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Can the 4 th Industrial Revolution be a Solution to the Challenges of Social Aging? Can the 4 th Industrial Revolution be a Solution to the Challenges of Social Aging?

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Abstract

This paper explores whether the fourth industrial revolution -robotization, automation, digitalization, and the Internet of Things -may mitigate the social, economic, and labor impacts of an aging society.The increasing role of advanced technologies in economic and social life has fueled concerns about the risks of such technologies to human labor, social relations, and human dignity. These risks seem particularly tangible in advanced societies which face a shortage of skilled labor and increasing demand for social and care services. By reviewing a variety of business practices in several developed economies, this research seeks to build a case in favor of the use of advanced technologies in aging societies. Taking into account the scale of population aging and the limited effectiveness of social and fiscal reforms in favor of a demographic change, the fourth industrial revolution appears to be a useful tool to tackle social aging. Without dismissing the ethical, social, and other concerns related to the use of advanced technologies, the research shows a wide range of successful solutions and symbiotic collaboration between humans and advanced technologies in socially aging contexts.

Index terms— technology, aging, labor, demographics.

1 Introduction

ocial aging has been a major concern for developed economies for quite some time. The 2019 G20 summit held in Fukuoka, Japan underlined that the combination of social aging, low birth rates, and rising life expectancy threatens the sustainability of labor markets, pension systems, and welfare policies. It may also hinder growth prospects, productivity, and competitiveness. Governments have been trying to counteract aging and its effects through various social and fiscal policies such as pro-family subsidies, vouchers, and tax breaks. Some governments have also sought to liberalize immigration policies to encourage demographic rejuvenation.

However, the impact of these anti-aging measures has been rather limited so far. Demographic trends are especially worrying in Japan and across the European Union. Because of the limited effectiveness of conventional social policies, it becomes relevant to explore alternative solutions such as harnessing the tools of the fourth industrial revolution. Although advanced technologies alone cannot reverse demographic trends, it is pertinent to explore how such technologies may favor labor and economic inclusion of the elder; and also, how they may stimulate growth, productivity, and competitiveness despite shrinking labor force.

2 I. The Scale of Aging in the Developed World

The aging society is "the process by which older individuals become a proportionally larger share of the total population." **??** It is an umbrella term that reflects relative changes in the age distribution within a society which overall increases the share of older generations. **??** This process applies both to developing and developed economies. However, it is more prominent among the developed. According to the UN World Population Prospects, the number of people aged 60 or older is forecasted to double by 2050 and triple by 2100. That

age group is projected rise to 2.1 billion in 2050 and 3.1 billion in 2100 worldwide. ?? That would imply that pensioners would represent almost one-third of the global population. ?? Japan, which has the oldest society in the world, is a strong case in point. According to some estimates, a third of Japan's population will be at least sixty-five years old by 2040. ?? force will have shrunk by 21%: from sixty-two to fortynine million. ?? In 2018, Japan's total fertility rate was 1. ??2. 7 The situation is alike in the European Union. By 2070, 30% of people living in the EU-27 are projected to be aged 65. People aged 80 may represent 13% of the total population of the bloc. The median age is on the rise and is projected to reach 49 by 2070. The working-age population (20-64) has been shrinking for years, and it is projected to represent 51% of the total population of the EU-27 by 2070. The EU-27 plus Switzerland and the UK are likely to lose 13.5 million working-age population by 2030.

At the same time, Japan's average life expectancy at birth is 81.25 years for males and 87.32 years for females. If the trend continues, Japan risks having 1 child under 15 for 3 pensioners over 65 by 2050. 8 In addition, the EU's-27 fertility rate, which has oscillated between 1. 25 population after Oceania, followed by Northern America in the third place. 10 Although longer life expectancy is a good thing in itself, it has far-reaching implications for the sustainability of public finance, growth prospects, productivity, and intergenerational equity. 11 According to an OECD report, older adults consume around 40-50% of the health budget, and the average health care cost per capita for older adults is 3 times higher than for the working population. 12 Before the pandemic of Covid-19, the EU-27 was projected to dedicate 26.6% of its GDP by 2070 to attend to the needs of the 65+ age group. 13 As the proportion of people over 65 in a society increases, people of productive age (14-64) face greater fiscal burden and social obligations, which is known as the old-age dependency ratio. "Old-age dependency ratios will rise in all G20 members in the next decades, although at different paces. Japan is experiencing the fastest aging of its population, with 47 people older than 65 per 100 working-age adults in 2015, up from 19 in 1990, and rising to 80 by 2060. Among advanced G20 countries, Italy, Germany, and Korea will also face some of the most significant challenges from aging." 14 This burden can be further aggravated by early retirement, increasing expenditure in the medical sector related to geriatric care, palliative care, and chronic conditions. Additionally, the risks of old-age poverty and inadequate care for persons with disabilities may increase as well. 15 To address the trilemma of longer life expectancy -rising social spending -shrinking demographics, governments in developed countries have considered a broad variety of measures ranging from raising the retirement age and introducing copayments for some medical services to re-incorporating retirees into the labor market on a part-time basis; reconciling work and family life; increasing employment opportunity for women; improving labor qualifications of 10 11 https://www.oecd.org/economy/ageing-inclusive-growth/.

people with low education level; enhancing the design of public pension schemes, and encouraging personal savings. 16 Nevertheless, there has been little progress in implementing these measures, for they challenge the fundamentals of the intergenerational social contract and call into question the acquired social guarantees. As the options for reform in labor and social policy seem rather limited, it may be relevant to look for alternatives that are more politically and socially viable. One such alternative might be the use of advanced technology to mitigate the costs associated with population aging. 17 According to the EU's New Industrial Strategy for Europe, the combination of the digital economy and green economy may be a trigger of new business models, working schemes, and productivity. 18 II. Technology as a Mitigating Measure of Social Aging

It may also help modernize health care, social services, transportation; improve productivity; and offer new products and services for the aging society. Section 2.0. will look at some business practices in that regard.

3 a) Nursing, preventive, rehabilitative, and assistance services

Health care is one of the sectors most affected by social aging. Not only is the public healthcare expenditure destined to grow, but also the demand for different healthcare services -from specialist consultations to daycare services for the elder population is projected to expand. According to research by Eurofound (European Foundation for the Improvement of Living and Working Conditions), personal care workers are the second most demanded occupation next to information and communication technology (ICT) professionals in the EU. Nevertheless, the study also points out that personal care jobs "are not yet strongly impacted by new technology and are not offshorable. They are in the lowest or second-lowest wage quintile." 19 For example, Germany has around 13,600 home centers for elder citizens which employ around 1 million caregivers. However, there still is a shortage of 15,000 geriatric nurses and around 8,500 auxiliary personnel. Although the number of foreign nurses, 16 https://ec.europa.eu/info/sites/default/files/demography_report_20 20_n.pdf; https://www.oecd.org/economy/ageing-inclusive-growth/; https://www.eurofound.europa.eu/publications/report/2017/workingco of-workers-of-different-ages 17 https://www.ilo.org/global/WCM_041965/lang–en/index.htm#P27_5453 especially from Asia, has almost doubled for the last decade, qualifying nursing candidates to cover only 1/5 of the demand. 20 Some encouraging examples come from nursing houses in Japan. More than twenty different types of robots-humanoid and non-humanoid-are already used to provide care for the elderly in Japan.

It becomes reasonable to ask whether this growing demand for personal care services may be supplemented by advanced technologies considering the shortage of personnel. 21 SHIN-TOMI Nursing Home is at the forefront of aid robotics, a market that may represent a $3.8 billion opportunity by 2035 in Japan. 22 Among them, there are humanoid robots that lead physical exercises, conversation partners, and even robotic pets. 23 In addition to humanoid robots such as SoftBank's Pepper, nursing homes in Japan use a variety of robotic devices to assist human caregivers. For example, RESYONE is an automated bed that transforms into a wheelchair. TREE is a

grab-hold device used in walking rehabilitation. A hybrid Assistive Limb is a robotic lever to help caregivers lift patients. In a sector where 80% of caregivers experience back problems, such robotic exoskeletons that can lift and move around patients help to reduce physical strain and injuries among staff. 24 Sohgo Security Services, known as ALSOK, created thumb-sized electronic devices that can help track dementia patients who are likely to wander from their homes or care facilities. **??**5 20 https://www.ilo.org/wcmsp5/groups/public/—dgreports/—dcomm/ documents/publication/wcms_710863.pdf, pp. 46-48 But though robotic 21 Malcom Foster, "Aging Japan: Robots may have role in future of elder care," Reuters, March 27, 2018, https://www.reuters.com/article/us-japan-ageing-robots-widerimage/aging-japan-robots-may-haverole-in-future-of-elder-care-idUSKBN1H33AB. 22 Malcom Foster, "How robots could help care for Japan's ageing population," The Independent, April 9, 2018, https://www.indepen dent.co.uk/arts-entertainment/photography/japan-robot-elderly-careageing-population-exercises-movement-a8295706.html; Don Lee, "Desperate for workers, aging Japan turns to robots for healthcare," Los Angeles Times, July 25, 2019, https://www.latimes.com/worldnation/story/2019-07-25/desperate-for-workers-aging-japan-turns-to-ro bots-for-healthcare; Al Jazeera, "Innovative Japanese projects help seniors with dementia," YouTube, September 18, 2017, https://www. youtube.com/watch?v=es1p16FIM-U. 23 Jun Wu, "Robots, Aging Population and Pets: A story of shifting demographics, aging population and robots," Towards data science, April 22, 2019, https://towardsdatascience.com/robots-aging-popula tion-and-pets-c84cdd5214cb. 24 Bryan Lufkin, "What the world can learn from Japan's robots," BBC, February 6, 2020, https://www.bbc.com/worklife/article/20200205-whatthe-world-can-learn-from-japans-robots. 25 Justin McCurry, "Japan's dementia crisis hits record levels as thousands go missing," The Guardian, June 16, 2016, https://www. theguardian.com/world/2016/jun/16/record-12208-people-with-demen tia-reported-missing-in-japan; nursing solutions are effective, they are not easy to afford without government subsidies; the cost per unit may vary between $4,000 and $9,000, not including maintenance, training, and assistance.

In addition to nursing services, advanced technologies play an important role in preventive and rehabilitative medicine ranging from retinal disease to Alzheimer's predictions, to advanced dentistry, nanorobotic surgeries, and psychological illness risk assessment 26 . Preventive and regenerative solutions based on advanced technology are a subset of a broader universe of services called telecare which "includes technical devices and assistive technology as well as professional health care services to assist, monitor and care for people from a distance. Telecare includes a variety of services such as communication, monitoring, consultation, diagnostics, and training." 27 Studies show that thanks to telecare elderly people can preserve their autonomy and active life for longer, which has a positive impact on the economy and frees up resources dedicated to social spending. Telecare also helps to reduce the number of injuries, and hospital admissions. 28 They can also help the elderly avoid the risk of social isolation, especially in the case of people who, due to illness, lack of family members, or natural aging, cannot easily leave their home or residence. 29 No-Isolation is a Norwegian startup that specializes in developing communication devices easyto-use for older generations. The company came up with KOMP a device that shares photos, messages and makes video calls. It does not require previous digital skills. The company recognizes that conventional tablets and smartphones are not easy to use for everyone. 26 KOMP features high contrast screens, enhanced audio, and a one-button interface. 30 Another interesting example comes from Cyberdyne Inc. a company that specializes in cybernetics, which is applied technology solutions at the intersection of human anatomy, robotics, and information technology. The company has developed treatment devices that help regenerate neuro-physical functions. It also manufacturers rescue devices, heavy labor devices, and entertainment equipment. Among its flagship products, there is hybrid assistive limb (HAL), "the world's first cyborg-type robot,"

The diffusion of telecare is closely linked to the development of smart homes and residences equipped with the internet of things, home health monitoring technologies for older adults, personalized interior design, and customized healthcare. 31 which stimulates brain functions. Cybernic treatments, which rely on HAL, recognize that a healthy nervous system is fundamental to maintain or regain kinetic capabilities. What HAL adds to conventional physiotherapy is the emphasis on regaining the connection loop between the human brain, the nerve system, and muscles. Not only can HAL be used in post-traumatic treatments (i.e., spinal cord injuries), but also in cerebrovascular conditions, degenerative conditions, and even non-medical wellbeing-oriented treatments oriented towards preserving the autonomy of movement. In addition, the company offers services such as NeuroHealthFit, which are guided rehab sessions with the use of HAL equipment to improve the nerve and muscular functions. 32 Cyberdyne's products and services aim to build a brighter future in which the elderly and the disabled can live active lives thanks to techno-peer support. 33

4 b) Public transport and mobility services

Whill, Inc. provides advanced mobility services for last-mile transportation. The company seeks to fill the void regarding near-home mobility for the disabled. While wheelchair-friendly infrastructure is commonplace at airports and railway stations around the globe, people in wheelchairs still tend to face steep mobility challenges running local daily errands. To increase mobility independence within a one-mile radius of the residences of the wheelchair-bound, Whill Inc. commercializes highly 30 https://www.noisolation.com/global/komp/#header 31 "What is HAL? The world's first cyborg-type robot," Cyberdyne Japan, last modified 2020, https://www.cyberdyne.jp/english/products /HAL/index.html. 32 "Cybernic Treatment," Japan Gov, last modified September, 2019, https://www.japan.go.jp/technology/innovation/cybernictreatment.html; "What is HAL? the world's first cyborg-type robot," Cyberdyne Japan, last modified 2020,

https://www.cyberdyne.jp/english/products/HAL/ index.html. 33 "Corporate Identification," Corporate Identification, Cyberdyne, last modified 2020, https://www.cyberdyne.jp/english/company/index.html. advanced mobility vehicles equipped with autonomous driving functions and light batteries, among other features. The company has also focused on aesthetics to create a new image for wheelchair mobility. 34 Whill's autonomous vehicles have also been tested at airport terminals in Japan to improve the quality of service to passengers without adding labor costs. 35 To provide the possibility of an autonomous and mobile life for elderly citizens, public-private projects are run to implement self-driving cars on a mass scale. There is a special need for autonomous vehicles in remote towns and rural regions where public transportation options are limited. For example, in the town of Suzu, at the tip of the Noto Peninsula, the rail station has been shut down and there are no more than a few bus links during the day. 36 Consequently, elderly citizens rely on private vehicles to get to medical appointments and other obligations. However, older motorists are twice as likely to cause fatal accidents in Japan. According to one study, "drivers and motorcycle riders aged seventy-five or older caused 8.2 fatal accidents per 100,000 licensed road users in 2018, about 2.4 times the number caused by those aged seventy-fours or younger. The number of accidents resulting in death by drivers aged seventy-five and over totaled 460." 37 34 "Advanced Mobility Service for Last Mile Transportation," Innovation Japan, The Government of Japan, last modified 2020, https://www. japan.go.jp/technology/innovation/personalmobility.html; Uesugi Tsukasa, "Next-generation wheelchair," NHK World Japan, March 3, 2019, This is not a minor issue for towns such as Suzu, where over 50% of the 15,000 local population is over sixty-five years old, with many of that number being bus drivers. https://www3.nhk.or.jp/nhkworld/en/news/backstories/390/. 35 Michael Gillan, "Self-driving wheelchairs tested at Haneda Airport," The Japan Times, December 5, 2019, https://www. japantimes.co.jp/news/2019/12/02/national/self-driving-wheelchairs-te sted-haneda-airport/#.XrB8pC_MzOR; "WHILL Autonomous Driving Trial for Personal Mobility Devices to be held at Haneda Airport," Press Release, Japan Airlines, last modified October 28, 2019, https://press.jal.co.jp/en/release/201910/005362.html; "Japan Airlines to trial WHILL autonomous wheelchairs at Haneda Airport," Airport Technology, last modified October 29, 2019, https://www.airport-technology.com/news/whill-autonomous-wheelchair-haneda-airport/. 36 Mike Ramsey et al., "Japan Road Tests Self-Driving Cars to Keep Aging Motorists Mobile," The Wall Street Journal, last modified January 21, 2016, https://www.wsj.com/articles/japan-road-tests-self-drivingcars-to-keep-aging-motorists-mobile-1453357504. 37 Jiji Kyodo, "The Japan Times, Older drivers in Japan cause fatal accidents at twice the rate of under 75s, report shows," The japan times, June 21, 2019, https://www.japantimes.co.jp/news/2019/06/ 21/national/75s-cause-fatal-traffic-accidents-twice-rate-younger-drivers -white-paper-shows/#.XrB_Hi_MzOT; "Over-75 drivers cause Japan road deaths at twice rate of younger set," Nikkei Asian Review, last modified June 21, 2019, https://asia.nikkei.com/Economy/Over-75drivers-cause-Japan-road-deaths-at-twice-rate-of-younger-set.

5 c) Industrial robotics

Although industrial robotization may look distant from the issues of aging and shrinking labor markets, it has the potential to improve productivity where a skilled labor force is ever-harder to come by. It may decouple economic growth and productivity from demographic trends. Despite shrinking labor markets, companies could stay competitive, generating revenues and tax income which may be used to address the problem of aging. Additionally, advanced technologies may transform various heavy industrial jobs into safer and less arduous work. It would make possible to postpone retirement.

A good example of this comes from a mineral mine in Garpenberg, Sweden which applies 440 persons, 18% of them are women. The mine is of the most technologically advanced in the world. Among other equipment, it deploys perforating machines which are remotely controlled from a monitor room as well as autonomous vehicles to transport the ore from the mine. 38 While traditional industrial robots used to be programmed meticulously to carry out strictly limited tasks and movements, the latest generation of industrial robots is versatile and adaptative in terms of movement and tasks. **??**9 Mira Robotics specializes in patrolling robots that can perform routine surveillance tasks at corporate buildings. **??**0 They can send voice and image reports to police officers and security guards, becoming a handy substitute for human guards and watchmen. In particular, there has been significant progress in the robotization of repetitive tasks such as product picking, sorting, and palletizing. **??**1 Thanks to the development of intelligent robot controllers such as Mujin, industrial robots have acquired much greater autonomy. 42 III.

6 Conclusions: Ethical, Political, and Social Challenges

Advanced technologies rather than being a threat can expand the possibilities for attractive and well-paid jobs in high-skilled sectors. In the context of demographic decline and population aging, the service economy cannot be labor-intensive. This applies in particular to health services and social services in advanced economies where the demand for healthcare services is on the rise while the pool of the healthcare workforce is shrinking. 43 The deployment of humanoid and nonhumanoid robots in nursing homes is a pragmatic response to a shortfall of specialized caregivers which cannot be easily filled by immigrant workers. Although it takes some time to get used to working with and be attended by a robot assistant, robotics in nursing homes has many advantages. Unlike human caregivers, android nurses are consistently patient and well-tempered, which is extremely important in

assisting patients with dementia or other degenerative conditions. They are good at memorizing names, dates, and prescription details. Moreover, they are not a source of health risks since they do not get sick.

Contrary to widespread concerns about the fourth industrial revolution stifling human labor, there is little evidence among the workforce in Japan and the EU-27 to see technology as direct competition. As a technologically advanced economy, the labor force seems to be more at ease working alongside humanoid and non-humanoid robots and other technologies. On the other hand, further research is needed to examine the reactions of labor unions, consumer associations, families, and society at large. Little evidence exists so far regarding the psychological, sociological, and spiritual responses of advanced societies to the adoption of advanced technologies in different aspects of life, especially among the elderly and the retired.

7 44

The mini-cases presented in this paper show that advanced technologies are used to improve the daily freedom of the elderly and to provide assistance when human-mediated care is scarce. However, the study found little evidence of using technology to reincorporate the elderly into the workforce. A demographic decline as sharp as the one experienced by Japan and the EU-27 may fuel greater interests in 43 https://www.mckinsey.com/~/media/mckinsey/featured%20insights/future%20of%20organizations/the%20future%20of%20work%20in%20e urope/mgi-the-future-of-work-in-europe-discussion-paper.pdf; https://futureworkforce.economist.com/modern-times; 44 Bryan Lufkin, "What the world can learn from Japan's robots," BBC, February 6, 2020, https://www.bbc.com/worklife/article/20200205-what-the-world-can-learn-from-japans-robots.

substitutive rather than complementary technologies. Thus one may ask whether a stronger effort is needed to come up with complementary technologies to keep the elderly active in the labor force.

Culture seems to play an important role in the public and private management of aging. Because of language and customs barriers, many advanced economies have attracted very few immigrants to fill the growing void of nurses, caregivers, and other professional positions needed in an aging society. Although one could wish for a more human-centric approach, the technological approach may be more attractive for highly homogenous societies where cultural barriers to immigration are high. On the other hand, the technological approach may fall short of fulfilling the human need for meaningful connections and genuine interpersonal relations.

While advanced technologies may help retirees lead more active and independent lives, they can also fuel further social polarization. The cost of high-tech solutions and the skills needed to use them may pose new social barriers. Hence, the use of advanced technologies to manage demographic decline presupposes a substantive agreement between the government, companies, pension funds, and other actors on how to cover costs and train retirees to use those technologies. The technological training of retirees could be a new challenge for corporate social responsibility.

Although several studies show an upward trend in the use of telecare and other advanced technologies, their widespread application in society implies a new agreement between governments, insurers, service providers, and users regarding cost coverage. The large-scale application of telecare also has important implications in terms of continuous training of the personnel involved, technological support, and systemic changes in the structure of the health and welfare system. In addition, there is the challenge of ensuring the security of sensitive personal data, such as patient medical records. In a highly technological environment, there is a risk of a lack of proper safekeeping where data circulates between different devices, clouds, and servers. There is also the challenge of ensuring equitable access so that telecare is not a luxury service for some. 45 All in all, the introduction of advanced technologies to mitigate the employment impacts of aging, especially in the health sector, presents benefits, [1] [2] [3] [4] [5]

[1] UN report on World Population Aging: 1950-2050. 2 The Encyclopedia of Population, Paul Demeny and Geoffrey McNicoll (Eds.), New York, Macmillan Reference USA, 2003. 3 https://www.un.org/en/development/desa/population/events/pdf/expert/29/session1/EGM_25Feb2019_S1_SergeiScherbov.pdf 4 Adriana Scardino, Improvements in life expectancy and sustainability of social security schemes, report for the International Conference of Social Security Actuaries and Statisticians, Ottawa, Canada, 16-18 September 2009.

[2] Dang T., Antolin P., Oxley H., Fiscal implications of ageing: projections of age-related spending, OECD Economics Department Working Paper, OECD, 2001. 13 https://ec.europa.eu/info/sites/default/files/demography_report_20 20_n.pdf14 https://www.oecd.org/economy/ageing-inclusive-growth/15 Ageing Europe looking at the lives of older people in THE EU 2020 https://ec.europa.eu/eurostat/documents/3217494/11478057/KS-02-20-655-EN-N.pdf/9b09606c-d4e8-4c33-63d2-3b20d5c19c91?t=1604 055531000

[3] ()

[4] https://ec.europa.eu/info/sites/default/files/demography_report_20 20_n.pdf 19 https://www.eurofound.europa.eu/publications/blog/current-chang es-to-the-labour-market-may-well-define-the-future-of-europe

[5] ()

By 2070 the EU's share in the world's
population is projected to decrease to 4% from 12% in
1960, making it the second-smallest slice of the world's
"The Socio-Cultural Implications of the Aging Population in Japan,"
Capstone Projects and Master's Theses, May, 2018, https://digitalcom
mons.csumb.edu/cgi/viewcontent.cgi?article=1289&context=caps_th
es_all.;Tami Saito et al., "Population aging in local areas and subject
ive well-being of older adults: Findings from two studies in Japan,"
BioScience Trends 10, no. 2 (2016): 103-112, http://doi.org/10.5582
bst.2015.01174.
6 Claudia Irigoyen, "Tackling the Declining Birth Rate in Japan,"
Centre for Public Impact, last modified April 7, 2020, https://www.
centreforpublicimpact.org/case-study/tackling-declining-birth-rate-
japan/.
7 Claudia Irigoyen, "Tackling the Declining Birth Rate in Japan,"
Centre for Public Impact, last modified April 7, 2020, https://www.
centreforpublicimpact.org/case-study/tackling-declining-birth-rate-
japan/.
8 The future of work in Europe https://www.mckinsey.com/~/media/
mckinsey/featured%20insights/future%20of%20organizations/the%20
future%20of%20work%20in%20europe/mgi-the-future-of-work-in-euro
pe-discussion-paper.pdf
9 https://ec.europa.eu/info/sites/default/files/demography_report_2020
_n.pdf; Ageing Europe -statistics on population developments https://
ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Eu
rope_-_statistics_on_population_developments#:~:text=In%202019
%2C%20there%20were%2090.4,22.1%20%25%20in%20predominantly
%20rural%20regions; Ageing

[Note: workforce: https://www.eurofound.euro pa.eu/topic/ageing-workforce; Population structure and ageing EUROSTAT https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing; Population: demography, population projections, census, asylum & migration https:// ec.europa.eu/eurostat/web/population/overview.]

Figure 1:

27 http://wp6.pacitaproject.eu/wp-content/uploads/2014/02/Telecare-

description-web.pdf
28 Teleassistance and future ageing http://wp6.pacitaproject.eu/tech
nology-description/ ; How smart monitoring technologies and AI
optimise patient safety https://www.healtheuropa.eu/how-smart-
monitoring-technologies-and-ai-optimise-patient-safety/107790/;

[Note: 29 https://www.noisolation.com/global/research/what-is-social-isolati on/]

Figure 2:

but also challenges and public policy dilemmas. 46
References Références Referencias
28
Volume XXII Issue VIII Version I ( ) Message. Volume XXII Issue VIII Version I /9b09606c-d4e8-4c33-63d2-3b20d5c19c91?t=160 4055531000. Accessed. April 2021. 6. Cyberdyne. 2020. Corporate Identification:

[Note: 30( )]

Figure 3: 45

[Deepmind] , Deepmind . https://deepmind.com/safety-and-ethics *2020. Safety and Ethics. Deep Mind*

[Smit and Tacke] , Sven; Tilman Smit , Tacke .

[Lund] , Susan Lund .

[Accessed (2021)] , Accessed . April 2021.

[Accessed (2021)] , Accessed . May 2021.

[Accessed (2021)] , Accessed . May 2021.

[Accessed (2021)] , Accessed . May 2021.

[Accessed (2021)] , Accessed . May 2021.

[Accessed (2021)] , Accessed . May 2021.

[Accessed (2021)] , Accessed . May 2021.

[Scherbov and Pdf (2021)] , Scherbov , Pdf . May 2021.

[Lee (2019)] '-07 -25/desperate-for-workers-aging-japan-turns-to-rob ots-for-healthcare'. Don Lee . https://www.latimes.com/world-nation/story/2019 *Los Angeles Times* 2019. May 2021. (Desperate for workers, aging Japan turns to robots for healthcare. Accessed)

[/jun/16/record-12208-people-with-dementia-report ed-missing-in-japan (2021)] */jun/16/record-12208-people-with-dementia-report ed-missing-in-japan*, May 2021.

[Japangov (2020)] *Advanced Mobility Service for Last-Mile Transportation. Innovation Japan-The Government of Japan*, Japangov . https://www.japan.go.jp/technology/innovation/personalmobility.html.Accessed 2020. May 2021.

[Eurostat (2020)] *Ageing Europe-statistics on population developments*, Eurostat . https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_statistics_on_population_developments 2020. May 2021.

[Aging societies: The benefits, and the costs, of living longer Magazine World of Work (2009)] 'Aging societies: The benefits, and the costs, of living longer'. https://www.ilo.org/global/WCM_041965/lang--en/index.htm#P27_5453 *Magazine World of Work* 2009. May 2021.

[Eurofound (2021)] *Aging workforce. Eurofound data*, Eurofound . https://www.eurofound.europa.eu/topic/ageing-workforce 2021. May 2021.

[Oecd (2019)] *Artificial Intelligence in Society*, Oecd . 10.1787/eedfee77-en.Accessed. https://doi.org/10.1787/eedfee77-en.Accessed 2019. May 2021. Paris: OECD Publishing.

[Artificial intelligence predicts Alzheimer's years before diagnosis (2018)] *Artificial intelligence predicts Alzheimer's years before diagnosis*, https://www.sciencedaily.com/releases/2018/11/181106104249.htm.Accessed 2018. May 2021. Radiological Society of North America.

[Foster (2018)] 'bots-widerimage/aging-japan-robots-may-have-role -in-future-of-elder-care-idUSKBN1H33AB'. Malcom Foster . https://www.reuters.com/article/us-japan-ageing-ro *Reuters* 2018. May 2021. (Aging Japan: Robots may have a role in future of elder care)

[Broadening the knowledge base in policy making (2021)] *Broadening the knowledge base in policy making*, PACITA. 2020. http://www.pacitaproject.eu May 2021. (PACITA project)

[Menéndez-Valdés (2016)] *Current changes to the labor market may well define the future of Europe*, Juan Menéndez-Valdés . https://www.eurofound.europa.eu/publications/blog/ 2016. May 2021. (Eurofound documents) (current-changesto-the-labour-market-may-well-define-the-future-ofeurope)

[Japangov (2020)] *Cybernic Treatment: Recovering lost bodily functions*, Japangov . https://www.japan.go.jp/technology/innovation/cybernictreatment.html.Accessed 2020. May 2021.

[Video (2018)] *Depalletizing robot operation*, Mujin Video . https://www.youtube.com/watch?v=th93jxqRm8U&feature=emb_logo 2018. May 2021.

[European Commission. 2020. the Impact of Demographic Change (2021)] *European Commission. 2020. the Impact of Demographic Change*, https://ec.europa.eu/info/sites/default/files/demography_report_2020_n.pdf.Accessed May 2021.

[European Stakeholder involvement in Ageing society (2021)] *European Stakeholder involvement in Ageing society*, PACITA. 2020. http://www.pacitaproject.eu/ageing-society May 2021. (PACITA project)

[Rouzet et al. ()] *Fiscal challenges and inclusive growth in aging societies*, Dorothée Rouzet , Aida Caldera Sánchez , Theodore Renault , Oliver Roehn . 10.1787/c553d8d2-en. https://doi.org/10.1787/c553d8d2-en 2019. OECD Publishing.

[Thai-Thanh et al. ()] 'Fiscal implications of aging: projections of age-related spending'. Dang Thai-Thanh , Pablo Antolin , Howard Oxley . 10.1787/503643006287. https://doi.org/10.1787/503643006287 *OECD Economics Department Working Paper* 2001.

[Future X: The future of work. The Economist. https://futureworkforce.econo mist.com/modern-times The Economist (2021)] 'Future X: The future of work. The Economist. https://futureworkforce.econo mist.com/modern-times'. *The Economist* May 2021. 2020.

[Foster (2018)] *How robots could help care for Japan's aging population. The Independent*, Malcom Foster . https://www.independent.co.uk/arts-entertainment/photography/japan-robot-elderly-care-ageing-population-exercises-movement-a8295706.html 2018. May 2021.

[Health Europa (2021)] *How smart monitoring technologies and AI optimize patient safety*, Health Europa . https://www.healtheuropa.eu/how-smart-monitoring-technologies-and-ai-optimise-patient-safety/107790 2021. May 2021.

[Scardino (2009)] 'Improvements in life expectancy and sustainability of social security schemes'. A Scardino . http://www.actuaries.org/PBSS/Documents/0910-Report_ISSA_Ottawa.pdf *International Conference of Social Security Actuaries and Statisticians archive*, 2009. May 2021.

[Innovation Japan: Making Industrial Robots Intelligent to Improve Productivity Prime Minister´s Office of Japan-YouTube (201 'Innovation Japan: Making Industrial Robots Intelligent to Improve Productivity'. https://www.youtube.com/watch?v=IWzEO2r69BU *Prime Minister´s Office of Japan-YouTube* 2019. May 2021. (Prime Minister´s Office of Japan)

[Video (2018)] 'Innovation Japan: Making Industrial Robots Intelligent to Improve Productivity'. Mujin Video . https://www.youtube.com/watch?v=IWzEO2r69BU *YouTube* October 9. 2018. October 15. 2018. April 1, 2019. Prime Minister´s Office of Japan. (Depalletizing robotoperation)

[Insertion into sorters] *Insertion into sorters*, MUJIN. 2020. https://www.mujin.co.jp/en/solution/distribution/sorter/

[Ramsey et al. ()] 'Japan Road Tests Self-Driving Cars to Keep Aging Motorists Mobile'. Mike ; Ramsey , Miho Inada , Yoko Kubota . https://www.wsj.com/articles/japan-road-tests-self-driving-cars-to-keep-aging-motorists-mobile-1453357504 *The Wall Street Journal* 2016.

[Mccurry ()] *Japan's dementia crisis hits record levels as thousands go missing, The Guardian*, Justin Mccurry . https://www.theguardian.com/world/2016 2016.

[Lüber (2020)] 'medicine-for-thefuture-research-in-robotics-and-ai'. Klaus Lüber . https://www.deutschland.de/en/topic/business/ *Medical innovations from Germany. Deutschland Government* 2020. May 2021.

[Manyika and Thiel (2021)] *mgi-thefuture-of-work-in-europe-discussion-paper*, James Manyika , Lea Thiel . https://www.mckinsey.com/~/media/mckinsey/featured%20insights/future%20of%20organizations/the%20future%20of%20work%20in%20europe/ May 2021. (Mckinsey Global Institute)

[Ministry of Foreign Affairs of Japan. 2021. EMPLEO: Haciendo frente a los retos del futuro (2021)] https://web-japan.org/factsheet/es/pdf/es39_employment.pdf.Accessed *Ministry of Foreign Affairs of Japan. 2021. EMPLEO: Haciendo frente a los retos del futuro*, May 2021.

[Video (2018)] *MUJIN Customer Case*, Mujin Video . https://www.youtube.com/watch?v=LlY4pEqNWAY&feature=emb_logo 2018. May 2021.

[Lufkin (2020)] 'Mujin's picking solutions accelerate factory automation for customers'. Bryan Lufkin . https://www.mujin.co.jp/en/product/controller/ *What the world can learn from Japan's robots*, February 6, 2020. 2020. (MUJIN) (Palletizing. What is the MUJIN Controller?," MUJIN, accessed 2020)

[Mujin's picking solutions accelerate factory automation for customers (2021)] *Mujin's picking solutions accelerate factory automation for customers*, MUJIN. 2020. https://www.mujin.co.jp/en/solution/fa/picking/.Accessed May 2021.

[Scherbov and Sanderson ()] *New Measures of Population Ageing. International Institute for Applied System Analysis*, Sergei Scherbov , Warren Sanderson . https://www.un.org/en/development/desa/population/events/pdf/expert/29/session1/EGM_25Feb2019_S1_Sergei 2019.

[Tsukasa (2019)] 'Next-generation wheelchair'. Uesugi Tsukasa . https://www3.nhk.or.jp/nhkworld/en/news/backstories/390/.Accessed *NHK World Japan* 2019. April 2021.

[Over-75 drivers cause Japan road deaths at twice the rate of younger set Nikkei Asian Review (2019)] 'Over-75 drivers cause Japan road deaths at twice the rate of younger set'. https://asia.nikkei.com/Ecotwice-rate-of-younger-set *Nikkei Asian Review* 2019. May 2021. Nikkei Asian Review

[Saito (2021)][Saito (2021)]php?title=File: Population_pyramids,_EU-27,_2019_and_2050_('Population aging in local areas and subjective well-being of older adults: Findings from two studies in Japan'. Tami Saito . 10.5582/bst.2015.01174. http://doi.org/10.5582/bst.2015.01174 *BioScience Trends* May 2021.

[Eurostat ()] *Population pyramids, EU-27*, Eurostat . https://ec.europa.eu/info/sites/default/files/demography_report_2020_n.pdf.Accessed 2020. 2019 and 2050. May 2021.

[Eurostat (2020)] *Population structure and aging. Eurostat data base*, Eurostat . https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing 2020. March 2021.

[Eurostat (2021)] *Population: demography, population projections, census, asylum & migration. Eurostat database*, Eurostat . https://ec.europa.eu/eurostat/web/population/overview 2021. May 2021.

[Revolutionary technology. For those who didn't grow up with it (2021)] *Revolutionary technology. For those who didn't grow up with it*, https://www.noisolation.com/global/komp/#header May 2021.

[Robot jaws show medicated chewing gum could be the future Science Daily (2020)] 'Robot jaws show medicated chewing gum could be the future'. https://www.sciencedaily.com/releases/2020/07/200714101226.htm.Accessed *Science Daily* 2020. May 2021. University of Bristol

[Wu (2019)] *Robots, Aging Population, and Pets: A story of shifting demographics, aging population, and robots. Towards data science. https://towards datascience.com/robots-aging-population-and-pets -c84cdd5214cb*, Wu . Jun.2019. April 2021.

[s-cause-fatal-traffic-accidents-twice-rate-youngerdrivers-white-paper-shows/.XrB_Hi_MzOT (2021)] *s-cause-fatal-traffic-accidents-twice-rate-youngerdrivers-white-paper-shows/#.XrB_Hi_MzOT*, May 2021.

[Gillan (2019)] *Self-driving wheelchairs tested at Haneda Airport. The Japan Times*, Michael Gillan . https://www.japantimes.co.jp/news/2019/12/02/national/self-driving-wheelchairs-tested-haneda-airport/#.XrB8pC_MzOR.Accessed 2019. May 2021.

[Takada (2017)] 'social-issues/in-test s-across-japan-new-tech-allows-speedy-tracking-oflost-dementia-patients/#.Xlf0f6hKjIU Accessed'. Hidetoshi Takada . https://www.japantimes.co.jp/news/2017/05/03/national/ *The Japan Times* 2017. April 2021. (In tests across Japan, new tech allows speedy tracking of lost dementia patients)

[Irigoyen (2020)] *Tackling the Declining Birth Rate in Japan. Centre for Public Impact*, Claudia Irigoyen . https://www.centreforpublicimpact.org/case-study/tackling-declining-birth-rate-japan 2020. April 2021.

[Irigoyen ()] *Tackling the Declining Birth Rate in Japan. Centre for Public Impact BCG Foundation*, Claudia Irigoyen . https://www.centreforpublicimpact.org/case-study/tackling-declining-birth-rate-japan/ 2017.

[Meidert et al. (2013)] 'Telecare Technology for an Ageing Society In Europe'. Ursula ; Meidert , Sina Früh , Heidrun Becke . http://wp6.pacitaproject.eu/wp-content/uploads/2014/02/Telecare-description-web.pdf *Centre for Technology Assessment* 2013. May 2021.

[The Future of Ageing. Technology, Innovation, and Organisation in European Health Care European Innovations Partnership (20
'The Future of Ageing. Technology, Innovation, and Organisation in European Health Care'. PACITA. 2020. https://ec.europa.eu/eip/ageing/events/future-ageing-technology-innovation-and-organisation-european-health-care_en.html *European Innovations Partnership* May 2021.

[Smith and Svean (2020)] 'The future of work in Europe: Automation, workforce transitions, and the shifting geography of employment'. Smith , Svean . https://www.mckinsey.com/ *McKinsey Global Institute* 2020. May 2021. (feature ed-insights/future-of-work/the-future-of-work-in-euro pe)

[Kyodo ()] *The Japan Times, Older drivers in Japan cause fatal accidents at twice the rate of under 75s, report shows. The japan times*, Jiji Kyodo . https://www.japantimes.co.jp/news/2019/06/21/national/75 2019.

[Koskimies (2019)] *the-future-of-remote-patient-monitoring-is-in-artificial -intelligence*, Oskari Koskimies . https://meddevops.blog/2019/10/09/ 2019. May 2021. (The Future of Remote Patient Monitoring is in Artificial Intelligence)

[Demeny and Mcnicoll (2003)] *Transforming healthcare with AI: The impact on the workforce and organizations. EIT Health and McKinsey Company*, Paul Demeny , G Mcnicoll . https://eithealth.eu/wp-content/uploads/2020/03/EIT-Health-and-McKinsey_Transforming-Healthcare-with-AI.pdf.Accessed 2003. May 2021. (New York: Macmillan. 12. EIT Health and McKinsey Company)

[United Nations World Population Ageing. UN archive (2015)] 'United Nations'. https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2015_Report.pdf.Accessed *World Population Ageing. UN archive*, 2015. May 2021.

[Deepmind (2020)] *Using AI to predict retinal disease progression*, Deepmind . https://deepmind.com/blog/article/Using_ai_to_predict_retinal_disease_progression 2020. May 2021.

[What is social isolation? No Insolation (2021)] *What is social isolation? No Insolation*, Insolation. 2020. https://www.noisolation.com/global/research/what-is-social-isolation May 2021.

[What is the MUJIN Controller? MUJIN] *What is the MUJIN Controller? MUJIN*, MUJIN. 2020. https://www.mujin.co.jp/en/product/controller/

[Lufkin (2020)] *What the world can learn from Japan's robots*, Bryan Lufkin . https://www.bbc.com/worklife/article/20200205-what-the-world-can-learn-from-japans-robots 2020. May 2021.

[Lufkin (2020)] *What the world can learn from Japan's robots*, Bryan Lufkin . https://www.bbc.com/worklife/article/20200205-what-the-world-can-learn-from-japans-robots 2020. May 2021.

[Airlines ()] *WHILL Autonomous Driving Trial for Personal Mobility Devices to be held at Haneda Airport*, Japan Airlines . 2019. Japan Airlines: Press Release.

[Vargas Llave et al. (2017)] *Working conditions of workers of different ages Publications Office of the European Union*, Vargas Llave , Oscar , Wilkens Mathijn , Jack Mullan . https://www.eurofound.europa.eu/publications/report/2017/working-conditions-of-workers-of-different-ages 2017. May 2021.