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Silicon caregivers: a multilevel analysis of European perspectives on robotic technologies for elderly care

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ABSTRACT

As populations age, women's workforce participation grows and AI advances, understanding attitudes towards care technologies becomes increasingly important. This study examines attitudes towards robot caregivers for older adults across 28 European countries, using 2017 Eurobarometer data from working-age adults (20–59; $n = 13{,}839$). We investigate how individual characteristics (gender, education, occupation) and local-level factors (GDP, female labour participation, over 65s as % of the population, spending on old age) are associated with comfort levels with domestic care robots. The results show that men, individuals with higher levels of educational attainment, and those in professional or managerial occupations report greater comfort with robot caregivers. Additionally, local context plays a significant role. Those living in local communities with higher female employment rates and lower spending on old-age support demonstrate higher acceptance of robotic care solutions. These findings highlight the dual influence of individual and community factors in shaping attitudes towards automated care technologies.

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KEYWORDS
AI; elderly care; automation; outsourcing; gender equality; Eurobarometer

Introduction

Unpaid household labour is a major social and economic activity that underpins families and households and is vital for social functioning. At the individual level, household labour is critical to health and well-being (Coltrane, 2000), but it is also very time-consuming and shared unequally within and between households (Churchill et al., 2023; Craig & Churchill, 2021a). As previous research has long demonstrated, women tend to spend more of their time on care work than men (Craig & Churchill, 2021b; Collins et al., 2021), and poorer households tend to spend more time on domestic work than richer households (Berthoud & Gershuny, 2000; Heisig, 2011). While the advent of domestic

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appliances, like the washing machine and microwave, have been sold to families and households on the promise of being time-saving technologies, the reality is that these domestic technologies, while saving some of the time spent on domestic tasks, have also modified nature of this tasks (e.g. raising hygiene standards) and, in some instances, creating new types of domestic work, especially for women (Wajcman, 2015). Still, the proliferation of domestic appliances has been linked with women's greater ability to participate in the labour market (Cavalcanti & Tavares, 2008) and with some reduction in time spent on household production (Gershuny & Harms, 2016). Domestic robots, currently dominated by robotic vacuum cleaners, are the most widely purchased robotic technology in the world and their use in the domestic sphere is growing (Hertog et al., 2023). So far, the usefulness of care robots, at least when used in institutional settings, has been doubtful (Wright, 2023). At the same time, a recent meta-analysis reports that globally one in four older adults have unmet long-term care needs (Rahman et al., 2022). Digital technologies and robots are widely seen as the future of elderly care throughout the ageing societies in the Global North (e.g. European Commission, 2022; Whitfield et al., 2024; Wright, 2019).

Despite the proliferation of smart domestic technologies, social science researchers, the media and policy-makers, have a limited understanding of who is supportive of adopting care work automation for their own care. In particular, we know little about individuals' attitudes towards care technologies and how they vary by individual and country contexts. Yet, this issue is important for several reasons. Differential acceptance of receiving care from technology could potentially deepen existing domestic workload inequalities described earlier across genders and classes. Further, attitudes towards receiving technological care might also reflect different labour market structures and underlying incentives across various country contexts. More gender-equal countries where more women are employed in paid work may be more supportive of domestic labour-saving technology, in part, because inequality in domestic work more significantly impacts women's employment (Fortunati, 2018; Strengers & Kennedy, 2020). Early adoption has significant impacts on the development of these technologies with early adopters' tastes and preferences more likely to structure subsequent refinements of the tech for global export. Further, early adopters are at risk of exposure to surveillance by unaccountable private providers. And, these technologies may have long-term impacts on gender norms and employment outcomes in early adopter countries. Finally, ageing populations in many European countries will place unparalleled caregiving challenges of which technology may form one solution. Thus, understanding who is most supportive of adopting and using tech to reduce domestic loads specifically around meeting the demand for aged care is critical to a range of interdisciplinary studies and to mitigate future problems driven by population ageing.

The purpose of this article is not to wade into the robust and well-established literature on the ethical and privacy implications of care technologies adoption (Berridge et al., 2019; Felber et al., 2023; Mittelstadt, 2017). Rather, we are interested in the sociodemographic and normative characteristics that are associated with support for the adoption of automated domestic outsourcing, specifically around using technology to receive elder or infirm care. We know women are more likely to use economic resources to outsource domestic work than men (de Ruijter et al., 2005). When it comes to using technologies for broad domestic outsourcing, evidence from recent qualitative studies is contradictory. Graf (2023) finds women to be early enthusiastic adopters of smart

cooking devices that alleviate their domestic workload. In contrast, Strengers et al. (2019) argue that currently household smart technologies are most appealing to masculine tech enthusiasts and tend to 'reinforce stereotypically gendered divisions of labour'. Despite growing investments in smart technologies to support elder care, little is known about the attitudinal support for its adoption and the mechanisms that may drive varying levels of willingness to receive care support. This study builds upon this existing scholarship to focus on three central questions: (1) Are women more supportive of being cared for by automated domestic outsourcing of elder or informal care than men?; (2) Are those with greater time pressures and higher opportunity costs, i.e. those who are highly educated and employed in demanding, professional occupations – more supportive of receiving this care?; and (3) Do macro-level factors, such as the proportion of women's employment at the local level, GDP, or generosity of welfare-state support for the aging inform individual attitudes to care from this technology?

We use data from the 2017 Special Eurobarometer surveys to measure the level of adoption of automated outsourcing within the home and attitudinal support for the use of robots to care when infirm or ageing. We assess whether levels of support are socially patterned by gender, occupation, education, and experience with robots at home or work while controlling for age, relationship status, co-presence of young children, rural, or urban residence, and whether an individual has difficulties paying for their bills regularly. We estimate how GDP, women's employment at the national level, as well as per cent of GDP spent on benefits for the elderly are associated with levels of support net of the concentration of ageing people (65 years or older) within the population. Ultimately, these analyses provide rich insights into the mechanisms associated with support for domestic elder/infirm automation to inform policy about the mechanisms of its adoption.

Background

Social robots and smart wives: the adoption of domestic automation

While machines and artificial intelligence (AI) are typically conceptualised as apparatuses to carry out paid work in the public sphere, the reality is that these kinds of technologies have already become a part of everyday living in the private sphere. The washing machine, the television and telephone, the Internet and the computer are all quintessential facets of the modern, Western home and it is the private, domestic sphere where most of the population uses these kinds of technologies and machinery (Fortunati, 2018; Graf, 2023). Indeed, the number of machines purchased for the private or domestic sphere now far outstrips the number of machines used in the public sphere like factories and services (Hertog et al., 2023).

This is part of the 'robotisation' of everyday life (Fortunati, 2018, p. 2685). Domestic and social robots are designed to respond to 'social' situations or those facilitating social reproduction, for example caring for others, managing individuals' health as well and carrying out domestic tasks like housework (Taipale, de Luca, Sarrica and Fortunati 2015, 12). They are part of a group of technologies that Strengers and Kennedy (2020, p. 3) refer to as 'smart wives' – smart technologies that carry out the kinds of domestic labour that have been historically and traditionally associated with women's unpaid labour in heterosexual households. They represent a clear shift away from technologies of the public sphere, which

are used to replace routinised human labour or labour involving danger and risk to robots that provide informal care to humans (Taipale, de Luca, Sarrica and Fortunati 2015, 12).

Technologies that aim to automate caregiving and caregiving-related tasks are mostly divided between technologies centred on young children, including education and monitoring (Belpaeme et al., 2018) and 'gerontechnology', which supports the care of elderly persons in the comfort of their own homes with the use of smart homes and assistive robots (Liu et al., 2016). The COVID-19 pandemic has exposed the risks many essential industries like health care and logistics face. The European Commission (Sostero, 2020, 33) observes that these are industries in which robotics will be critical to limit physical proximity between humans and making things like cleaning for example easier and more effective. We know that population aging will intensify demands on aged/infirm care highlighting the importance of understanding levels of support for robots to step into these jobs, especially given the potential for workforce shortages. We focus here on these relationships.

Smart men for 'smart wives'? The gendered use and management of domestic automation

Like previous domestic technologies in the home, the use of 'smart wives' is also heavily gendered. As Strengers and Kennedy (2020, p. 3) observe, 'smart wives [are] entangled in the social and political agendas about the role of women, wives and heteronormative relationships in contemporary society'. For example, the basis of smart wife technologies harks back to the 1950s housewife archetype in the United States or the United Kingdom – a 'white, middle class, and heteronormative housewife, with her perfect home, breezy white linens, artfully arranged flowers, gleaming cookware and homemade meals'. In short, the smart wife embodies idealised versions of the domesticated housewife. Even in countries where the 1950s housewife archetype did not exist, for example in Asian countries and cultures, smart wife technologies still embody these Western, gendered characteristics and qualities (Strengers & Kennedy, 2020). Embedded alongside these ideals is the assumption that the labour that is typically performed by women as part of social reproduction, like housework and care, is routine and replaceable by robots (Strengers & Kennedy, 2020). This, Strengers and Kennedy (2020, p. 34) argue, ignores the invisible work that women, wives, and mothers often perform as part of their domestic labour that is more difficult to automate.

The growth and dispersion of these technologies are seen in tandem with the growth of women's labour force participation. For example, Taipale et al.'s (2015) link the growth and dispersion of smart wife technologies and social robots in the private sphere with women's increases in paid work in the public sphere. They argue that increases in women's employment led to a decline in their supply of domestic, and household labour and time to undertake family-based care. Someone has to undertake this labour and robots are one potential resource. Given women's disproportionate share of housework in time and allocation across couples (Hook, 2010; Ruppanner, 2010), it is perhaps no surprise that women are most likely to use their income to outsource domestic work (Treas & De Ruijter, 2008). Historically, labour-saving domestic technologies have been linked to women's greater labour market participation (Wajcman 2015). Existing scholarship shows increases in women's earnings linked to paid work are positively associated

with spending on domestic outsourcing (Killewald, 2011; Treas & De Ruijter, 2008). For men, these associations are non-significant. Women are most likely to outsource routine, time-intensive domestic tasks like cooking, cleaning, and shopping while maintaining the more emotive tasks like caring for children (de Ruijter et al., 2005).

Fortunati (2018) argues that the more women have resisted social reproductive labour (e.g. care and housework), the more these technologies have been introduced into the domestic sphere. It is thus not surprising that these technologies are marketed towards men to give them a 'helping hand' in the absence of their wives' labour (Strengers & Kennedy, 2020). This is in stark contrast to earlier notions of domestic technologies which were meant to 'free up' women's time by eliminating most housework (Wajcman, 2015). Moreover, smart technology reinforces stereotypical ideas of men, husbands and fathers as 'hopeless' when it comes to housework or 'incompetent' when carrying out domestic duties (Strengers & Kennedy, 2020, p. 37).

Reflecting this is the gendered nature of the production and consumption of domestic automation. On the production side, men are overwhelmingly more likely to be the creators of 'smart wives' (Strengers & Kennedy, 2020) which is not surprising given computer science, robots and engineering are men-dominated (Wajcman, 2015). Men are more likely to be buyers and consumers of smart home technologies than women and are more likely to be what Strengers and Kennedy (2020, 39) call 'smart home obsessives' responsible for the introduction and management of these technologies into the home. This type of work involves both physical labour – installation, and management of cables – as well as cognitive labour – thinking about how to connect and manage the technologies. This is what might be referred to as 'digital housekeeping' (Strengers & Kennedy, 2020, p. 42). In their study, Strengers and Kennedy (2020, p. 44) found that 'this extra tech work was not commonly seen as a burden or chore by men. Most took pleasure in the activities involved in setting up and maintaining a smart house'. Indeed, most men identified these tasks as leisure rather than a form of housework. Despite men's initial contributions to installation, the responsibility of managing these technologies can fall to women and wives (Strengers & Kennedy, 2020). Yet, what happens when the technology is intended to support the care of the aged/infirm? Do we seed the same level of support for its adoption into the home? The literature is less clear on whether support for the adoption of robots that can help the elderly or infirm will be more common amongst women, as a labour-saving device, or men as a form of digital adoption in their roles as technology managers. It is feasible that women will be more supportive given their employment most often suffers from care demands or men may be more supportive given their propensity to adopt technology across platforms. Here, we help illuminate these relationships.

Individual characteristics associated with attitudes towards robots for elderly care

In addition to individual attributes, the macro context can also structure the adoption of smart technology in the home. Where local institutions, policies, social norms, or economic conditions make it difficult for women to maintain career and family roles, the conflict between work and family will be more keenly experienced by women.

Taipale et al. (2015) argue that the use of social robots faces different obstacles than industrial robots, including attitudinal preferences for their adoption in the European

context. They found that in areas in which robots have been used for a long time, such as manufacturing and space exploration, and in areas where robots 'can save human lives', like military and search and rescue, there is increased support for using robots as a priority. In contrast, Europeans are much less keen on bringing robots into areas associated with social reproduction, like care and domestic activities. Overall only 22 per cent of Europeans wanted to see robots used as a priority in health care followed by 13 per cent of Europeans in domestic activities, transportation, and agriculture (Taipale et al., 2015). Yet, these aggregated measures fail to account for regional variation in attitudes towards domestic technology adoption, an important gap given divergent gender profiles within Europe. What is more, the broader market demands – notably the demand for this labour driven by population structures and the percentage of women in employment – may impact levels of support for its adoption.

Here, we ask this critical question – how do attitudes towards the acceptance and ownership of domestic technologies differ across individuals and countries? Drawing on the research analysing domestic outsourcing to paid human domestic help, we expect support for smart technology adoption for the elderly and infirm to be shaped by the following major factors: (1) gender and (2) one's ability and willingness to pay. We draw upon classic sociological explanations for the allocation of domestic labour by bringing these ideas to a new domain – digital domestic outsourcing. Given their application in housework studies across decades of research, we outline our expected relationships briefly. We test whether men and women demonstrate different openness to domestic technological care, perhaps as a reflection of inequalities in the domestic division of labour. To capture the resources arguments, we analyse whether those who have higher resources, as measured by education and higher occupational position, report greater support for receiving care from this technology, perhaps because they are more comfortable with technological adoption in other areas of their lives (Tapiale et al, 2015; Fortunati, 2018))of higher opportunity costs associated with spending time on care (Ferree, 1990).

Below we present a series of hypotheses across gender, access to resources and their association with attitudes to care robots.

Gendered adoption hypotheses

We present competing gendered outcomes as per the research above.

> H1a. Women will be more comfortable than men to adopt eldercare/infirm robots because their burden of care work is higher and they stand to benefit more from these technologies.

> H1b. Men will be more comfortable than women to adopt eldercare/infirm robots because technology is largely seen as a masculinised domain, and they will be keen to use technology to reduce their burden to the 'feminine' domestic work.

Testing resource hypotheses

We expect those with greater economic resources to be most supportive of technological adoption as per below.

> H2. Those with higher levels of education will be more comfortable with using care technologies than those with lower levels of education. This relationship may be stronger for women than men for whom care provides a bigger opportunity cost.

H3. Those in professional, managerial, and white-collar occupations will be more comfortable with using care technologies than those in other occupations. This relationship may be stronger for women than men for whom care provides a bigger opportunity cost.

In addition to individual characteristics, we also expect individual attitudes to eldercare technologies to vary depending on the local context within which the elderly care takes place.

Macro-level explanations: economic conditions and social expectations

Previous studies suggest that people's attitudes to technology are nuanced and vary across countries (Dekker et al., 2017; European Commission, Directorate General for Communication 2021). In this paper, we consider several potential contextual measures that could impact domestic technology acceptance and adoption for elder and infirm care. These include local GDP, women's labour force participation, per cent of total population that is aged 65 or older, and per cent of GDP spent on old age support. Here, we test whether living in areas with more economic resources, in areas where more women work, as well as in countries characterised by older populations and those that offer more generous old age welfare support is associated with domestic robotic adoption for the reasons outlined below. We expect these contextual factors to influence support for technological adoption, in part, because they capture dynamics at the macro-level that may structure care for reasons outlined below.

First, people in richer areas (higher GDP) will likely be more familiar with using technology in a variety of contexts and will have more money to purchase these technologies to reduce domestic work. Similar to the individual associations, we anticipate that those in higher GDP areas will be more supportive of adopting domestic technology than those in areas with fewer economic resources. We expect regions where more women work for pay outside their homes, will have a relative shortage of unpaid household production workers. We posit that the aggregated absence of women from the home means time pressures to meet domestic demands should be higher and options to outsource care work to other women will be more limited. Consequently, men and women living in areas characterised by higher rates of women's employment will also be more open to using technologies for care work as an alternative to women's labour. Existing research supports these claims documenting that domestic outsourcing is more common in highly affluent cities (Schneider & Hastings, 2017) where women's labour force participation is more common (Bowen & Finegan, 2015). These cities tend to have higher concentrations of migrant labour to fill the domestic void but, as we test here, GDP and the aggregated absence of women from the home to employment may also shift attitudinal support for using robotics to care when infirm or elderly. Further, attitudes to care technologies also form against the backdrop of current demand for and investments in care. We expect that those living in countries with younger populations as well as countries with higher investments in eldercare will see robots as less critical to filling the care void and thus report lower levels of support as there may be more options for humans to step into this careTaken together, we weigh these different economic levers – GDP, women's employment and current demand for and spending on elder care – to identify whether each is associated with support for adopting robots to perform care at home. Our specific hypotheses are outlined below:

Macro-level hypotheses

H4. Higher local GDP will be associated with greater comfort with care technology among both men and women than in local areas with lower GDP. This relationship may be stronger for women than men.

H5. Higher levels of women's employment will be associated with greater comfort with care technology among both men and women than in local areas with lower levels of women's employment. This relationship may be stronger for women than men.

H6. Fewer older people and higher levels of resources already available to support eldercare will be associated with less comfort with robots taking on care work than in local areas with more older people and lower levels of resources. This relationship may be stronger for women than men.

Method

Data and sample

This article uses data from the 2017 Special Eurobarometer survey. The 2017 survey covers attitudes towards the impact of digitisation and automation on daily life, it interviewed 27,901 people aged 15 years and over in 28 European countries (European Commission, Directorate General for Communication, 2021). In the survey, respondents were provided with the following broad definition of robots: 'A robot is defined here as an autonomous machine which can assist humans in everyday tasks e.g. as a kind of co-worker helping on the factory floor or as a robot cleaner, or in activities which may be dangerous for humans, like search and rescue in disasters. Robots can come in many shapes or sizes, including human-like. Traditional kitchen appliances, such as a blender or a coffee maker, are not robots.'

We restrict our sample to working-age adults, so we only include the respondents aged between 20 and 59 years old who are not currently in education. We also dropped individuals who have no formal educational qualifications or reported being retired. After listwise deletion, the sample contains 13,839 observations. Country sample sizes range from 207 for Malta to 630 for Germany.

Measures

The dependent variable is comfort with using robots in elderly care. The 2017 survey contains a set of questions introduced as follows: 'Here is a list of things that could be done by or with robots. For each of them, please tell me, using a scale from 1 to 10, how you would personally feel about it. On this scale, '1' means that you would feel 'totally uncomfortable' and '10' means that you would feel 'totally comfortable' with this situation.'. The item that deals with elderly care is specifically worded as 'Having a robot to provide you services and companionship when infirm or elderly'. This measure specifically encourages individuals to reflect on their own future experiences and preferences. Table 1 summarises the attitudes to this item by gender.

Individual-level independent variables

We measure gender as a binary variable (0 = 'Women' (ref.), 1 = 'Men'). The original sample only contains individuals who identify either as men or as women and thus other

Table 1. Attitudes towards robots providing care and domestic labour tasks, by gender (%).

How would you personally feel about:	Having a robot to provide you services and companionship when infirm or elderly	
	Women	Men
1 Totally uncomfortable	2,401 (30.9%)	1,491 (24.6%)
2	597 (7.7%)	395 (6.5%)
3	740 (9.5%)	519 (8.6%)
4	518 (6.7%)	387 (6.4%)
5	914 (11.8%)	770 (12.7%)
6	574 (7.4%)	517 (8.5%)
7	662 (8.5%)	613 (10.1%)
8	614 (7.9%)	566 (9.3%)
9	266 (3.4%)	244 (4.0%)
10 Totally Comfortable	493 (6.3%)	558 (9.2%)
Unweighted N	**7779**	**6060**

identities are not included. Two independent variables are used as indicators of economic position to test our individual-level resources-demand (H2 and H3) hypotheses: one's level of education and labour market position. Level of education measure has three categories: 1 = studied until the age of 15 years (ref), 2 = studied until the age of 16, 17, 18 or 19 years, and 3 = studied until the age of 20 or older. A higher number of years in education indicates a higher skill level and earning potential, and thus, a higher opportunity cost for not working. Also, higher levels of education are known to be associated with greater openness to and adoption of new technologies. Labour market position is measured as a binary variable: 1 = individuals in professional and managerial occupations, as well as white-collar workers, versus 0 = everybody else (ref).

Individual-Level controls

We further add several controls, which are correlated with attitudes to technology, following others' work. We measure individual exposure to domestic automation as two dummy variables. The dummies to the value of 1 for those who responded 'Yes, at work' or 'Yes, at home' respectively to a question 'Have you ever used or do you currently use a robot at home or work (e.g. a robotic vacuum cleaner at home or an industrial robot at work)?' and 0 if any other response to this question was chosen. Further, we include a series of sociodemographic controls including age, measured as four 10-year categories; partnership status ('0 = single (ref.),' '1 = partnered'); the presence of a child under the age of 10 in the household ('0 = no child under 10 in the household (ref.),' '1 = a child under 10 present the household'); a dummy for poverty ('0 = no difficulty paying bills in the last 6 months (ref.),' '1 = had difficulty paying bills in the last 6 months'); and a dummy for living in a rural area ('0 = Urban residence (ref.)', '1 = Rural residence').

Macro-level independent variables

In our analytical sample individuals are nested within 207 subnational regions, that are in turn nested within 28 European countries. The data allows us to link individuals with the characteristics of the countries and sub-national regions where they live. We use the Eurostat database to collect macro-level variable measures. In most countries, Eurostat

provides the regional characteristics at the NUTs 2 level. United Kingdom is one exception, in the UK we only get local characteristics at the NUTs 1 level. We use three regional indicators: 2017 regional GDP per person, adjusted for local purchasing power (Eurostat, 2019b), per cent of women in employment locally in 2017 (Eurostat, 2019a), and proportion of those aged 65 or older in the region (Eurostat, 2017b). We also use one country-level variable, the per cent of the country GDP spent on old age support, as this information is not available in Eurostat on a more granular level (Eurostat, 2017a).

GDP per person measured in euros ranges from 9,300 to 75,900 with a mean value of 29,426, in the analysis we use a logged measure for GDP. Women's labour force participation also varies across the local areas ranging from 29% to 78% with a mean of 62%. The proportion of people aged 65 out of the total adult population ranges between 12% and 28% in our sample. Finally, % of GDP a country spends on old age support varies between 4.6% in Ireland and 13.9% in Greece.

Table 2 provides a descriptive overview of the key individual and macro-level measures.

Table 2. Sample Characteristics Special Eurobarometer survey 87.1 (weighted).

	Men	Women	Total
Gender (%)	49.4	50.6	100.0
Education (%)	.	.	.
Fin before 15	7.6	8.6	8.1
Fin between 16 to 19	50	49.5	49.8
Fin at 20 or over	42.4	41.9	42.1
Occupation (%)	.	.	.
Professional/ managerial/ white collar	40.2	40.1	40.2
Other variables (%)	.	.	.
Aged 20–29	18.4	18.4	18.4
Aged 30–39	28	27.8	27.9
Aged 40–49	28.8	28.1	28.4
Aged 50–59	24.8	25.6	25.2
Child in house under 10 years	28	34.5	31.3
Partnered	70.3	74.6	72.5
Rural residence	22	24.5	23.3
Difficulty paying bills	35.1	38.4	36.8
Use(d) robot at work	10	4.9	7.5
Use(d) robot at home	9.3	10.2	9.7
Local-level indicators			.
Local GDP per capita (in euros)			.
Min			9300.0
Mean			29426.8
Max			75900.0
Women in local employment (%)			.
Min			29.2
Mean			62.2
Max			77.9
People over 65 as per cent of the total population (%)			.
Min			11.7
Mean			18.8
Max			28.3
GDP spent on old age (%)			.
Min			4.6
Mean			10.5
Max			13.9

Note: Results reported at % of individuals in a given category, unless otherwise specified.
Source: Special Eurobarometer 87.1.

Analytical approach

We start by describing the country-level variations in our macro variables of interest and attitudes to using robots for adult care. To do this we calculate the average level of comfort with using robots for elderly care in a given country and plot those against the country-level means for GDP per person, per cent of over 65s in the adult population, employment rate of working-age women, and per cent of GDP spent on old age support using scatterplots (see Figures 1–3).

We then apply a multilevel regression analysis to test our Hypotheses 4-6 (DiPrete & Forristal, 1994). Multilevel models are a class of models recognising that macro processes may have an impact on the individual actor over and above the effects of any individual-level variables. In particular, this type of regression analysis is sensitive to the nested structure of the data – in this case, individuals nested within regions – recognising that individual-level outcomes are correlated within macro-level units. Importantly, they disentangle the variance of the dependent variable into its individual-, and regional-level components, allowing us to test both individual-, and regional-level hypotheses. Using Intraclass Correlation Coefficient we confirm that regional characteristics account for about 10% of the variation in attitudes to elderly care in the null model. To ensure reliability, nested models require adequate sample sizes at all levels. Given our relatively small country sample, estimating models at the local level satisfies the sample size criteria at level 2 to provide more robust and reliable estimations (Bryan & Jenkins, 2016). In our

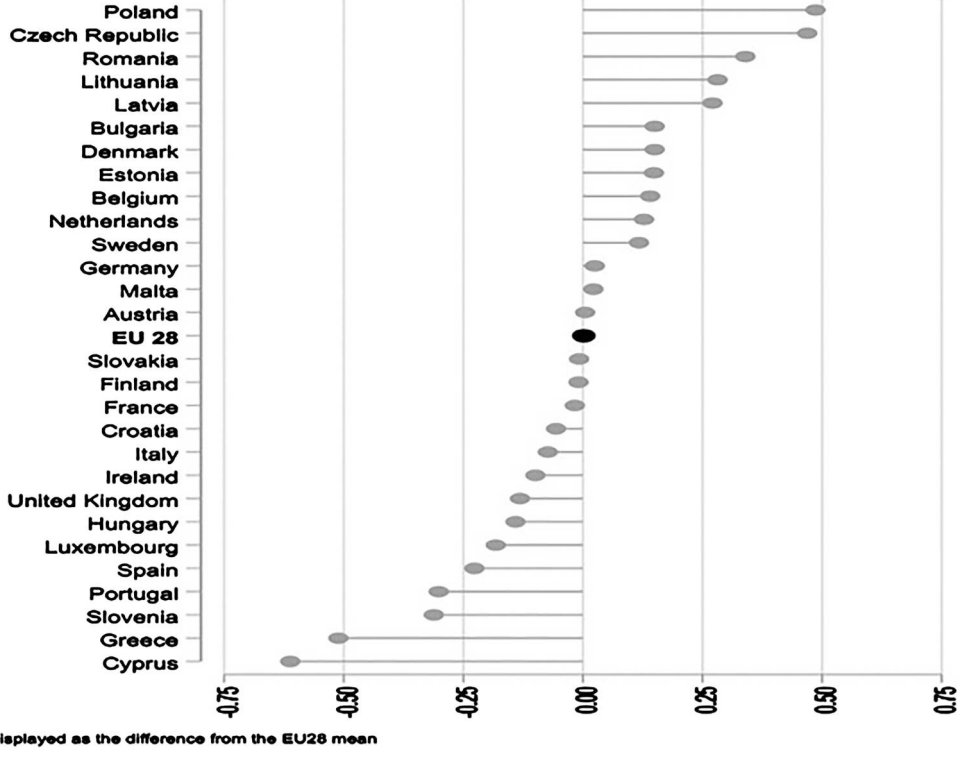

Figure 1. Variation in average comfort with being cared for by a robot when elderly across Europe.

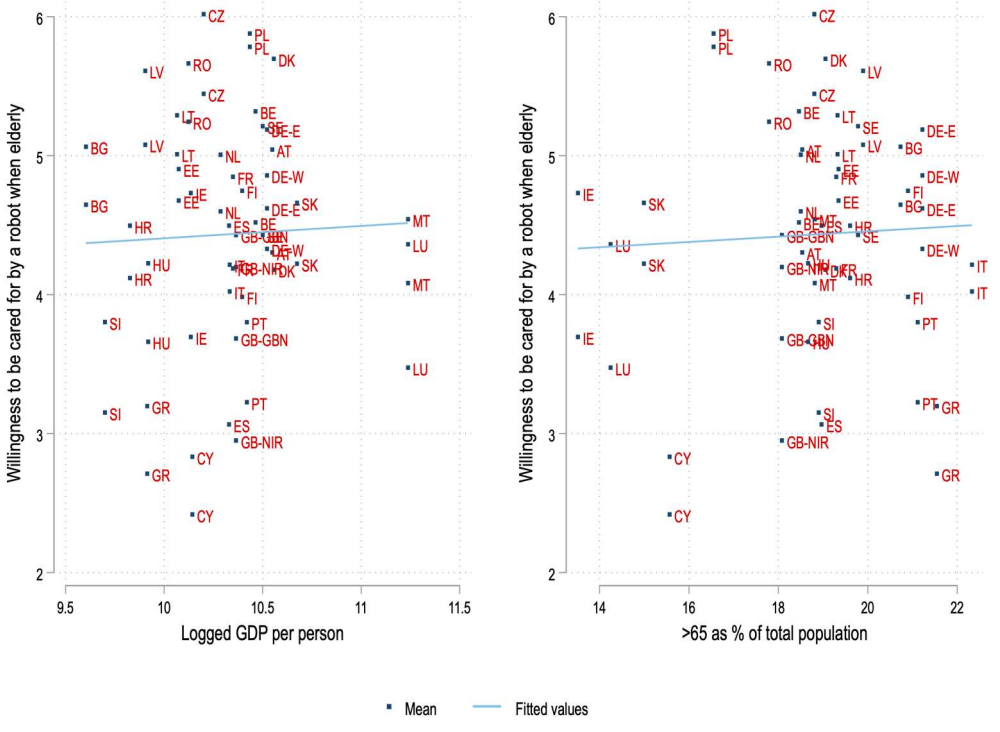

Figure 2. Mean comfort with eldercare robots by logged GDP per person and by per cent of over 65s in the population

multilevel models, we use a weight provided in the Eurobarometer for the total sample of 28 European countries to correct for the fact that most samples are of almost identical size, no matter how large or small the populations are from which they were drawn.

As our dependent variables are attitudinal scales we use multilevel ordered logit models. Our baseline specification allows random intercepts and random slopes across sub-national regions, meaning that different regions may have different baseline levels of comfort with domestic automation. In this model, we allow slopes to vary depending on the individual education. As a robustness test, we also estimated random intercepts, and fixed slope models, in which slopes for the individual level variables are assumed fixed across countries, and, therefore, do not depend on context. We compare our random intercept random slope model with the random intercept fixed slope model using a likelihood ratio test. Furthermore, we also compare the random intercept random slope multilevel ordered logit model with a multilevel linear regression model using Akaike and Bayesian Information criteria. Multilevel-ordered logit models with random intercepts and random slopes performed the best.

Results

European adults are, on average, slightly uncomfortable being cared for by a robot when they find themselves old or infirm. The mean preference is 4.4. on a scale of 1 (totally uncomfortable) to 10 (totally comfortable).

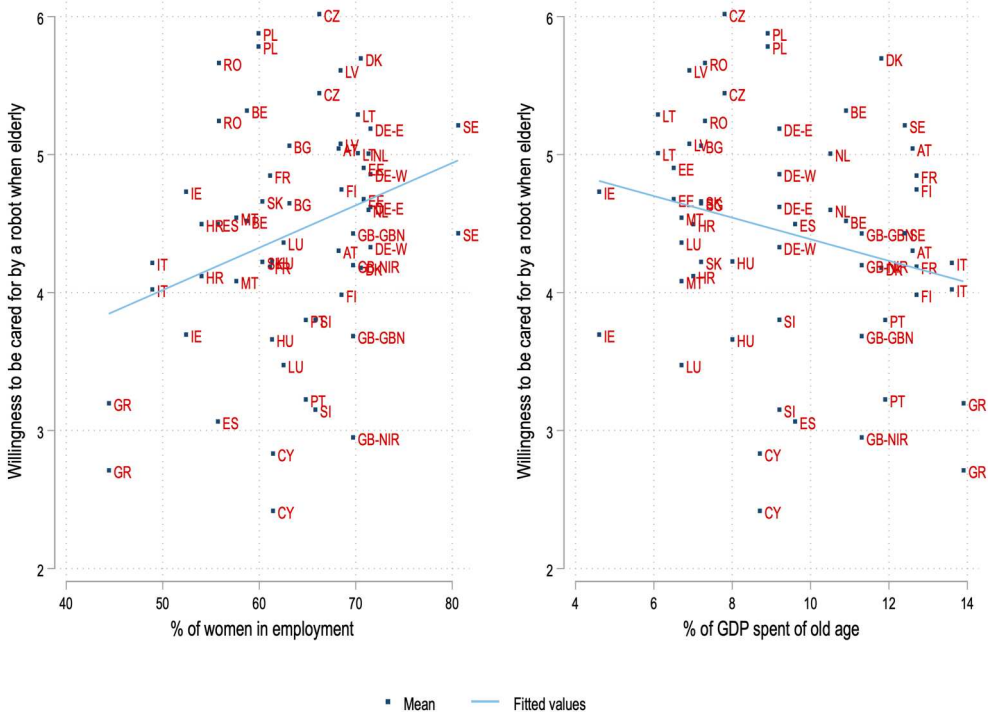

Figure 3. Mean comfort with eldercare robots by % of women in employment and by % of GDP spent on old age support

Figures 1–3 present the means of our four local-level indicators ('% of GDP spent on old age support', '% of adults over the age of 65 in the population', '% of women in employment' and 'local GDP per person') and their associations with average attitudes to using robots to automate some elderly care across European countries in our sample. These descriptive suggest that there is no clear association between average attitudes to robots and GDP (Figure 2). In contrast, we find that willingness to adopt technologies to receive help when elderly or infirm is positively associated with higher rates of women's labour force participation in a given country and negatively associated with the generosity of local resources available to the elderly (Figure 2). Of course, these associations may be explained by individual confounders, so we estimate regressions net of controls and present them below.

Regression results

We start by estimating a null model to gauge the variance in the openness to using robots to help with infirm/elderly care across different regions in Europe. The results are summarised at work at the two levels of analysis. Figure 4 provides visualisations of the relationships between our dependent variables and individual and local characteristics.

We find that men are more open to adopting robotic technologies for their own care, in alignment with our H1b. Consistent with our resource-demand hypotheses, we find that more educated men and women are more supportive of robotic adoption for their

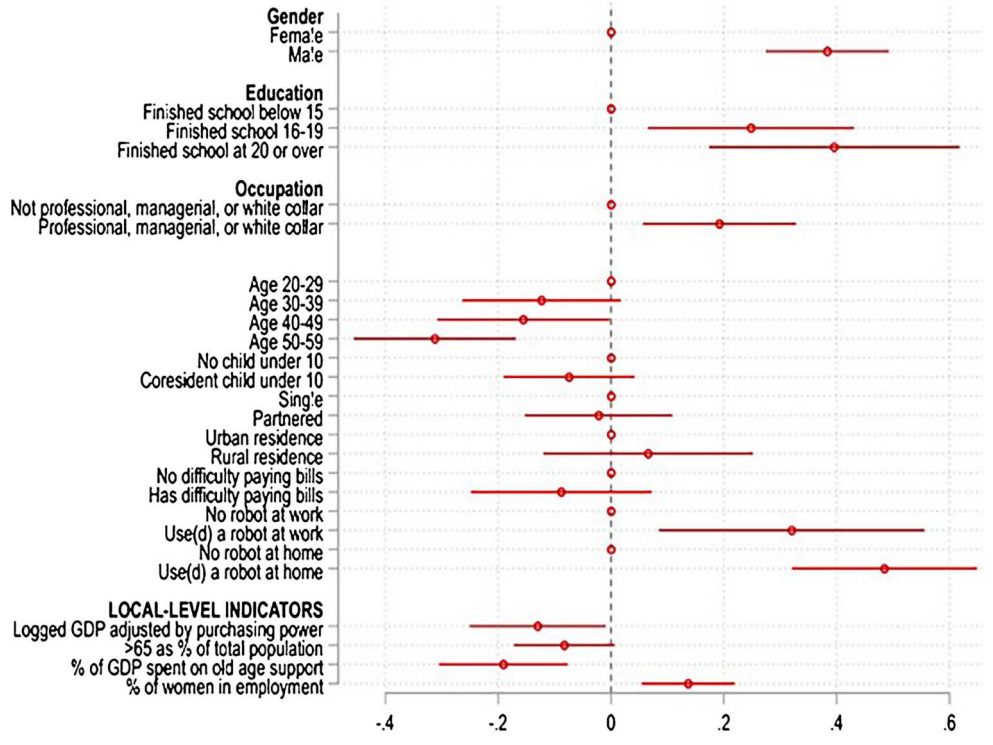

Figure 4. Predicted answers to a question 'How comfortable will you be to be cared for by a robot in old age?'

own care, as expected by H2. We also find that those in professional, managerial or white-collar jobs are more supportive of the adoption of robots for their own care when infirm or elderly care than those in non-professional occupations, consistent with our H3. Regarding the individual-level control factors age and experience with using technology at home or work are significantly associated with willingness to adopt robotic technologies to care for themselves. Older people were less open to adopting technologies for their own care, while those with experience in using robots in work or domestic contexts were more open to using them in the future to help with their own care. The model with coefficients is available in Table A1 in the Appendix.

We have explored the possibility that our pooled models mask more nuanced gendered variation by education and occupational position and ran additional models where education and occupation variables were interacted with gender (see Table 3). We find virtually no significant interactions between gender and our resource proxy variables, education and occupation. Gender and education become insignificant as main effects and there is a borderline significant positive interaction effect between male gender and being in education up to the age of 20 or longer. Thus, counter to expectations that these would be highly gendered relationships, we don't find strong evidence of this claim. Rather, we find that higher levels of educational attainment and having a professional, managerial, or white-collar occupation make both men and women more open to having robots care for them in old age.

Table 3. Predicted answers to a question 'How comfortable will you be to be cared for by a robot in old age?', a model with interactions between gender and resources variables.

Women	–
Men	0.046
	(0.207)
Finished school below 15	–
	–
Finished school 16-19	0.104
	(0.129)
Finished school at 20 or later	0.185
	(0.156)
Women # Finished school below 15	–
	–
Women # Finished school 16-19	–
	–
Women # Finished school at 20 or later	–
	–
Men # Finished school below 15	–
	–
Men # Finished school 16-19	0.293
	(0.219)
Men # Finished school at 20 or later	0.432*
	(0.212)
Not professional, managerial, or white collar	–
	–
Professional, managerial, or white collar	0.184*
	(0.086)
Women # Not professional, managerial, or white collar	–
	–
Women # Professional, managerial, or white collar	–
	–
Men # Not professional, managerial, or white collar	–
	–
Men # Professional, managerial, or white collar	0.012
	(0.104)
Aged 20–29	–
	–
Aged 30–39	−0.122
	(0.071)
Aged 40–49	−0.151*
	(0.077)
Aged 50–59	−0.315***
	(0.073)
No child under 10	–
	–
Has at least one child under 10	−0.076
	(0.059)
Single	–
	–
Partnered	−0.022
	(0.067)
Not rural	–
	–
Rural	0.068
	(0.095)
No difficulty with paying bills	–
	–
Difficulty with paying bills	−0.090
	(0.082)
No experience using robots at work	–
	–
Has experience using robots at work	0.319**
	(0.120)
No experience using robots at home	–
	–

Has experience using robots at home	0.482***
	(0.083)
Std. 2017 GDP per capita adjusting by local purchasing power	−0.133*
	(0.061)
Standardised values of pop_65prop_17	−0.084
	(0.045)
Standardised values of cn_oldexp_gdp_17	−0.190**
	(0.058)
Std. 2017% of women in employment	0.138**
	(0.042)
cut1	−0.912***
	(0.166)
cut2	−0.579***
	(0.166)
cut3	−0.150
	(0.164)
cut4	0.157
	(0.162)
cut5	0.718***
	(0.163)
cut6	1.146***
	(0.159)
cut7	1.716***
	(0.161)
cut8	2.493***
	(0.161)
cut9	2.944***
	(0.168)
var(educomp[regi])	0.283***
	(0.066)
var(_cons[regi])	2.062***
	(0.447)
cov(educomp[regi],_cons[regi])	−0.707***
	(0.166)
Observations	13,839

Note: Standard errors in parentheses.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

We now turn to testing the country-level hypotheses. In our model, local-level indicators are standardised to have zero mean and unit standard deviation across localities. The findings reported in Figure 4 with respect to local-level factors are mixed. Consistent with our descriptive figures, we found no support for the positive association between living in higher GDP locations and support for using robots for elderly care (H4). Further, we find those living in locations where women's employment is higher report greater support for using robots to help with their own infirm/elderly care in line with H5. Finally, we find that those living in countries with higher levels of resources allocated to support older adults are less interested in technological support to care for them when infirm or elderly (H6).

Discussion and conclusion

Drawing on data from the 2017 Special Eurobarometer study, this research examines support for automated domestic outsourcing across European countries. Our dependent variable measures individual reflections on receiving care themselves, rather than on using robots as part of providing care for somebody else allowing us to identify

support for direct use of these technologies. One of the key contributions of this research is the ability to highlight both the individual- and local-level characteristics that shape attitudes towards the adoption of automated domestic outsourcing technologies in Europe. At the local level, the proportion of women employed was associated with greater support for using domestic technologies for one's own care whereas the per cent of GDP spent on old age support tended to be associated with less support towards adopting robots as part of one's care when elderly or infirm. These are all net of the concentration of older workers meaning that investments in high-quality aged care suppress public support for technological intervention for their own care possibly because they may see alternative options currently on the market.

At the individual level, men along with those who have greater resources such as higher levels of educational attainment and those in professional occupations were more supportive of these technologies being relied upon in the home.

The findings highlight an interesting, gendered dimension regarding support of automated care technologies, which differs at the individual- and local levels. At the individual level, we find that European men are more personally supportive than European women in having a robot provide them services and companionship when they become elderly or infirm. In short, European men are more comfortable using technology to fulfil their care needs, which is perhaps not surprising given that these kinds of technologies are heavily marketed towards men (Strengers & Kennedy, 2020). However, it also highlights the discomfort or unease which women feel about these technologies. While women will outsource domestic labour (de Ruijter et al., 2005) and adopt technology like smart cooking devices to assist with domestic labour (Graf, 2023), it appears there is a limit to their enthusiasm when it comes to using technologies that may potentially replace human care. These views may reflect the gender gap in attitudes towards beliefs about the societal usefulness of technology (Cai et al., 2017) where women tend to be less positive than men about the benefits of technology.

At the local level, individuals who live in areas where the share of women's employment is higher also report greater support for the adoption of care technologies. This suggests that in areas where the absence of women from the household is greatest (i.e. because they are in paid work), there too is greater support for care technologies to fill the care labour gap usually performed by women. This is similar to previous studies on domestic outsourcing, which have found that when individuals have less time for domestic labour because of time constraints (i.e. paid employment), they rely on outsourcing. Alternatively, when the volume of domestic labour increases, so does the demand for domestic outsourcing. In this scenario, the adoption of technologies can be seen as a way of outsourcing domestic labour to offset women's increased labour force participation.

Another important local-level dynamic has to do with the generosity of local welfare provision for old age. Existing research finds that older adults are often sceptical about care technologies and have a strong preference for human contact (e.g. Turner & Berridge, 2023). Currently, higher investment in elder care is associated with more human carers available. To give two examples, countries that spend higher percentages of GDP on older age support on average have more doctors per resident and more long-term care workers available for every 100 elderly people (authors' calculations using data from Eurostat, 2017a, 2017b; OECD, 2021). Our findings are consistent with an interpretation that individuals are not keen to introduce robots as part of their older/infirm care support,

at least when the available support is generous, and they have ample access to human care. Thus, policy-makers should be aware of these tensions between a desire to meet elder/infirm care demands with human or technological labour. Technology should not be inevitability, but rather any investment into technological solutions needs to be evaluated against investing in support for paid or unpaid carers.

Our study highlights eldercare scepticism broadly. Given that across the European Union, 45% of people over 55 with care needs reported a 'lack of assistance' in 2019 (Eurostat, 2019a, 2019b, 2019c), welcoming attitudes to technology might reflect a lack of other options, rather than a genuine preference. At the same time, the question in Eurobarometer is generic. Older people are keen on certain technologies, such as location tracking in cases where these technologies support their autonomy. Thus, more attention to specific tech and more research are necessary. The question also focuses exclusively on individuals receiving care for themselves and does not give us any insight into the views of others who may receive care, the perceived quality of technological care itself or the expected trade-offs between human and technological care. Future research should look into both, and for the best outcomes, we need to take into account a range of perspectives.

Taken together, the individual- and local-level results have wider implications for men, women and gender equality more broadly. First, women's discomfort or unease with automated care, relative to men's support for these technologies, may mean they are less likely to adopt these technologies and therefore lessen their domestic load. Second, greater support for these technologies amongst men, and in areas where there are higher levels of female employment may reflect ideas about turning to technology to solve the issue of care work within households through technological use rather than through the encouragement of men to take on greater levels of domestic labour.

Of course, these findings are not without limitations. First, we draw upon the most recent data from 2017, but these patterns may have changed given the rise of automation and robotics at home and the intensification of in-home care during the COVID-19 pandemic. This may have shifted views towards greater support for robots given the intensification of care and the inability of many to be with those who were infirm or elderly for fear of viral spread. This may have created a period effect whereby people 'saw' the value of robots in caring for those who were often in social isolation. Thus, an additional survey to benchmark these periods is warranted. Second, individuals across Europe may be weighing a more diverse range of automation and AI supports at home beyond those currently surveyed. Given the importance of gender in smart homes, it is valuable to include a wider range of measures about in-home robots. Again, this calls for additional data collection on what is an increasingly salient issue. Finally, we restrict our sample to those in their prime working age to better understand these contextual measures, but a more thorough cohort, age and period analysis would be fruitful. Those who are closest to needing infirm or aged care from robots may have very different opinions than those who are much younger. Further, those who are younger may have greater experiences with receiving services virtually and through robots. Thus, age and exposure are critical components that may structure support for outsourcing care to technology.

Ultimately, our results are clear – those with a greater vested interest in robot support with elder/infirm care at home report the greatest comfort with their adoption. This includes men, those with more resources and those where women spend more time in employment and are thus living in households where women have less time to do valuable domestic

labour. At the same time, we also find that when governments invest more heavily in elder care, people report (on average) being less comfortable with relying on robots in the home to provide care for the infirm and the elderly. This suggests that when human care is ample, individuals may not be keen to see it replaced with robots. As societies are aging, technologies, including technologies to support elderly and infirm care, may be necessary to support older adults and their carers. Policy-makers need to consider how to integrate elderly and infirm care technologies in a way that preserves and perhaps even amplifies the ability of human carers to maintain the connection with those they care for. Ultimately, our research provides insights for governments that will be facing intense caregiving challenges that will require human-machine interfaces and solutions.

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