can be utilized properly in the production process.

In light of this interplay between accumulation and utilization, Section 4 concludes the paper by providing an outlook on the future importance of human capital for several mega-trends that are transforming the way production is organized. We argue that human capital will likely play an important role in shaping the effects of climate change, demographic change, and urbanization on the economy. More research is needed to identify the specific skills and traits that are more relevant for each of these trends, as well as the best ways to encourage their accumulation and effective utilization. Overall, these trends are all likely to increase the demand for highly specialized skills, which leads us to speculate that the XXI century will continue the human capital era.

2 How and when is human capital accumulated?

2.1 Conceptual Framework

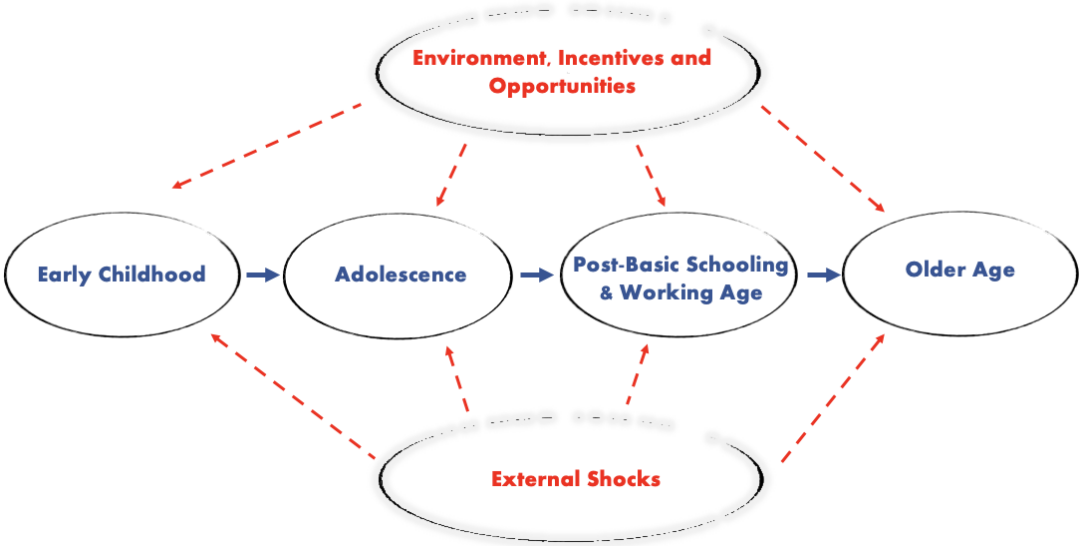
Human capital accumulates and multiplies across different stages over the life cycle (Figure I). The productive capacity of an individual is shaped by the skills and traits acquired in early childhood, during adolescence (through formal schooling and other channels), during the working age period (through tertiary education, vocational training, and learning on the job) and at older ages. This accumulation process applies both to cognitive skills and other forms of human capital, such as non-cognitive skills, health, and culture. A large empirical literature documents that the human capital accumulation process features dynamic complementarity, such that the skills accumulated at one stage affect the productivity of further investments undertaken at later stages. This implies that barriers to human capital accumulation at early stages of the life cycle are particularly costly. In addition, investments in human capital, such as improving health, nutrition, and education, have a multiplicative effect over time, as they not only enhance an individual's productivity and earnings potential, but also benefit future generations by creating a virtuous cycle of development.

At each stage, the accumulation of human capital is driven by expected returns and perceived costs. Both returns and costs depend on the economic environment, available opportunities, as well as a host of external shocks, as represented in Figure I. For example, individuals might choose to acquire less schooling when most employment opportunities are in

sectors with low skill requirements (low return), when the opportunity cost of child labor is high (high perceived cost), and when a war disrupts the economy and educational system (low return and high cost). In addition, the incentives to accumulate human capital today depend on future accumulation opportunities, given the dynamic complementarity of these investments. All these factors are likely to vary dramatically over the development spectrum, contributing to the correlation between various forms of human capital and economic development.

The next subsections review the existing evidence on some of the specific factors affecting human capital accumulation at each stage represented in Figure I, emphasizing whether and how they vary across countries. Given the broad scope in terms of the types of human capital investments being considered and the goal of keeping a cross-country perspective, this review abstracts from important issues on the practical implementation of each of these investments, on which the evidence is more scattered and country-specific.[1] Later in the paper (Section 3), the discussion will turn to how the utilization of the skills acquired at different stages shapes growth and development.

Figure I: Human Capital Accumulation over the Life Cycle



2.2 Early Childhood and Parental Inputs

Human capital accumulation starts before birth. An extensive literature suggests the course of fetal development and the quality of the in-utero environment are important determinants of health conditions and overall productivity later in life (Barker, 1990; Almond and Currie, 2011b). To establish causality, several papers study random shocks affecting pregnant mothers,

[1] This includes important issues on the delivery of formal education, such as the advantages and disadvantages of private and public provision.

such as pandemics (Almond, 2006), conflict (Lee, 2014), or family bereavements (Persson and Rossin-Slater, 2016), typically concluding that children of mothers affected by negative shocks are characterized by higher incidence of various diseases, lower educational attainment and poorer labor market outcomes during adulthood. Human capital differences due to pre-birth conditions plausibly contribute to exacerbate inequalities within and across countries, as disadvantaged households are generally more exposed to negative shocks and poor nutrition.

Early exposure to poor nutrition and diseases impairs human capital accumulation over the rest of the life cycle (Currie and Vogl, 2013). Policy interventions that provide food supplements to children in developing countries are often associated with large gains in terms of educational attainment and cognitive development, as shown for example in Field et al. (2009) for an iodine supplementation program in Tanzania and Maluccio et al. (2003) in the context of a randomized experiment providing high-protein drinks in Guatemala. In addition, eradication efforts for diseases such as malaria (Lucas, 2010) and pneumonia (Bhalotra and Venkataramani, 2011) are associated with life-time benefits in terms of schooling and earnings for cohorts covered by these programs during early childhood. These estimates might even understate the effects of improving nutrition and reducing exposure to diseases because of mortality selection, i.e., the idea that reductions in mortality might be associated with lower average health outcomes if relatively unhealthy individuals are more likely to die (Currie and Vogl, 2013).

In addition, there is growing evidence that pollution experienced during childhood is another key determinant of human capital formation. Several studies show that environments with strong exposure to carbon monoxide (Currie et al., 2009), lead (Troesken, 2008), and other airborne particulates (Chay and Greenstone, 2003) are associated with high infant mortality and low birth weight. The evidence (mostly from rich countries where long panels are more readily available) suggests that this early exposure also has long-term consequences. For example, Almond et al. (2009) find that Swedish children more exposed to radioactive fallout following the Chernobyl disaster perform worse in secondary school, while Ferrie et al. (2012) document adverse cognitive effects of early lead exposure for US Army enlistees. These sources of disruption to human capital formation are likely to be particularly important in developing countries, where levels of pollution are much higher than what was observed historically in the developed world (Currie and Vogl, 2013).

A large body of work establishes that skills acquired during early childhood have an important impact on adult outcomes (Almond and Currie, 2011a). A key reason for this is that investments in skills feature important dynamic complementarities: acquiring skills and preserving health early on facilitates the further accumulation of skills later on in the life cycle (Heckman and Mosso, 2014). The investments identified as important include the quantity and quality of parental time with children (Del Boca et al., 2013), the parental involvement in children's education (Heckman and Mosso, 2014) as well as the quality of other forms of childcare (Fort et al., 2020). These results highlight the importance of acting early to close

human capital inequalities, as investments in young adults lacking suitable foundations of basic skills are relatively less effective (Heckman and Mosso, 2014). The literature includes several evaluations of highly cost effective interventions; for example, García et al. (2020) show that two early childhood programs implemented in the United States in 1970s had sizeable positive impacts on the participants' education, health, and labor market outcomes over the life cycle. The benefits of these programs are even larger when their intergenerational effects are taken into account (Daruich, 2018; Garcia et al., 2021).

This literature highlights the important role played by noncognitive skills, such as self-confidence and discipline, which are found to foster subsequent cognitive development (Cunha et al., 2010). An implication of this is that mentoring and guidance directed at fostering character and personality skills are often important ingredients of successful early childhood interventions; for example, Heckman et al. (2013) show that most of the positive impact of a US pre-school program on adult outcomes is due to improvements in noncognitive skills. Importantly, noncognitive skills also appear to be relatively more malleable during adolescence and early adulthood, suggesting that remedial programs targeting these skills can be somewhat effective in closing existing gaps, even though earlier interventions lead to larger returns (Heckman and Mosso, 2014). Moreover, accounting for the effects on noncognitive skills is crucial to properly evaluate the effects of policies involving monetary transfers or tax credits for parents (Morchio, 2022).

While it is broadly accepted that early childhood inputs contribute to within country inequalities, the evidence is scarcer on whether they are also important to explain cross-country gaps. Schoellman (2016) shows that labor market outcomes of refugees arrived in the US during early childhood are independent of the age of arrival; in other words, spending an extra year in a rich country environment does not significantly boost the formation of early childhood human capital. On the other hand, parents in poor countries plausibly face stronger informational, monetary and more generally poverty-driven constraints that lead to under-investment in young children (Attanasio et al., 2021). Relatedly, De Philippis and Rossi (2021) document that parental influence contributes to cross-country differences in standardized test performance. More work is needed to evaluate the quantitative importance of parental inputs for overall human capital accumulation and economic development.

2.3 Adolescence

2.3.1 Formal Schooling

A large body of evidence shows that formal schooling is a key determinant of workers' productivity. Estimates of Mincerian regressions from several countries show that an extra year of schooling is associated with about 10% higher wages, with limited variation between rich and poor countries (Caselli et al., 2016). While in principle these correlations could reflect differences in unobserved ability, estimates based on instrumental variable strategies suggest

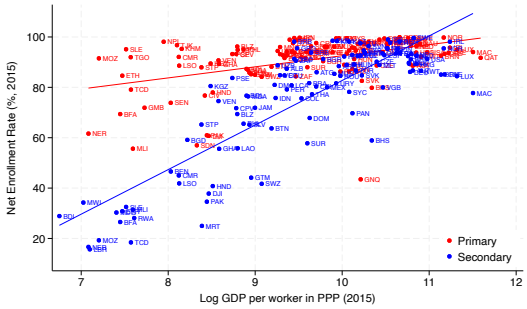
that the causal effect of schooling is of a similar magnitude (Card, 1999). Moreover, schooling is associated with a broad variety of desirable outcomes, such as lower crime (Lochner and Moretti, 2004), higher civic participation (Milligan et al., 2004), improvements in child health (Currie and Moretti, 2003), and higher wellbeing (Easterbrook et al., 2015).

Formal educational attainment varies substantially across rich and poor countries. Figure IIa displays the average years of schooling of the adult population against GDP per worker. In 2015, the average worker in Norway was a high-school graduate (about 12 years of schooling), the corresponding average worker in Mozambique had not completed primary education (about 3 years of schooling). While most countries are relatively close to universal enrollment in primary schools, large gaps remain for what concerns secondary school enrollment (Figure IIb). A large development accounting literature quantifies the contribution of these gaps in educational attainment in explaining cross-country income differences. The emerging consensus is that this contribution is limited: even low-educated workers in rich countries are much richer than high-educated workers in poor countries, leaving little space for the educational composition to account for income gaps (see Rossi, 2020, for a review).

Figure II: Educational Attainment and Development

(a) Average Years of Schooling

(b) Enrollment Rate

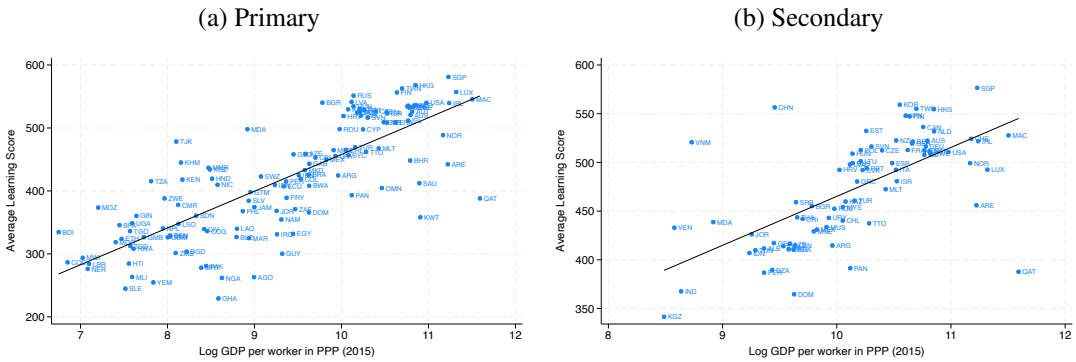


Notes: Panel (a) plots average years of schooling in the population above 25 against log GDP per worker (in PPP terms) in 2015. Panel (b) plots the net enrollment rate in primary and secondary school against log GDP per worker (in PPP terms) in 2015. Average years of schooling is taken from Barro and Lee (2013), the enrollment rates are from the World Development Indicators, while GDP per worker is from version 9.0 of the Penn World Tables (Feenstra et al., 2015).

More recent work, however, points to large gaps in learning achievements and educational quality across countries, which compound the effect of gaps in schooling quantity. Figure III displays the average learning scores of primary and secondary school students from the Harmonized Learning Outcomes Database (Angrist et al., 2021a), a collection of average scores in standardized tests administered across 164 countries, against log GDP per worker. Students in rich countries vastly outperform their peers in poor countries, conditional on a given level of educational attainment; as a result, the vast majority of the young generations in the developing world do not achieve the skills needed to participate effectively in modern economies (Gust et al., 2024). In addition, Singh (2019) exploits panel data to show that an

extra year of primary schooling is associated with larger learning gains in Viet Nam compared to other developing countries.[2] More broadly, large increases in educational enrollment in many developing countries have been associated with stagnant or even declining learning achievements by level of education (Pritchett, 2013; Le Nestour et al., 2023), highlighting the challenges brought by rapid educational expansions. Several studies argue that when quality differences are incorporated in the measurement of human capital, its contribution in accounting for cross-country income gaps can be substantially larger (see for example Schoellman, 2012; Angrist et al., 2021b).

Figure III: Average Learning Score and Development



Notes: The figure plots the average learning score for primary (left panel) and secondary school (right panel) students from the Harmonized Learning Outcomes Database (Angrist et al., 2021a) against log GDP per worker (in PPP terms) in 2015. The learning score is averaged across all available subjects and years. GDP per worker is taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015).

These results underline the need for effective investments making schools in poor countries well-equipped to deliver learning against the backdrop of a rapidly growing student population. The existing literature highlights a number of promising margins. Based on a comprehensive review of the evidence, the Global Education Evidence Advisory Panel (2023) concludes that improving classroom instruction through structured pedagogy and targeted support for students falling behind, and the provision of information on education quality are particularly cost-effective interventions. In many developing countries, it has been documented that teachers perform poorly in terms of both subject knowledge and exerted effort (Bold et al., 2017); in light of this, the returns to policies that train teachers and provide them with appropriate incentives are likely to be high (Kremer et al., 2013; Evans and Popova, 2016). New technologies could help by both complementing teachers' efforts and accommodating a growing and increasingly diverse student population; for example, Muralidharan et al. (2019) reports large performance gains associated with an instruction program that dynamically adapts the proposed content to the learning level of each student. More broadly, systemic reforms are

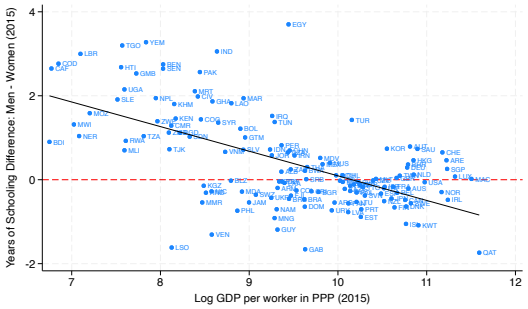
[2]Indirect evidence on the crucial role of school quality for human capital formation comes from the learning losses experienced by several countries during the pandemic, which were large and highly heterogeneous across countries (Hanushek and Strauss, 2024).

needed to ensure that all parts of the educational system are aligned with the goal of improving learning, overcoming political challenges and technical constraints that are often particularly severe in developing countries (Pritchett, 2013; World Bank, 2018).

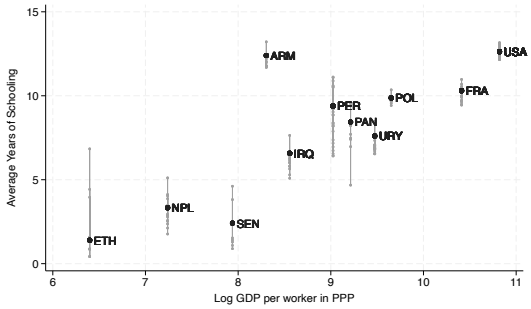
Within countries, access to formal education varies substantially across gender, location and socio-economic classes, contributing to inequalities across these groups. Figure IVa highlights the gender dimension, displaying the difference between men's and women's average years of schooling against GDP per worker. In most of the poorer countries, women are less likely to be educated than men, while this gap disappears or even reverses with development.[3] Figure IVb visualizes the extent of educational disparities across administrative units for countries at different deciles of the income distribution. Poorer countries feature very large gaps in average education between regions, while richer countries tend to be more homogeneous. In addition, the importance of the family's socio-economic status for children's educational achievements has been widely documented in several rich countries (Björklund and Salvanes, 2011), and its role might be even larger in poorer countries (though intergenerational data are less readily available for developing economies). These different sources of within-country heterogeneity highlight the importance of understanding the barriers faced by different groups in human capital accumulation and utilization, an issue discussed in greater detail in Section 3.

Figure IV: Schooling Gaps within Countries

(a) Gender Gap



(b) Across Regions



Notes: The left panel plots the difference in the average years of schooling in the population above 25 between men and women against log GDP per worker (in PPP terms) in 2015. The right panel plots (for countries belonging to the first to tenth deciles of the income distribution, plus the United States) average years of schooling in the population above 25, across regions (grey dots) and for the whole country (black dots), against the country's log GDP per worker (in PPP terms). Data on years of schooling by gender is taken from Barro and Lee (2013), years of schooling by region is from IPUMS International (, n.d.), while GDP per worker is taken from version 10.0 of the Penn World Tables (Feenstra et al., 2015).

[3]Evans et al. (2021) document that in most developing countries gender gaps in education have typically widened first (as boys started going to school) and then shrunk in a second phase (as educational expansions started involving girls as well).

2.3.2 Other Sources of Human Capital Accumulation

Diseases contracted during adolescence represent a significant obstacle to skill accumulation. Part of the reason for this is that sick children can hardly attend or learn at school. This idea is supported by the analysis of the experimental introduction of deworming treatments in Kenyan primary schools (Miguel and Kremer, 2004; Hamory et al., 2020a), which resulted in higher school attendance and cognitive performance for the treated children. Similarly, the eradication of malaria is typically associated with higher educational attainment and labor market outcomes for the exposed school-age children (Lucas, 2010; Barofsky et al., 2015); in a structural framework calibrated to replicate the effects of a large-scale anti-malaria campaign in Tanzania, Kim (2022) shows that taking into account human capital formation substantially amplifies the economic gains from a universal malaria vaccination. These results highlight the important complementarities between different sources of human capital accumulation.

In developing countries, child labor represents a significant barrier to human capital accumulation during adolescence. According to the International Labor Organization about 10 percent of the global child population is involved in child labor (International Labor Organization, 2020), which dramatically reduces learning opportunities by being associated to reductions in the time and energy dedicated to schooling as well as various health hazards (Basu, 1999; Edmonds and Pavcnik, 2005). Child labor is mostly a consequence of poverty, and is way more common among low-income households in developing countries with little access to credit. The potential returns of policies targeted at reducing child labor are very large, though simple bans, fines or compulsory schooling laws are difficult to enforce in developing countries and might actually backfire by lowering the equilibrium wage and inducing more children to work to meet their family's subsistence needs (Basu and Van, 1998; Edmonds and Pavcnik, 2005).

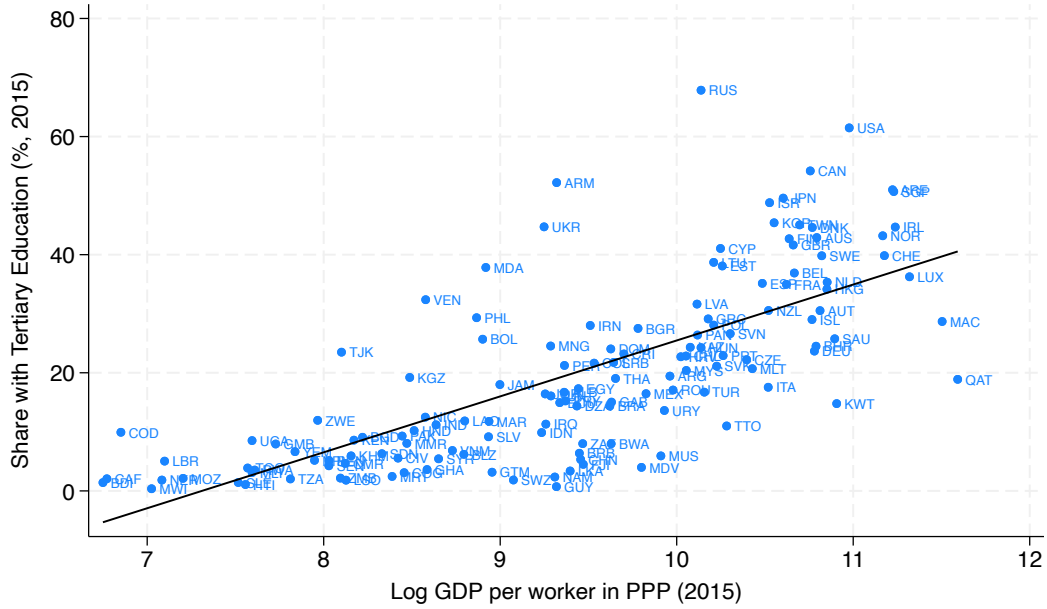
Children and young adults also learn directly from their peers. A large literature in economics documents positive associations between students' test scores and the ones of their peers, in particular when focusing on groups with similar socio-economic backgrounds and close friendships (Sacerdote, 2011; Hahn et al., 2019). These peer effects go beyond educational performance and extend to health outcomes (Giulietti et al., 2022), migration decisions (Munshi, 2020) and risky behavior (Lindquist and Zenou, 2019), therefore shaping human capital accumulation in multiple forms. In light of this evidence, the effects of all the barriers to human capital accumulation typical of developing countries are likely amplified by the fact that they not only harm individual children, but also their peers.

2.4 Post Basic Schooling and Working Age

2.4.1 Tertiary Education

The prevalence of tertiary education varies dramatically across countries. As shown in Figure V, tertiary educated workers are virtually absent in poor countries, while they represent half or more of the working age population in the richest countries. The rise of upper tail knowledge is thought to have played an important role in the historical development process of currently rich countries, by facilitating innovation and the adoption of new technologies (Mokyr, 2002; Squicciarini and Voigtländer, 2015). Today, in many countries inventors, entrepreneurs and executives in leading firms are educated disproportionately in a small set of universities (Bell et al., 2018; Levine and Rubinstein, 2016; Martellini et al., 2022).

Figure V: Tertiary Education and Development



Notes: The figure plots the share of the 25-64 population with some tertiary education against log GDP per worker (in PPP terms) in 2010. Data on educational attainment is taken from Barro and Lee (2013), while GDP per worker is taken from version 10.0 of the Penn World Tables (Feenstra et al., 2015).

Recent work shows that the quality of tertiary educated workers also varies substantially across countries. Martellini et al. (2022) use data on the earnings of migrants across many host and origin countries to show that those educated in universities in developing countries earn less than their peers from rich countries, everything else equal. Moreover, migration reinforces cross-country differences in the quality of the tertiary educated labor force, as migrants from poor to rich countries are positively selected in human capital. These results reinforce the conclusion (already discussed for primary and secondary schooling in Section 2.3.1) that closing educational gaps between countries requires more than increasing enrollment in the developing world.

The low prevalence of tertiary education in the developing world also reflects a lack of demand for the types of skills acquired in universities. As discussed in greater detail in Section 3, the demand for advanced skills is higher in environments with large and modern firms, complex technologies, and a low prevalence of agriculture, which are all features typical of rich countries. Standard growth models predict that countries closer to the productivity frontier rely more on innovation, an activity performed by highly skilled workers, while countries at early stage of development can grow out of imitation and investment-based strategies (Acemoglu et al., 2006). However, the accumulation of advanced skills can also initiate a virtuous cycle of firm creation and structural transformation towards modern sectors. This view is supported by the findings in Cox (2023) and Coelli et al. (2023), showing that policy-induced expansions in the provision of higher education result in an increase in firm size and a reallocation of labor away from agriculture and towards manufacturing or skill-intensive services in the most affected regions.

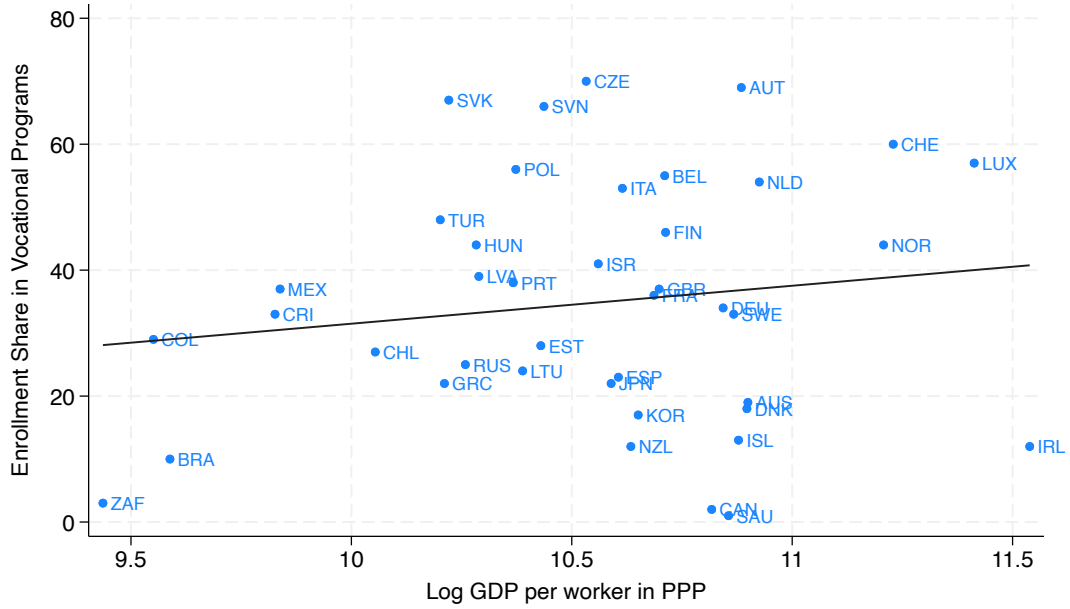
2.4.2 Vocational Training

Vocational training refers to a variety of educational programs aiming to prepare students for a particular craft or trade. The prevalence of vocational education varies substantially across countries. Figure VI displays the share of upper secondary students enrolled in vocational (as opposed to general) training, against GDP per worker. In some countries vocational programs represent the norm at the secondary level, while in others they are virtually nonexistent. There does not appear to be a strong relationship with the level of development, though the overall enrollment rate in secondary education is higher in rich countries. This implies that the overall enrollment share in vocational education with respect to the schooling-age population is higher in those countries.

Vocational education appears to facilitate the school-to-work transition. Zimmermann et al. (2013) reviews various studies documenting how the participation to occupation-specific training is associated with lower youth unemployment and higher labor market attachment at the beginning of workers' career, with the effects on wages being more mixed (Ryan, 2001; Brunner et al., 2021). Importantly, vocational education can also act as a leveler of the playing field, by allowing a relatively larger improvement of the labor market outcomes of disadvantaged students (Bertschy et al., 2009).

However, vocational education might involve a trade-off between short-run gains and long-run losses. At times of rapid transformation of the labor market, the specific skills acquired through vocational programs might become obsolete relatively quickly, while more general education insures against this possibility by providing a stronger ability to adapt. In line with this hypothesis, Hanushek et al. (2011) shows that across 11 rich countries individuals with general education obtain worse labor market outcomes at entry, but gradually catch up and overtake their peers with a vocational education background. This result underscores the

Figure VI: Enrollment in Vocational Training across Countries



Notes: The figure plots the share of upper secondary students aged 15-19 enrollment in vocational programs in 2019, against the country's log GDP per worker (in PPP terms) in 2019. Enrollment by program orientation is taken from OECD (2022), while GDP per worker is taken from version 10.0 of the Penn World Tables (Feenstra et al., 2015).

more general theme that the appropriateness of general and vocational education is context-specific, with faster technological process and higher labor market uncertainty favoring the accumulation of general skills, and increases in the division of labor favoring specialization (Alon, 2018; Alon and Fershtman, 2023).

2.4.3 On the Job Accumulation

The accumulation of human capital on the job is an important determinant of wage growth over the life cycle. Such accumulation is facilitated by both formal training programs provided by firms (Acemoglu and Pischke, 1998), as well as more informal learning opportunities associated with work experience (Bagger et al., 2014). Within countries, firms are heterogeneous in the quality of the learning environment they offer; for example, firms with more knowledgeable co-workers, (Jarosch et al., 2021) involved in exporting activities (Ma et al., 2020), of larger size (Arellano-Bover, 2020) and located in big cities (De La Roca and Puga, 2017) allow their workers to achieve faster human capital growth.

The rate of wage growth over the life cycle is significantly higher in rich countries. Lagakos et al. (2017) document this fact for 18 countries; while wages roughly double over the life cycle in countries like Germany and the United States, they only increase by about 50% in poorer countries like Jamaica and Mexico. Jedwab et al. (2021) extend this result to a broader and more diverse sample of 145 countries. While higher returns to experience in rich countries might also reflect lower labor market frictions and a more experience-biased organization

of production, several pieces of evidence point to human capital as an important driver. For example, Lagakos et al. (2018) show that, among US immigrants employed in the same labor market, the returns to experience are lower for those coming from poor countries, suggesting that the cross-country variation in life cycle growth is not entirely driven by technological and institutional factors. Moreover, Jedwab et al. (2021) show that experience accumulated under a subsequently overturned Communist regime has lower returns, consistently with the value (or obsolescence) of acquired skills being a determinant of returns to experience.

Lower life cycle growth might be the endogenous response to lower returns to human capital investments in poor countries. Seshadri and Manuelli (2014) develop a model where the accumulation of human capital during the early childhood, schooling and post-schooling phases is the outcome of an income maximization problem. Their analysis show that relatively small increases in total factor productivity, reflected into higher wage rates and lower relative prices of goods used as inputs for the production of human capital, can lead to large differences in human capital per worker, with pre- and post-schooling investments both playing a quantitatively important role. Ma et al. (2021) focus on the role of firm-provided training programs: first, they document empirically that such programs are relatively more common in rich countries; second, their quantitative model suggests that a key reason for this is the higher job turnover in poor countries, which depresses firms' incentives to invest resources in the training of their current workers.

2.5 Older Ages

Population aging calls for continued investments in human capital at older ages. As populations around the world age, understanding the dynamics of human capital accumulation in old age becomes crucial. In contrast to traditional notions that suggest a decline in productivity and skill acquisition in later life, recent studies reveal an encouraging trend of continuous human capital development among more mature workers. By debunking stereotypes and recognizing the value of mature workers, (aging) societies can leverage their skills, experience, and expertise for continued economic development and growth.

Potentials of learning later in life challenge stereotypes of diminished learning abilities while opening new opportunities. Contrary to popular belief, studies show that older adults can acquire new skills and knowledge effectively, challenging the stereotype of diminished learning abilities in old age. Lifelong learning programs and targeted training initiatives have been successful in enhancing the human capital of older individuals, enabling them to adapt to evolving job requirements (Jenkins, 2003; Fleming, 2011; UNESCO, 2022). Older adults who engage in learning activities have higher cognitive function. For example, Park and Bischof (2022) finds that older adults who participated in intellectual activities, such as reading, puzzles, and learning new skills, experienced slower cognitive decline compared to those who were less engaged. This suggests that continued learning in later life contributes to maintaining cognitive

abilities.

Tapping into the experience and expertise of older workers can enhance productivity and economic performance while also benefiting younger cohorts. Older workers furthermore possess a wealth of experience and expertise accumulated over their careers, making them valuable assets to organizations. Research indicates that age-related changes, such as improved problem-solving abilities and enhanced decision-making skills, can compensate for potential declines in cognitive functioning (Ng and Feldman, 2013). These characteristics contribute to the productivity and overall performance of mature workers. Furthermore, the transfer of knowledge from older to younger workers enhances organizational performance. The expertise and experience of older workers, when effectively shared, contribute to the overall success and competitiveness of businesses (Harvey, 2012; Dietz et al., 2022).

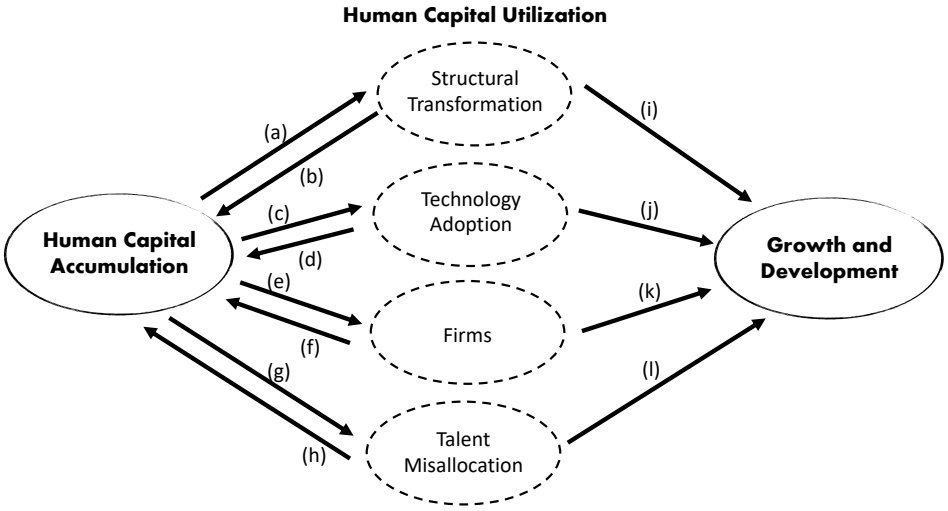
3 Human Capital Utilization and the Organization of Production

3.1 Conceptual Framework

Figure VII displays a conceptual framework on the links between the accumulation and utilization of human capital and growth and development. Traditionally, the macro-development literature postulates that human capital increases workers' productivity, and therefore directly shapes growth and development. For example, the development accounting approach relies on the cross-sectional dispersion in wages among workers with different levels of education and experience, or alternatively among migrants from different countries, to measure the underlying variation in average skills, and its contribution to cross-country income gaps. Moreover, quantitative structural models are typically used to study the extent to which human capital accumulation itself is driven by economic development (see Rossi, 2020, for a review of both accounting and structural approaches).

More recent work emphasizes the importance of human capital utilization as a mediating factor of the link between human capital and economic development. The heterogeneity in the utilization of skills across firms, occupations, sectors and tasks demonstrates that human capital confers comparative advantages for some economic activities over others, suggesting that changes in the set of skills supplied by the labor force might drive economic development through changes in the organization of production. Moreover, various features of the organization of production are likely to affect in turn the incentives to accumulate human capital in the first place. The next subsections review the existing evidence on the forces shaping the utilization of human capital across various types of economic activities and organizations, illustrating the evidence supporting the channels represented by the arrows in Figure VII.

Figure VII: Human Capital Utilization and Development



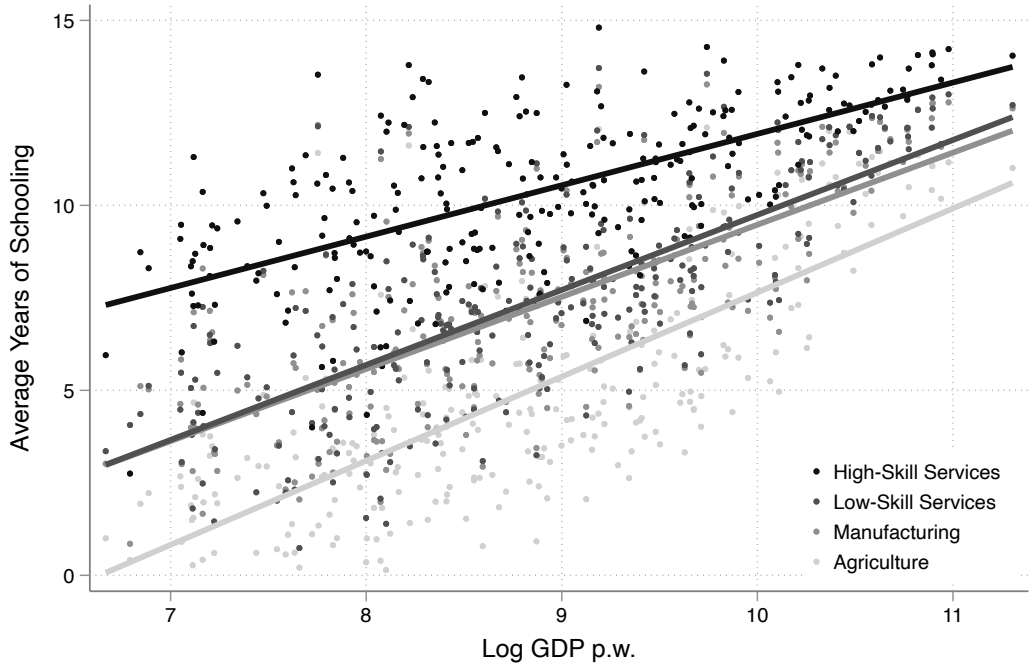
3.2 Structural transformation

Human capital is not equally distributed across sectors and space. Across multiple countries, highly educated workers are less likely to work in agriculture and live in rural areas (Gollin et al., 2014; Young, 2013), and more likely to work in skill-intensive services such as education, finance, public administration and health (Herrendorf and Schoellman, 2017).[4] Figure VIII visualizes this pattern by plotting average years of schooling across four broadly defined sectors against GDP per capita. High-skill services is the most schooling intensive sectors, followed by low-skill services and manufacturing, and then agriculture. Interestingly, these cross-sectors differences in schooling are largest in poor countries and tend to diminish with development.

Returns to education are generally larger in sectors with many highly educated workers and urban areas. Herrendorf and Schoellman (2017) document across 13 countries that an additional year of schooling is associated with a significantly larger increase in wages in outside of agriculture compared to agriculture. Figure IX makes use of the World Bank I2D2/GLD database to generalize this finding to a larger sample of country - on average, the return to schooling is 9% in non-agriculture and 7% in agriculture. One caveat for these comparisons is that many agricultural workers in poor countries are self-employed, and as such are not in-

[4]Moreover, when focusing on workers moving across sectors, the more educated agricultural workers are more likely to leave agriculture, while the less educated non-agricultural workers are more likely to move to agriculture (Young, 2013; Hamory et al., 2020b).

Figure VIII: Years of Schooling by Sector



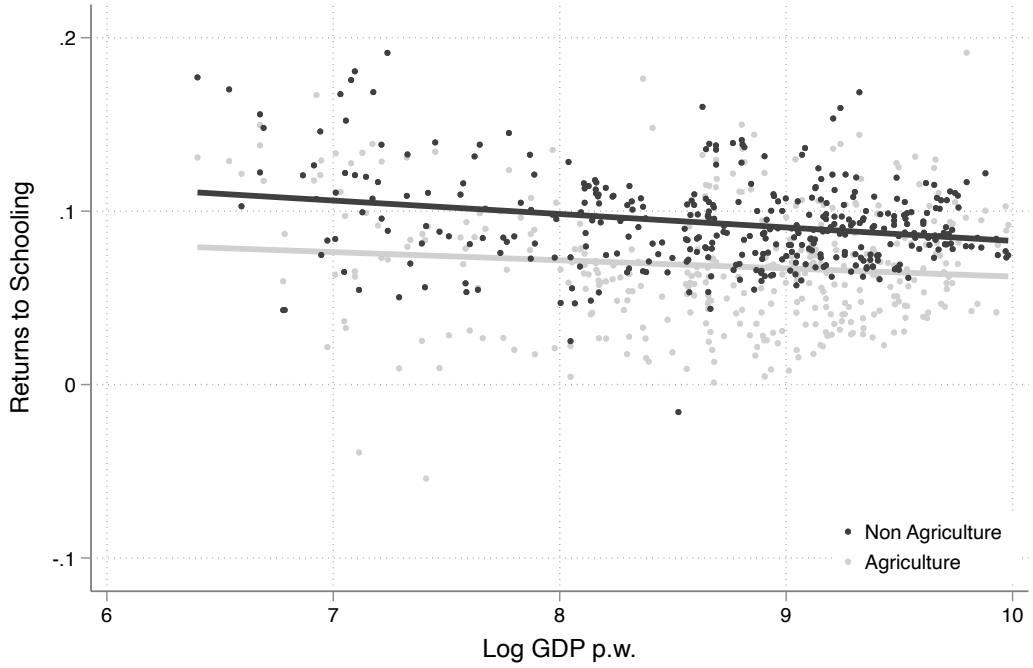
Notes: The figure plots average years of schooling by sector for all country × year pairs in IPUMS International, against GDP per worker from version 9.0 of the Penn World Tables (Feenstra et al., 2015).

cluded for the computation of agricultural wages. However, the estimated returns to schooling are not dramatically affected when computed using self-employed income as well (Herrendorf and Schoellman, 2017; Rossi, 2022).

New cohorts are disproportionately more likely to work outside agriculture, contributing significantly to structural transformation out of agriculture (Schoellman and Hobijn, 2017; Porzio et al., 2022). Porzio et al. (2022) show that a key reason for this is that more recent cohorts are typically more educated, which gives them a comparative advantage in non-agriculture. Human capital growth across cohorts is both a cause and a consequence of structural transformation; on one hand, the entry of more educated cohorts allows the non-agriculture sector to expand (Figure VII.a), while on the other the increase in the demand for agricultural labor driven by technological change and income effects incentivizes the accumulation of human capital (Figure VII.b). These conclusions are consistent with a broader literature arguing that the expansion of formal education is a key ingredient of the transition from stagnation to growth (Galor, 2005).

Overall, these findings describe a complex relationship between human capital, structural transformation, and economic development. While human capital growth is a potential tool to accelerate the economy wide transition out of agriculture, a crucial factor is given by the extent to which the labor market is able to absorb an increase in the supply of highly educated workers. Barriers to the growth of advanced skill-intensive sectors are likely to limit the productivity effects of educational expansions, leading to an inefficient utilization of human

Figure IX: Returns to Schooling by Sector



Notes: The figure plots the estimated sector-specific coefficient on years of schooling from a regression with log wage income as dependent variable against log GDP per worker (in PPP terms). Each dot corresponds to a different country × year sample. The estimation is performed on the World Bank I2D2/GLD database, while GDP per worker is taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015).

capital. This would result in skills mismatch, workers' frustration, and lower returns to human capital investments. In addition, given that agriculture is the sector displaying the largest productivity differences between poor and rich countries (Caselli, 2005), facilitating the reallocation of workers away from this sector through human capital accumulation might support economic growth in the developing world (Figure VII.i).

3.3 Technology Adoption

Human capital is a key driver of both the invention and the adoption of new technologies (Figure VII.c). One reason for this is that understanding new technology developments and adapting to changes in the production process require advanced skills, which are typically acquired through education and experience (Nelson and Phelps, 1965). The literature has offered several pieces of evidence in support of this idea. For example, Ciccone and Papaioannou (2009) show that countries with higher levels of education in 1980 saw faster growth in human-capital-intensive industries (relative to other industries) in the following decades, a period characterized by the ICT revolution and the rapid introduction of skilled labor augmenting technologies. Consistently with this idea, Maloney and Caicedo (2022) show that countries with a larger share of engineers in 1900 are characterized by faster technology adoption historically and higher levels of income per capita today. At a more micro level, Foster and

Rosenzweig (1995) document that Indian farmers with more experience or more experienced neighbors were more likely to adopt the high-yielding varieties associated with the Green Revolution. Given the important role played by technological change for economic growth (Figure VII.j), this makes human capital a key proximate driver of economic development.

Recent work argues that younger generations play a particularly important role for technological diffusion. A fundamental reason for this is that new cohorts, in particular those at the formal education stage, have far more flexibility and malleability in the acquisition of new skills compared to older workers. When new technologies require a fundamentally different set of skills compared to the existing ones, their diffusion and consequent adjustment of the labor market can take several decades, as new cohorts acquire the necessary skills (Chari and Hopenhayn, 1991). In recent work, Adao et al. (2022) show that the ICT revolution is an example of a technological innovation which required very specific skills, and hence unfolded more gradually compared to the improvements in manufacturing productivity of the early 1900s. More generally, most recent forms of technological change have plausibly increased returns to skills (Acemoglu, 2002), providing a further incentive to acquire further human capital (Figure VII.d).

3.4 Firms

Economic development is associated with a dramatic transformation of the organization of production. Most workers in developing countries are self-employed, while firms generally employ few workers, operate in a single establishment, and are characterised by limited growth over time (Gollin, 2008; Hsieh and Klenow, 2014) On the contrary, a large part of the labor force in rich countries is employed in large multi-establishment corporations, with complex organizational structures (Poschke, 2018; Garicano and Rossi-Hansberg, 2015).[5] The macro-development literature traditionally focuses on the relaxation of financial frictions and technological change as potential causes of this transformation of the production landscape (Gollin, 2008; Buera et al., 2015; Poschke, 2018), which in turn is associated with productivity growth and economic development (Figure VII.k).

More recent work highlights the role of human capital in facilitating the rise of large and modern firms (Figure VII.e). Gomes and Kuehn (2017) point out that at the country level the share of secondary educated workers is positively correlated with firm size, even when controlling for proxies of financial development and institutional quality, and proposes a theory where more educated managers are able to grow larger firms. Seshadri and Roys (2014) and Guner et al. (2018) consider models with endogenous human capital accumulation, and show that higher productivity and lower barriers to firm growth incentivize the accumulation of managerial skills over the life cycle (Figure VII.f), which in turn is an important driver of

[5]Firms are also highly heterogeneous within countries, and this heterogeneity contributes to worker earnings' inequality (Song et al., 2019; Tomaskovic-Devey et al., 2020). More work is needed to characterize the evolution of firm heterogeneity and its contribution to inequality over the process of development.

cross-country differences in the firm size distribution and productivity. The hypothesis that the availability of managerial know-how grows with economic development is supported by the evidence in Hjort et al. (2022), which exploits data from a global consulting company to show that the relative remuneration of middle managers is much higher in poor countries.

More generally, a growing literature documents the key role played by managers for firm-level performance. The World Management Survey has collected detailed firm-level information on managerial practices over the past two decades, showing a wide variation across firms and countries closely associated to differences in productivity (Bloom and Reenen, 2007; Bloom et al., 2014). Moreover, the randomized controlled trial in Bloom et al. (2013) supports the existence of a causal relationship between managerial practices and performance, as plants that were randomly provided with free managerial consulting saw faster growth in total factor productivity and a persistent increase in the probability of adopting modern management practices. Consistently with the literature on human capital and firms discussed above, managers' education and know-how are commonly found to be positively associated with more effective managerial practices and firm-level upgrading (Bloom et al., 2014; Verhoogen, 2021).

3.5 Misallocation of Talent

A key factor mediating the impact of human capital on economic performance is the allocation of talent. It is self-evident that workers vary widely in their comparative advantage for different occupations and tasks, as a function of their education, experience and idiosyncratic ability (Figure VII.e). Models of occupational choice such as Roy (1951) make it clear that frictions that prevent workers from pursing their comparative advantage are detrimental to aggregate productivity, partially undermining the positive effects of investments in the accumulation of skills (Figure VII.l). A growing literature attempts to quantify the extent of the misallocation of talent and associated productivity losses in various contexts.

Several studies emphasize the misallocation resulting from discrimination and social norms against specific demographic groups. Hsieh et al. (2019) documents that the occupational distribution of women and black men has changed dramatically in the United States since the 1960s, and concludes that the relaxation of the labor market barriers faced by these groups can explain between 20% and 40% of the observed economic growth. Ashraf et al. (2022) exploit personnel data from a multinational firm active in many countries to show that women's wages are higher for countries with lower female labor force participation, consistently with the idea that these labor markets are characterized by larger barriers faced by women (and hence more positively selected female workers). Hurst et al. (2021) provides more evidence on the barriers faced by black workers, showing that in the United States the discrimination against this group is stronger for occupations involving interaction with others, suggesting that the growing demand for these tasks might underlie the stagnation of the wage race gap since the 1980s. It is plausible that the relaxation of these barriers might itself encourage human capital

accumulation (Figure VII.h), though it is challenging to establish this link empirically.

The inequality of opportunities induced by differences in economic backgrounds is also an important source of talent misallocation. Bell et al. (2018) document that in the United States the probability of becoming an inventor is strongly related to parental socio-economic characteristics, suggesting that there might be many "lost Einsteins" in the poorer segments of society, i.e. individuals with high innovative potential who are prevented from creating innovations by their socio-economic background. A similar theme emerges from the development literature on poverty traps, which highlights how in the presence of capital market imperfections the distribution of wealth can shape the allocation of talent across different economic activities and economic growth (Banerjee and Newman, 1993; Galor and Zeira, 1993). Balboni et al. (2021) provide evidence for this mechanism through a randomized transfer of cows in Bangladesh, by showing that households treated with a large enough transfer are more likely to start their own business and grow out of poverty.

4 Global challenges and the future of human capital

4.1 Climate Change

The anthropogenic emissions of carbon into the atmosphere are causing dramatic changes in the climate of our planet. A growing literature is debating the economic consequences of this process. Global warming is likely to reduce labor productivity - particularly so in agriculture - and to induce migration flows and shifts in the geographic distribution of economic activities (Dell et al., 2014; Cruz and Rossi-Hansberg, 2021; Feriga et al., 2024). The rise in sea levels might lead to coastal flooding and the associated destruction of physical capital and infrastructure, as well as growing migration towards inland areas (Balboni, 2019; Desmet et al., 2021). More frequent natural disasters might slow down growth by destructing productive capital and reducing the incentive to accumulate it (Hsiang and Jina, 2014). Given their geographical characteristics and strong specialization in agriculture, it is likely that poor countries will be hit hardest by these trends, which is particularly alarming as these countries are the least prepared (in terms of fiscal space and institutional quality) to deal with such shocks.

Human capital might play an important role in facilitating the reallocation of labor made necessary by climate change. The evidence from Porzio et al. (2022) discussed in Section 3.2 shows that more educated workers are better positioned to leave the agriculture sector, which is the hardest hit by global warming, and join less climate-dependent sectors.[6] Moreover, highly educated individuals are generally more geographically mobile, which makes them potentially more resilient to climate shocks hitting specific regions (Burzyński et al., 2021). More work is needed to establish whether the labor reallocation facilitated by human

[6]Though it is important to recognize that climate-driven productivity losses are not limited to agriculture (Dell et al., 2014).

capital growth can be considered a quantitatively important adaptation strategy.

Human capital might also contribute to the reduction of carbon emissions through technology adoption, behavioral change and the political process. As discussed in Section 3.3, high-skill individuals are crucial for both the invention and adoption of new technologies, suggesting that a more educated labor force might contribute directly to the diffusion of green innovation (Acemoglu et al., 2016). Moreover, survey evidence shows that more educated citizens are both more aware of climate change issues and more supportive of policies aimed to mitigate its impact (Dechezleprêtre et al., 2022). Using compulsory schooling laws as a source of exogenous variation, Angrist et al. (2023) show that an extra year of education is causally associated with more pro-climate beliefs, behaviors, and policy preferences. The ongoing process of educational expansion might therefore contribute to creating a stronger constituency for more ambitious climate policies.

4.2 Demographic Change

The demographic composition of the labor force is changing rapidly throughout the world. Due to a combination of lower fertility and mortality rates, the average worker is becoming older in both poor and rich countries. The implementation of policies aimed at widening contraception provision and changing cultural norms on family size have led to a particularly fast decline in fertility in developing countries (de Silva and Tenreyro, 2017), whose demographic structure is projected to converge to the one in rich countries within this century.

Existing studies argue that the demographic composition of the labor force has important macroeconomic consequences. Feyrer (2007) shows that a larger proportion of workers in the 40-49 age bracket is associated with greater productivity, which Feyrer (2011) argues to be due to the higher managerial talent of middle-aged workers. Population aging might hurt economic growth by reducing startup entry and labor market dynamism (Karahan et al., 2019; Peters and Walsh, 2021), while it might increase it by promoting the adoption of labor saving technologies such as robots (Acemoglu and Restrepo, 2022). Moreover, the endogenous growth literature highlights that the rate of population growth is an important determinant of the rate of discovery of growth-enhancing ideas, through a scale effect in the innovation process (Jones, 2022).

Increasing utilization of human capital of older individuals can foster economic growth and productivity levels while alleviating labor shortages. Increasing labor force participation among older individuals has been observed in many countries, with individuals choosing to work longer due to financial necessity, personal fulfillment, or both (Coe et al., 2012). This trend presents an opportunity to tap into the human capital of older workers, fostering economic growth and alleviating potential labor shortages in aging societies (Isele and Rogoff, 2014). Research by Ng and Feldman (2013) reveal that older workers tend to have higher job satisfaction levels compared to their younger counterparts. Additionally, mature workers

demonstrate higher productivity and commitment to their work, attributed to their experience, work ethic, and sense of purpose. Older adults are also engaging in entrepreneurship at higher rates, utilizing their accumulated knowledge and experience to start businesses. Studies suggest that senior entrepreneurs have a higher likelihood of entrepreneurial success compared to their younger counterparts (Zhao et al., 2021). Among others, age has a positive effect on firm size and financial success. Encouraging entrepreneurship among older individuals can contribute to job creation. Still, research suggests that the development of entrepreneurial human capital should ideally start early in life, beginning with teaching adolescents a wide variety of skills and engaging youth in multiple activities (Krieger et al., 2021).

The effects of population aging are likely to be shaped by differences in the human capital accumulated by younger and older workers. For example, the evidence reviewed in Sections 3.2 and 3.3 suggesting that young cohorts are key drivers of structural change and technology adoption implies that an older labor force may be less adaptable to changes in the productive landscape. Moreover, a longer lifespan for many workers suggests a growing importance of skill accumulation over the life cycle, the pace of which (as reviewed in Section 2.4.3) is highly heterogeneous across countries. More work is needed to shed light on the optimal design of training programs and other policy initiatives aimed at boosting and updating the human capital of older workers.

4.3 Urbanization

The world is urbanizing at a rapid pace. Since 2007, the number of people globally living in cities is larger than the one living in rural areas; by 2050, the urban share is projected to reach two-thirds of the global population (United Nations, 2018). Historically, urbanization has been associated to economic development and structural transformation (Michaels et al., 2012; Henderson, 2010). However, developing countries are currently urbanizing at an unprecedented pace, so that most of the world's largest cities today are located in relatively poor countries (Jedwab and Vollrath, 2019). A large body of work documents that urban areas in present times are typically characterized by higher consumption and income (Young, 2013; Gollin et al., 2014).

In light of the evidence reviewed in the previous sections, it is plausible to postulate that human capital growth has been a driver of urbanization. As discussed in Section 3.2, more urban sectors such as manufacturing and services are relatively skill-intensive compared to agriculture, and the growing availability of educated labor has likely contributed to structural transformation and the associated reallocation from rural to urban areas. Moreover, given the role of skills in promoting technology adoption discussed in section 3.3, human capital growth might have contributed indirectly to urbanization by spurring economic growth and hence increasing the demand for mostly urban-produced goods and services.

In addition, the existing evidence suggests that cities represent favorable environments

for human capital accumulation. Using data from Spain, De La Roca and Puga (2017) show that workers living in bigger cities see faster growth in earnings over the life cycle, consistently with the view that they acquire more valuable experience; this conclusion is supported by the evidence in Eckert et al. (2022), which leverages the quasi-random allocation of refugees across local labor markets in Denmark. In the context of developing countries, Monge-Naranjo et al. (2018) argue that the formation of slums (a key driver of urban growth in many countries) has accelerated human capital accumulation and provided a stepping stone to low-income households.

At the same time, both developing and developed countries face several challenges in ensuring that cities remain environments where human capital can easily form and thrive. The living conditions and standards of urban services are still very low in the developing world, which might constitute a barrier to skill accumulation and participation in urban labor markets. Another key issue is represented by the growth in residential segregation by income, which is amplified by and contributes to differences in educational opportunities across neighborhoods (Fogli and Guerrieri, 2019). Tackling these issues is crucial for urbanization and human capital growth to continue to be as intertwined as they have been in the recent past.

5 Conclusions

The research presented in this paper provides some important lessons for the role of human capital for economic development. First, the accumulation of human capital is a dynamic and multifaceted process, which involves different types of investments across all stages of the life cycle, as well as the accumulation of a wide variety of skills and traits. Individuals in developing countries face significant obstacles in all these dimensions, calling for a holistic approach when designing human capital policy for economic development. Increasing educational attainment is only one of the many possible margins for policy action in this context, and likely not very effective if not associated by improvements in educational quality and the relaxation of barriers to the accumulation of other complementary forms of human capital.

Second, there is growing evidence that the way human capital is utilized in practice shapes the extent to which its accumulation is reflected in a stronger economic performance. The accumulation of different forms of human capital represents both a cause and a consequence of structural changes associated with economic development, such as the reallocation of labor across sectors, occupations, and firms, as well as the adoption of new technologies. Barriers to these processes, such as those often encountered in developing countries, partially undermine the potential gains associated with human capital growth by preventing an efficient utilization of talent. This underscores important complementarities between policies targeting human capital accumulation and those aiming at removing obstacles to firm growth and labor mobility.

Third, several mega-trends will shape the global economic environment over the next century, likely leading to important transformations in the organization of production and the allocation of resources across different economic activities. The existing evidence suggests that human capital might be an important factor mediating the effects of these transformations, by facilitating adaptation and allowing to seize the opportunities brought about by new productive environments. However, more research is needed to understand which specific forms of human capital are going to be more important in this context, and how policy can facilitate their accumulation and efficient utilization.

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