Robotics and the Transformation of Economic Dynamics (A Focus on African Experiments)

Prof. Peter John Opio

> "We must decide, now, whether the future will see broad based prosperity or catastrophic levels of inequality and economic insecurity. Unless societies change their approach to growth and development, they will not only end up in a broken planet and conflict-ridden communities: they will face massive unemployment" – Martin Ford: *The Rise of the Robots.*
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> "Pitting man against machine only stokes antipathy towards technology and could have a chilling effect on the technology and the innovation and adaptation of technology essential to grow the economy" – Robert Atkinson: *Stop Saying that Robots are Destroying Jobs.*

Introduction

In this paper we closely examine the dynamic interplay between robotics and human labour in relation to the economy. Our goal, by way of an apology, is not to further the economic arguments for and against robotic in relation to growth, and productivity in the first place. Nor is it the aim of this paper to provide an elaborate analysis of the effects of robotics on labor, wage and income. These are all crucial issues. The key challenge that this paper seeks to address is anthropological: namely, *how can we achieve the integration of robots and human activity in the production of goods and services towards the transformation of the society, without subjugating humans to the robots or robots to humans?*

We maintain in this paper that this and related challenges posed by robotics require a broader understanding of economic growth, and an understanding of productivity that transcends mere income and or efficiency gains. Investment decisions in robotics, and decisions on what type of robotics to leverage upon, must be driven by a consideration for the *wellbeing of the society*, and informed by the common good (*bonum communis*) rather than mere economic growth.

Using recent African robotic experiments --(1) the Ethiopian Sheba Valley Initiative and the Icog-Labs' participation in creating Socio-bots; (2) the Rwandan medical supplies drone delivery and (3) the Kenyan use of drones in the utility sector to some extent – the paper demonstrates that even in the context of developing economies, "pitting man against machine not only stokes antipathy towards technology and could have a chilling effect on innovation and adoption of

economy essential to grow the economy"[1]. An unbridled "robophobia" may subject employees to work-based risks, and eventually undermine their rights to a dignifying safe work environment as well as their wellbeing.

The paper proceeds as follows. After a brief discussion on robotics, its definition and the problems of productivity, and competitiveness in the global context (1.0 - 1.1), the paper examines two African robotic experiments: (2.1) the ambitious Ethiopian venture into artificial intelligence, internet of things and subsequent development of applications for robotics and humanoids; and Rwanda's groundbreaking efforts towards leveraging on drones for the delivery of blood to remote rural health facilities (2.2). In the light of the challenges encountered within the African experience (2.3), we recast the polarized debates on benefits and shortcomings of robotics ventures in relation to human work and socio-economic transformation by leading economists (3.0). In section (3.1) we present the unexamined yet crucial assumptions that stymied the effective integration of robotics and human labor for socio-economic transformation. Section (4.0 - 4.1.5) discusses the core (ethical) principles which can help to recast the robotics, human labor and productivity debates in the light of a broader perspective on wellbeing and human flourishing. Finally, some key lessons learnt from the African experiments, in the broader context of the robotics and economic transformation, are outlined (5.0)

1. 0. Robots, Productivity, Competitiveness and Human Labour

1.1 The Robot: What it is and its growing economic and social importance

Stemming from the Czech word "robota", which means forced labor, the term "robot" denotes tasks accomplished by a physical machine that moves and responds to its environment, or tasks completed by software, devoid of physical embodiment, and whose outcome *excludes human intervention*. Although in its origin, it is nothing short of dystopian science fiction masterpiece[2],

[1] Atkinson, RD. "Stop saying robots are destroying jobs: they aren't", *MIT technology review*, 3 September, 2013. (accessed on 28.11.2018 at: https://www.technologyreview.com/s/519016/stop-saying-robots-are-destroying-jobs-they-arent/

[2] The term "robot" first appeared almost 100 years ago with the publication of *Rossum's Universal Robots (R.U.R)*, a science fiction play by the Czeck writer Karel Čapek. The play begins with the general manager of Rossum's Universal Robots discussing the potentials of his assembled beings to raise the living standards by lowering the prize to zero and thus ending poverty and toil. Unfortunately, robots decide to destroy the humans and overthrow the masters. See IFR, "The impact of robots on productivity, employment and jobs" *A position paper by the international federation of robotics,* April 2017 (At https://ifr.org/img/office/IFR_The_Impact_of_Robots_on_Employment.pdf. Accessed on 19/1/2019)

the robot has now assumed such prominence in our time that it is considered an indispensable transformational force that not only drives the economic manufacturing and service sectors. Its impact on the economy, society and human persons is however, far from fictional (see Box 1).

BOX 1. DEFINITION AND TYPOLOGIES OF ROBOTICS

According to the *International Organization for Standardization (*ISO) definition 8373, a robot refers to:
An automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation application.

- Reprogrammable: whose programmed motions or auxiliary functions may be changed without physical alterations;
- Multipurpose: capable of being adopted to different application with physical alterations;
- Physical alterations: alteration of the mechanical structure or control system except for changes of programming cassettes, ROMs etc.

A service robot is one that performs useful tasks for humans or equipment excluding industrial automation application. This may be

- A *personal service robot* such as: servant robot (*Sociobot*), automated wheelchair, personal mobility assist robot, and pet exercising robot -- perform non-commercial task
- *Professional service robot* is commercial robot operated by a properly trained operator and includes: delivery drones, cleaning robots, surgery robots in hospitals, firefighting robot, utility drones.

Adopted and modified from *IFR Position Paper April 2017*[3]

Together with Artificial Intelligence (AI), Information Technologies (IT), and Internet of Things, the robot has been touted as a driving force for the "Fourth Industrial Revolution". Increasingly perceived as a formidable transformational force, the global market for industrial robots is on the rise, and is projected to rise to over 2.5 million robots in 2019. This represents an annual growth rate of 12%.[4] There has been a significant rise in sales from the pre-recession period to the post-recession. By 2014 the worldwide market value of robots had risen to USD 32 billion. In similar vein, the stocks of robots for million hours worked (i.e., *Robot density*) has experienced an upward trend with Germany leading the fray at nearly 3 million (see table 1 below). Industry-wise, the greatest density the highest density of robots per million hours worked stood at 8 million in the transport equipment.[5]

[3] *Ibid.*
[4] Bandholz, H. "The Rise of the machines: Economic and social consequences of robotization", *Economic & F1/FX Research* ,No. 36, UniCredit Bank New York, August 2018, p.4 (At https://www.research.unicredit.eu/DocsKey/economics_docs_2016_155340.ashx?M=D&R=37323940. Accessed on 20/1/2019). See also: IFR, *Op. Cit.*, p.1
[5] *Ibid.*

Table 1. Estimated Operational Stock of Industrial Robots, Number of Units					
	2013	**2014**	**2015**	**2018**	**Average Growth 2014-2018**
America	**226071**	**248430**	**272000**	**343000**	**8%**
Europe	**392227**	**411062**	**433000**	**519000**	**6%**
Germany	167579	175768	183700	216800	5%
France	32308	32233	32300	33700	1%
Italy	57078	59823	61200	67000	3%
Spain	28091	27983	28700	29500	1%
UK	15591	16935	18200	23800	9%
Asia/Australia	**689349**	**785028**	**91400**	**1417000**	**16%**
China	132784	189358	262900	614200	34%
Japan	304001	295829	297200	291800	0%
Korea	156110	176833	201200	279000	12%
World	**1332218**	**148778**	**1664000**	**2327000**	**12%**

Adopted and modified from IFR (2015), UniCredit Research

These increasing levels of investments in robotics by governments and key players in the global market place demonstrate how in the contemporary economic contexts the robot is a key success factor and an indispensable force for attaining national and global competitive advantage.

2.0. The African Robotic Experiments

Although Africa does not feature prominently among the leading global players in the robotic industry and has instead invariably been cautioned against the harmful risks associated with automation and robotics,[6] Africa's resurgence as a key player in the global digital transformation is uncontested.[7] The development of the mobile banking ecosystem, with the resultant financial inclusion, is now widely acclaimed a ground-breaking global innovation, which has pit Africa as "the Silicon Valley of banking".[8] In the following sections we present the two recent experiments with robotics representing Africa's diverse responses: (a) The Ethiopian Sheba Valley and the iCog Lab's Robotics; and (b) Rwanda's medical drone delivery. These are not the only experiments on the continent. However, they crystalize the African quest for modernization more noticeably than the rest, because they are used by the respective governments as show-cases for the national socio-economic transformation agenda.

2.1. Robotics and Artificial Intelligence: The Ethiopian Experience

The Ethiopian Sheba Valley, akin to the Silicon Valley, offers a compelling case. Acclaimed as a "Growing miracle", Sheba Valley is a premier Artificial Intelligence hub within the Great Lakes, which is pioneering digital transformation in Africa. Its protégé is the iGog Labs**,** which was co-founded in 2012 by a young Ethiopian roboticist, Getnet Aseffa Gezaw, and an American AI pioneer, Ben Goertzel. With a team of twenty five Ethiopian software engineers, iCog pursues full-on "Strong Intelligence".

The iCog Labs contends that computers can potentially emulate the entire human brain. Accordingly, its mission is: *to create software that not only simulates the brain, but pushes the envelope of what the brain can do*. True to this mission, the lab focuses on several practical applications for clients around the world, including *humanoid robots* for Hanson Robotics,

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[6] BBC, "Robots and automation: how Africa is at risk", *BBC News Africa*, March 19, 2018 (At https://www.bbc.com/news/world-africa-43459138. Accessed on 26/1/2019). Also: Idowu, T. "African countries are importing robots and young people's jobs are at risk", *CNN* April 20, 2018 (At https://edition.cnn.com/2017/08/22/africa/robots-in-africa/index.html. Accessed on 1/26/2019)

[7] Ndemo, B and Weis T, "Making sense of Africa's emerging digital transformation and its many futures", *Africa journal of management*, 3:3-4, 2017 At https://doi.org/10.1080/23322373.2017.14002.1400260. See also Opio, P.J. "'System D' – creativity, innovation, and ethics in an Africa context: bridging the gap between the informal and formal economies", in Enderle, G. and Murphy, P.E. *Ethical innovation in business and the economy*, Edward Elgar, USA, 2015.

[8] Fox, K. "Africa's mobile economic revolution", 2011 cited in Opio, P.J., *Op cit.* p.281

makers of the renowned Robot Einstein and the humanoid; AI-driven automated pill dispensers and elder-care robots for a Chinese company, Telehealth; and mapping the genetics of longevity for two Californian corporations: Age Reversal Incorporated and Stevia First. iCog also explores "deep learning" algorithms for vision processing and object recognition (used in drones, satellites and security systems), machine learning algorithms to predict patterns in everything from agriculture to electricity consumption, and algorithms that react to English and a host of African languages.[9]

These are all high-end, world-class AI undertakings, which avidly demonstrates that Africa is a competitive player on the global robotic industry. The economic transformational possibilities are massive and pervasive. Current AI ventures and supporting infrastructure projects, which will all be Ethiopian-operated, include: (i) a $1.4 billion mobile phone deal for Ethiotelecom to install network-quality-assessing robots in moving vehicles for mobile calls; (ii) a considerable $4 billion electric Light Rail project, the largest in East Africa; (iii) French/US machine-learning self-diagnostic intelligence software to support the Blue Nile's $5 billion Grand Renaissance Dam, the largest hydro plant in Africa (which will also come with its own tech park); (iv) *cement loading robots, quality assessment robot technology and a robotics lab for Dangote Cement*, the largest cement plant in East Africa; (v) and self-diagnostic intelligence for power grids of the Ethiopian Electric Corporation and the Ashegoda Wind Farm, the largest in Africa.

These AI-induced robotic-related transformations are undoubtedly hugely attractive. To the Ethiopian government, investment in IA and robotics is a defining task. During the much acclaimed "Transform Ethiopia" expo visit by the *humanoid Sophia robot*[10] to Ethiopia, the Prime Minister Abiy acclaimed iCog Lab for setting the stage for a new AI transformation. However, seen against the concrete experiences of the population, these transformations remain merely ornamental at best. As Galbraith cautions, the much touted "Technological leapfrogging"

[9] Galbraith, C. "Artificial Intelligence catches fire in Africa". At http://www.icog-labs.com/artificial-intelligence-catches-fire-in-ethiopia/#more-1213

[10] The iCog Lab takes credit for building the cognitive engine of the humanoid robot Sophia. As the iCog's director, Getnet Assefa, notes: "We built…the emotional activities, expression and also an engine called the cognitive engine…for example when Sophia observes a crowd, she would perceive a gathering, a meeting, an event or expo. Such types of decisions are made by her cognitive brain that was built by iCog labs." See Allison, S. "Ethiopia's Prime Minister got stood-up by a robot". At https://mg.co.za/article/2018-07-04-ethiopias-prime-minister-got-stood-up-by-a-robot

buzzing around the ministries and tech community of Addis Ababa and other African cities may be "hugely attractive, but…

> *"(…) if basic human conditions don't improve, all this high-tech, artificially intelligent economics will end up as just artificial, neocolonial circuitry hubris*. The country needs rapid progress in health, education, representation, labor rights, and private sector GDP growth (now the 6th lowest in the world). It needs to end the forced relocation of entire communities, with little to no compensation, to accommodate the government's mega-plans. These real challenges still starkly face what could be one of the most promising economies in Africa."[11]

2.2. "Uber for blood": Rwanda's medical delivery robots - Leveraging Technology towards Socio-Economic Transformation

Acclaimed "Uber for blood", Rwanda's medical drone delivery is a showcase on an effective leveraging of robotic technology in the health care sector. During the 2018 World Economic Forum in Davos, in a show of support towards the Rwandan transformational experience, especially the universal health coverage, and overall improvements in health indicators such as child mortality, life expectancy and maternal mortality,[12] Rwanda was chosen as the first country in the world to adopt a performance-based regulation for all drones and co-design policy frameworks for scaling medical drone delivery supplies.[13] The medical delivery drone program, a partnership between the Rwandan Government and the American California based robotic company, Zipline, was launched in October 2016, to deliver emergency medical supplies to remote part of the country. In the words of the President of Rwanda, the investment in drone delivery is driven by Rwanda's policy of making technology a key pillar to *change and save lives* and achieve rapid socio-economic transformation, through effective health care provision for the most underprivileged population in the remotest and hardly accessible parts of the country. Due to the remoteness of health care facilities and the difficult terrain, using road

[11] Galbraith *Op. Cit.*

[12] Rwanda has recorded, over the last decades, significant improvements in health indicators. Death rate has dropped by 50% from 14.6 to 7.7 per 1000 people while life expectancy rose from 51.2 to 64.6, according to the national statistics. Maternal mortality significantly reduced by 75% (from 1071 in 2000 to 340 per 100,000 life births. Child mortality has also reduced by 66% from 153 per 1000 live births in 2005 in 2005 to 54 in 2012, though below the target of 51 per 1000 live births. See World Health Organization. *WHO country cooperation strategy 2014 -2018 Rwanda.* World Health Organization Regional Office for Africa.

[13] Chency, C. "Rwanda could become a model for drone regulation". At http://www.devex.com/news/rwanda-could-become-a-model-for-drone-regulation-91868

ambulances to deliver emergency medical supplies like blood has proved to be wasteful and profoundly ineffectual. Either the blood does not arrive on time to perform the emergency medical procedures (as on average it takes four hours to transport blood from the Center for Blood Transfusion in Kigali), or the stock of blood in the remote health facilities expire due to poor refrigeration and storage. The hot climate exacerbates this.

2.2.1 Key Achievements and Milestones

Through the launch of the delivery drones, the country achieved the following milestones: (a) the decrease in the delivery time (down from four hours to 45 minutes) has led to a reduction of wastage of blood donated to hospitals from 6% to 1%. (b) Operational efficiency: when doctors need blood, they either log onto Zipline's order site or send a WhatsApp and receives an immediate confirmation of the precise dispatch and arrival time. A WhatsApp message alerts the doctor just before the delivery arrives. Using onboard sensors to measure the wind and judge the right speed and the direction for the final approach, the craft spirals down to an altitude of 20ft before releasing the load. (c) Since inception in 2016, Zipline has delivered 12,000 units of blood and positively impacted on health care delivery through transfusion of blood in emergency. Maternal death at labor has been significantly reduced. (d) The drone-based delivery has reduced work load for medical practitioners who, in rural areas, routinely double as doctors, transporters and suppliers

2.2.2 Challenges and Drawbacks

Critics of the scheme in Rwanda have questioned why the Government has invested in high-tech schemes such as robotic delivery instead of improving basic infrastructure, roads and networks and health centers whose demand far exceeds the current supply. This disquiet is not misplaced. In their study *Making Sense of Africa's Emerging Digital Transformation and Its Many Futures* Ndemo and Tim emphasize: "*In order to better understand how digital technologies can help transform societies into a noble version of themselves"*, we should *"focus on multi-dimensional change processes"* rooted in *"economic, organizational, political, social and cultural*

environments".[14] Whether the benefits derived from drone delivery matches the financial cost is far from ascertainable. Besides, autonomous flying delivery drones are not entirely safe. A report by the *Institute of Technology Assessment* notes that "the main challenge regarding the operation of the operation of autonomous delivery drones is the development of *sense & avoid technology* (…). Beyond this, delivery drones would need to have the technical readiness to overcome challenges and weather, physical obstacles (tall buildings, electric poles, cables, flying birds, other drones, and not least humans) and internal malfunctions cause".[15] Even more disturbing is the problem of safety of blood and vaccines delivery. Bruce Y. Lee, from the John Hopkins Bloomberg University cautions that "heat can denature proteins in vaccines or any other logical products like blood".[16] Not less critical is the issue of ownership of the technology and the sustainability thereof, despite the fact that thirty of the hundred employees are Rwandans.

These challenges notwithstanding, the decision by the Rwandan Government to venture into an unknown robotics terrain demonstrates that technological disruption has no boundaries and can be effectively harnessed to promote the much needed socio-economic transformation. To Keller Rinaudo, Chief executive and co-founder of Zipline, Rwanda's groundbreaking venture into the robotic domain, largely held with suspicion by skeptics in the West, demonstrates that "people there (sic) are more open-minded about the way technology can improve lives". It ultimately challenges the assumption "that advanced technologies in robotics will start in the US or Japan and trickle its way down to developing economies". Instead, "small countries can move much faster in seizing the benefits of disruptive technologies".[17]

2.3. Concluding Observations on the African Experiments

Despite the formidable strides made by African countries in the applications of robotics towards socio-economic transformation, these strides are likely to remain in-effectual without a multi-

[14] Ndemo, B & Weiss, T. "Making sense of African digital transformation and its many future". *African journal of management*. P.341. *Italics* added.
[15] Nentwich, M. & Horvath, D.M. "Delivery drones from a technology assessment perspective: Overview report". *Institute of Technology Assessment*, Vienna, March 2018.
[16] Bruce Y. Lee cited in Duan N., "On-demand medical drone delivery". *Stanford social innovation review*. Fall 2018
[17] Cited in Nuki, P. "Pointing the way: how medical drones are saving lives in Africa". At https://www.telegraph.co.uk/new/0/pointing-the-way-medical-drones-saving-lives-africa/

dimensional transformation process. The unemployment rates among the youth is at 29.3% and 10.3% for Northern and Sub-Saharan Africa respectively, against a population of 1.2 billion people, and is expected to rise to 2.8 billion by 2016; and increasing poverty rates, poor health and infrastructure will continue to challenge the appropriateness of digital transformation and rise of the robots. A study carried out by the World Bank in 2016 cautions that the increasing use of the robots for industrial automation poses the risks to youth employment. Paradoxically, while Ethiopia boasts of leading the continental pack of robotics, artificial intelligence and the internet of things (IoT), youth unemployment stands in Ethiopia stands at staggering 85%. These, and related challenges experienced on the continent challenge the robotic venture: how truly adequate are robotics and related digital technologies for socio-economic transformation in Africa? What kind of digital technologies and robotics does Africa need in its pursuit of economic transformation? How can Africa pursue the so-called ”race with the machine” without undermining the good of the people? Before addressing challenges, in the ensuing section below, we re-visit the contending economic voices on the merits and demerits of robotics in economic transformation.

3.0. Robots, Productivity and the Human Equation

According to the International Federation of Robotics (IFR), the rapid spread of robotics across the continent and their extensive use across industries is driven by the following assumptions on the robot economy, namely: (1) used effectively, robots enable companies to increase their productivity while lowering cost; (2) higher level productivity gains lead to increased demand and may create new job opportunities; (3) overall, automation has a net positive impact on labor and wages. Although the reduction in middle income and middle-skilled jobs may lead to income inequality, the net gain from the use of robots is positive, especially as robots create an increased demand for workers at the higher skilled spectrum. (4) Robots complement and augment rather than substitute labor/human activities and the impact on jobs and quality of work is positive.[18]

However, these assumptions seem to be at odds with the canons of mainstream economics itself. In his article, *The Best of Times, the Worst of Times: Macroeconomics of Robots*, the eminent economist Jeffrey Sachs smacks at the very logic of robo-economics as far removed from the

[18] IFR. *Op.Cit.*p.2

received economic assumption, namely: productivity and wages always tend to rise together. The robot revolution is a no brainer in this respect:

> "Productivity and wages have always tended to rise together. Indeed, one of the stylized facts of long-term growth has been the stability of labor share of income, $s=wL/Y$, where s is the real wage, Y is the real output, and L is labor input. Since **s** may be re-arranged as $s=w/(Y/L)$ we see clearly that the stability of **s** means that W and productivity Y/L move in parallel".[19]

To Sachs and other like-minded economists, the assumption that productivity gains from robotics necessarily spill over into higher wages and the resulting inequality towards the low-skilled can be re-aligned through retraining and government policy, is spacious and shortsighted.

However, the labor-wage-inequality is far from conclusive and economists do not agree on the correlation thereof. In their study on job polarization , wage inequality and robotics, *Don't Blame the Robots,* Lawrence Mishel, Heidi Shierolz and John Schmitt call into question the underlying assumptions that drive the three contending models, namely: (1) the "skill biased technological change" (SBTC); (2) "canonical model" and (3) the "job polarization" model. According to the skill biased technological model (SBTC), "technology raises the demand for educated worker, allowing them to command wages – which in turn increases wage inequality". However, "this has failed to explain the wage trends in 1990s and the 2000s, particularly the wage gap between low and middle income earners and the deceleration of the college wage premium". Similarly, their study has shown that "job polarization" model – claiming that due to computerization, "employment has grown relatively strongly at the top and bottom of the wage scale" while eroding the middle – provides little insight into the wage trends of the 2000s.[20] During this period, there is no evidence of job polarization and wage inequality cannot accurately be attributed thereunto. Similarly, attributing this rise in wage inequality to robotics is wrought with challenges. There is no evidence to show that there is a correlation between technology driven changes in tasks and employment occupational patterns and wage inequality. The wage in-equality mantra tells the story of robotic intervention half-way.

An increase in robotic productivity is likely to reduce demand for labor, if robotics outputs are taken as close substitutes for production by humans. More worrying is the fact that *"a fall in labor demand may trigger further declines in wages, savings and economic*

[19] Sachs, J. "The Best of Times, the Worst of Times: Macroeconomics of Robotics" At: http://jeffsachs.org/wp-content/uploads/2016/06/The-Best-of-Times-the-Worst-of-Times.pdf . Accessed on 1/30/2019)

[20] Mishel, L., Shierholz, H. & Schmitt, J. "Don't blame the robots: Assessing the job polarization explanation of growing wage inequality". *Economic Policy Institute.* Center for Economic Research and Policy Working Paper Washington, Nov. 19, 2013, pp.4-5.

wellbeing".[21] Thus, the problem is not merely that the wage gains from the robotics are skewed towards the highly skilled. Rather, it may adversely affect economic wellbeing" of workers.

Besides the wage decline for low-skilled and the resulting wage inequality, robots are more likely than not, to *immiserise future generations.* How? By pushing profits up while depressing wages, the robotic revolution tends to favor capital-owning older generation relative to younger generation and future generation. Unless constrained, the behavior of older generations is to maximize their net gains, and will, as rational economic agents, place their utility gains over that of younger generations. This results into inter-generational inequality. Measures such as *inter vivos,* and intra-family transfers from the young to the old, can only favor richer households and their offspring, leaving poorer households worse. Thus, instead of raising the standard of living and wellbeing of all, *"the robot revolution is likely to increase the inequality of income and wellbeing by making the rich richer and the poor poorer"*.[22]

According to Richard Freeman, the labor-wage-inequality antagonistic nature fails to address the crucial question of ownership. The problem in the robotics era is not merely that workers are losing jobs to machines. Labor market analysis of inequality focuses only on incomes from labor, forgetting that it is capital that substantially contributes to inequality. "Unless workers can earn income from capital as well as from labour, the trend towards a more unequal distribution is likely to continue, and the world will turn into a form of economic feudalism".[23] If the distribution of capital remains narrow, as it is now, the main beneficiaries of robotization would be a small number of wealthy owners, while the living standards of the vast majority of workers would suffer. That would exacerbate the growth of inequality and risk producing a new robot-age feudalism, with workers captive to a small number of overlords who own robotic technology. Like the old feudalism, *robo-feudalism* will, far from promoting a prosperous society and engendering the much needed socio-economic transformation, create a more fragmented world.

[21] Sachs, J. D.F., Seth, G.B., and Guillermo L. *Robots: Curse or Blessing? A Basic Framework*, 2015, p.4 (accessed on 30/1/2019 at: https://www.nber.org/papers/w21091.pdf)
[22] Sachs, J, *Op. cit.*
[23] Freeman, R.B. "Who owns the robots rules the world: The deeper of robotization", *Harvard Magazine*, May-June 2016. At https://harvardmagazine.com/2016/05/who-owns-the-robots-rules-the-world. Accessed on 301/1/2019

3.1 What the Debates Say and What is not Said: Unanswered Questions

Not only are the narratives supporting and challenging robotics and the effects on productivity, labor, and inequality compelling; they are alsocoherent. Indeed, robot capital tends to drive wages down and replace workers, while raising output and productivity. The resulting efficiency is positive for economic transformation. On the other hand, the quest for greater efficiency and productivity at the expense of human labor eliminates jobs, raises unemployment, drives down wages and entrenches inequality.

In our estimation, these debates do not only ineffectually address the robotic dynamics in economic transformation; they also capriciously ignore existential and fundamental questions: What is the purpose of economic growth? To what extent should growth be the determining factor in the decision on what type of robotics to use, when to use it? What is the purpose of human work? To what extent does robotics foster this purpose (should robots serve this purpose anyway)? It is against these questions that Charles Handy's laments in *The Empty Raincoat: Making Sense of the Future* against economic growth and efficiency can be heard. Namely, the challenges faced by our capitalist societies stem from the confusion that "the pursuit of efficiency and economic growth…..are the necessary ingredients of progress" while forgetting that "it is we, we individual men and women, who should be the measure of all things, not made to measure for something else."[24]

Accordingly, the key challenge with the robotics and economic transformation debate is how to integrate the triple economic mandates of efficiency, effectiveness and competitiveness (sustained growth) with ultimate human concerns (*menschliches Dasein)* including the quest for meaning on the one hand; how best to promote the human good through work without "stok(ing) antipathy towards technology" and fomenting "a chilling effect on the technology and the innovation and adaptation of technology essential to grow the economy"[25] on the other hand.

[24] Handy, C. *The Empty Raincoat: Making Sense of the Future.* Hutchinson: London, 1994, p.1. Martin Ford, bestselling author of *The Rise of the Robots*, also emphasizes: *We must decide, now, whether the future will see broad based prosperity or catastrophic levels of inequality and economic insecurity.* Unless societies change their approach to growth and development, they will not only end up with a broken planet and conflict-ridden communities: they will also face massive unemployment".

[25] Atkinson, RD. "Stop Saying Robots are Destroying Jobs- They aren't", *MIT Technology Review*, 3 September, 2013. (accessed on 30/1/.2019 at: https://www.technologyreview.com/s/519016/stop-saying-robots-are-destroying-jobs-they-arent/)

The next section offers some guidelines on how best to integrate the demands of efficiency, effectiveness and competitiveness (growth) with the human/common good.

4.0. An (Ethical) Framework for integrating Robotics, Economic Growth and Human Flourishing

While it all makes moral sense to stage a defense for the robotics economy based on the net gains from productivity and higher income, the resulting inequality poses a real challenge and calls into question the promises of robotic economy. We are nevertheless faced with one critical challenge: how can the human good be safeguarded within the robotic economy, without stocking the "innovation and adaptation of technology essential to grow the economy"?

Concern for principles "rules" to guide the use of robotics is not new. The earliest dates back to Isaac Asimov, who in 1942 devised the following rules based on a short story *Turnaround.* Namely: (1) A robot may not injure a human being either directly or through its intervention, that is the First Rule; (2) The Second Rule states: A robot must obey the order given to it by human beings, except where such orders would conflict with the First Rule; (3) The Third Rule: A robot must protect its own existence as long as such protection does not conflict with the First or Second Rule.

While these rules are certainly useful, it is not evident how they can be employed to determine when, how and to what extent to use robotics. The SecondRrule, for instance, presumes that the robot is enshrined with independent decision-powers that enable it to assess the pros and cons of any given situation – something that IA algorithms have yet to venture into. Similarly, the Third Rule also accords a self-determination that far supersedes the most advanced humanoid robots to date. Amitov later added a new rule, least attended to, but more instructive, namely: "A robot may not injure humanity or, through inaction, allow humanity to come to harm".[26] Amitov's rules have been inadvertently misconstrued as apologetics for an unabated robo-economics, concluding that "we should worry less about the potential replacement by human labor by robots

[26] Amitov, I., *Runaround*, 1942 cited in Roig, R. de Assis, "Ethics and Robotics. A First Approach". *The Age of Human Rights Journal*, June 2014, p.4.

than how to share fairly the prosperity that the robots produce".[27] While the need to share fairly the gains from robots is crucial, by no means does this justify human displacement by robots, nor are attendant inequalities mere tradeoffs.

A far more comprehensive and systematic attempt to offer guidance on decisions pertaining to the use of robotics is the UK-based joint *Engineering and Physical Sciences Research Council* and the Arts and Humanities Research Council. According to this consortium, (1) Robots are multi-use tools. Robots should not be designed solely to kill human beings, except in the interest of national security. (2) Humans, not robots are responsible agents. Robots should be designed and operate as far as practicable to comply with existing laws and fundamental rights and freedoms, including privacy. (3) Robots are products. They should be designed using processes which assure their safety and security. (4) Robots are manufactured artifacts. They should not be designed in a deceptive way to exploit vulnerable users; instead their machine nature should be transparent. (5) The person with legal responsibility for a robot should be attributed.[28]

The two commissions clarify what robots are, their purpose and their limits in relation to humans. However, the challenge that remains is how these principles can be used to moderate robotic activities in a balanced manner such that human good and economic progress are equally safeguarded.

4.1. Five Interdependent Guiding Principles

I redefine the above "rules" and guidelines into four interdependent principles, which are neither new nor particularly unique to Robotics, in the light of Catholic Social Teaching. Moreover, they are not meant to provide the "blue-prints"; rather, what I propose through them is a "heuristics" for integrating robotics, economic growth and the human good. The first principle

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[27] Freeman, R.B, *Op cit.* Taking a leaf from Amitov's three laws, Richard Freeman, has crafted the three the following laws of robonomics: (a) Law 1: Advances in artificial and robotics will produce machines that are better substitutes for humans –in economic language, an increasing elasticity of substitution between robot and human work; (b) Law 2: The cost of robot machine substitutes for humans will decrease as technology reduces production costs, placing downward pressure on wages; (c) Law 3. Income will increasingly come from down from ownership of robots or other forms of capital and the stream of income they produce, rather than from human labor.

[28] Cited in Roig, R. de Assis, "Ethics and Robotics. A First Approach", *Op. Cit.*

(P1*), fostering and enhancing wellbeing*, requires that robo-economic undertakings should be driven by the concern for and promote *the Common Good* (P2), protect the *dignity of employees* (P3), ensure there is justice and inclusivity (P4) while "*balancing harms and benefits*" (P5).

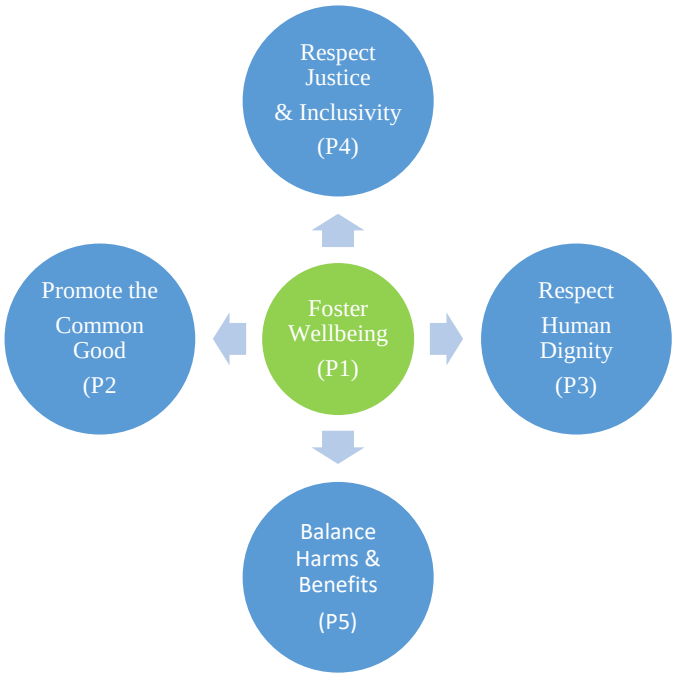

Figure 3*: Framework for Integrating Robotics, Economic Growth and Human Flourishing*[29]

4.1.1. Principle 1: *Fostering and Enhancing Wellbeing*

The report by *The World Economic Forum Agenda Council on Health and Wellbeing* notes that although the idea that wellbeing matters is not new, nor is its importance a recent phenomenon, wellbeing is the "new concept of progress", to which "Global Success" is inextricably tied.[30] In recent times, governments and world leaders themselves have cast great doubt on the adequacy of the traditional growth model and the relevance of the traditional statistical measures (the GDP), prompting a shift of focus from a disproportionate concern with "economic growth, budget deficit and GDP" to *general wellbeing* (GWB). Indeed according to David Cameroon,

[29] Adopted and modified from Opio, P.J. *Op cit.* p. 297.
[30] World Economic Forum, *Wellbeing and global success: World economic forum agenda council on health & wellbeing*, World Economic Forum, 2012, p.6

the GDP taken on its own is not only "an incomplete way of measuring a country's progress" it may even distort the desired growth. [31]

In relation to robotics economics, both advocates and critics agree that wellbeing is a desirable outcome which is either enhanced in favor of skilled workers in the robot economy or undermined through the ensuing inequalities. However, both perceive wellbeing as correlates of income, diminished or enhanced by the loss of employment to robotics or through higher skills attainment. Although income is an important determinant of economic wellbeing, there is more to wellbeing than income, and conversely, wellbeing is far more dynamic than economic wellbeing.

The *Report by the commission on the measurement of economic performance and social progress* emphasizes that, adequately understood, "wellbeing has to do both with economic resources such as income and *non-economic* aspects of peoples' life (what they do and what they can do, how they feel…)".[32] Therefore, not only is it inaccurate to reduce wellbeing to income; a disproportionate focus on income crowds out important factors such as: Positive Emotions, Engagement, Relationships, Meaning, Accomplishment (PERMA) – which serve as important building blocks for a "flourishing life"[33]. In their seminal work *Wellbeing Manifesto for a Flourishing Society,* Shah and Marks emphasize that the term "flourishing" points towards "positive" and enabling conditions that allow an individual to live a meaningful life. "As well as feeling satisfied and happy, wellbeing means developing a person, being fulfilled and making a contribution to the community".[34] The attainment of wellbeing cannot be left to unbridled initiatives of individuals and enterprises; the commitment by the government is crucial. According to Shah and Marks, the aim of any democratic government should be "to promote the

[31] In his speech to Google Zeitgeist Europe as far back as 2006, the British Prime Minister David Cameroon argued that unless we widen our horizon on our understanding of growth, in pursuit of growth, things that really matter to people life security, health, education etc. become mere statistics: "So, for instance, when a country is hit by an earthquake, that can increase GDP, because of the extra spending on reconstruction. When a city is torn apart by crime and disorder that actually increases GDP, because we spend money on locks, and more people get employed in security. When someone falls seriously ill, that can increase GDP, because of the cost of buying the drugs and paying for care – all those things that also count as economic activity. So, destruction, crime, disease – in a very crude way all these things can amount to progress in terms of GDP."

[32]Stiglitz, J., Sen, A., and Fitoussi, J.P. *Report by the commission on the measurement of economic performance and social progress.*

[33] Seligman, M.E.P. *Flourish - a new understanding of happiness and wellbeing- and how to achieve them.* London: Nicholas Brealey Publishing,

[34]Shah, H. and Marks, N. *Wellbeing manifesto for a flourishing society*. London: The New Economics Foundation, 2004, p. 4.

good life: a flourishing society, where citizens are happy, healthy, capable and engaged".[35] The *Commission on the measurement of economic performance and social progress* also emphasizes that, while income (along with consumption) plays a vital role in evaluating the standard of living, the following factors are indispensable towards people's wellbeing: (a) Health and healthcare provisions, access, quality etc.; (b) Education: literacy, learning, cognitive functioning and skills; access, spread, coverage; (c) Personal activities including decent work, adequate earnings, safe work environment, protection from harm at work (quality of working life); (d) Social connections and relationships; (e) Political voice and governance; (f) Present and future environment. In the context of robo-economics, a shift from a heavy-handed focus on productivity driven economic undertaking to one *informed and inspired* by the pursuit of wellbeing is better placed to safeguard growth, and productivity, as well as promote the human good.

4.1.2 Principle 2**:** *Promote the common good*

An entirely growth-driven robo-economics will hardly achieve the much-desired human and socio-economic wellbeing which world leaders and more progressive economists like Stiglitz, Sen, and Fitoussi passionately advocate for. The prevalent economic model driving robotics intervention, notably productive efficiency, cost-effectiveness and competiveness, ultimately accelerate the utility of the owners of means of production (robotics) at the expense of the low-skilled workers. "There is nothing in economics that guarantees that humans displaced from jobs by will end up with a new jobs that pay as much as their former jobs"[36]. Indeed, as Pope Francis points out in *Laudato Si,* this "technocratic paradigm"- assessing interventions in nature and the economy solely on grounds of utility and efficiency - ultimately serves the self [37]. Without a paradigm shift, that celebrates the good of all stakeholders – owners of enterprises, workers and community - robotics undertakings, howsoever well-intentioned, will escalate global inequality to an unprecedented level, entrench a new form of *robo-feudalism,* and create a new *dangerous* class of social deprivation – *robo-poverty*. Unlike the medieval endangered poor who were

[35] *Ibid.*
[36]Freeman, D. *Op. cit*
[37] Pope Francis. *Laudato Si.* 2015. Retrieved from http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html

powerless before their feudal masters, the robo-poor include tech-wiz, highly skilled youth, extremely versatile, endowed with skills to manipulate AI systems. Unlike the medieval poor, they will not stand and watch; they have the capacity to manipulate AI systems for catastrophic subterfuge.

Robotic driven enterprises that celebrate "the common good" are better placed to promote a more dynamic economy than narrowly growth-driven, utility maximising enterprises. As a guiding principle, the common good signals and advocates for the fulfillment of the "one" and "many" (the whole), without subsuming the "individual" to the "collective". It is defined as "sum of those conditions of social life which allow social groups and their individual members, relatively thorough and ready access to their own fulfillment".[38] However, in striving for self-fulfillment, each individual at the same time seeks the good of the other. Indeed, according to St. Thomas Aquinas, through the common good (*bonum commune),* each person wills the good of the other for their own sake. It is therefore, in attending to the good of the other as an irreducible person, that the true common good is attained. "The common good is common because it is received in persons, each of whom is a mirror of the whole".[39]

The two dimensions of the common good, namely (a) "the attainment of the good life by all" and (b) "the common conditions of social life", ensure that no one is impeded from flourishing and the right conditions are put in place to enable every person to achieve self-fulfillment. This balanced approach to the common good provides a more realistic guide to robo-economic activities. The decision as to what kind of robotics to use should be driven by the following considerations: (i) to what extent does the employment of a particular robotic promote the good of the enterprise owners/investors, employees and the society? (ii) Are there policies in place to ensure that enabling conditions are provided by the enterprise and the government to safeguard the good of the society? Promoting the common good through robotics entails: (a) procuring the "good" of all stakeholders, including clients, and the enterprises themselves; and (b) creating the space and promoting an equitable structure that provides a platform for all, especially the least advantaged, to participate in the economic life of their community, nation or society.

4.1.3 Principle 3**:** *Respect for human Dignity and Human Rights*

[38] *Gaudium et Spes.*No. 26.
[39] Maritain, J. *The person and the common good.* New York: Charles Schribner's Sons.

Human dignity, human rights and freedoms are *leitmotifs* of universal significance in the secular and religious domains. There is an ever growing concern that employees should be treated with dignity. *The Universal Declaration of Human Rights (1948)* recognizes that "inherent human dignity and inalienable rights of all human family is the foundation of freedom, justice and peace in the world". Human rights, in their various categories – right to work, living wage, right to a safe and conducive work environment-- "*derive from the inherent dignity of the human person".*[40] Because every human has an inherent worth, he/she remains substantially *irreducible* and cannot, therefore, be subjugated to the machine (robotics) on the one hand, nor be subjected to work environment that undermine his/her inner worth as well as essential rights.

In relation to robotics, the dignity principle goes beyond merely not treating persons as means to promoting efficiency and productivity. It also involves enforcing the basic rights, upon which the inherent dignity of employees are grounded, such as the right to safe working environment. Paradoxically, the respect for this right may require the use of robots as substitutes for human labor. This is not only economically beneficial but also anthropologically dignifying as well as morally justifiable. In unsafe environments of toxic chemicals (such as fumigation of medical facilities) or radiations (in the utility sectors) which would harm employees, robots are "friends" of employees rather than "foes" to be castigated for "taking over jobs".[41] In this respect, the extensive use of robotics and unmanned drones in the Kenyan utility sector not only shortened the construction of the power-line by a record seven months, and "saved taxpayers billions in monthly fines" from the delays.[42] More importantly, in using the drones rather than human labor, risks that accrue to the workers climbing high voltage towers and having to pull heavy metals cables in a difficult terrain, were averted, thereby safeguarding workers' right to safety. In such risky work contexts, drones can protect, and ultimately enhance inherent human dignity and

[40] *United Nations Covenant on Economic, Social and Cultural Rights.* Adopted by GA Res.2200A (XXI) of 16 Dec. 1966.

[41] Mishel, L., Shierholz, H. & Schmitt, J. *Op. Cit.* They argue that the three contending models, namely the "skill biased technological change" (SBTC) and the "canonical model" as well as the "job polarization" model, "do not adequately account for rise wage inequality. Attributing this rise in wage inequality to robotics is wrought with the following challenges. There is no evidence to show that there is a correlation between technology driven changes in tasks and employment occupational patterns and wage inequality. The wage in-equality mantra tells the story of robotic intervention half-way.

[42] Mutua, J. "How drones saved Kenyans billions in power penalties". *Daily Nation*. November 2, 2018. At https://www.nation.co.ke/news/How-drones-saved-Kenyans-billions-in-power-penalties/1056-4834132-mkn2mez/index.html

safeguard against using employees as means to economic ends. Adequately considered, dignity promotes economic transformational dynamics in a balanced and constrictive manner, beyond the classical efficiency, productivity measure on the one hand, and the adversarial, anti-robotics rhetoric on the other. Respect for persons as "ends" in themselves may require that human labor be substituted by robots. Against instances of occupational hazards, robots become necessary "means" for safeguarding human dignity. Using robots as substitutes for human labor is not only economically effective, but also morally defensible. The assumption that robots blatantly undermine human labor, take away jobs, and should therefore be sanctioned entirely, is wanton and can, in hazardous work context, like Ceasar's spirit, come hot from hell.

4.1.4 Principle 4: *Justice and Inclusiveness*

From an ethical perspective, it is necessary to ascertain whether a robotic program might result in significant benefits to some individuals (shareholders and business owners) at the expense of other groups – employees and the society. Justice implies that benefits and burdens are fairly distributed. Therefore, no segment of the population should be unfairly burdened with the harms of robotics. Because employees are less likely to seek restitution when adversely affected by robotics investment, appropriate measures are needed to ensure that their rights and dignity are upheld and that they are exploited for the advancement of robotic programs.

4.1.5 Principle 5: *Balancing Harms and Benefits*

Every new technological breakthrough, howsoever positive, comes with unforeseen and unintended harm. A key principle of any ethical innovation is that "subjects must not be subjected to unnecessary risks of harm, and their participation in [a project] must be essential in achieving (…) socially important aims that cannot be realized without [their] participation" (Tri-Council Policy Report).[43] However, not all potential harm can be obvious at first glance, due to information constraints. This is particularly true of the use of robotics. Although the benefits of drones are visible in the medical and utility sectors, not all the potential harms can be prevented.

[43] Canadian Institutes of Health Research, National Sciences and Engineering; Research Council of Canada, Social Sciences and Humanities; and Research Council of Canada, *Tri-council policy statement: ethical conduct for research involving humans*, accessed 2/10/2019 at http://www.pre.ethics.gc.ca/pdf/eng/tcps2/TCPS2_2_FINAL_Web.pdf.

Therefore, due to information constraints, "the foreseeable harms should not outweigh the anticipated benefits". Although in the Rwandan drone-based medical supplies delivery, the subsequent impact on the blood supplies being delivered are not fully known, and scientists believe studies have yet to be undertaken to ascertain the safety of such deliveries, the immediate benefits to patients who urgently need blood to survive outweigh the unforeseen negative effect. The principle of double effect, embedded in the scholastic philosophy, in its most simple form, distinguishes between *primary purpose of an act* (to save a life, or alleviate pain) and any foreseen negative but unavoidable, consequences of the same act.[44] It would be intractable in matters of life and death not to act -- in this case, not to use a drone because the long-term harms are not known. On the other hand, it is also uncanny and negligent not to establish measures to ascertain that the negative effects of robotics, including psychological impacts, and effects on human dignity, are not addressed.

5. Conclusion: Some lessons to learn from the African robotic experiments and recommendations

In order to better understand and appreciate how robotics and artificial intelligence can help transform the economy and society at large, we have advocated for a shift from a contrived "technocratic paradigm" to one inspired by wellbeing, human flourishing and the pursuit of the common good. The following salient conclusions and lessons can be drawn from this paper:

(i) The advances in robotics, artificial intelligence and internet of things (IoT) have, and will continue to exert great influence on the economy, and many other dimensions of the society in ways beyond predictions. What is needed is a courageous, balanced and realistic understanding of what robotics *can* and should do (*operational* adequacy), *when* they may best be used (*contextual* adequacy) and to *what extent* they should be used in relation to human agents (*anthropological* adequacy). Just as an unbridled embrace of robotics as *the* inevitable driver of economic transformation is contrived and may be socially catastrophic, a rejection of every application of robotics in every socio-economic undertaking is equally morally intractable. Rwanda's embrace of the drone technology may, as critics would have it, appear as a show-biz or a mere political stunt; however, it

[44] Mason, J.K. and Laurie, G.T. *Double effect,* in *Mason and McCall Smith's Law and Medical Ethics.* 7th Edition. Oxford: Oxford University Press, pp. 634-5.

demonstrates avidly, how a technological (robotic) adaptation, driven by human flourishing and wellbeing, can constructively contribute towards the transformation of the human society, and not merely the economy.

(ii) The robotic versus employee antagonistic opposition is beneficial neither to the employee's dignity and self-worth nor to the broader economy. Instead, a dynamic integration of robotics with humans, informed by wellbeing and human flourishing, is likely to deliver economic efficiency and productivity while safeguarding the dignity of the workers simultaneously. The utilization of drone technology in the utility sector for instance, may, *prima facie*, appear as an assault on the right to work (if the substitution of human engagement by drones is interpreted narrowly); yet, against occupational hazards, the robot does not "replace" humans but "protects" his/her right to a dignified employment.

(iii) While the inequalities (both wage/income based and inter-generational) resulting from the subjugation of human labor by robotics are highly disturbing and have rightly evoked wide-spread condemnation, they are only symptomatic of an even more disturbing problems, on which the solution to the robotic paradox rests – the *ownership* of robots as *means of production*, on the one hand; and the quasi-human status accorded to robotics – so-called "*homo roboticus*", on the other. Once robots are accorded human status as in the case of *humanoids* and when these are subsequently mainstreamed into the social and economic ecosystems, it becomes increasingly hard to draw the line between the worker (*homo laboris*) and *"homo roboticus"* and which really matters in the broader economic enterprise.[45] This is probably why the iCog Lab's ground-breaking feat in building the

[45] See Shaw, J. (2015). "From homo economicus to homo roboticus: An exploration of the transformative impact of the technological imaginary". *International Journal of Law in Context*, 11(3), 245-264. doi:10.1017/S1744552315000130. She notes: the virtual world - largely "unrestrained by the divergent equivalence of human categories of difference such as gender, race and class, or conceptual binary oppositions such as good/evil, happy/sad, freedom/oppression"-- is in the process of transforming the real world or, at least, subordinating it as slave to the machine world. This shift is fostering an imbalance of power between human and the post-human (homo roboticus). Consequently the epoch of the machine is progressively being perceived to be both modern miracle and monster. Just as at a human level, rational thought processes restrain ideas which are unruly and require control, ICT advancements have proliferated to the point where these technologies also need to be classified, constrained where necessary, and diluted into the real world in real time. In this current climate of endless technological transformation, along with the growth of mass surveillance technologies together with the expansion of regulatory state powers any further innovations cannot be left to market forces without first considering the groundwork for the development of an appropriate monitoring mechanism. Before an appropriate set of regulatory mechanisms can be

cognitive engine of the humanoid Sophia, viewed against the challenges faced by Ethiopian population, is one cheer too many. Thus, although robotics can unleash economic transformation and generate positive outcomes they also risk sending false hopes that investing in robotics will *ipso facto* procure national competitive advantage.[46]

(iv) Robotics-led economic transformational efforts are not all-defining. While the growing impacts of robotics on the economic landscape seems intractable, a contrived use of robotics and artificial intelligence is, more likely than not, to cause socio-economic disequilibrium. What is needed in an African context as well as the global context, is a multi-dimensional transformational approach. Ndemo and Weiss caution cogently: "*The continued introduction of digital technologies (and robotics) also evoke(s) the need to continuously observe the impact digital technologies have on prominent societal issues such as (…) poverty*" in their various forms. To avoid "the sparking dissonances that arise from a divergence between societal expectations and actual developmental outcomes" attention needs to be placed on how actions in the economic environment can be translated into subsequent cultural and political environments.[47]

Against the influx and growing influence of robotics, artificial intelligence (AI) and the internet of things (IoT) the time is ripe to re-examine with an even greater urgency, the purpose of the economy, the function of growth in the context of the broader purpose of human labor, human experience and the meaning of human life within the robo-economy debacle. It is a time for bold imaginings!

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explicated, it is first necessary to consider the nature of the evolving transgressive human–machine relationship and the possible implications for humanity in the modern hyper mediated world.

[46] Ndemo, P. & Wiess, T. *Op. Cit.* p. 330.
[47] *Ibid.* p. 342.