

Demography as a Driver of Robonomics

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Abstract

This article looks into demographics and how the changes in demographics in the most developed countries in recent decades will work in ways to introduce more robots and automation technologies into the economy and society. The author looks at demographic and population trends to illustrate the expectations of substantial demographic decline in most countries. The discussion then turns to the social and technological factors that cause the decline in population in many developed countries, explaining how choice and fertility, technologies of contraception, and liberalized abortion laws have led to decreases in the number of humans born in the most developed countries. The article concludes, explaining the inevitable, that humanity is pushing itself into a robonomic economy with the challenges and externalities that will be substantial since there is a global tendency toward lower rates of fertility and an aging global population.

Keywords: Demography, Robots, Artificial Intelligence, Population Decline, Fertility, Automation

Type: Article

Citation: Webster, C. (2021). Demography as a Driver of Robonomics. *ROBONOMICS: The Journal of the Automated Economy*, 1, 12.

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I. Introduction

Change in the demographic composition of populations is a historical process that is as ancient as it is natural. Humans, throughout history, have moved from place to place and have changed the demographic/genetic and cultural composition of the landscape. These migrations and the general success of the human species have resulted in the *status quo*, a world in which there are about 8 billion people (Roser, 2019). Now, the success of the human species is threatened, as there is a question as to the carrying capacity of the Earth with regards to humans, although making projections as to how many humans the Earth can carry is a difficult debate (see, for example; Dahl, 2005; Salmony, 2004). The truth is, it is hard to determine how many people Earth can sustain and the sustainability of the human populations is an existential issue. The good news is that there are general trends in human fertility that suggest that most of the regions of the world have declining fertility, with some looking into the various scenarios of human population and the ramifications of these scenarios (See, for example; Vollset *et al.*, 2020). The change in fertility and the uneven changes in fertility in countries, regions, and classifications of countries have massive ramifications on the global economy and global politics. Fertility trends will assist in the robotization of the economy while at the same time impacting upon international relations and the international political economy in ways that are obvious but acknowledged by few.

Traditionally, demographic change is caused by migration, government policy, disease, intermingling, and death/reproduction rates. Often spoken of are the historically important movements such as the importation of millions of Africans as slaves to the Americas, the Muslim slave trade, and the massive reduction of indigenous populations in the Americas. The demographic change in the Americas is still recent enough that there is still the language used to denote those who are a mixture of European immigrants and the local indigenous peoples (“Métis” in Canada and “Mestizos” in Latin America).

Other massive changes in more recent years that will change societies for a very long time include the influx of Muslim populations into Europe since the end of World War Two (guest workers/gastarbeiters from Turkey to Germany, immigrants from the Maghreb in France, and the more recent surge of migrants from Africa and the Middle East throughout Europe since 2015) and the influx of Latin American populations into the USA since the 1970s. In the not-so-distant past, the Ceausescu regime outlawed contraception and abortion in 1966 to increase the population size of Romania (Mackinnon, 2019) and the policy was generally successful, but since the fall of the regime and reversal of these policies, the country’s population is in decline. The current policies of China towards the Uyghur minority appear to be intended to limit the minority’s demographic presence inside of the People’s Republic of China (Landale, 2021).

However, demography not only changes because of massive movements of people from migration (forced or by choice) or targeted pro-natal (or anti-natal) policies, but also because of personal choice, technology, and shifts in social attitudes. The technology and availability of contraception, paired with the liberalization of abortion in many countries gives women a great deal more control over pregnancy risk and choices once a woman is pregnant. This means that sexual interactions in a few decades have dropped from being something carrying a high risk of pregnancy to a much lower risk, since no contraceptive offers a guarantee that pregnancy will not result. When abortion is an option (both in the chemical form as the “morning-after pill” and as a more invasive medical procedure), the risk of having a child is reduced to almost nil, for those willing to accept all the available options.

Here, we will highlight the changes that have taken place in many countries in recent years that have had an impact upon demography. We will explore changes in terms of choice of having children, contraceptive technologies, and liberalization of abortion to look at how these changes impact population sizes/reproduction rates. We then investigate how these demographic changes encourage the transition to an economy in which automation technology plays a more central role than ever before, especially in the most developed countries.

2. Changing Demographics with Fewer Babies

The growth of the human population on the Earth over the recent centuries has been substantial. For example, while there were only about 600 million humans on Earth in 1700, there were two billion in 1928 (Roser, 2019). But the growth of the size of the human population has increased dramatically since then, with a massive 7.7 billion people on Earth, as of 2019 (Roser, 2019). The trajectory is suggestive of explosive growth that is not entirely desirable nor sustainable, since such exponential growth of population is problematic in terms of resources needed to sustain such a large population. It is projected, by some, that the human population will stop growing by the end of this century (Cilluffo, & Ruiz, 2019), which will be a relief, although it is unclear whether the Earth will have the capacity to sustain a population of the size that it will be at the end of the century. A great deal of brainpower and attention has been invested into the human population scenarios for the future (Vollset et al., 2020).

While the population has grown a great deal in recent centuries due to all sorts of technological and political improvements, for the first time in recorded history, there is an expectation of a sustained reduction in the population of humans in most regions, as Figure 1 illustrates. What is noteworthy is that there are unequal growth rates in populations in a regional sense. The continued growth of the population in the poorest continent (Africa) is of the most concern, since the growth is occurring in a region in which lower levels of development means that supplying biological and social necessities (water, food, sanitation, education, medical care, and other necessities) is a challenge even with current population levels. The more developed countries have a very different issue since most developed countries are nowhere near population replacement levels. The data also show that any serious discussion about humans meeting or surpassing the carrying capacity of the planet seems to be driven by the very high population of Asia (that has generally stabilized) and the relatively uncontrolled population growth in Africa.

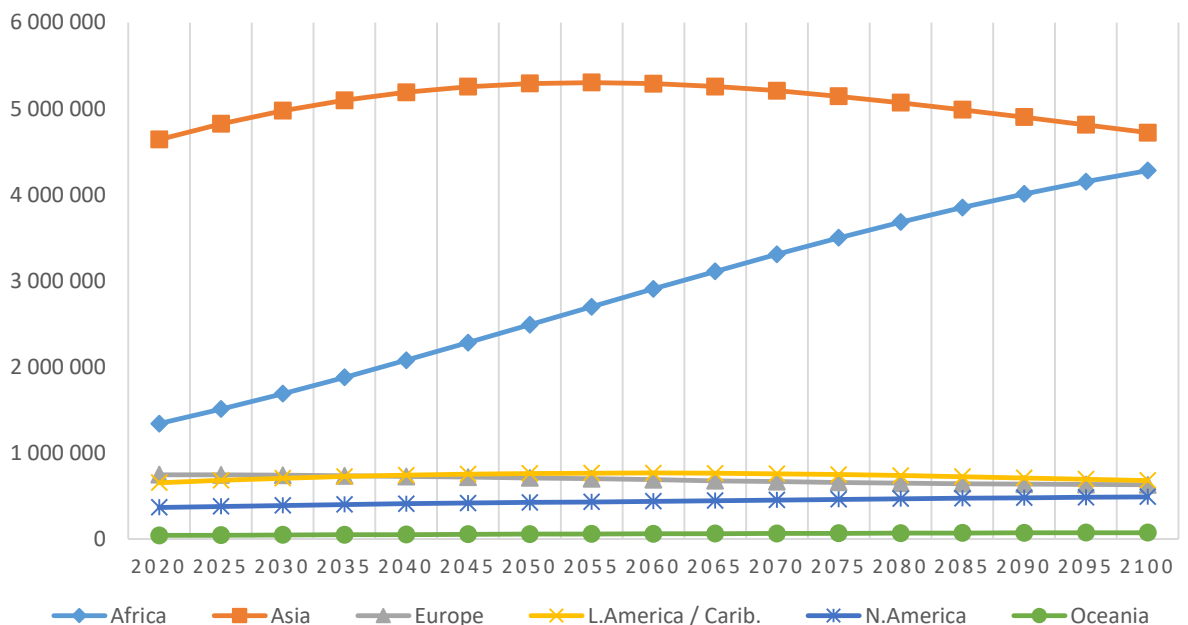


Figure 1. Projected Population in Regions (thousands) (Data Source: UN Population Division, 2021)

While the population for most regions will either decline or remain about where they are, there are remarkable declines in fertility rates throughout most of the world. Figure 2 illustrates some general trends among some

regions and some countries with noteworthy and high population growth countries. While the countries with the highest fertility rates are all in Africa, they all illustrate a substantial downward trend. All those regions that are above replacement levels are on gradual paths towards less growth. Those countries with the highest fertility rates (Niger and Mali) are substantially higher than any other countries or collections of countries but they still display a slow decline in fertility rates over the past few decades. While many less developed countries are far above replacement levels, the data do show a gradual decline in fertility, even if they are nowhere near the very low European Union fertility level, a level that is well below replacement level (2.1 children per woman).

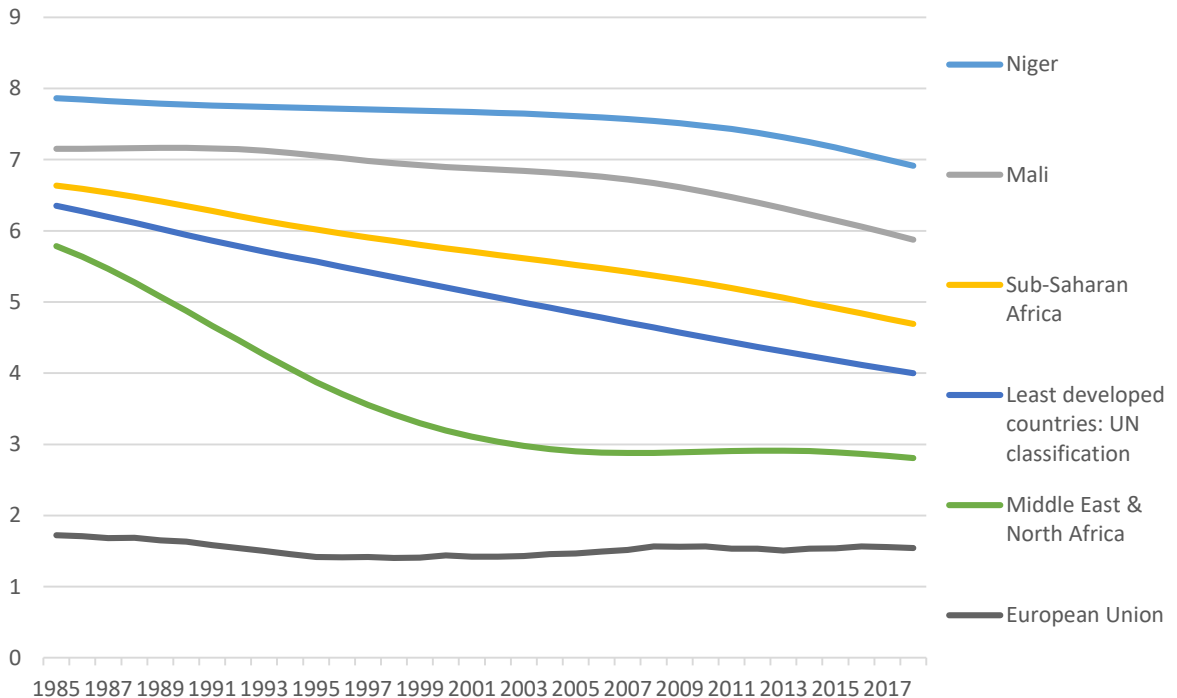


Figure 2. Female Fertility Rates --Selected Countries/Regions (Data Source: World Bank, 2021)

3. Why Fewer Babies

There are many reasons that people have fewer babies, especially in more developed countries. According to one paradigm of development, modernization theory, countries go through stages of development to become “modern” (“developed” in our common language). Rostow (1960) pioneered the language and conceptualization of this, explaining that societies move from being traditional through several stages leading to the highest stage he described as “high mass consumption.” This approach is largely economic, but it has serious implications for society, as the end-stage has a society that is more closely centered around nuclear families, is far from an agricultural society, and stresses individual choice and freedom. Linked with this is the much more demographic concept of the demographic transition, a description of how societies go through phases in which there are high birth rates and then leading to societies with low fertility rates (Galor, 2011). The empirical data show quite clearly that low fertility rates and high rates of economic development in societies are highly correlated, meaning that a population that is developing is expected to have the externality of a lower birth rate (Myrskylä, Kohler & Billari, 2009). Whatever the reason, more developed societies generally have lower fertility rates, as a general rule. The People’s Republic of China is a good example of a country that has designed policy to follow this demographic generalization, having a “one-child” policy from 1979 and then ending policy in 2015 (Wang, Gu, & Cai, 2016) to encourage higher fertility rates after the country had developed sufficiently.

In the developed world, the reduction in the fertility of women has been the most pronounced. Figure 3 illustrates the low rate of fertility of women in selected OECD countries. For populations to retain their population size, about 2.1 babies per woman is needed (Castles, 2003). The data show that in none of the selected countries do women have enough children to maintain population sizes, with a few notable exceptions. Of the member states of the OECD for which 2018 data are available, only Turkey, Mexico, and Israel have fertility rates that are near or surpass replacement levels (OECD, 2021). Turkey has a fertility rate of 2.069, Mexico 2.129, and Israel 3.09. What is interesting about these data are that Turkey and Mexico are some of the least economically developed of the OECD countries and Israel is a special case, consisting of populations that are very dissimilar from an average OECD country. Turkey and Mexico are interesting, as despite not being as developed as most of the other OECD countries, their fertility rate hovers around replacement levels, meaning that a country need not be as developed as the most developed in the world to exhibit low fertility rates.

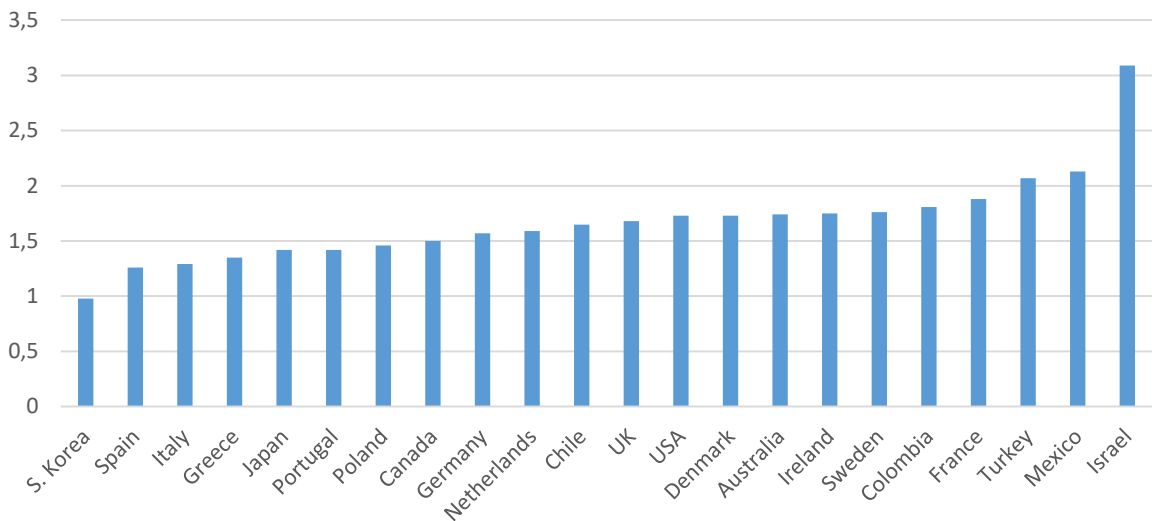


Figure 3. Fertility Rates of Selected OECD Countries (2018) (Data Source: OECD, 2021)

Low fertility rates in developed countries is the general rule, so some discussion of what caused the lowering of fertility rates should be discussed. While there may be more general issues common to all highly developed countries that facilitate the lowering of birthrates (such as high literacy rates, access to medical care, and sophisticated welfare states), a look into the more specific and proximate causes of the suppression of fertility rates is needed. The major and more direct factors that enable a lowering of fertility rates in developed economies are choice/fertility issues, technology, and the liberalization of abortion.

Choice and Reduced Fertility

In terms of choice, women have a limited timeframe in which to bear children. Since women have entered the workforce in large numbers, many have delayed becoming a parent until they are older. The delay in childbirth in women is a major issue in terms of female fertility (Delbaere, Verbiest & Tydén, 2020). While it is not entirely known why women delay having children (Mills, Rindfuss & McDonald, 2011), it seems many women prefer to spend time in the workforce rather than spending time in pregnancy and as mothers. To encourage women and couples to have children, there have been policies in some developed countries that have given inducements to encourage women to have children, a “baby bonus.” But these instituted policies have had little or no impact upon births by young women. For example, the Australian experience of ten years with the baby bonus seems to have had no noteworthy impact upon births (Deutscher & Beunig, 2018; Laetitia & Takongmo, 2018). It

seems that the preference of women to put off having children until later has resulted in lower fertility rates and that most governmental incentive schemes have not successfully incentivized women to have more children.

However, there are issues apart from female fertility and female choices, since male fertility is responsible for about 40-50% of fertility issues (Kumar & Singh, 2015). There have been many studies with regards to reductions in sperm counts in recent years and there is good reason to believe that there is a decline in sperm counts in the West for decades (Levine *et al.*, 2017). While much of the research is country-specific about developed countries (see, for example, Rahban *et al.*, 2019) there is also some research in developing countries (see, for example, Wang *et al.*, 2017; Feki *et al.*, 2009). In general, the data show that there are significant declines in the quality of sperm globally, meaning that less fertility may not just be a problem with females delaying their pregnancies and their choice but also an issue with male fertility capabilities, for whatever reason(s).

Technology

Historically, there have been superstitions and cultural practices used to give humans a feeling of control over their reproduction (Planned Parenthood, 2012). The condom has a particularly long history, perhaps going as far back as 3000 BCE (Khan, Mukhtar, Dickinson & Sriprasad, 2013) but it was not until fairly recently they were used widely as a technology to prevent pregnancies. Historically, condoms were primarily thought of as a technology to prevent the spread of disease. Early condoms were made of many different organic materials, although later when rubber and latex technologies advanced, they were made from these more modern materials. By 1924, condoms were the most prescribed form of birth control (Planned Parenthood, 2012), since there was some reason to believe that they were effective and not just a preventative measure against sexually transmitted infections. There were other methods of contraception used apart from the condom, such as a contraceptive sponge, a technology that is so old it is even mentioned in the Talmud (Planned Parenthood, 2012). While behavior and technological methods of contraception before the 20th century may have met with some level of success, the modern methods beyond the modern condom have serious social implications for society, since more modern methods can be used in stealth, are highly effective, and are out of the control of the male partner.

The real revolution in terms of reproductive technology came with the birth control pill when it was approved by the FDA in 1960 (Christin-Maitre, 2013). It remains the first modern technology that empowered women in ways that were not available before, as they could separate vaginal intercourse effectively from pregnancy (Bullough & Bullough, 1990). The outcome of this technology is that the birth control pill empowered women to control their fertility separate from their male partners. It is no coincidence that the sexual revolution occurred following this innovation, an innovation that is highly effective and permits women to focus on sexual pleasure with a very low risk of pregnancy and does not require the male partner to participate in the method.

The development of birth control technologies did not stop at the birth control pill. Modern contraceptive sponges were introduced to the US market in 1983 (Planned Parenthood, 2012). Although taken off the market for some years, the contraceptive sponge has been reintroduced. There have been several other innovations, such as diaphragms and cervical caps, IUDs, and implants, giving women more choices in terms of the methods they choose to prevent themselves from pregnancy. While there may have been more ancient versions of some of these technologies to help control births, the modern versions are quite effective and safe. What it means for modern women is that there are many different forms of birth control available and that if they have access, effective and relatively safe technologies are available. So, in a dyadic sexual interaction between a male and a female, there are many technologies that are available that the female may use to prevent pregnancy that are not visible and can be used with stealth, while the male has a highly reliable and inexpensive technology (the condom) that can be used to prevent pregnancies and is an excellent preventative measure against sexually transmitted infections. So, technology has advanced in ways that make it possible to vastly reduce unwanted

pregnancies, although the cost of the technologies, access to the technology, and cultural factors may work in ways to limit the use of such technologies for some individuals.

Abortion Liberalization

Apart from preventing pregnancy, there are options with regards to how a woman may terminate a pregnancy. While this remains a contentious issue in many societies since it brings up many religious and ethical sensitivities, there are many countries (about 66) in which abortion has been decriminalized or is fully legalized (United Nations Department of Economic and Social Affairs, 2020). The USA's 1973 decision of *Roe v. Wade* determined that abortions were permitted in a legal sense upon demand during the first trimester after fertilization. In the USA, however, there are ongoing controversies with regards to abortion and when it is acceptable, including the issue of those fetuses that are aborted but still are viable, suggesting abortions that take place far beyond the first trimester (Grady, 2019). While countries may have many rules and regulations about the circumstances under which abortions are permissible, many are quite liberal and so many women have the choice of terminating their pregnancies via a medically invasive procedure.

Apart from the medical/invasive forms of abortion, there are also chemical abortions, something developed soon after the birth control pill was available on the market in the 1960s. However, it took years to get from development to its approval by the FDA in 1999 as a prescription drug (Sifferlin, 2013). In 2013 the morning after pill/emergency contraception was made available over the counter in the USA. Most developed countries (and many other countries) today allow for access to emergency contraception, whether through a pharmacist or as an over-the-counter medication that the consumer picks up in the pharmacy (International Consortium for Emergency Contraception, n.d.).

The ability to legally terminate a pregnancy, either through chemicals or a medical intervention has given women another tool to limit births. While there is little indication that emergency contraception has had an impact upon births as a public policy tool (Baird, Cameron, Evers, Gemzell-Danielsson, Glasier, Moreau *et al.*, 2015), there is some indication of the impact of abortions. In recent years (2015–2019), there are about 73 million abortions a year globally per year (Bearak, Popinchalk, Ganatra, Moller *et al.*, 2020). Since human growth is exponential, the impact of 73 million abortions per year would be expected to be a substantial effect on population over several generations.

One interesting aspect of the ability to abort freely is the eugenics behind it. With prenatal testing and other techniques, abortion may be applied selectively (as has been done frequently in Asia) to abort females (Hesketh, Lu & Xing, 2011) and to prevent children with Down Syndrome from being born, as is common in Denmark (Zhang, 2020) and Iceland (Will, 2018). With screening and liberal laws towards abortion, humans have the chance to shape the genetic pool as never before. While there may be ethical issues with disproportionately aborting females and those that are likely to have Down Syndrome, prenatal observations and testing allow individuals to eliminate the types of babies they do not want to have. Humans may soon be able to do quite a bit more and have their “designer babies,” babies chosen for their genetic makeup or modified to have the desired traits (Pang & Ho, 2016).

4. The Political Consequences of Decreased Fertility

In the most developed countries, human populations have generally chosen to have fewer children. The factors causing women (primarily) and men to have fewer children are many and are a mixture of conscious decisions, advances in reproductive technology, and liberalization of abortion. As such, there is a population issue within the most developed countries, a reduction in population size. The reduction in the size of the population is a major issue since there is a need for human labor to maintain the economy (including government pension schemes). While we see that there is a general trend towards lower fertility rates globally, the developed

countries experience the lowest levels and therefore suffer from the greatest political and economic consequences of the massive reductions.

To make up for the population reduction, countries have instituted various policies, including policies to import labor, policies to encourage fertility, and policies to automate labor (Webster & Ivanov, 2020). Each of these policies has strengths and weaknesses but only one of the policies is likely to be successful in terms of supplying the needed labor to fit the demand for labor in an attainable timeline and without extremely unpleasant and politically problematic externalities. That policy is the replacement of human labor with robotic labor.

Importing labor to developed countries comes at a cost. For example, the movement of labor from places where there is a surplus of labor to places where there is a shortage of labor can lead to cultural conflict. Muslim immigrants to Western countries seem to be hard to integrate into the host society (Koopmans, 2015; Mohiuddin, 2017) and some societies have a very hard time integrating these new populations. For example, while the Turkish guest workers had been in Germany since the 1960s, it was only in 2000 that the descendants of those workers were granted German citizenship. But it is not just the state that may not entirely embrace new immigrant groups, sometimes the new migrant groups for one reason or another have a hard time integrating into the host culture, something that the substantial numbers of ISIS/ISIL fighters from the European Union member states seem to suggest.

The importation of a labor pool with very different cultural perspectives may bring all sorts of integration problems and resentment from the host population. There may be not only a problem with the integration of the workforce into the host community but also a political backlash towards those who are supportive of the importation of such labor from abroad. At any rate, importation of labor from less developed societies may not fully solve a labor shortage issue (Cappelli, 2005), even if used to the maximum level.

Policies that give incentives to people to be more fertile do not seem to be particularly effective, in a historical sense, since populations in more developed countries seem to favor smaller families when given the choice. Even if such policies were effective and women in developed countries were to have more children, the impact of the births would take a long time to be effective. It would be about twenty years for an effective incentive structure in developed countries to have a noteworthy impact upon population sizes if an effective pro-natalist policy could be crafted in a democratic country. Also, it would be unlikely that a developed and democratic country would be able to institute draconian policies against abortion and contraception as did the Ceausescu regime in Romania during the last century.

The other policy, moving to a more automated economy seems to be the most feasible, since it is almost immediately effective and does not lead to substantial cultural frictions, apart from a neo-luddite reaction to the introduction of substantial automation into the economy. Indeed, there may be significant social resistance to new technologies today, as has been the case in earlier instances (Jones, 2006). Today's automation is somewhat different since it is based upon a very real issue of what the alternative is since there are shrinking labor pools and impractical or problematic solutions to the shrinkage of the labor pools. So, while there may be resistance to the increased replacement of tasks towards automated systems in the developed world, the lack of a better and immediate solution to the labor shortage suggests that automation is the most effective and immediate, although it will entail externalities.

The demographics of humanity, especially in the most developed countries, suggest a movement to an economy that is more robonomic at its core, an economy in which labor is predominantly done by various automation technologies (Ivanov, 2017). Since the Industrial Revolution, manufacturing has become much more automated and efficient, leading to high levels of production. While early automation of production (for example, from a handloom to an automated loom producing textiles) may seem quite basic compared to modern automation

technologies, it still increased productivity of industries and enabled the modern world in which we live with a massive amount of material wealth. As such, robots already provide a great deal of labor in much of our manufacturing industries and have done so for some time now (Ross, Fardo & Walach, 2018). For some industries, such as the automobile industry, robots have been doing large amounts of labor in the industry for many years (Robotics Industries Association 2017). But many other industries are only now catching up, especially service industries.

The demographics of developed countries are likely to steer industries and policies towards increasing automation of all sectors of the economy but some externalities will have to be dealt with, some of which have an international relations dimension, as Table I illustrates. The first major externality is the creation of an international issue that may create even greater rifts between those countries that have an excess amount of labor and those that have found they are no longer dependent upon the importation of labor to solve their labor shortage. For example, those countries with large population growth typically suffer from instability from “youth bulge,” the presence of large numbers of young men who do not have adequate work opportunities to keep them busy. Since World War Two, the developed countries have served as hosts to millions of imported laborers from countries in which there were few opportunities. This exodus of millions to developed countries to work was a pressure valve, stabilizing those less developed countries with excess labor (with many family members sending money back home from developed countries). If developed countries can no longer host large numbers of young men from less developed countries because the tasks and jobs that such people would do will be automated, then youth bulge could be an increasing issue with less developed countries (Inayatullah, 2017). However, there is also the other positive impact, that the brain drain from the less developed countries may slow, leaving a great deal of brainpower in less developed countries to assist in building economies there.

Table I. *Population Externalities and Issues*

Region	Major Demographic Issue	Best Solution to Demographic Issue	Externalities Faced
Developed Countries	Fertility Decrease	Automation of Industry	<ul style="list-style-type: none"> ✓ Unemployment of less skilled workers ✓ Decline in demand for imported labor ✓ Decline in demand for services and products
Less Developed Countries	Population Increase	Development	<ul style="list-style-type: none"> ✓ Political instability ✓ End of the brain drain

The issue with youth bulge in less developed countries is also likely to lead to a great deal of friction between the developed and less developed countries in this century and the next century. Less developed countries will still want their millions of excess laborers to go abroad to work, but the more developed countries may not need them. The cheap labor in less developed countries will not have the value it once did, since much production will be automated. So, the development model that worked for the Asian Tigers economies (cheap and hardworking labor pools) may no longer be an option, since automation technologies may make cheap unskilled human labor something unneeded by many industries. This will threaten the political stability of less developed countries since the major value that these countries have for the global economy (beyond natural resources) are as markets and suppliers of inexpensive unskilled labor. Governments in less developed countries will be under stress and will need to find opportunities for their citizens, denied the traditional pressure value that allowed for desperate young men who wanted the opportunity to simply leave the country. This will increase demands for development in less developed countries, likely leading less developed countries to create all sorts of make-work projects for their populations.

Another major issue is what to do with all the labor that is not needed in the developed countries. There is an indication that robots harm wages and the demand for labor (Acemoglu & Restrepo, 2020). This may suggest that humans may no longer be central to the functioning of the economy, except perhaps as consumers. However, it seems a bit more likely that what will happen is that the skilled labor that has capabilities that robots and artificial intelligence do not yet have will be favored in the job market over those whose only value is as unskilled labor. Since most of the tasks that are currently done by unskilled labor will soon be done by automation technologies, there could be a significant portion of the labor market that is unneeded, even if there are currently issues with labor shortages for unskilled or less skilled labor in developed countries. This brings up political and economic solutions such as universal basic income, a topic that has been becoming popular in the most developed countries (Caputo, 2012; McDonough & Morales, 2020).

At any rate, the new economy will have to figure out how to use human labor, since population decline will lead to greater automation out of necessity and yet there will be too much excess labor in the market. A key issue with the labor that remains in the market is the capability of those who remain since those with skills that are needed will still find a place in the economy. Those who have technical capabilities that are of value to the economy will be employed while those who do not have the ability will not be employed. This is the labor division Stubbs (2017) refers to as the “god” class and the “useless” class in the new economy. This division will have a profound impact upon society, favoring those with technical skills and those with the requisite intelligence to attain technical skills.

5. A Brave New Robonomic World

Apart from the demographic changes that are generally predictable giving policymakers and industry the ability to prepare for them, there is fantastic growth in the capabilities of robots. A little over a hundred years ago, the word “robot” was coined (NPR, 2011) and now they are a reality, creating much of the material wealth that we experience while at the same time making headway into providing us with services. New ways of doing things are needed since the role of human labor in the production of wealth for humans has changed so radically in just one century. The expectations are that we will have a very different economy very soon. That means that our entire society and polity will also have to be rethought. While speaking about such topics as universal basic income fifty years ago may have been innovative and fantastic, currently, the idea may be pragmatic to solve the real problems that society, the economy, and political systems will face in a robonomic world.

The demographic changes are a driver for how governments, industry, and the citizenry will have to convert into a more robotized economy. A shortage of humans means that people will have to be replaced with technology, indeed research shows that middle-aged workers are already being replaced by robots in the USA (Acemoglu & Restrepo, 2018). While there will be winners and losers from this transition, there will be externalities within countries and a change in international relations. The transition to a robonomic society will not be without turbulence, so humanity (and our robots) will have to be brave or at least be programmed to appear brave for the new world we are entering into. May the robotic force be with us all!

References

- Acemoglu, D. & Restrepo, P. (2020). Robots and jobs: evidence from US labor markets. *The Journal of Political Economy*, 128(6), 2188-2244.
- Acemoglu, D. & Restrepo, P. (2018). *Demographics and automation*. National Bureau of Economic Research Working Paper No. w24421. Retrieved 01.03.2021 https://www.nber.org/system/files/working_papers/w24421/w24421.pdf
- Baird, D.T., Cameron, S., Evers, J.L.H., Gemzell-Danielsson, K., Glasier, A., Moreau, C., Trussell, J., von Hertzen, H., Crosignani, P.G., La Vecchia, C., Volpe, A., Glasier, A. & Crosignani, P.G. (2015). Emergency contraception: widely available and effective but disappointing as a public health intervention: a review. *Human Reproduction*, 30(4), 751-760.
- Bearak, J., Popinchalk, A., Ganatra, B., Moller, A. B., Tunçalp, Ö., Beavin, C., Kwok, L. & Alkema, L. (2020). Unintended pregnancy and abortion by income, region, and the legal status of abortion: estimates from a comprehensive model for 1990–2019. *The Lancet*, 8, e1152–1161. Retrieved 01.03.2021 [https://www.thelancet.com/journals/langlo/article/PIIS2214-109X\(20\)30315-6/fulltext](https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(20)30315-6/fulltext)
- Bullough, V. L. & Bonnie, B. (1990). *Contraception: A Guide to Birth Control Methods*. Buffalo, NY: Prometheus Books.
- Cappelli, P. (2005). Will there really be a labor shortage? *Human Resource Management*, 44(2), 143-149.

- Caputo, R. (Ed.). (2012). *Basic income guarantee and politics: International experiences and perspectives on the viability of income guarantee*. Springer.
- Castles, F. (2003). The World Turned Upside Down: Below Replacement Fertility, Changing Preferences and Family-Friendly Public Policy in 21 OECD Countries. *Journal of European Social Policy*, 13, 209-227.
- Christin-Maitre, S. (2013). History of oral contraceptive drugs and their use worldwide. *Best Practice & Research Clinical Endocrinology & Metabolism*, 27(1), 3-12.
- Cilluffo, A. & Ruiz, N. G. (2019). *World's population is projected to nearly stop growing by the end of the century*. Pew Research Center. Retrieved 01.03.2021 <https://www.pewresearch.org/fact-tank/2019/06/17/worlds-population-is-projected-to-nearly-stop-growing-by-the-end-of-the-century/>
- Dahl, R. (2005). The population equation: balancing what we need with what we have. *Environmental Health Perspectives*, 113(9), A598-A605. <https://doi.org/10.1289/ehp.113-a598>
- Delbaere, I., Verbiest, S. & Tydén, T. (2020). Knowledge about the impact of age on fertility: a brief review, *Upsala Journal of Medical Sciences*, 125(2), 167-174, DOI: 10.1080/03009734.2019.1707913
- Deutscher, N. & Breunig, R. (2018). Baby bonuses: natural experiments in cash transfers, birth timing and child outcomes. *Economic Record*, 94(304), 1-24.
- Feki, N. C., Abid, N., Rebai, A., Sellami, A., Ayed, B.B., Guermazi, M., Bahloul, A., Rebai, T. & Ammar, L.K. (2009). Semen quality decline among men in infertile relationships: experience over 12 years in the South of Tunisia. *Journal of Andrology*, 30(5), 541-547. doi: 10.2164/jandrol.108.005959.
- Galor, O. (2011). The demographic transition: causes and consequences. *Cliometrica*, 6(1), 1-28. doi:10.1007/s11698-011-0062-7
- Grady, D. (2019, February 26). 'Executing Babies': Here Are the Facts Behind Trump's Misleading Abortion Tweet. *The New York Times*. Retrieved 01.03.2021 <https://www.nytimes.com/2019/02/26/health/abortion-bill-trump.html>
- Hesketh, T., Lu, L. & Xing, Z.W. (2011). The consequences of son preference and sex-selective abortion in China and other Asian countries. *Canadian Medical Association Journal*, 183(12), 1374-1377. doi:10.1503/cmaj.101368
- Inayatullah, S. (2017). Youth bulge: demographic dividend, time bomb, and other futures. *Journal of Futures Studies*, 21(2), 21-34.
- International Consortium for Emergency Contraception. (n.d.) *EC Status and Availability Countries with non-prescription access to EC*. Retrieved 01.03.2021 <https://www.cecinfo.org/country-by-country-information/status-availability-database/countries-with-non-prescription-access-to-ec/>
- Ivanov, S. (2017). Robonomics – principles, benefits, challenges, solutions. *Yearbook of Varna University of Management*, 10, 283-293.
- Jones, S. E. (2006). *Against technology: from the Luddites to Neo-Luddism*. New York and London: Routledge.
- Khan, F., Mukhtar, S. I., Dickinson, K. & Sriprasad, S. (2013). The story of the condom. *Indian Journal of Urology*, 29, 12-15. doi:10.4103/0970-1591.109976
- Koopmans, R. (2015). Religious fundamentalism and hostility against out-groups: A comparison of Muslims and Christians in Western Europe. *Journal of Ethnic and Migration Studies*, 41(1), 33-57.
- Kumar N. & Singh A.K. (2015). Trends of male factor infertility, an important cause of infertility: A review of literature. *Journal of Human Reproductive Sciences*, 8(4), 191-196. doi:10.4103/0974-1208.170370
- Landale, J. (2021). Uighurs: 'credible case' China carrying out genocide. *BBC*. Retrieved 01.03.2021 <https://www.bbc.com/news/uk-55973215>
- Laetitia, L. & Takongmo, C. M. (2018). The impact of universal child benefits on family health and behaviours. *Research in Economics*, 72(4), 415-427.
- Levine, H., Jørgensen, N., Martino-Andrade, A., Mendiola, J., Weksler-Derri, D., Mindlis, I., Pinotti, R. & Swan, S. H. (2017). Temporal trends in sperm count: a systematic review and meta-regression analysis. *Human Reproduction Update*, 23, 646-659.
- Mackinnon, A. (2019) What Actually Happens When a Country Bans Abortion. *Foreign Policy*. Retrieved 01.03.2021 <https://foreignpolicy.com/2019/05/16/what-actually-happens-when-a-country-bans-abortion-romania-alabama/>
- McDonough, B. & Bustillos Morales, J. (2020). *Universal basic income*. Oxon and New York: Routledge.
- Mills, M., Rindfuss, R. R., McDonald, P. & Velde, E. (2011). Why do people postpone parenthood? Reasons and social policy incentives. *Human Reproduction Update*, 17(6), 848-860. doi:10.1093/humupd/dmr026
- Mohiuddin, A. (2017). Muslims in Europe: citizenship, multiculturalism and integration. *Journal of Muslim Minority Affairs*, 37(4), 393-412.
- Myrskylä, M., Kohler, H.P., & Billari, F. C. (2009). Advances in development reverse fertility declines. *Nature*, 460(7256), 741-743.
- NPR. (2011). Science diction: the origin of the word 'robot'. Retrieved 01.03.2021 <https://www.npr.org/2011/04/22/135634400/science-diction-the-origin-of-the-word-robot>
- OECD (2021). *Fertility Rates*. Retrieved 01.03.2021 <https://data.oecd.org/pop/fertility-rates.htm>
- Pang, R. T. K. & Ho, P. C. (2016). Designer babies. *Obstetrics, Gynaecology & Reproductive Medicine*, 26(2), 59-60.
- Planned Parenthood. (2012). *A history of birth control methods*. Retrieved 01.03.2021 https://www.plannedparenthood.org/files/2613/9611/6275/History_of_BC_Methods.pdf
- Rahban, R., Priskorn, L., Senn, A., Stettler, E., Galli, F., Vargas, J., Van den Bergh, M., Fusconi, A., Garlantezec, R., Jensen, T.K., Multigner, L., Skakkebaek, N.E., Germond, M., Jørgensen, N., Nef, S. & the NICER Working Group (2019). Semen quality of young men in Switzerland: a nationwide cross-sectional population-based study. *Andrology*, 7(6), 818-26.
- Robotics Industries Association (2017). *The history of robotics in the automotive industry*. Retrieved 01.03.2021 <https://www.robotics.org/blog-article.cfm/The-History-of-Robotics-in-the-Automotive-Industry/24>
- Roser, M. (2019). *Two centuries of rapid global population growth will come to an end*. Retrieved 01.03.2021 <https://ourworldindata.org/future-population-growth>

- Ross, L. T., Fardo, S. W. & Walach, M. F. (2018). *Industrial Robotics Fundamentals: Theory and Applications*. Tinley Park, IL: Goodheart-Willcox Co.
- Rostow, W. W. (1960). *The stages of economic growth: A non-Communist manifesto*. Cambridge, England: University Press.
- Salmony S. E. (2004). The human population: accepting earth's limitations. *Environmental Health Perspectives*, 112(17), A979–A980. <https://doi.org/10.1289/ehp.112-a979b>
- Sifferlin, A. (2013). Timeline: the battle for plan B. *Time*. Retrieved 01.03.2021 <https://healthland.time.com/2013/06/11/timeline-the-battle-for-plan-b/#:~:text=1999%3A%20The%20FDA%20approves%20Teva,was%20taken%2012%20hours%20later.>
- Stubbs, A. (2017). Automation, Artificial Intelligence, and the God/Useless Divide. *Perspectives on Global Development and Technology*, 16(6), 700-716. Doi: <https://doi.org/10.1163/15691497-12341457>
- United Nations Department of Economic and Social Affairs. (2020). *World Population Policies 2017: Abortion Laws and Policies*. United Nations Department of Economic and Social Affairs, Retrieved 01.03.2021 https://www.un.org/en/development/desa/population/publications/pdf/policy/WPP2017/WPP2017_Report.pdf
- United Nations Population Division (2021). *World Population Data*. Retrieved 01.03.2021 <https://population.un.org/wpp/Download/Standard/Population/>
- Vollset, S.E., Goren, E., Yuan, C-W., Cao, J., Smith, A.E., Hsiao, T., Bisignano, C., Azhar, G.S., Castro, E., Chalek, J., Dolgart, A.J., Frank, T., Fukutaki, K., Hay, S.I., Lozano, R., Mokdad, A.H., Nandakumar, V., Pierce, M., Pletcher, M., Robalick, T., Steuben, K.M., Wunrow, H.Y., Zlavog, B.S. & Murray, C.J.L. (2020). Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study. *The Lancet*, 396, 1285-1306. doi:10.1016/S0140-6736(20)30677-2.
- Wang, F., Gu, B. & Cai, Y. (2016). *The end of China's one-child policy*. Brookings. Retrieved 01.03.2021 <https://www.brookings.edu/articles/the-end-of-chinas-one-child-policy>
- Wang, L., Zhang, L., Song, X., Zhang, H., Xu, C. & Chen, Z. (2017). Decline of semen quality among Chinese sperm bank donors within 7 years (2008-2014). *Asian Journal Andrology*, 19(5), 521-525. doi: 10.4103/1008-682X.179533.
- Webster, C. & Ivanov, S. (2020). Demographic change as a driver for tourism automation. *Journal of Tourism Futures*, 6(3), 263-270. <https://doi.org/10.1108/JTF-10-2019-0109>
- Will, G. (2018). The real Down syndrome problem: accepting genocide. *The Washington Post*. Retrieved 01.03.2021 https://www.washingtonpost.com/opinions/whats-the-real-down-syndrome-problem-the-genocide/2018/03/14/3c4f8ab8-26ee-11e8-b79d-f3d931db7f68_story.html
- World Bank (2021). *Fertility rate (births per woman)*. Retrieved 01.03.2021 <https://data.worldbank.org/indicator/SP.DYN.TFRT.IN>
- Zhang, S. (2020). The Last Children of Down Syndrome. *The Atlantic*. Retrieved 01.03.2021 <https://www.theatlantic.com/magazine/archive/2020/12/the-last-children-of-down-syndrome/616928/>

Received: 22/02/2021

Revised: 04/03/2021

Accepted: 06/03/2021