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Comparing the Development and Commercialization of Care Robots in the European Union and Japan

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Abstract

Faced with ageing populations, escalating care needs, and growing shortages of care workers, Japanese and European Union governments have pursued large, publicly funded research projects to develop and commercialize care robots. Yet despite being the two world leaders in this field, having both spent hundreds of millions of euros (tens of billions of yen) on its development, Japan and the EU have rarely been compared directly and substantively in social studies of care robotics. How similar are their approaches to care robot development and commercialization, and what do the differences tell us about contrasting priorities in science, technology and innovation policy as well as tensions between treating care robotics as an industry and as a research domain? The first two sections of this paper chart Japanese and EU approaches to the development and implementation of care robots since the late 1990s. The final sections identify and analyse their key similarities and differences.

Keywords

Care robots; Japan; innovation; research and development; EU; Europe; Horizon 2020

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Contents

1. Introduction

Care robotics is a growing area of research at the intersection between industrial technology, trade policy, and public science, technology and innovation strategy. Over the past two decades, European Union (EU) and Japanese governments have explored the development of care robots as a possible solution to the challenges presented by ageing populations with growing care needs, in particular difficulties recruiting and retaining care workers. In Japan, the proportion of people aged over 65 is expected to reach nearly 40 per cent of the total population by 2050 (METI 2019), and the current shortage of care workers is expected to rise to 337,000 by 2025 (MHLW 2018). In the EU, it is estimated that 30 per cent of the total population will be aged over 65 by 2060, leading to a doubling of older adults' care needs compared with the level in 2012 (European Commission 2012a, 2012b, 63). Figures on projected shortages of care workers collated at the EU level are not available as they are for Japan, but various individual EU countries expect significant shortages of different types of staff involved in care provision (European Commission 2012b; Schultz 2014).[1]

Actors in the technology market often present care robots as a way to replace care workers, to make care work more efficient and provide staff with more time to spend interacting with the people they are caring for, or to enable older people to live independently for longer (Honda 2016; European Commission 2016; cf. Wright 2019). The Japanese government and Japanese robot industry groups in particular see care robots as an important future global market. An influential 2001 report co-authored by the Japan Robot Association and the Japan Machinery Federation predicted a large future market for next-generation robots by 2020 (JARA/JMF 2001), and helped contribute to a growing impression that this new robotics industry could be as important to Japan's 21st century economy as the automobile industry was to its post-World War II economy. Moreover, in Japan, where immigration is a highly contested issue, some government technocrats have seen care robots as a means to replace the need for migrant care workers from Southeast Asia, although the limited capabilities of current models suggest that they may be more likely to facilitate rather than pre-empt migrant care labour (Wright 2019).

Despite a strong shared interest in the possibilities presented by care robots, the EU and Japan have rarely been compared directly and substantively in social studies of care robotics. Much Human-Robot Interaction (HRI) literature focuses on the specific implementation of a particular care robot in one or more settings (e.g. Wu et al. 2014; Khosla, Khanh, and Chu 2017), or on ethical issues pertaining to the use of care robots in general (e.g. Sharkey and Sharkey 2012, Sorrell and Draper 2014). Anthropologists and science and technology studies (STS) scholars have researched attempts to introduce Japanese care robots to Japanese as well as to Northern European or American care settings (Hasse 2013; Leeson 2017; Ishiguro 2018; Wright 2018a; Wright 2019). Several studies have compared public attitudes towards care robots in European countries with those in Japan (Shibata et al. 2008; Broadbent, Stafford, and MacDonald 2009), but in terms of policies and structures of robot development, Japanese care robotics and European care robotics are rarely compared in a substantive manner.

It is commonly assumed that Japan is far ahead in the development and dissemination of such devices, owing to an apparent 'love' of robots that is culturally unique.[2] Japan has long been described, for example by Schodt (1988), as a 'robot kingdom', in which robots are welcomed as helpers due to techno-animist beliefs rooted in Shinto or Buddhism, as well as pervasively positive representations in pop culture, for example the hugely popular robot characters Astro Boy and Doraemon in manga and anime (see, for example, Robertson [2010] and Wagner [2013]). These views have been actively encouraged by the Japanese government both inside and outside of the country, as part of the construction of an invented tradition of robotics that has formed a key element of post-World War II Japanese techno-nationalist identity (Sabanović 2014). However, this narrative has increasingly been called into question. For example, scholars have refuted the concept of techno-animism as confused, speculative, reductivist and even nonsensical (Gygi 2018; Frumer 2018); studies such as that conducted by Broadbent, Stafford, and MacDonald (2009) have shown that people in Japan have no greater liking for robots than people in other countries; and in all areas of robotics Japan is facing considerable challenges from South Korea, China, the United States, and the EU. Other relatively underreported factors beyond cultural and media representations are also important in explaining Japanese state and industry interest in robotics, including sustained political support and investment, and the public and private research and development landscape.

In fact, as this paper will show, the EU's care robot strategy is far closer to Japan's than has previously been acknowledged. Japan and the EU have both invested considerable amounts of money – hundreds of millions of euros (tens of billions of yen) – in the research, development and implementation of these technologies over the past twenty years. Both seek to grow the availability and market for care robots while learning from each other's research, development and commercialization strategies: both Japan and the EU develop science, technology and innovation strategy in a process that explicitly involves benchmarking against each other's strategies (European Commission 2010; Carraz and Harayama 2018). These policies have, however, led to differential outcomes: very few robot care devices developed or tested through EU projects have been commercialized and are available for purchase,[3] while in Japan, as of October 2019, at least 19 products had been commercialized via publicly funded care robot projects, with 73 more in active development.[4] This paper aims to address the questions of how similar EU and Japanese approaches are to care robot development and implementation, and what their differences tell us about contrasting priorities in science, technology and innovation policy as well as tensions between care robotics as an industry and as a research domain – and how these have led to differing results in terms of commercialization.

The first part of the paper presents a brief history of the development of care robots in Japan and the EU, and considers some aspects of public innovation policy with a particular focus on project funding and investment. This is based on a review of policy documentation, and also draws on academic literature as well as fieldwork interviews I conducted with robotics engineers and policy actors in Japan and France between 2016-9. The second part will move on to a comparative analysis of these findings, and will consider some implications for the future of care robotics in Japan, EU member states, and beyond.

2. Care robotics in Japan

There is no universally accepted definition of care robots, partly reflecting differing understandings of the individual terms care and robot, as well as shifting portrayals of robots in popular media (Brucksch & Schultz 2018). In 2014, the International Organization for Standardization introduced the standard ISO 13482 ('Robots and robotic devices – safety requirements for personal care robots'), which was developed by Japanese robotics engineers and describes three categories of robots used for 'personal care' applications: mobile servant robots, physical assistant robots, and person carrier robots. The standard defines a personal care robot somewhat vaguely as a service robot 'that performs actions contributing directly towards improvement in the quality of life of humans' (Ibid., 4), and excludes various other types of robots, including toys and medical devices (British Standards Institute 2014). The latter exclusions are problematic, since some robots may be classed as toys, medical devices, and personal care robots simultaneously in different jurisdictions. For example, one of the best-known care robots, the seal-shaped robot Paro, started life (and continues to be used by some consumers) as a robotic pet before beginning to be used in the care of older adults, and is classified as a medical device in the US but not Japan, where it is classified more loosely as a welfare robot due to the more difficult medical device certification process,[5] nor in the EU, where it holds a non-medical CE (conformité européenne) certification. At the same time, some devices described as robots in Japan, such as fall monitoring sensors, are classed as telecare devices in Europe. Despite the lack of a clear and universal definition of care robots, similar types of devices are being developed and implemented in both Japan and the EU, and this paper follows broad Japanese state and EU definitions of care robots to include wearable and non-wearable transfer aids, indoor and outdoor mobility aids, toilet and bathing aids, monitoring systems, and communication robots.[6]

Following the bursting of the bubble economy in the early 1990s, the Japanese government began to invest heavily in science and technology as a way to rebuild long term economic growth. The Science and Technology Basic Law was passed in 1995, laying the groundwork for over two decades of massive investment in research and development: the First Science and Technology Basic Plan (1996-2000) had a total budget of ¥17tr (~€140bn), and the second Plan (2001-5) increased this to ¥24tr (~€200bn). During this period, from the mid-1990s, engineers in Japan started developing robots intended to be used in the care of older adults, with rehabilitation and interactive 'next-generation' (*jisedai*) robots emerging out of a context of previous research in the fields of industrial robots, robots for hazardous environments, and humanoids (Dethlefs and Martin 2006; Wagner 2013).[7] In 1999, Sony released the first generation of the Aibo dog-shaped robot, and Shibata Takanori from the National Institute of Advanced Industrial Science and Technology (AIST) unveiled Paro, the seal-shaped robot mentioned previously. Both were designed primarily to act as toys or robotic pets, but both came to be used with older adults in care settings to provide robot communication therapy or companionship.

However, notwithstanding an early (1995-9) project by METI to develop a 'mobile meal delivery robot for aged and disabled people' (Lechevalier et al. 2008), as well as the general environment of increased public investment in science and technology, it took the Japanese government several more years to devise policies explicitly supporting the development of a range of robots intended primarily for care applications, as part of a concerted state strategy. For example, Shibata had to move to MIT in the United States to develop Paro because of a lack of institutional support from AIST; research managers in Japan were unconvinced of the potential of the robotic animaloid he proposed (Interview with Shibata Takanori, 30 June 2016). However, care robotics received a large boost when Shinzo Abe became prime minister. His strong support for robotics, which began during his first term from 2006-7, led in part to the publication of the government strategy document *Innovation 25*. This document featured an imaginative portrayal of a future Japanese society making use of various different types of robots, including some that provided care.

Over the following years, a succession of projects to develop care robots was introduced. The first major state-funded project, initiated under the Third Science and Technology Basic Plan (2006-10), was the 2009-13 ¥6bn (~€50m) 'Project for the practical utilization of personal care robots' (*seikatsushien robotto jitsuyōka purojekuto*), which involved the creation of the ISO standard for personal care robots mentioned above (ISO 13482), as well as the construction of a warehouse-sized Robot Safety Testing Centre – the only single-location facility in the world able to certify care robots to this standard, testing features including strength and durability, movement, and electromagnetic compatibility (EMC). The larger 2013-7 'Project for the development and promotion of the introduction of robot care devices' (*robotto kaigo kikikaihatsu dōnyūsokushinjigyō*) followed under the Fourth Science and Technology Basic Plan (2011-5), providing ¥12.5bn (~€110m) mainly for product development. Over 80 companies ultimately participated in this project and its follow-on. Other projects included the 2016 ¥5.2bn (~€43m) 'Special project to support the introduction of care robots' (*kaigorobottotō dōnyūshien tokubetsu jigyō*), aimed at facilitating the uptake of care robot products that had already been developed. In 2015, Abe announced the establishment of the Robot Revolution Initiative, promising to 'spread the use of robotics from large-scale factories to every corner of our economy and society' (quoted in Bremner 2015). In the same year, the Headquarters for Japan's Economic Revitalization, a government group set up and headed by Abe to spearhead economic policy, published a comprehensive robotics strategy for Japan, and part of this ambitious strategy aimed at expanding the global market for nursing care robots to ¥50bn (~€425m) by 2020. The 2016-21 Fifth Science and Technology Basic Plan continues to emphasize an expansion of the development of robotics, information and communications technology and artificial intelligence, and their role in building what it describes as 'Society 5.0'[8], particularly in the field of healthcare (Cabinet Office 2015). Projects at the local and national levels are continuing, for example, with a follow-on project to the 'Project for the development and promotion of the introduction of robot care devices', now titled the 'Project for the development and standardization of robot care devices' (*robottokaigo kiki kaihatsu hyōjunka jigyō*), which is due to end in 2020.

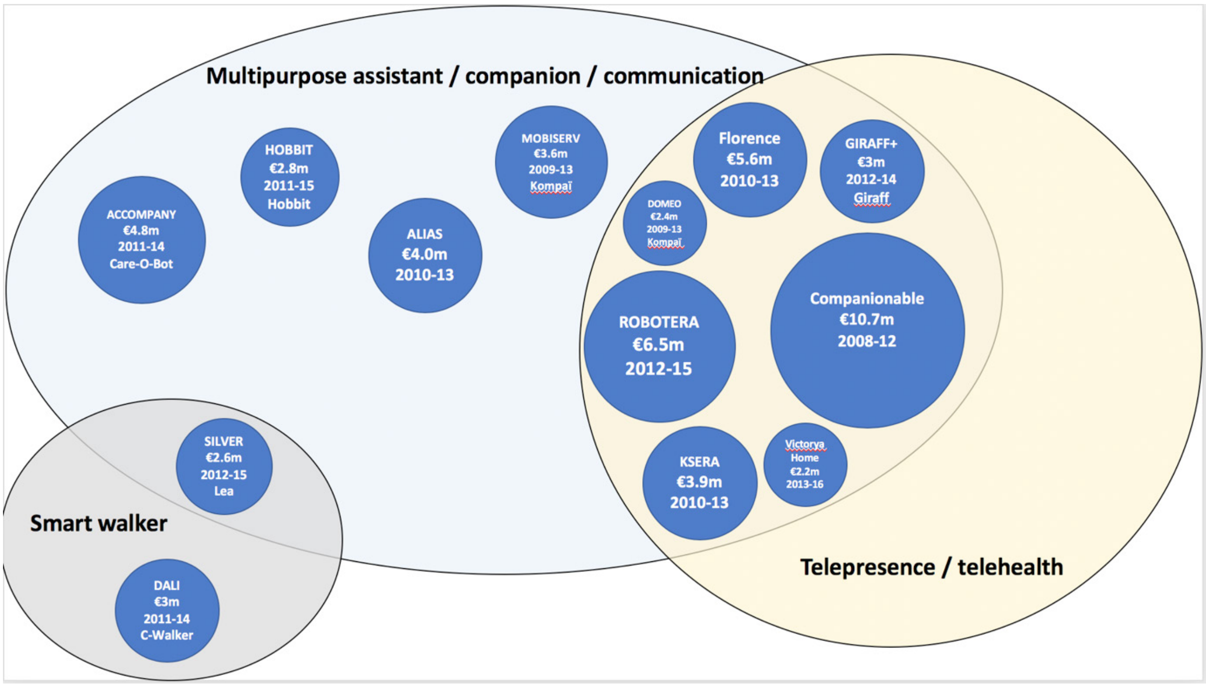
3. ICT policy and care robotics in the EU

The EU started investing in care robotics and other digital technologies related to ageing at around the same time as the Japanese government. The scale of investment, while not quite matching that of Japan, has also been very considerable, setting up a compelling basis for comparison. Following on from a policy agenda focusing on 'active ageing' from the early 2000s (Mantovani and Turnheim 2016), in 2007 the European Commission launched an 'Action Plan on Information and Communications Technology (ICT) for Ageing' as part of the framework of its i2010 plan, aimed at promoting ICT for independent living (European Commission 2010). The action plan was described as having: 'not only the objectives of enabling a better quality of life for older people with significant cost-savings in health and social care, but also… to help creating a strong industrial basis in Europe for ICT and ageing' (European Commission 2007). The plan built on a previous 2003-10 European Commission action plan for people with disabilities, as well as an earlier 2006-7 'e-inclusion' policy aimed at addressing digital divides and inequalities in access to technologies, particularly in the area of employment (Mantovani and Turnheim 2016). The 2007 action plan on ICT for Ageing focused on three areas of user needs: ageing well at work (reflecting the e-inclusion focus on employment), in the community, and at home. It led to the commissioning of a study entitled 'ICT and Ageing' in 2008, which involved a comparative analysis of ICT adoption in EU member states as well as Japan and the US, reflecting a similar benchmarking against international innovation strategies that also characterizes the Japanese Science and Technology Basic Plan development process (Carraz and Harayama 2018).

Since 2008, the EU, its member states, and its industries, have been investing heavily in a 'Research for Ageing Well' agenda aiming to raise the quality of life for older people through technology and innovation. This investment has included about €2bn over the past ten years under the Seventh and Eighth Research and Innovation Framework Programmes (FP7 and FP8; the latter also known as Horizon 2020), and under the Active and Assisted Living Joint Programme (AAL), which similarly funds research into technology to support older people.[9] The European Commission further launched the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA) in 2011, with the goal of 'contributing to the transformation and innovation of health and care in the Digital Single Market' by connecting cross-sectoral actors at all geographical levels across the EU who are involved in innovation and the digital transformation of health and social care.[10] FP8/Horizon 2020 is intended to operationalize the EU's 'Innovation Union' initiative, which in turn is one of seven initiatives of the Europe 2020 strategy aimed at building public-private innovation partnerships, developing the EU's unified 'European Research Area', and ultimately increasing Europe's global competitiveness.[11]

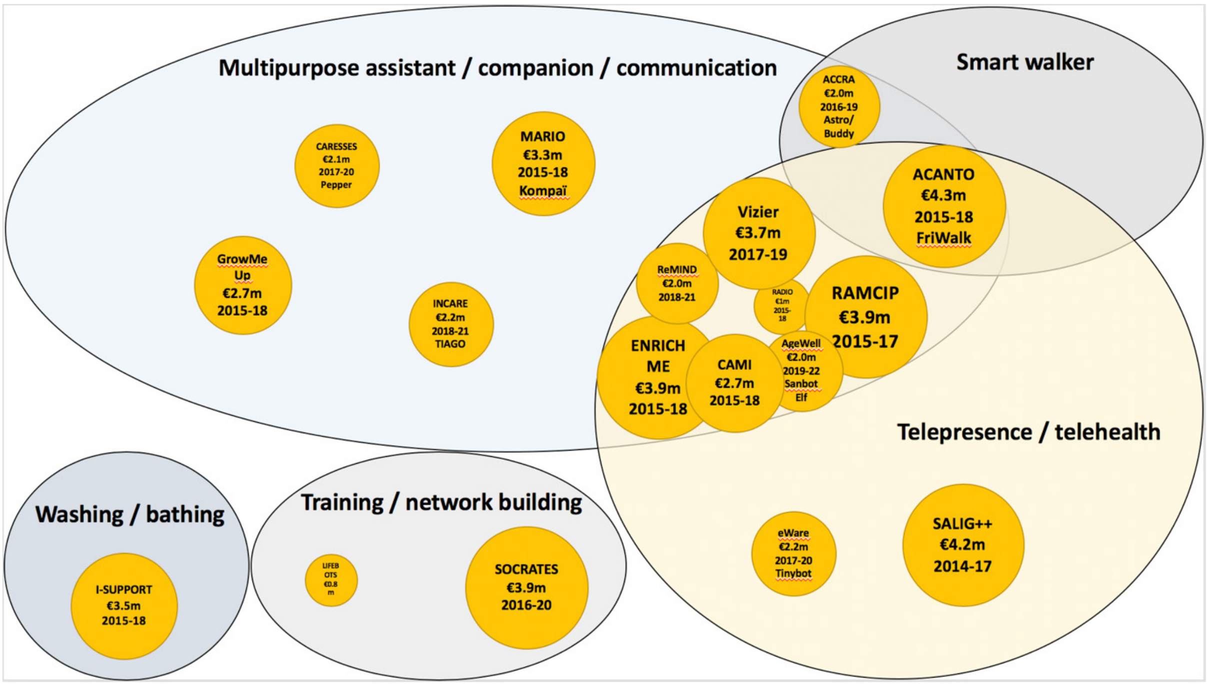
Within this broader context, care robotics constitutes a relatively small yet significant area of investment, and the amount of funding for such projects has been growing. Before 2008, very few EU robotics projects were explicitly related to the care of older adults, with one example being the 2007 €3.3m ROBOTS@HOME project, funded as part of an 'Advanced Robotics' research topic. However, under FP7 (2007-13), which included the new research category of 'ICT and Ageing', the number of funded projects involving care robotics increased dramatically. These projects are displayed in Figure 1 using a Venn diagram in which the bubble size is proportionate to the size of funding, divided into rough categories by the type of care robot developed or used in each project. There is considerable overlap between these types, and the categorization provided here is only for the purpose of providing a rough overview. FP8/Horizon 2020 (2015-20) explicitly disbursed €85m to a ‘Robotics for Ageing Well’ programme, mainly related to the research topic entitled ‘Active Ageing and Self-Management of Health’. An ‘Ageing Well in the Digital Age’ programme was also launched under AAL, which provides separate additional funds for more industry-led approaches to care robot product development. Projects related to care robotics funded under FP8/Horizon 2020 are shown in Figure 2.

Figure 1: Care robot projects funded by the European Commission under FP7 (2007-13)



Sources: European Commission: Cordis; AAL Programme website.

Figure 2: Care robot projects funded by the European Commission under FP8/Horizon 2020 (2014-20)



Sources: European Commission: Cordis; AAL Programme website.

In sum, over the past fifteen years, significant amounts of money have been invested in the emerging field of care robotics: at least €275m on the Japanese side in projects funded by 50 per cent contributions from the government and the companies involved, and at least €235m on the EU side, again composed of a mixture of public and private funding that does not take into account additional national funding.[12] Yet the outcomes of these projects have differed – as previously noted, while very few care robots developed through EU projects have been commercialized, in Japan at least 19 products had been turned into commercial products via publicly funded care robot projects, primarily through the 2013-7 'Project for the development and promotion of the introduction of robot care devices', and many more are in active development. The numbers of units sold by Japanese companies remains relatively small, although available data indicates that the size of the market is slowly increasing.[13] According to the International Federation of Robotics, the global market for nursing care and disability aid robots increased from US$19.2m in 2016 to US$48m in 2018 (International Federation of Robotics 2018) – still far short of the 2020 target of €425m set in 2015 by the Headquarters for Japan's Revitalization, but growing rapidly.

4. Disconnection between development and implementation

There are several clear commonalities between Japan and the EU in terms of care robot development and implementation strategy, which provide some explanation for why care robots have not yet become widely disseminated. As I will show in this section, in both cases, a top-down approach has been taken to research and development, while implementation has been largely bottom-up. In Japan, as previously described, care robotics is integrated into a concerted national robot strategy, and research and development have been directed primarily by the Ministry of Economy, Trade and Industry (METI), the New Energy and Industrial Technology Development Organization (NEDO), and the Japan Agency for Medical Research and Development (AMED).[14] The central role of METI in developing and overseeing this strategy, as well as the emphasis on creating an international standard, reflects longstanding political interest in developing care robotics as a future global export market, with a specific focus on the welfare states of Northern Europe that have represented the main market for Japanese care robot exports to date. Care robotics also fits within the context of Science and Technology Basic Law aimed at using research and development to address key societal issues including population ageing, while building the society and economy of the future following the economic slowdown of the 1990s. In the EU, care robotics has entered the successive research and innovation Framework Programmes as part of larger strategic plans related to the opportunities and challenges presented by information and communication technology, the 2010s agenda of promoting active ageing, as well as the development of the European Research Area.

By contrast, in both territories, implementation has been the responsibility of local actors, reflecting the broadly devolved responsibility for the operational level of adult social care to the local level both in Japan (Peng 2000) and in many European countries (e.g. Gray & Birrell 2013). While a national or EU-level project may help develop a particular robot product, those making the decisions about trialling, leasing or buying it tend to be local government commissioners, care home managers, care managers, or older adult users themselves and their relatives or carer providers. They generally have to make these decisions with almost no guidance on the range, efficacy or value for money of the robots, and little financial support for what is often a significant investment. In Japan, there is some additional support: for example, Kanagawa prefecture has a 'Care Robot Popularization and Promotion Centre' (*kaigorobotto fukyūsuishin sentā*) run by the Kanagawa Welfare Association and sponsored by the prefectural government, which provides tours of a nursing home that uses care robots, and there have also been modest subsidies available for purchasing robots provided to care institutions by METI and the Ministry for Health, Labour and Welfare (MHLW). Nevertheless, there is still relatively little guidance or information about care robots outside of media showcases, online articles and blogs, or word of mouth.

It might be expected that MHLW would have greater involvement in the implementation of robots in care institutions, since the provision of care falls under its jurisdiction. According to Dethlefs and Martin, writing in 2006, '[i]nterviews with academics and people working in the area of aged care in MITI [the previous name for METI] and the Ministry of Health and Welfare [the previous name for the Ministry for Health, Labour and Welfare] revealed that seeking to develop technological assistance to address the needs of aged care is as natural as seeking medical assistance to cure physical ailments' (Dethlefs and Martin 2006, 48). However, my own interviews with senior stakeholders involved in robotics projects in Japan between 2016-9 indicated that MHLW was generally opposed to the idea of care robots, and thus withheld its full support for coordinating their implementation.[15] As one senior manager at a large care company that was involved in the 'Project for the development and promotion of the introduction of robot care devices' told me:

> METI doesn't really know about care. They just help with research and so on, but the ones who actually deal with practical implementation at the actual site of care are MHLW. MHLW are not very positive about robots – that's how it is in Japan. Why? Because no matter how hard this side tries, they don't really understand the other side [he gestures with his hands to indicate the two ministries].
>
> Interview, 15 May 2015

Science, technology and innovation (STI) were enshrined in Japanese policy making in the form of the Council for Science and Technology Policy (renamed the Council for Science, Technology and Innovation in 2014), which was set up in 2001 to sit at the highest cabinet office level. Yet despite occupying a position elevated above that of individual ministries, technology policy-making still requires backing from those ministries in order to be effective at the micro level. The disconnect described above manifests a significant lack of consensus between areas of government in Japan emblematic of a broader socio-economic disconnect between developers and those involved in the delivery of care. The emphasis in the current Fifth Science and Technology Basic Plan on the so-called 'Society 5.0' seems to be an attempt to bridge this divide by bringing citizens into the research and development process to a greater extent, although based on interviews I conducted with robotics researchers at AIST in 2019, so far this does not appear to have had a significant impact on development practices of care robotics.

In the EU, a similar imbalance exists, similarly driven by institutional structures as well as political expediency. For example, in the case of the United Kingdom, while the delivery of social care is the responsibility of one of the lowest administrative levels of government (local authorities), responsibility for social care robot research and development was centralized to the highest administrative level of government (the European Commission). While overall funding for STI in the EU rose from €50bn under FP7 to €80bn under FP8[16], local authorities in England alone cut funding for social care by £7.7bn in real terms between 2010 and 2019, in response to the central government's austerity policies (ADASS 2019). Providing funding for social care innovation projects continues to be viewed by some EU member states, particularly those with conservative governments committed to reducing public spending, as more politically acceptable than increasing funding for the day-to-day delivery of social care services. Yet without adequate funding at the operational level of care, it is unlikely that care commissioners or providers will invest in (often expensive) new technologies such as care robots.

The lack of financial and informational support for local decision-makers provides an important reason for why care robots have not yet been widely adopted either in Japan or the EU and instead seem to be experiencing what Morita Akira, Director-General of the Research Institute of Science and Technology for Society (RISTEX), refers to as the 'valley of death' between engineering and social impact – in other words, the difficulties of effectively implementing newly developed technologies.[17] Policies with a singular focus on technocratic solutions are likely to be self-defeating when they overlook local, socio-cultural contexts of implementation.

5. Contrasting development landscapes

While this structural asymmetry between development and implementation provides one striking similarity between Japan and the EU, there are also key differences in approach based on contrasting strategic aims and differing commercialization practices. There has been a shift in the focus of Japan's innovation funding policy since the 1990s away from directly funding universities and research institutes to develop care robots themselves, and towards providing funds and subsidies for private companies to develop robots to specifications set by the Japanese funding agencies NEDO and, since its creation in 2015, AMED. This seems to have been precipitated in part by frustration at the low pace of commercialization of academic research in the area of service robotics in the 1990s and 2000s, with robotics engineers accused by critics inside Japan of wasting time and resources on pet projects to develop 'useless' robots (Wagner 2013). This critique intensified following the perceived failures of Japanese robots in the immediate aftermath of the Fukushima nuclear power station disaster following the 3/11 earthquake in 2011, when American military PackBot robots had to be brought in to assess damage after Japanese disaster recovery robots repeatedly failed when faced with real world conditions.

Carraz and Harayama describe how the innovation model in Japan has changed since the 1960s, when it was characterized by a 'big project' approach to research initiated and supported by the government acting as facilitator of industry, as portrayed in Chalmers

Johnson's classic 1982 work, *MITI and the Japanese Miracle*. Carraz and Harayama argue that as Japan has become a technology leader rather than follower, this approach has given way to a prioritization of science-based technologies that depend to a greater extent on collaborations with public research institutes and universities: a 'decentralisation of the innovation process', presented most recently in the form of Society 5.0 (2018, 36). However, in the case of care robots, the big project approach appears to have continued in an altered form. Wagner (2013) argues that whereas early state interventions in robotics research in the 1980s and '90s were conceptual and visionary, since the early 2000s such technically unfeasible visions have been scaled back as the government has turned to more concrete plans.

During my fieldwork in Japan in 2016, engineers who had spent their whole careers at AIST told me they were encouraged by research managers in the early 2000s to form spin-off companies to bring high-tech products such as robots to market, following the model of American institutions with excellent reputations for robotics, such as the Massachusetts Institute of Technology and Carnegie Mellon University. However, this drive for spin-offs proved largely unsuccessful, as Japanese engineers found themselves unable to refashion themselves as robot entrepreneurs (Wright 2018b). By the 2010s, NEDO and AMED had shifted strategy towards creating an environment to foster publicly supported private sector innovation, using public research institutes to provide research administration, management, project auditing and technical consulting services, and standards development, rather than to develop robots directly. The government moved towards setting specifications related to the perceived needs of the care industry, and providing private companies with the funds to develop products to these specifications, with the strategic aims of building a care robot market both domestically and for export, while developing the care robotics industry (Interview with senior engineer at AIST, 30 June 2016).

While some robotics companies have been less interested in large project consortium collaborations led by government despite their benefits (as described by Lechevalier et al. [2008]), many have engaged with recent government projects that have not involved the risk of co-developing and thus sharing technology with competitors. During the 2013-7 'Project for the development and promotion of the introduction of robot care devices', senior engineers at AIST told me that annual stage-gate activities at the Robot Safety Testing Centre, aimed at confirming that commercial care robot projects were on track, were meticulously choreographed by AIST staff to ensure that representatives from companies involved in the project would not accidentally catch sight of a robot belonging to another company. Technologies such as software models and tools developed by AIST were shared with companies involved in the project, but technologies developed by companies themselves were not.

These shifts have had major implications for the role of public research institutes involved in robotics, such as the Robotics Innovation Research Centre (RIRC) at AIST. Although it may be too early to judge, the optimistic rhetoric of Society 5.0 about empowering various actors, including entrepreneurs and citizens, to create paradigm shifts through new linkages, was not reflected in interviews I conducted between 2016-9 with senior researchers at RIRC, who portrayed a situation in which their centre had essentially become a research support group facilitating the development of robots by private companies. Many of the latter were established companies moving into care robotic projects in order to diversify their product ranges, or spin-offs from large corporations, rather than start-ups or spin-offs from universities, research institutes, or individual entrepreneurs.

In Europe, by contrast, much of the development of care robotics, particularly under the framework programmes, has been coordinated by university robot labs or through consortia made up of universities and companies. This reflects the dual goals of European Commission robot projects: they are aimed on the one hand at creating commercialized care robot products, and on the other at supporting higher education institutions, training PhD students, fostering international research ties between universities and business, and, by extension, developing the European Research Area. This in turn mirrors a broader ideological interest in supranational research collaboration: member states specifically pool the vast majority of their investment in care robotics to the EU level where all research projects involve joint collaborations between several member state partners – very few care robot projects are funded domestically at the national level. While under the Framework Programmes, the European Commission sets the broad research themes and calls for proposals from international public or public-private consortia, this differs from the specificity with which Japanese funding agencies have defined the required functionalities of robotic devices and called for bids from companies to develop products based on these specifications, with a stage-gate process to ensure timely progress against quantifiable goals that can be tested at the Robot Safety Testing Centre – a far more tightly controlled development process. The prioritization of treating care robotics as an industry rather than as a research domain may help explain the greater number of robotic care products commercialized through Japanese research projects.

6. Conclusion

This article has compared care robot policy, investment, and development and implementation projects in the EU and Japan, the two global leaders in this field. The similar scale and timeline of care robot investment across both territories highlight the similar level of prioritization afforded to this field among STI policy makers. This interest shows no signs of abating, as media in both Japan and Europe continue to report regularly on the potential for robotic solutions to the worsening crises in care affecting post-industrial nations, and as trials of care robots grow in number and size, with a large number of Japanese products in the final stages of development seemingly poised to be released into the growing global marketplace.

I have argued that despite a similar disconnect between top-down development and bottom-up implementation which has constituted one major impediment to more widespread dissemination of these devices, the Japanese state approach to research and development has differed considerably from the EU's. With its far stronger focus on product development and more tightly controlled development process concentrated on established private companies under the primary guidance of METI, the ministry in charge of trade, exports and industry, the rate of product commercialization has far outpaced that of EU projects. This may, however, have come at the expense of long-term development of the public research sector, with research centres such as RIRC losing funding and becoming less involved in hands-on robotics research. At the same time, the differing goals of the EU's care robot projects, which have focused more on supporting engineers and programmers in the higher education sector and nurturing high tech start-ups, suggest that a lack of commercialized products may be less problematic than in Japan, where public expectations about robots are greater due to the high profile of Japanese robotics reinforced by more frequent and enthusiastic media reports. Nevertheless, in Japan, as in the EU, there is a need to balance development and commercialization with an emphasis on implementation if care robots are to be widely adopted and have a tangible impact on global care systems.

In addition to highlighting the salience of comparisons between Japan and the EU in this field, it is also important to draw attention to institutional and policy-making structures and processes in social studies of robots more broadly. Much social science work on robotics particularly in Japan has focused on pop cultural depictions of robots, on invented traditions of robotics and manufacturing, and on the construction of techno-nationalist and techno-animist narratives, while much work on European robots has concentrated on ethical and philosophical issues. These are important topics that feed into and co-construct cultures of robots and robotics in Japan and Europe. However, it is also vital to study institutional actors involved in the literal construction of care robots, such as METI and the European Commission, in addition to factors that shape policy and research, such as the regular international flows of engineers and ideas between Japan and Europe, as well as macro changes to the research environment and funding mechanisms. These are central to shaping the landscape of robotics research and, ultimately, the range of robot products that will eventually end up in the marketplace and play their own role in reconfiguring the future of care. Only by paying attention to the full spectrum of socio-cultural context and praxis in each territory will we more accurately grasp its particular configuration of robotic care, as well as limiting factors in the development and implementation of individual care robots.

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8. Endnotes

1. See also: ‘Germany aims to revamp crisis-hit care industry amid worker shortage’ (https://www.dw.com/en/germany-aims-to-revamp-crisis-hit-care-industry-amid-worker-shortage/a-47268886; accessed 23 Jan 2020).

2. For example, Berthin (2014) and Rathmann (2015). This assertion is also based on anecdotal evidence of my own numerous conversations about care robots with care users, workers and academic researchers across Europe.

3. The only robots I could find that were developed through an EU-funded project and are available to buy ‘off the shelf’ are the Giraff telepresence robot and the Kompaï assistant robot. Other robots, such as Fraunhofer’ Care-O-bot 4 and the ‘Buddy’ emotional companion robot, are still in testing or pre-commercialization phases.

4. The full list of commercialized care robot products can be found at: http://robotcare.jp/en/news/20191004_073.php (accessed 23 Jan 2020). A further list of product developments underway can be found at: http://robotcare.jp/en/development/index.php?PHPSESSID=vgue1hd0k0b7dt31isb9f23mh2 (accessed 23 Jan 2020).

5. Interview with Shibata Takanori, inventor of Paro, 30 June 2016. The categorizations of ISO 13482 have also been critiqued by Villaronga (2016).

6. This includes, for example, the definitions used by the Japanese ‘Project for the practical utilization of personal care robots’ (see http://robotcare.jp/en/; accessed 17 Dec 2019), as well as EU project descriptions of ‘robotics for ageing well’ (see https://ec.europa.eu/digital-single-market/en/news/overview-eu-funded-running-research-projects-robotics-ageing-well; accessed 17 Dec 2019).

7. The HRP project (1998-2002) was the first major NEDO/METI robotics project intended to help develop the industry at large (Lechevalier et al. 2008), and paved the way for the future care robot projects of the mid-2000s and 2010s.

8. Society 5.0 is defined on the Japanese government’s Cabinet Office website as ‘[a] human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space’ (https://www8.cao.go.jp/cstp/english/society5_0/index.html).

9. AAL previously stood for the Ambient Assisted Living Programme, and was renamed the Active and Assisted Living Joint Programme under FP8.

10. https://ec.europa.eu/eip/ageing/home_en (accessed 17 Dec 2019).

11. https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020 (accessed 17 Dec 2019).

12. See https://ec.europa.eu/digital-single-market/en/news/overview-eu-funded-running-research-projects-robotics-ageing-well (accessed 17 Dec 2019). The Japanese figure is calculated by summing the budgets of all national care-related robotics projects during this period.

13. The care robot with the highest sales figures is perhaps ‘Smile supplement Kabochan’, a relatively inexpensive soft-toy-like robot that had sold around 10,000 unit by 2016 (Interview with manufacturer PIP&WiZ Co. Ltd., 6 April 2016). Paro, probably the care robot with the highest international media profile, had sold around 5,000 units in total between 1999 and 2018 (Reuters 2018). A robotic walker, RT1, made by RT. Works Co., sold around 3,000 units in 2018 (Interview with Japanese robotics researcher, 30 October 2019). Most other care robots on the market in Japan have sold tens to hundreds of units, based on sales data made publicly available on company websites and in news articles, as well as on interviews I conducted with manufacturers between 2016-19.

14. AMED was created in 2015 as the funding agency for all medical research projects across government, and assumed the oversight of care robot projects despite the fact that these are not technically classified in Japan as medical devices.

15. MHLW has also long been opposed to the introduction of migrant care workers, which was also a policy promoted by METI as a solution to the shortage of Japanese care staff (see Świtek 2016). As a result, relatively few migrant care workers have entered the Japanese work force (Wright 2019).

16. Figures from https://ec.europa.eu/research/fp7/understanding/fp7inbrief/what-is_en.html and https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020 (both accessed 17 Dec 2019).

17. Presentation at Fondation France-Japon, 4 June 2019. Various other factors have contributed to the lack of adoption, including a widespread lack of engagement between engineers developing these robots and end users, leading to very different understandings of practices and meanings of care (Wright 2019).

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