Future of the Labor Market: Labor Mobility or I, Robot

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The slow economic growth combines disappointing productivity growth in the past two decades with a continual rise of inequality in the past four decades. In the United States and European countries, a key characteristic of the evolution of inequality has been employment and wage polarization. As employment grows, wage grows in a U-shaped form in relation to skill level. The highest gains are in the upper tail, modest gains in the lower tail, and significantly smaller gains in the median. The turning of the lower tail of the wages and employment distributions is largely defined by growing wages and employment in only "service occupations" (Autor and Dorn 2013). The U-shaped evolution of labor demands and the future demographics of the rich industrial countries imply that if there is continued labor demand growth at the left side of the U, there will not be enough native-born workers willing and able to do the low-education work. Innovation is considered to have a low impact when Total Factor Productivity growth is relatively slow. Hence, automation is not likely to solve this any time soon. The technology required to replace workers in low-education service occupations is far more advanced than the current state of technology advances. On the other hand, a key policy priority for low-income countries with rapidly growing youth populations is how to provide low- and medium-level skill occupations for their youth. At the same time, the highest skilled talent in the rich industrial countries is making that job harder through automation and labor-saving technologies. Labor mobility can solve both problems by having adequate workers in high-income countries filling low-education jobs and providing jobs for the youth of low-income countries. Regardless of the effects of labor mobility on economic growth, it would address those fundamental causes and create a more equitable and better-educated society, with higher labor participation rates for women and new sources of tax revenues to address the fiscal headwind and pay for high-priority government programs.

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1 Introduction

The current trend of demand revolutions and demographic changes, including aging and low labor force participation growth rate, is resulting in the issue of labor scarcity in low-education service occupations. Also, the slow total factor productivity (TFP) growth rate results in less likelihood of innovation and technology to address labor scarcity in the near future. These trends highlight the slow economic growth in the rich industrial countries and put TFP under stress in the coming years. Additionally, they hinder development in developing countries.

In this paper, I discuss the issues and solutions of low-education labor scarcity in high-income countries and how all can be on the right side of history and create an economy that can work for everyone.

2 What is Happening in the World?

Between 1770 and 1870, economic growth was slow. The United States then experienced outstandingly rapid economic growth in the revolutionary century ending in 1970. However, following 1970, economic growth slowed. In the late 1950s, starting with the first mainframe computers, the digital age of information and communication technology (ICT) started the third industrial revolution. The second industrial revolution was more far-reaching than the third industrial revolution. The former transformed the manufacturing and production technologies, whereas the latter reshaped information communication and had little to no effect on most categories of personal consumption expenditures, e.g., food, clothing, housing, transportation, retail products, health care, education, personal care, etc. Until 1990, the third industrial revolution was mostly limited to accounting and retail. Computers automated clerical tasks and then rolled out to the banking industry. Also, two notable breakthroughs in the information age were pioneered by: (a) communication companies providing internet, phone service, and cable TV; and (b) Apple and Google mainstreaming the smartphone industry to the extent that 85 percent of the United States population were smartphone users in 2021. In the mid-90s, computers were started to connect to the internet, which induced the e-commerce industry and the search engine, Google. All of today's internet giants were founded by 2004, almost two decades ago: Amazon in 1994, Google in 1998, Wikipedia and iTunes in 2001, and Facebook in 2004. However, the years of upsurge from 1994-2004 in productivity did not sustain through the following decades.

The total factor productivity (TFP) measurements, a widely accepted economic metric to calculate productivity. The TFP growth of the third industrial revolution was not as high in magnitude as the second industrial revolution, nor was it as prolonged. The most significant point about TFP performance is that rapid growth was not extended equally over the thirteen decades since 1890. The growth happened in 1920-1970, with an average annual rate of TFP growth of 1.89 percent per year. However, the growth from 1970 and 2014 was only .64 percent per year, a third of the rate in 1920-1970. The main effect of the third industrial revolution happened in 1994–2004. The TFP rates spiked while the businesses transitioned towards the computers and internet browsers presented in the mid-1990s. During 1994-2004, TFP grew at a rate of 1.03 percent per year, slightly more than half that of 1920–1970 and significantly rapider than the rates of 0.57 percent per year in 1970–1994 and 0.40 in 2005–2014.

Can great inventions happen in the future as in the past? According to Godron (2016), innovation is considered to have a high impact when TFP growth is relatively fast and to have a low impact when TFP growth is rather slow. This standard of comparison across years distinguishes the pace of innovation and the impact of innovation on TFP. The facts about the TFP growth rate demonstrate that the answer to this question does not look optimistic. In the following sections, some other evidence is provided to support the idea that near future innovation cannot be like in the years of 1920-1970 or 1994-2004.

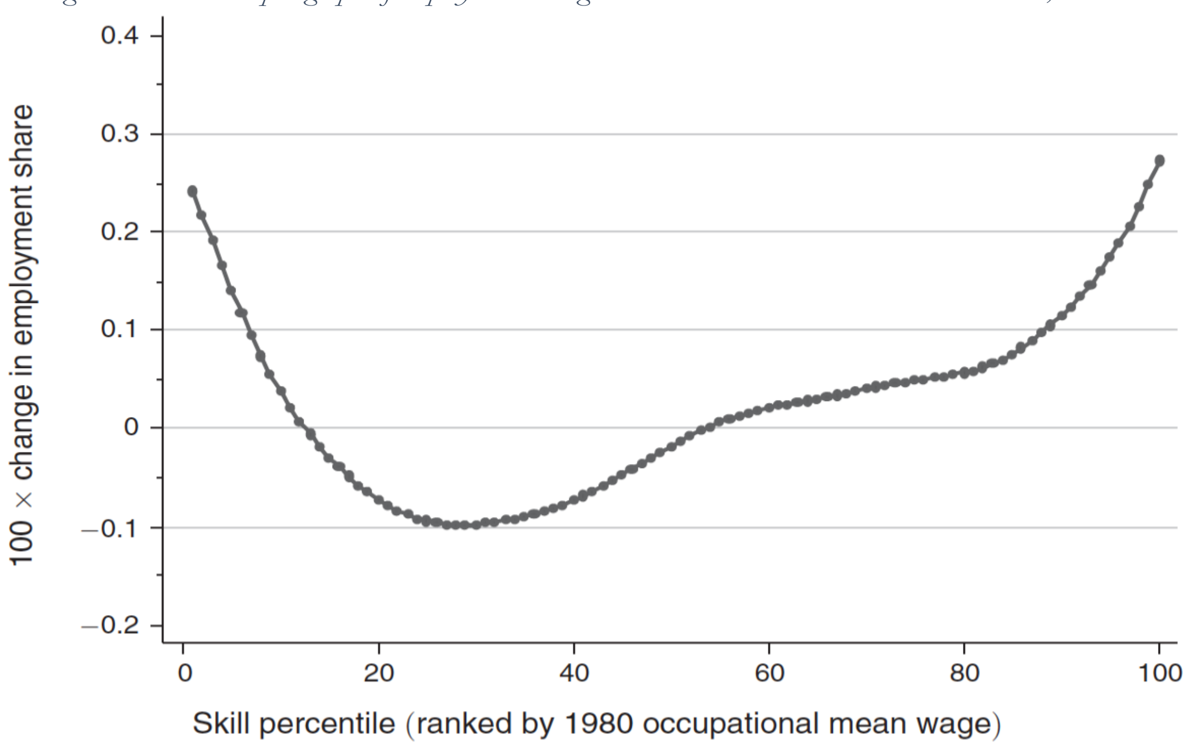
2.1 Employment and Wage Polarization and Inequality

Automation of routine task activities has changed labor specialization. It has driven employment and wage polarization, as well as inequality. The development of these polarizations and inequality has two major features. The first is consumers prefer variety. The second is the dramatically non-linear growth of employment by skill levels. Autor and Dorn (2013) calculated the changes in the share of employment in 318 occupations including all the United States nonfarm employment in 1980-2005 by using Census and American Community Survey data. Jobs were ranked by skill level, which is computed by the mean log wage of workers in each job in 1980. Autor, Levy, and Murnane (2003) define "jobs" as a group of tasks that can be categorized as routine versus non-routine, and manual versus cognitive. Routine tasks are those tasks that can be broken down into easily repeatable parts; manual tasks are those demanding the use of physical labor, and cognitive tasks are those requiring the use of mental labor. Some examples of routine tasks would be scanning the price of items at a grocery store counter or doing the same analysis repetitively on the same sets of consumer data. The more routine a task is, the more the task can be programmed into software or robots. Consequently, the more non-routine a task becomes, the more difficult it is to perform and automate. Reviewing the United States labor economy through this framework, the United States employment is moving towards non-routine, highly cognitive, and interpersonal activity. Examples of these jobs include elderly care, preschool teaching, and management (Autor, Levy, and Murnane 2003).

It is commonly believed that technology and automation generate relatively more high-education jobs. According to this view, jobs below the median skill level would decline as a share of employment as automation increases. However, data tells a different story - while there has been a decline in jobs in the second skill quartile, there has been a sharp rise in jobs in the lowest quartile. The result of this unexpected spike in jobs in the lowest skill quartile is the U-shaped graph of employment changes relative to skill level in the United States (See Figure 1). Interestingly, this pattern of employment polarization has been happening in almost all rich industrialized economies during the last three to four decades. 16 European countries were studied by using harmonized European Union Labor Force Survey Data in the 1990s and 2000s. In all these studied countries, low-wage jobs increased relative to middle-paying jobs (Goos, Manning, and Salomons 2011). This has been a key driver of increased inequality in the last three decades that wage changes have been non-monotonic by skill level. Mostly high-education jobs have increased; however, low-education jobs have increased beyond expectation, with median-skill jobs rising slightly. Both employment and wage growths exhibit the U-shaped distribution in skill level. The increase in the lower tail of the employment and wages distributions is largely described by growing employment and wages in only "service occupations" (Autor and Dorn 2013).

To understand the polarization of employment and wages in the United States and other rich industrialized countries, it is necessary to comprehend the rapid growth of employment and wages in service occupations. Autor and Dorn (2013) define "Service occupations are jobs that involve assisting or caring for others, for example, food service workers, security guards, janitors and gardeners, cleaners, home health aides, childcare workers, hairdressers and beauticians. Though among the least educated and lowest paid categories of employment, the share of US labor hours in service occupations grew by 30 percent between 1980 and 2005 after having been flat or declining in the three prior decades". This trend is projected to remain in the service and goods sectors in the next decade (Dunbina, Kim, Rolen, and Rieley 2020). By 2029, growth in low-education "non-substitutable" (non-mechanizable and non-offshorable) jobs is as large as all the projected labor force growth—and growth in high-education "non-substitutable" jobs is even bigger (United States Bureau of Labor Statistics). There is a distinction between service occupations and the service sector: The first is a group of low-education occupations delivering personal services. The service sector is a broad category of industries varying from health care to real estate. In 2005, it covered 83 percent of nonfarm employment and service occupations covered 20 percent of labor input (Autor and Dorn 2013).

Figure 1: The U-shaped graph of employment changes relative to skill level in the United States, 1980-2005



Source: Autor and Dorn 2013

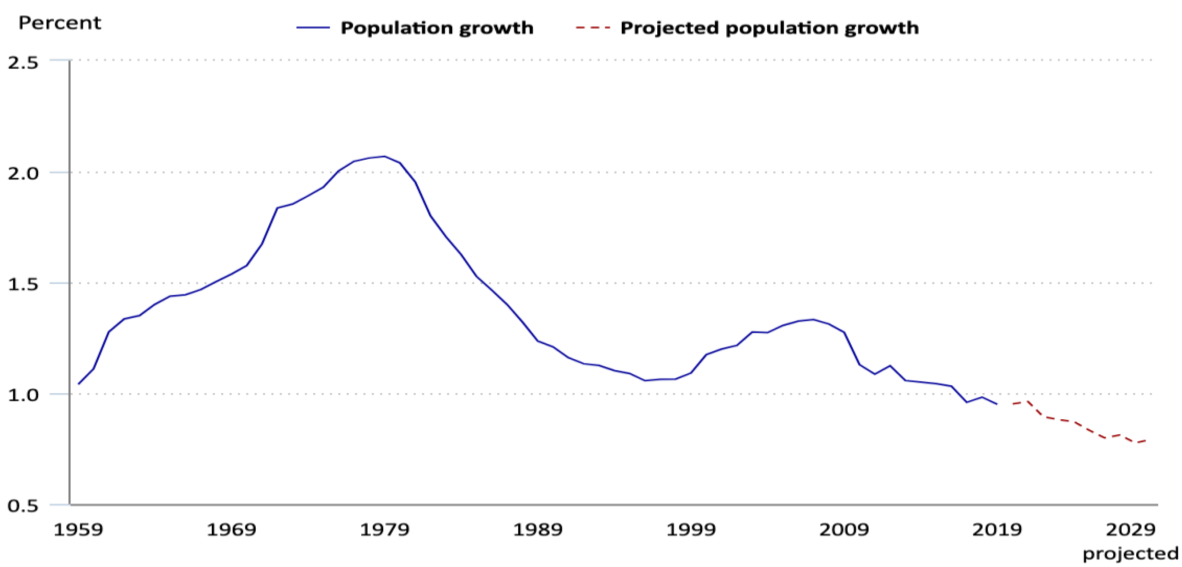
Computerization and automation have the dual effect of replacing workers at low-education, routine tasks while also supporting high-education workers in non-routine and cognitive tasks. Because service occupations are non-routine and interpersonal, they cannot be easily automated and so wages in this sector have risen at the same time as automation has increasingly substituted for routine jobs in goods production. In 1980-2005, the distribution of hours worked in service jobs among noncollege labors rose above 50 percent. Simultaneously, real hourly wages of noncollege workers in service jobs increased 11 log points. Rising employment and wages in service occupations explain a significant share of polarization and growth of the lower tail of employment and earnings distributions in the United States and other industrialized countries (Autor and Dorn 2013).

2.2 Aging and Decline in Population Growth Rate

In rich industrialized countries such as the United States, the growth of the population, labor force, and labor force participation has slowed, with even slower growth projected over the next decade (see

Figure 2). Compounded annually, the overall population growth rate is estimated to decline to 0.8 percent in 2019-2029. These demographic and labor market trends have lowered the Gross Domestic Product (GDP) per capita in recent years. The main reasons of the decline of the labor force participation rate are the aging of the baby boomer generation and some demographic trends, such as the slower immigration growth rate. The slight increase in the population growth of 3.8 percentage points of the resident population in 1999-2009 is partially attributed to increased immigration. Declining immigration is also projected to continue to distress overall population growth during the projected period of 2019-2029 (United States Bureau of Labor Statistics). The growth of people ages 65-and-older and 75-and-older are anticipated to continue its upsurge. All 76.4 million baby boomers will reach 65 by 2030. Old populations are estimated to outnumber population under age 18 by 2034 (Unites States Census Bureau). This trend has contributed and will contribute to the decline of labor force participation rate. Hence, the aging of the population, longer life expectancies, and growth in the number of people with chronic diseases are projected to increase demand for caring (Dunbina et al. 2020).

Figure 2: Population growth rates, 10 years compounded annual average, 1959-2019 and 2019-2029 projected



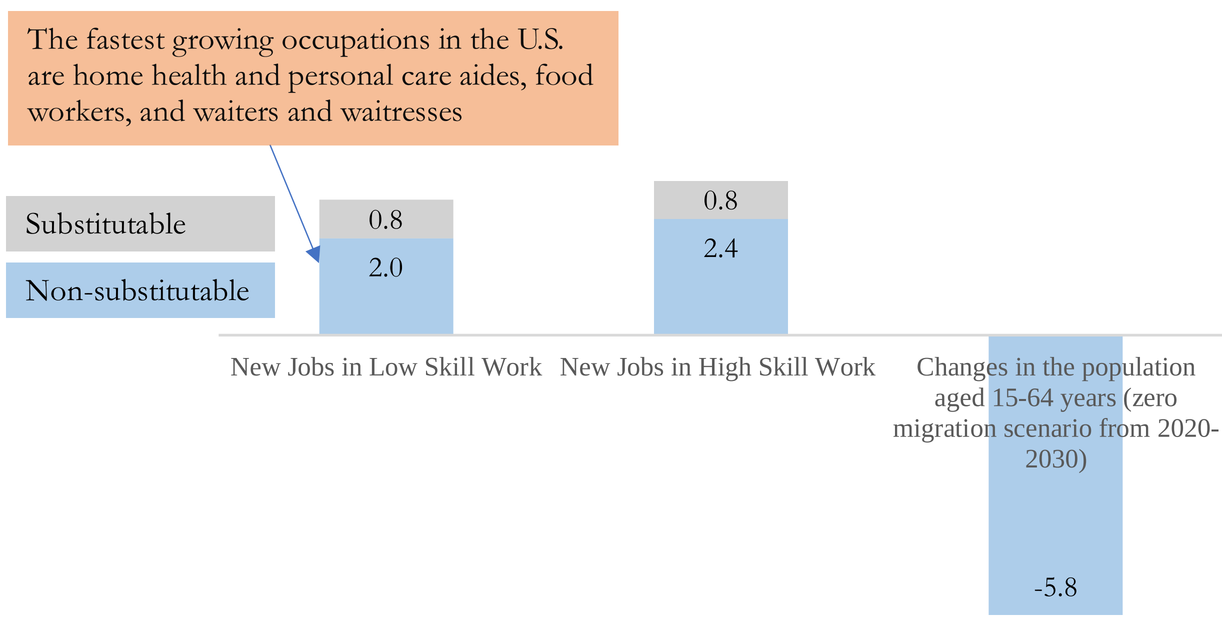
Source: United States Bureau of Labor Statistics

The projected annual growth rate for all jobs is 0.4 percent from 2019 to 2029, with a projected increase of 6 million new jobs. Healthcare-related occupations are predicted to account for a large share of new jobs; the fastest-growing occupations are expected to be occupations that provide healthcare or services related to healthcare (United States Bureau of Labor Statistics).

Given the U-shaped evolution of the labor demand relative to skill levels, future demographic trends (which implies there is continued labor demand growth in low-education service occupations), and higher education among the population[1], there will not be enough native-born willing and able to fill the low-education service occupations. In the United States, in the zero-migration scenario, between 2019 and 2029 the population aged 15-64 years old will decrease by 5.8 million while 6 million new jobs will be created in the economy. Growth in low-education non-substitutable jobs is as large as all of the projected labor force growth—and growth in high-education non-substitutable jobs is even bigger. In fact, (a) there are "good jobs" (e.g., high-education, non-offshorable) for all native-born workers and (b) there are less than zero additional workers for the low-education "sticky" jobs. In short, by 2029, the economy will have more than 2 million low-education "non-substitutable" jobs, but there will not be any labor to take those jobs (See

Figure 3).

Figure 3: Substitutable and non-substitutable new jobs and working-age population changes in the United States (2019-2029) (millions)



[1] In the United States, the share of workforce with an elementary school education dropped from 75 percent in 1915 to 30 percent in 1960 and to 3 percent in 2005 (Goldin and Katz 2008). At the same time, the share of workforce with post-graduate degrees, college degrees, and enrollment in college courses (without graduation) rose to 48 percent from 4 percent (Gordon, 2016).

Source: United Nations, Department of Economic and Social Affairs, Population Dynamics; and United States Bureau of Labor Statistics Projection

There are very real societal implications of these aging demographics and the current tax structure. They would cause social security and Medicare trust funds to get to zero by 2034 and 2030, respectively. Extrapolating the calculations of the Congressional Budget Office, the federal debt will reach the GDP level by 2038 optimistically. At this rate, the government certainly needs to investigate structural reforms such as increasing the taxes and/or reducing government transfers (Congressional Research Service 2020). However, they are not easy policy corrections or implementations. Consider, "The Highway Trust Fund": in 1956, the Highway Trust Fund (HTF) was established to fund the United States interstate highway system and certain other roads. HTF attains cash from a federal fuel tax. Because of the recession, higher gas prices, and lower consumption of gas, there has been an overall decrease in revenues. From 2008 to 2010, Congress approved the General Fund of the Treasury to transfer $35 billion to the Trust Fund to maintain its solvency. Since the shortage is lasting, the Congressional Budget Office projected, the scheme would cause extra billions in debt or stop repair and expansion of the Federal highway system. Hence, since 2000, there have been many efforts by individual members of Congress to adjust the federal gas tax scheme. All such efforts have been unsuccessful.

2.3 Employment Scarcity in Developing Countries

The rich industrialized countries' share of global income tripled from a fifth in 1820 to almost two-thirds in 1990 because of technological advances and trade globalization. It then leveled out until 2000 before plunging to its historic levels in 1914 in recent years. A few developing countries got the share of global income. The reason is G7 decided to train and outsource a few of developing countries according to their geography and availability of cheap labor. Hence, it only advanced the manufacturing fortunes of few of them (Baldwin 2016).

Hence, the growth in "good jobs" in low-income countries is unlikely to provide enough employment for all of their new labor market participants. Consider Africa: according to the World Bank estimates, the working-age population of Africa will grow by around 450 million young people from 2015 to 2035. At current estimations of job creation, 100 million of these individuals can be predicted to have stable employment opportunities. This leaves the rest of the 350 million individuals in the next 20 years with no appealing productive job opportunities (The Africa Competitiveness Report 2017).

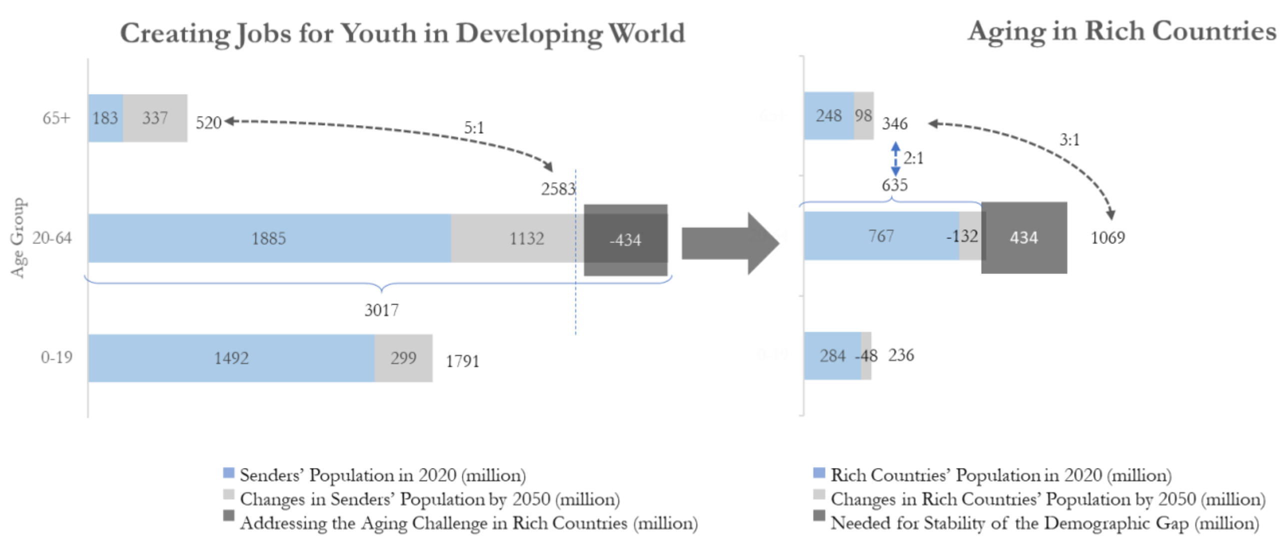
The challenge of jobs for youth in developing countries can be compounded in the era of technological innovation which is prone to be labor-saving. Automation risk for jobs in developing countries ranges from 50 percent to 66 percent with a median of 58 percent, compared to the OECD countries' range from 35 percent to 44 percent with a median of 38 percent (Frey and Osborne 2017). Hence, automation risks in developing countries are notably higher than the OECD and developed countries. Moreover, developing nations are much more inclined to automation than OECD countries. Looking at the overall percentage of automatable tasks, the developing countries' range is much greater than the OECD range, implying that the potential effect of automation on all developing countries is much more (Egana del Sol 2020).

In short, a key issue is to get the remaining low-income countries past the "youth bulge" phase of the demographic transition and provide low and medium-level skill work for youth. However, the highest skilled talent in developed countries is making that job harder by replacing jobs with machines.

3 The Future of the World: The World with Controlled Borders or with Current Borders and Robots

At the global level, the two biggest demographic challenges facing the world are aging in the rich world and unemployment in the rest. By 2050, the rich industrialized countries need an estimated 434 million young individuals to keep the dependency ratio at the current rate, and the developing countries need to provide jobs for their billions of youths (See Figure 4). Even if the rich countries do not consider managing their dependency ratios, they need to deal with the low-education labor scarcity.

Figure 4: The biggest demographic challenges facing the world



Source: United Nations, Department of Economic and Social Affairs, Population Dynamics with zero-migration variant

Considering the lack of low-education labor supply in high-income countries, there are two futures at play. The first is that "low-education labor mobility" would fill the gap, and the second is that the "I, Robot" future would shift the demand from labor to capital plus technology. The I, Robot vision is that technological change would go after the left side of the U-curve of the demand for skill sets and if it succeeds would eliminate the need for labor. In the next section, I provide some arguments around the intentionality of technological changes and technology as a solution to address the low-skill labor scarcity. Then, I discuss the second solution, low-education labor mobility. At the end, I provide a discussion on choosing the workable solution.

3.1 Technological Change and its Intentionality

The literature on the future of work indicates the direction of technological change is endogenous. Governments and industries direct highly talented workers to specific areas and create specific technological changes. In a few years, up to a third of the workforce will be affected by disruptions caused by governments and industries in high technology and robotics. In doing so, executives and experts in McKinsey's survey expect talent shortages in specific areas, especially in data scientists, artificial intelligence experts, and programmers (McKinsey research 2018). In the United States until 2030, 100,000 software engineers are needed just to manage increased complexity of in-vehicle software (Chui et al. 2016). In the following sections, some arguments regarding technological changes as the result of governments' policy distortions and businesses' ongoing massive investments are discussed. I show that technology is directed to where incentives and prices lead it.

3.1.1 Induced technological changes as the result of massive policy-based distortions

Governments can shape the direction of technology through different channels such as 1) providing financial incentives, 2) changing work visa laws and the availability of foreign labor, 3) raising taxation, and 4) putting border-based barriers to workers in developing countries. In the following paragraphs each channel is explained.

1) As a case in point for incentivizing technological change because of labor shortages in agriculture, the UK government published the following statement in May, 2021: "We welcome the announcement in November of additional Government funding for new technology and call upon Defra to publish a strategy within 6 months setting out how it will work with technology providers and the food supply chain to ensure our farming and food production sectors can help develop and take advantage of the latest technological advancements. The government should monitor the speed at which the mechanization of roles currently done by seasonal labor becomes economical for all farmers, including small farmers, and this should be reflected in the setting of the cap on the Seasonal Workers Pilot."[2]

2) There are many historical instances that labor market deficiencies through migration policies have become a driving force for technological changes. For instance, through the Great Mississippi Flood of 1927 as part of the Great Migration, the exodus of Black agricultural workers reinforced the implementation of agricultural mechanization. Hornbeck and Naidu (2014) showed labor scarcity rising from interstate migration after flooding stimulated technical innovations in agriculture. Also, Hornbeck and Naidu confirmed that agriculture in the flooded counties turned out to be more automated by 1970 than in non-flooded counties.

3) Pritchett (2019) mentions governments and societies use formal sector jobs as a low-cost mechanism for collecting taxes and providing a variety of social insurance benefits. As a result, the cost of labor in formal sector jobs could exceed marginal revenue product to firms because of both tax and mandated benefits for employees. This incentivizes firms to simultaneously

1. Push labor to lower cost places;

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[2] Available at https://committees.parliament.uk/oralevidence/1232/default/

2. Shift out of labor by adopting machines and technology;
3. Shift labor from jobs to non-job modes of labor (e.g., contracting and in-sourcing customer labor by implementing technology)

4) Immigration constraints have created a vicious cycle of technological advances targeted in specific domains. Pritchett (2020) explains: "border-based barriers to low (and medium) skill labor in rich countries have created the perverse situation in which the scarcest resources on the planet are devoted to attempts to economize on one of the most abundant resources on the planet. The scarce resources of super-star quality …. technical and engineering talent are devoted to creating innovations to economize on the use of low/medium skill labor because they are responding to a rich country, market distortion induced, prices, and not to global supply, availability, or costs."

3.1.2 Induced technological changes as the result of businesses' ongoing massive investments

Research shows that industries choose to create more innovation and technological advances in specific areas. The specific sets of industries that are ongoing massive investments to progress technologies are automotive, aerospace and defense, and diversified industries (i.e., building and industrial technologies, machinery, and power equipment). A third of the senior leaders in these three industries believe in reallocating more than 30 percent of their resources for technology disruptions. This result is a sizable shift of capital expenditures across industries. For the top 15 suppliers in each automotive, aerospace, and defense industry, a 30 percent reallocation of capital expenditures would mean allocating above $12 billion (McKinsey research 2018). Consequently, there is extensive agreement among industry members that they would face unprecedented shocks in their industries in the near future. McKinsey research (2018) concludes "there are five major forces driving these disruptions: connectivity-driven business models, artificial intelligence and autonomous systems, internet of things, electrification, and cybersecurity." To overcome such disturbed situations, organizations are compelled to react on multiple faces. This dynamic generates a vicious cycle. These challenges look overwhelming, and some organizations are undeniably struggling.

3.2 I, Robot: A Solution To Low-Education Labor Scarcity

Considering the endogeneity of the direction of technology, technology can be considered as a solution to low-education labor scarcity in the service sector. However, there is significant evidence that technological progress is unlikely to be capable of addressing labor demand in the service sector in the near future. Previous studies have found that those occupations with a high level of routine tasks are the most likely to be automated (e.g., Autor and Dorn 2013). Even technological advances in those occupations have not created mass unemployment and freed up labor. The United States unemployment rate was only 4.8 percent in September 2021 (United States Department of Labor). Furthermore, non-routine tasks involve knowledge and skills, requiring the worker to use judgment to choose the correct action. Autor (2015) argues that "the challenges to substituting machines for workers in tasks requiring flexibility, judgment, and common sense remain immense."

Daniela Rus (2015), Director of MIT's Computer Science and Artificial Intelligence Laboratory, provided some arguments about the restrictions of current robots. Robotic reasoning is narrow, and "the scope of the robot's reasoning is entirely contained in the program… Tasks that humans take for granted—for example, answering the question, 'Have I been here before?'—are extremely difficult for robots." Another example, consider the task of folding laundry, simple and routine for humans at any education level: "No machine can yet match a human's dexterity and problem-solving abilities when attacking a pile of irregular shaped clothes of different fabric types and weight. The difference between picking up a lace nightgown versus unraveling a pair of crumpled jeans knotted with other clothes is a calculation that requires massive computing power and a soft touch." Aeppel (2015) explains. Also, in situations that robots have not been programmed to handle, they enter error states and stop operating (Rus 2015). Multiple- function robots would most likely be developed. It is this sector that suffers from slow productivity growth. However, the process would be slow and gradual until robots become a major factor in the service sector like robots in the manufacturing and production sectors.

In the next section, four reasons are provided to demonstrate how slim the chance is of technology to address the issue of labor scarcity in near future: First, technological innovation has leveled out in terms of economic figures such as the Total Factor Productivity (TFP). Second, the ability of technology to fill the labor scarcity has been overpromised. Third, technology is not always labor-saving; it is labor shifting instead. Finally, technology gives rise to wage and employment polarization and reinforces wage and employment inequality. Hence, it is deemed an inferior solution.

3.2.1 Moore's Law and its Death

Moore's law is one of the popular measurements of technological advancements in microprocessors and sometimes the broader industry of information and communications technology. In 1965, Gordon Moore —the co-founder of Intel— forecasted that every two years the number of transistors on each microprocessor would double. His forecast was followed through until 2006; by 2009, it took 8 years for transistors to double, and by 2014 it took 4 years. There are technology enthusiasts like Moore who believe that the current innovations would boost the economy at unprecedented rates, repeating the TFP rates of the Internet boom in 1994-2004. Nevertheless, labor productivity as one of the two factors of TFP raised only by an average of 0.5 percent annually in 2010- 2015 compared to an average of 2.3 percent growth annually in 1994-2004. This is because commodity computers are more than capable of carrying out most of the computation for which they are currently being used, so there is no pressing need for faster chips. Given the slackening demand and the saturation of scientific/engineering potentials, the demise of Moore's law is bound to happen soon (Gordon 2016).

3.2.2 Overpromise of Technology

The recent history and current practices of automation show that the ability of technology to substitute for labor—and to fill the labor shortage gap—has been overpromised. After decades, the results of technological advances have not even met their promises in routine tasks.

Amazon is a prime example of a high incentive actor to maximize automation without making as much progress. As of January 2021, Amazon's warehouse costs were around $90B per year. $20B of these costs is the cost of warehouse workers. With these growing costs, one of Amazon's largest profitability advantages is through improved warehouse efficiency: all routine picking, packing, and sorting operations can already be done by robots, but pretty poorly. There is a lot of room for progress in robotic arms loading higher racks, automated item picking, machine loaded trucks, or autonomous workflows. Amazon's R&D and automation funds are $10s of billions per year. It has already spent

$100s of billion to build delivery robots. After years, it has not found a way to make robots pick goods as well as humans can. Generally, automation in these key components of the e-commerce supply chain and other more difficult tasks has not been very successful.

In another example, the UK government attempted to modernize and make their food production supply chain independent because of Brexit and COVID-19. In 2018, 99 percent of the workers in the edible horticulture harvesting part of the supply chain were migrants (Randall 2018), who would no longer be available. This surprising figure urged the House of Commons Environment, Food and Rural Affairs Committee to consider labor-saving immigration policies. While agri-tech companies and their advocates have been very interested in using automation to address this significant labor shortfall, no significant progress has been made.[3]

The overpromise of the technology can be seen in instances of migration. The overpromise of technology is the incomplete substitution of technology in dealing with labor supply shocks. For example, in the United States dairy industry from 2005 to 2012, the government implemented immigration policies (the 287(g) agreement) that reduced labor supply. When the industry responded by modernizing, all substantial productivity measures suffered: total milk production, average dairy size, and the number of dairies in operation in the county declined. This suggests the failure of technology to fill the labor shortage gap (Chalrton and Kostandini 2020).

Notwithstanding the slow TFP growth since 2004, analysts predict the future of technology with great excitement. The famous techno-optimists Brynjolfsson and McAfee (2014) emphasize "we are at an inflection point" between a past with slow technological advances and a future with rapid advances. According to Gordon (2016): "This view is challenged by the extrapolations of the recent depressing trends such as increasing income inequality, flagging educational attainment, increasing dependency ratio, and declining hours worked per person, increasing the government's debt-GDP ratio. In other words, peoples' life has not improved in the areas where technology has been presented in the past few years." Some economists assert that it is because further innovation is hard to accomplish. A case in point is the retail sector, where all of the big gains were made in the 1980s and 1990s and little has changed since then (Gordon 2016).

Many techno-optimists such as Brynjolfsson and McAfee (2014) believe in revolutionary productivity growth in a few main categories —medical, robotic and 3D printing, big data, and driverless vehicles. Supporters of big data usually label this class of enhancement as artificial intelligence. In the following section, the potential of these groups of future advances is inquired in turn to create an increase in TFP growth back

Small Robots. General Motors introduced the first industrial robots on its assembly lines in 1961. Robots have been used in mechanical, highly accurate, and dangerous tasks to date. Most workplace technologies are intended to save labor. However, after two centuries of introduction, robots have not ended up largely substituting human labor. This is evident in the steady unemployment rates around 6±2.5 percent throughout 1950-2019—as opposed to much higher unemployment rates of 20-50 percent expected in the counterfactual scenario of significant displacements. Just as Baxter cooperates with human workers, other robots do not just displace workers but also may make the remaining workers more valued and create new jobs, with those who are building and software designing the robots. On the other hand, robots have served an assistive role for humans, enabling them to be more productive. Typically, human workers provide judicious intuition where robots

[3] Available at https://committees.parliament.uk/oralevidence/1232/default/

follow their programmed routine (Gordon 2016). David Autor (2015) studies this phenomenon in more detail and projects future machines and robots not only to substitute for labor but also to complement labor.

Big Data and Artificial Intelligence. As a result of widespread digital adoption, companies are looking into applications that can monetize this data. Relatively, artificial intelligence, i.e., any computer program that exhibits human-like cognition often enabled by learning patterns in large amounts of data, has become trendy for more than a decade. Some endeavors have shown signs of success in a range of fields, such as medical diagnosis, fraud detection, default predictions, investment management, and marketing. In some of the cases, they have replaced humans and others; despite providing some level of productivity, they still rely on human supervision. For instance, JetBlue Airways data has enabled analysts to study the airline's market share among travelers in different demographics. It has also enabled tiered pricing for their seats based on booking patterns and calendar dates. However, JetBlue's analysts are reported to regularly override these pricing decisions at a rate that has surprised JetBlue's director of revenue management. In short, some steady progress is being made in the big data and artificial intelligence industries and the number of electronics such as smartphones and iPads generating data is rising fast; however, they have not caused a TFP growth raise (Gordon 2016).

Driverless Cars. Future progress in this category is minor in comparison with the invention of the car itself or improvements in safety that have resulted in a tenfold reduction of fatalities per vehicle mile since 1950. Despite techno-optimists' enthusiasm for driverless cars, numerous questions remain unanswered. There is a significant difference between cars and trucks. Cars are used to get people from A to B, and many of them are used for essential purposes such as commuting or shopping. Thus, people must be inside the driverless cars. Having no need to drive for a commute proves relatively minor in terms of consumer surplus. Rather than listening to something, drivers will have the option of reading a book, keeping up with their emails, or surfing the web on their computer screens. Accordingly, the use of driverless cars will further reduce the incidence of automobile accidents and fatalities, which has already occurred. Driverless cars might also result in a shift away from nearly universal car ownership towards widespread car sharing in cities and perhaps suburbs, which would reduce gasoline consumption, air pollution, and parking requirements, all of which would result in an improvement in quality of life, if not productivity. As a result, potential future productivity advantages are left for driverless trucks; although, truck drivers make up a small share of the employment (e.g., in the United States). Nevertheless, driving from place to place is only half of what truck drivers do. The drivers of Coca-Cola and bread delivery trucks usually load the cases of Coca- Cola or the stacks of bread loaves onto dollies and manually place them on the store shelves. Surprisingly, even in these late stages of the computer revolution, the placement of cans, bottles, and tubes on retail shelves is almost entirely performed by humans rather than robots. Driverless delivery trucks will not save labor unless work is reorganized (Gordon 2016).

In conclusion, after decades, the results of technological advances have not even met their promises in routine tasks.

3.2.3 Labor Shifting, not Labor-Saving

There is a conflict between the excitement of techno-optimists regarding the recently enhanced capacity of artificial intelligence to simulate and surpass human activity, and the slow growth of TFP during the last decade. One analysis is that the substitute of human jobs by computers has been happening since more than six decades ago, and the substitute of human jobs by machines has been happening since more than two centuries ago. Jobs such as financial advisers, credit analysts, and insurance agents are going to be substituted, and these displaced workers follow those who lost their employments within the past three decades such as travel agents, encyclopedia salesmen, and Borders' employees. However, employment rates in high-income countries have not reflected these substitutions. The United States unemployment rate has been 5.1 percent on average in the past five years, in line with historical rates (U.S. Bureau of Labor Statistics). That is because new jobs have been created and have replaced jobs lost.

Hence, technology does not necessarily decline employment rate and labor demand. According to Autor and Salomons (2018), the result of mechanization in non-farm sectors has been increased labor demand in downstream sectors and increased consumer demand. That is because new jobs have been created and have replaced jobs lost. Robots have ended certain jobs and also created new jobs in the past two centuries of their growth and similarly computers have existed for more than six decades. Consider finance and banking. The ICT revolution has changed them in a variety of ways, ranging from the humble corner ATM to fast trading on stock exchanges. Both the ATM and billion-share trading days are inventions of the 1980s and 1990s. From 1960 to 2005, New York Stock Exchange's daily shares increased from 3.5 million to 1.7 billion, but then declined to around 1.03 billion in early 2022. Stocks have gone up and down for more than 10 years and ATMs have been installed in many places, and many people now manage their bank accounts online rather than in branch banking. However, the nations such as the United States still maintain a system of 97,000 bank branches, many of which are empty much of the time, and employment of bank tellers has declined only from 484,000 in 1985 to 361,000 in recent years (Aeppel 2015). Bessen (2015) explains the longevity of bank branches in part by stating that ATMs have reduced total employee numbers from about twenty in 1988 to just over thirteen in 2004. Thus, banks were able to open more branches at a lower cost, which led to a 43 percent increase in bank branches from 1988 to 2004. Banking provides an example of the fact that the impact of robots, in this case ATMs, in destroying jobs is often overstated. Furthermore, Bessen demonstrates that the invention of bookkeeping software did not prevent the hiring of accounting clerks from growing between 1999 and 2009.

In summary, the automation of many routine tasks has mostly shifted employment. There are many instances that technological innovations have shifted labor. Labor shifting technological innovations do not necessarily use technology or innovation to reduce the total number of laborers but rather to shift employment and compensation. Also, workers lose their jobs and get non-jobs (contracts), provide involuntarily free work for companies (automated check-in, both online and at kiosks at places like airports), or/and do tasks which they are not good at and need to spend much more time than experts do (assembling a bed at home). Consider the range of household technologies from dishwashers and washing machines to vacuum cleaners that have not been labor-saving machines. These devises shifted labor away from men and children to women. They also forced from employed women to unpaid family labor. Also, they were devices that raised expectations of what the gendered role of housemaker should produce, rather than a source of less work for women (Pritchett 2020).

3.2.4 Technology in Developing Countries

In developing countries, although the technology transfer can bring higher productivity, it is potentially destructive to their labor markets and can significantly decrease their employment level. Labor productivity gains and output growth resulting from domestic demand and trade determine the final employment outcome (Taylor 2004). However, according to Hall and Heffernan (1985), addressing the final employment outcome, price, and income compensation mechanisms are complicated challenges in developing countries: 1) R&D-based product innovation does not exist in most developing countries. Thus, they lose the effects of the labor-friendly component of technological advances as endogenous outcomes on their employment. 2) price advantages by reducing both prices and wages can be neutralized by the lack of competition in local markets and goods. 3) income advantages through both new investments and incomes can be reduced by spending additional incomes on imported luxury goods and investing abroad (Vivarelli 2014).

As a result, "absorptive capacity" of developing countries determines the final effects of technology transfers on their growth and employment (Abramovitz 1986 and Lall 2004). A developing country can potentially develop its new technology's growth and employment, with reference to labor-friendly product innovations, if it has the adequate levels of R&D and innovation capabilities. Also, its government's capabilities and support are critical in this process. However, developing countries' institutions usually lack the driving forces to use job creation impact of product innovation, while relieving their job destructing potentials. For example, they lack a workable regulatory system to protect and patent new products (Kim, Park, and Lee 2013).

4 Future on the Right Side of History: Low-Education Labor Mobility

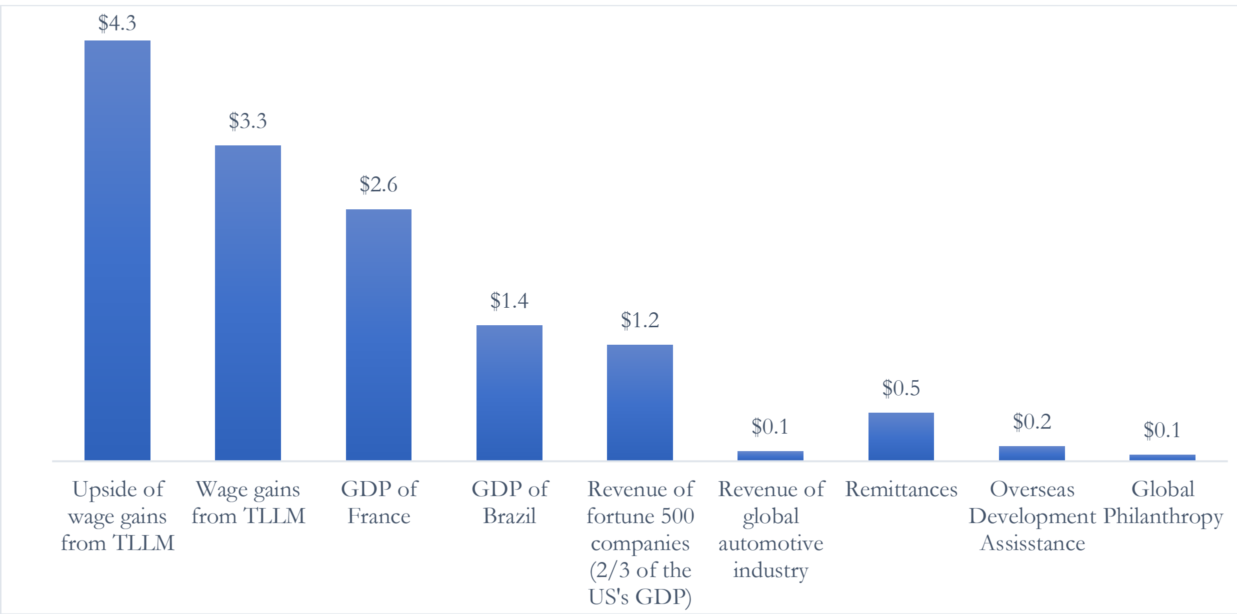
The "I, Robot" view may or may not be correct about whether technology can go after the left side of the U-shaped distribution of labor demand in skill level. However, doing so is a much, much worse choice than low-education labor mobility. We cannot send service jobs to developing countries or change the characteristics of the work, but labor from developing countries can come to rich countries and provide much needed services. Hence, migration restrictions are possibly the most significant distortion in the world economy and the most harmful to the world. According to Pritchett (2020), companies and businesspersons in the rich industrialized countries are dealing with the large distortion of prices created by limiting the availability of foreign low- and medium-skill workers in their economies. Since the expansion of automation in goods production raises wages and employment in low-education service occupations, increasing low-education service providers can avoid increasing employment and wage polarization, and inequality. Also, the availability of labor prevents the distortion of technology into labor displacement. Increasing the number of low-education workers under time-limited labor mobility programs supports a part of the "care infrastructure" and can improve the labor force participation of women and youth in the near future. In the following section, I discuss the impact of labor mobility on the world, receiving countries, as well as sending countries and workers.

4.1 Labor Mobility and Potential Gains

Clemens (2011) asserts "the gains to lowering barriers to emigration is much larger than gains from further reductions in barriers to goods, trade, or capital flows – and much larger than those available through any other shift in a single class of global economic policy. Quantitatively, the price equivalence of the barriers to mobility of low-education labor is measured in tens of trillions of dollars." Klein and Ventura (2004) assess that world output could surge up to 172 percent by eliminating restrictions on labor mobility in OECD countries. Walmsley and Winters (2005) prove that 3 percent surge in labor supply in immigration can increase global welfare by 0.6 percent while the gain of complete trade liberalization is twice of this welfare gain. Admitting only 7 percent of the labor force as private household workers potentially surges natives' welfare by increasing GDP by 2 percent (Kremer and Watt, 2005). Figure 5 demonstrates the potential gains of immigration is the highest across a range of assumptions.

No need to mention that machines and automation cannot increase tax revenues in the current systems. Also, according to the current practices and tax structures, policy adoption does not happen easily, i.e., taxing Google or Facebook.

Figure 5: In gross revenues, the potential gain of immigration is the highest across a range of assumptions (Trillion in 2020)



Source: Calculated by the author using different sources

4.2 Labor Mobility and Receiving Countries

The United States has hosted numerous immigrants and the results on the economy have been positive at least on four fronts: 1) decreasing the wages of natives by a small amount and mainly competing with domestic workers with no high school degree, 2) reciprocating employment supply with employment demand, 3) increasing population growth, and 4) boosting the economy and revenues. workers are admitted and employed to tackle structural labor shortages in the economy.

1) Addressing the concern on natives' wages and employment, it is important to stress that the impact of immigration on the natives' wages and employment has been close to zero over the past 20 years (See Table 1 for the summary of the various empirical studies exploring this concern.) The migrant workers' wage reductions generally apply to natives who are high school dropouts. This trend has decreased migrant workers' wages. The reason is that a lot of foreign workers shadow their predecessors and occupy other immigrant workers' occupations. As evidence, foreign workers earned 80-85 percent in 2004, compared to no significant change in 1980 (Gordon 2016).

The United States ostensibly has a fairly skilled workforce because it has expanded its education levels since the last 40 years (National Academic of Science 2017), hence immigration policies admitting low-education labor increase the economic benefits to citizens by fully utilizing the production complementarities between citizens and immigrants (Borjas 1995).

Table 1: The impact of immigration on the natives' wages and employment is close to zero

Study	**Wage Effect (%)**	**Which Natives**
A. Spatial Studies		
Altonji and Card (1991)	-1.7 -1.0	*Dropouts, black men* *Dropouts*
Borjas (2016b)	-1.4 -0.5	*Dropouts, non-Hispanic men* *Dropouts, non-Hispanic men*
Monras (2015)	-0.7	*High school graduates or less, non-Hispanic, including immigrants*
Cortes (2008)	-0.6 -0.3 -0.1	*Dropouts, Hispanic with poor English* *Dropouts, Hispanic* *Dropouts*
Card (2001)	-0.1 0.1	*Men* *Women*
Peri and Yasenov (2015)	0.3	*Dropouts, non-Cuban*
B. Skill Cell Studies		
Llull (2015)	-1.7	*Men*
Borjas (2003)	-0.6	*Men*
Card and Peri (2016)	-0.2	*Men*
Card and peri (2016)	-0.1	*Men*
C. Structural Studies		
	-0.8 -0.4 -0.4	*Dropouts* *All* *Dropouts*

-0.3	*Dropouts*
-0.2	*All*
0.1	*All*
0.1	*Dropouts*

Source: National Academic of Science, 2017

Policies for reducing or excluding migrant labor from the labor force to improve the labor market for domestic workers have failed to create jobs or increase wages. At the same time replacing labor with automation, has often been imperfect or non-viable. For example, , the Bracero program between the United States and Mexico spanning 1942-1964 was meant to regulate the flow of migrant labor between the two countries, with a focus almost exclusively on agriculture after World War II. Under the agreements, roughly half a million seasonal labors worked for United States farms on regular contracts lasting between six weeks and six months. According to the agreements, Mexican Bracero workers were not allowed in the United States labor market. By reducing the workforce size, the United States attempted to improve the labor market for domestic workers. This was one of the largest and most ambitious policies in this regard. A cooperative effort by farmers and agricultural engineers had limited success in replacing lost agricultural labor with capital and automation. The exclusion of Braceros did not result in significant improvements in wages and employment in this sector. After the Bracero exclusion, wages in states that were not affected by the agreement increased more than those affected by the agreement. Where technological innovation and progress were possible, they were made necessary by this shock to the labor supply; however, farming declined since technology was not able to substitute labor completely (Clemens, Lewis, and Postel, 2018).

2) This kind of immigration can cause spatial aggregation economies in high-education labor (for example, Glaeser and Mare 2001) and the effects of low-education labor availability on the productivity of high-education labor, particularly women's high-education labor (for example, Kremer and Watt 2009; Cortes and Tessada 2011). A new set of effects occurs whenever foreign workers provide services previously performed within households, such as cooking, cleaning, and caring. Immigrants involved in these industries arguably displace pre-existing non-market labor. As native high-education workers have a higher opportunity cost of time, they are more likely to consume these services, resulting in native high-education workers, especially women, spending more time on the job. By increasing high-education workers' labor supply to the market, foreign workers create a new effect that is not captured in standard models such as Borjas's (1995). The freeing up of high-education labor allows immigrants to reduce wage inequality, since the increase in supply of high-education workers leads to a decline in their relative wages and an increase for complementary low-education native labor. In addition, when high-education women hire immigrant household workers and switch their production from home to market, their output is taxable, providing a financial benefit even if one ignores the taxes paid by the migrants themselves. In addition to reducing gender inequality among high-education natives, foreign low-education workers may also help eliminate the glass ceiling by allowing women to work more flexible hours (Kremer and Watt 2005).

3) Looking at history, the United States' population growth rate was an average of 2.1 percent between 1870 and 1913 and interestingly, the unemployment rate did not suffer due to immigrants' arrival. Migrant workers required housing, workplace, equipment, etc. which stimulated the economy. The unemployment rate wats only 4.3 percent in 1913. The United States' anti-immigration laws of 1921 and 1924 caused the annual immigration to population ratio to drop from 1.0 percent in 1909-1913 to 0.25 percent in 1925-1929. These laws are accepted as a main reason behind the Great Depression

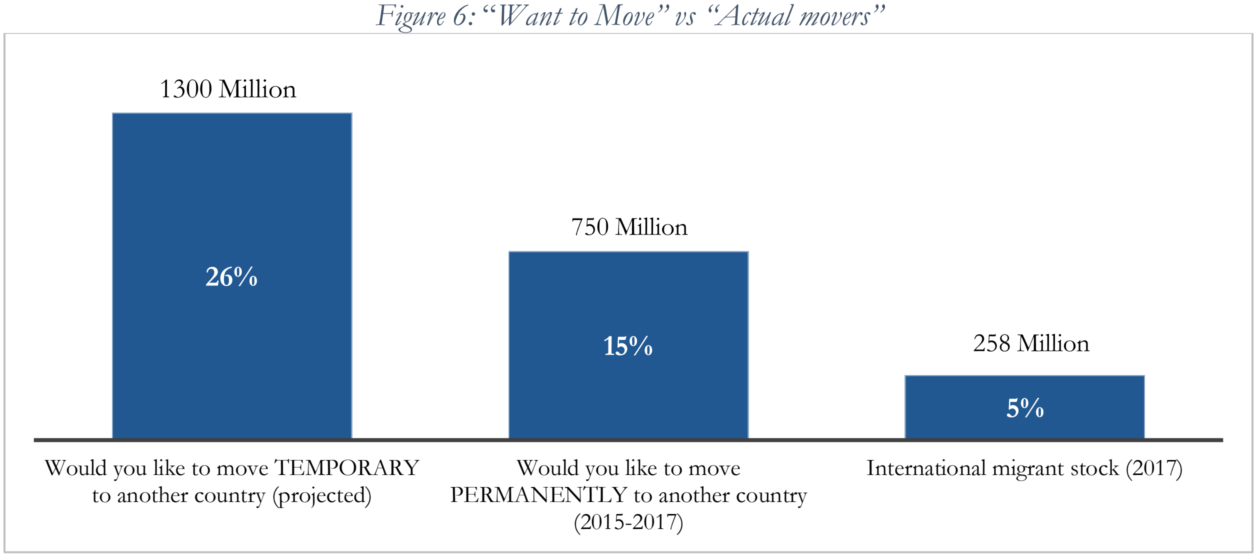
in 1929-1939 since they unexpectedly suppressed the demand for housing and productions (Gordon 2016).

4) In short, immigration creates a lot of positive externalities in the labor market. The United States economy faces shortages of low-education workers in some industries where, even if there were low-education natives to take these jobs, they would not have done so. This directly impacts industries and the surrounding regions; the North Carolina economy would have lost 2800–4300 jobs in different sectors and lost $500 to $750 million in the short run, if 7000 foreign seasonal workers had not worked in the North Carolina farm industry in 2012. It also would have lost 1400–2100 jobs and $250–370 million in the long run. As a result, each H-2A worker added 1.5-2.3 jobs to North Carolina in the short run, and 3.5-4.6 jobs in the long run. Interestingly, having each H-2 worker in the United States, employers add more than $20,000 annually to their revenues, thus creating higher tax revenues for the government as well (Clemens 2013).

Addressing the concern that if rich countries want to create some pathways for foreign workers, they will have to deal with many immigrants, more than needed in their economies: the numbers show different facts. First, numbers indicate interesting facts about the current national culture and nationality. A lot of citizens in the United States are already immigrants. National Academy of Science (2017) shows around a quarter of Americans are the first or second generation of immigrants. Hence, many Americans are immigrants, and the fact is that no natural culture can be available with current number of immigrants in the country and there should not be fear of losing it with admitting more immigrants. Second, in 2015-2017, 15 percent of adults worldwide, or about 750 million people, expressed a desire to move to another country if they had the chance (See

Figure 6). In reality, people's desire for immigration does not always line up with what they do in the real world. For instance, women in Central Asia are more likely to express a desire to move and work temporarily rather than to truly go. In fact, only 5 percent or 258 million of the world's population would immigrate (Gallup, 2018), while only the rich industrialized countries' economies need more than 400 million low-education labor. Hence, the concern should be to design policies and strategies to have enough immigrants in the economy since most likely there would not be enough foreigners wanting to leave their countries and work in other countries.

Figure 6: "Want to Move" vs "Actual movers"



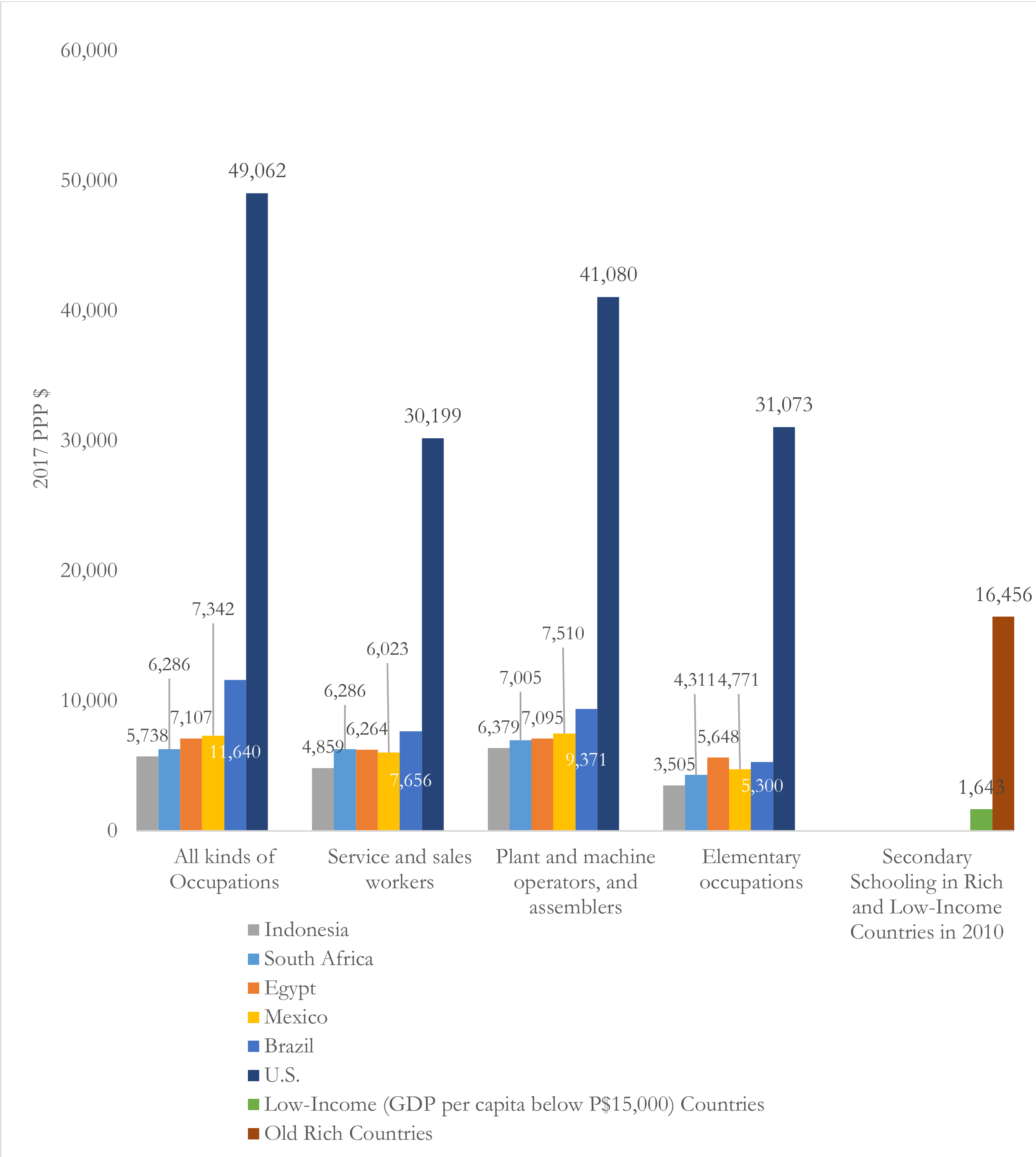
Source: Gallup 2018

4.3 Labor Mobility and Sending Countries

Immigration barriers maintain wage differentials across borders between individual workers who are equally productive (see

Figure 7). These differences –by two orders of magnitude, at least a factor of 100– are larger than the price distortions produced by trade barriers (Pritchett 2020). Globally, above 50 percent of the differences in individuals' income are explained by their country of birth. This means that individuals' skills, effort, and luck explain only a small amount of the global distribution of wages. A main element of an individual's income is the productivity of the place in which he or she lives. Using data from a naturally randomized visa lottery, Clemens (2011) shows little unobserved positive self-selection is seen in immigrants to the United States. The productivity gap between rich and poor countries is not because of the differences of workers' characteristics. Place-specific total factor productivity is accounted for most of the productivity gap. Large differences in place-specific total factor productivity mean that goods and capital free movements cannot succeed the global equalization of wages (O'Rourke and Sinott 2004; Kremer 2006).

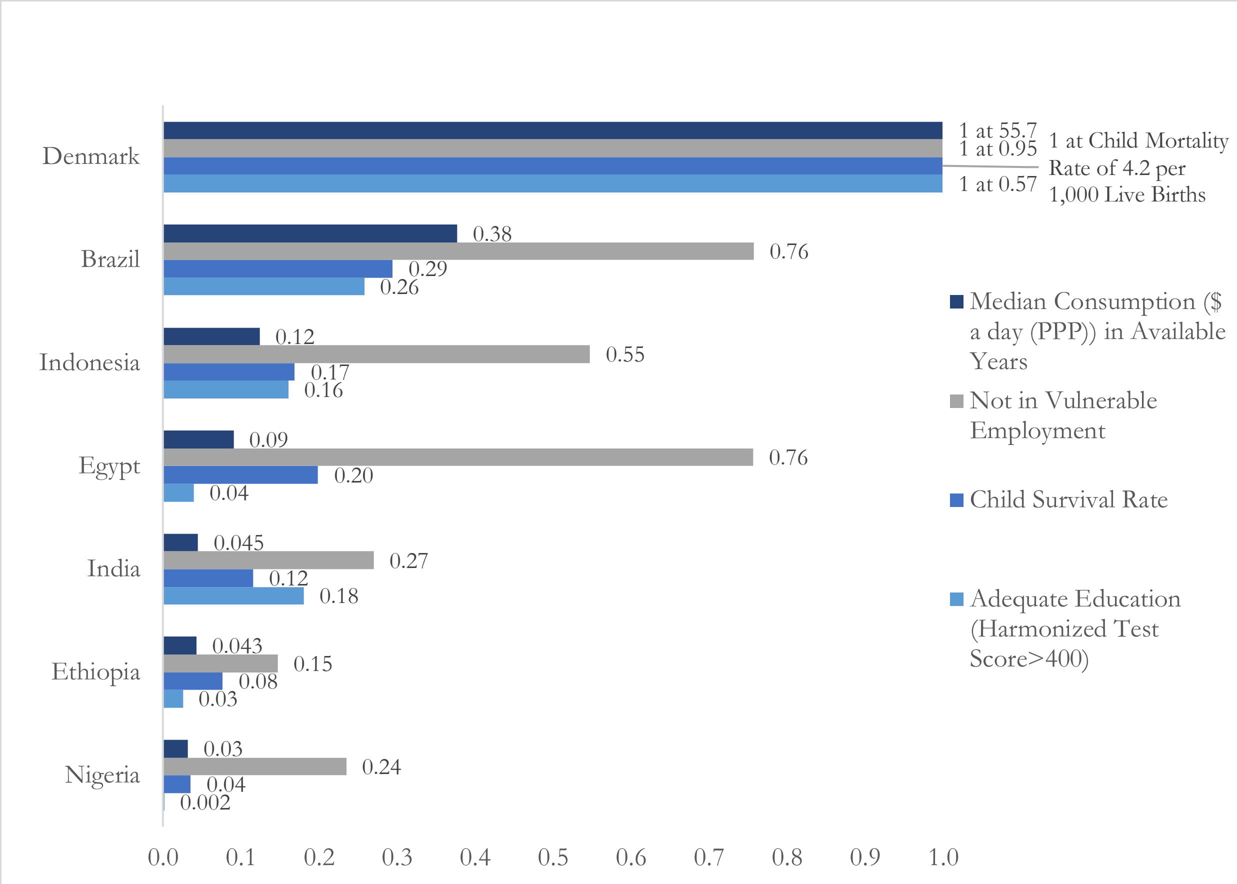
Figure 7: Productivity is driven by places; consumption wages gaps across workers with secondary schooling, in the same occupations and in all occupations in 2018



Source: Pritchett and Hani (2020) and International Labor Organization STAT

Without immigration, not only the global equalization of wages but also the global equalization of health, education, and wellbeing will not be achieved even in many years (see Figure 8).

Figure 8: Reaching the "Global Middle Class" (Decent Income, Good Job, Good Health, Adequate Education) is A Long Way Off for the Typical Person in Most Countries (Relative to Denmark = 1 for Each Indicator in 2020)



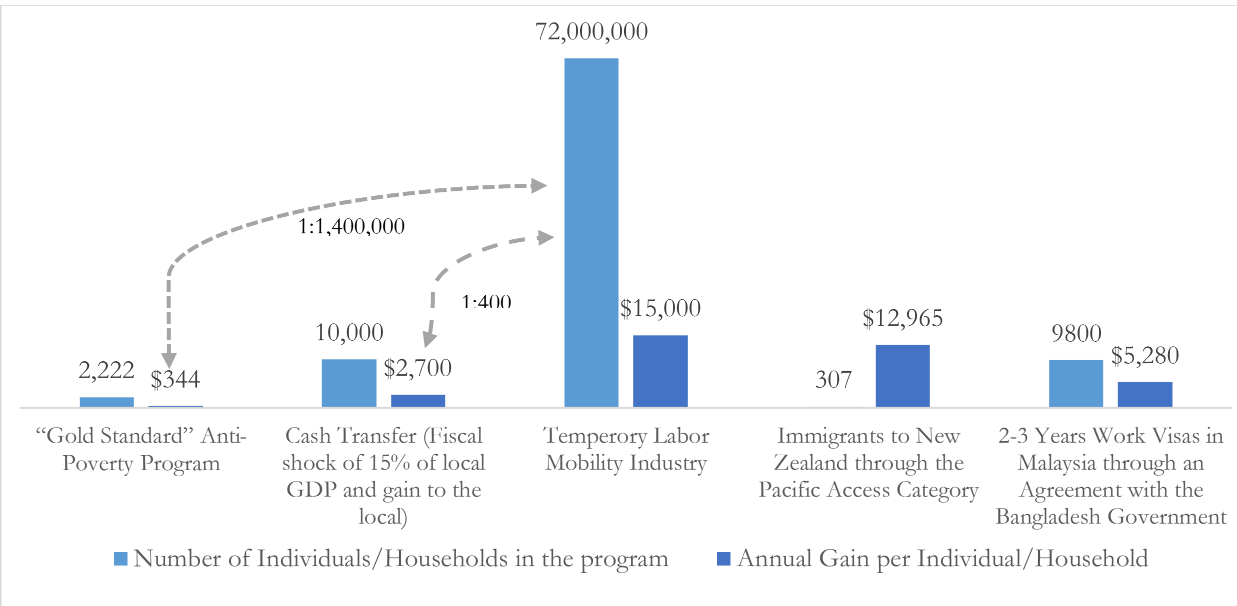
Source: World Bank's World Development Indicators, Institute for Health Metrics and Evaluation, and AlAzzawi and Hlasny, 2020 (to extract vulnerable employment in Egypt in 2018)

Migration raises the wages of non-emigrants in origin countries. In the 19th Century, mass migration led to reducing labor supply in the sending countries and raising the wages of the migrants in their origin countries (Williamson 1996). Mishra (2007) shows that the vast emigration of Mexicans to the United States during 1970 and 2000 may have caused Mexican's nominal wages to have increased 8 percent in Mexico. Also, mass emigration from Sweden (Karlström 1985) and Ireland (Hatton and Williamson 1993) caused equal increases in home wages. These estimates are aligned with the elasticities utilized in the global welfare estimates. For instance, Moses and Letnes (2004) found that a 10 percent reduction in migration barriers leads to a 3-4 percent increase in wages for non-emigrants at the origin. The estimated efficiency gains are unlikely to change even by substantial adjustment of these elasticities.

Programs addressing poverty reduction are not as successful as well-designed and implemented labor mobility programs (Pritchett 2018) (see **Error! Not a valid bookmark self-reference.**). Generally, labor mobility can offer both a jobs solution and a powerful development tool through remittances and the accumulation of skills in developing countries which face significant increases in their youth populations (Smith and Cepla, 2020).

The removal of emigration barriers has several other impacts on the sending countries. One piece of evidence of this is the foreign private household worker programs. These programs are likely to raise the status of women in these societies by receiving more control over resources. Additionally, workers are mostly more educated than women in their home societies. For instance, most of Filipina migrant women aged between 25 and 44 had a high school education, while only 60 percent of this geographic group in Philippines was educated. Therefore, there is the possibility of some aggravating the problem of inequality in the sending countries; however, this can stimulate investment in female education (Kremer and Watt 2005).

Figure 9: The relaxation of the binding constraints on labor mobility addresses economic inefficiency and generates the highest return to human well-being (trillion dollars) in the world



Source: Egger et. al. (2019), Banerjee et. al. (2015), Gibson et. al (2015), and Mobarak et. al. (2021)

5 Conclusion

Aging and the low-education labor scarcity in the service sector are causing significant social and economic issues in almost all high- income countries. Also, technology distortions and polarization in employment and wages are the current reality of these countries as a result of their policies and practices. At the same time, in developing countries, young people do not have the opportunity to have good jobs; nevertheless, billions of dollars are being spent to help them fight against poverty. As Sterman (2012) states "the policies we implement to address difficult challenges have not only failed to solve the persistent problems we face but are in fact causing them. All too often, well-intentioned programs create unanticipated side effects. The result is policy resistance, the tendency for interventions to be defeated by the system's response to the intervention itself." Policy based barriers to labor mobility, for example, has created the most pronounced price distortion in history, driving unfair technological change. Businesses do not economize on scarce resources; instead, they economize on what are in actuality abundant resources. A distortion is causing a massive negative externality—namely, changes in technology seeking to automate the low-to mid- skill segments of the labor market are destroying jobs, since firms respond to distorted relative prices. In addition to highly skilled technical expertise, innovation capabilities, and entrepreneurial talent, some of the most globally scarce factors are devoted to increasing efficiency and reducing the demand for one of the most globally abundant factors: low to medium skill labor (Pritchett 2020).

As the United States and other high-income countries experience slow population growth rates, having migrants will be the only way to sustain the taxes and revenues to provide Medicare and social security, and staff restaurants and the retirement homes that these countries' aging population demands (Kenny 2021).

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