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Service Robots in the Workplace: Fostering Sustainable Collaboration by Alleviating Perceived Burdensomeness

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Abstract: This study investigates the impact of job demands and perceived burdensomeness on employees' willingness to collaborate with service robots (SRs) in the workplace, with a focus on the moderating effects of organizational support, self-esteem, and self-development. Conducted among 200 employees in South Korea, the results show that higher job demands significantly increase perceived burdensomeness, which negatively affects employees' willingness to collaborate with SRs. Organizational support moderates the negative impact of job demands, reducing their detrimental effects, although it was less effective in buffering the reduction in social interaction. Self-esteem and self-development positively moderated the relationship between burdensomeness and collaboration. This study contributes to the understanding of sustainable workforce management by highlighting the importance of fostering personal and organizational resources to ensure that SR integration enhances both operational efficiency and employee well-being. The findings align with broader sustainability goals by promoting human–robot collaboration that optimizes resource use, enhances workforce adaptability, and maintains social and psychological balance in the workplace.

Keywords: workforce adaptation; job demands; perceived burdensomeness; human–robot collaboration; organizational support; employee resilience; cognitive load; automation challenges; socio-economic impact of automation; employee well-being

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Citation: Almokdad, E.; Lee, C.H. Service Robots in the Workplace: Fostering Sustainable Collaboration by Alleviating Perceived Burdensomeness. *Sustainability* **2024**, *16*, 9518. https://doi.org/10.3390/su16219518

Academic Editors: Jian Ming Luo, Anthony Kong and Rob Law

Received: 4 October 2024
Revised: 28 October 2024
Accepted: 30 October 2024
Published: 1 November 2024

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1. Introduction

The rapid integration of service robots (SRs) into workplace environments, especially in sectors like hospitality and tourism, is reshaping how organizations operate [1]. SRs, defined as autonomous systems that interact with customers and perform various organizational tasks, are celebrated for enhancing efficiency, improving customer satisfaction, and driving economic gains [2]. However, their adoption also brings complex challenges for the human workforce that extend beyond operational concerns into psychological and emotional territories [3].

Recent studies highlight the impact of SRs on employee well-being, with evidence suggesting that SR integration can elevate feelings of stress among workers [4]. This study examines these implications, specifically focusing on perceived burdensomeness and its impact on employees' willingness to collaborate with SRs. Unlike prior studies that broadly address automation's negative impacts, this research offers a detailed analysis of how SR integration can create environments where employees feel overwhelmed by both job demands and the psychological pressures of working alongside autonomous systems [5].

The shift toward automation often introduces concerns about job security, as employees fear displacement or diminished value. This anxiety is particularly impactful in industries where human skills were once irreplaceable, fostering a climate of uncertainty [6,7]. SR integration also requires employees to acquire new skills for interacting with these technologies, handling technical issues, and ensuring smooth collaboration between humans and robots. This increased mental load makes daily responsibilities

more demanding [8,9]. Furthermore, as SRs take on roles traditionally requiring human interaction, opportunities for meaningful social engagement decrease, potentially leading to isolation and a weakened workplace community [10,11].

In the post-COVID-19 era, the adoption of SRs has accelerated as organizations prioritize solutions that enhance efficiency and reduce physical interactions. However, this shift amplifies the psychological challenges employees face, underscoring the need for targeted support during this transition [12,13].

Organizational resources, such as strong support structures, are vital in helping employees adapt to these changes. When employees feel valued and supported in adapting to new technologies, their overall stress is reduced, enabling them to view SRs as complementary to their roles rather than a threat [12]. Personal resources, like self-development and a culture of continuous learning, further empower employees by helping them turn potential obstacles into manageable challenges [14]. This emphasis on growth enables employees to embrace SRs as opportunities for professional development. Additionally, self-esteem plays a crucial role in this process. Employees with higher levels of self-esteem tend to exhibit greater resilience in the face of technological changes, as they feel more confident in their ability to adapt [15]. Together, these personal and organizational resources encourage a collaborative outlook toward SRs and foster a more positive work environment.

This study goes beyond acknowledging these factors by examining how they interact to influence perceived burdensomeness and willingness to collaborate with SRs. Grounded in the Job Demands–Resources (JD-R) model [16], this research addresses this gap by analyzing how SR integration impacts employees, focusing on the roles of organizational and personal resources in mitigating these effects.

The objectives of this study are as follows:

1. To identify the job-related factors that significantly contribute to perceived burdensomeness in an SR-integrated workplace.
2. To analyze the role of job resources in supporting employee adaptation and reducing perceived burdensomeness.
3. To evaluate the broader impact of perceived burdensomeness on employees' willingness to collaborate with SRs.
4. To provide recommendations for organizations on effectively managing SR integration to minimize negative impacts on employees.

By examining these dynamics in depth, this study contributes new insights to the literature on workplace automation and employee well-being, offering practical and theoretical implications for organizations navigating the transition to automated workplaces.

2. Literature Review

2.1. Perceived Burdensome

Perceived burdensomeness captures employees' feelings of strain and overload from the demands of their roles [17]. It is not just physical; this concept also includes the mental and emotional weight that work can impose. The term "burden" itself is defined as "a heavy load to carry" or "something difficult or unpleasant that you have to face" [18]. In the workplace, burdensomeness can show up as worry, stress, discomfort, and sadness, largely influenced by the specific conditions and support the workplace provides [19].

Addressing perceived burdensomeness is crucial for workplace well-being, as it directly impacts employee health, productivity, and safety. It can arise from various stressors: strained interactions with supervisors or colleagues, the anxiety of potential job loss, or the physical and mental exhaustion that comes from excessive workload and fast-paced demands. Long-term exposure to these stressors often results in tardiness, anxiety, and declining performance [20]. Critically, burdensomeness is linked to job demands that exceed employees' capacity to manage, leading to chronic stress and even burnout [17].

In the context of this study, perceived burdensomeness is particularly relevant when it comes to integrating service robots in the workplace. Employees working alongside service robots might find their workload intensified, their pace accelerated, and additional time

and focus required to manage robot interactions, all of which contribute to their sense of burdensomeness [21]. Studies confirm that automation and service robots can amplify job demands, creating greater stress and discomfort among employees [22].

The COVID-19 pandemic intensified these challenges by fast-tracking the adoption of service robots in sectors like hospitality and tourism, impacting employees' mental well-being. A joint study by the World Health Organization and the International Labour Organization in 2021 highlighted the pandemic's negative effects on occupational health, noting that the sudden and, often, reactive integration of service robots to meet health crises increased job anxiety and burdensomeness [4,23].

Research shows that when employees view their work environment as overly demanding or threatening, it can lead to significant psychological strain, making it more difficult for them to adapt to working with service robots [24].

2.2. Job Demands–Resources Model and Employee Perceived Burdensome (Hypotheses Development)

The Job Demands–Resources (JD-R) model is a heuristic framework for analyzing perceived burdensomeness in employees by examining the interplay between job demands, resources, and outcomes in an organization. It provides a broad perspective on work conditions and their effects on employees' willingness to collaborate with service robots (SRs).

The model first considers job demands [15], which are aspects of a job that place physical, social, or organizational strain on employees. When these demands exceed an employee's capacity to adapt, they can lead to stress, negatively impacting well-being by causing fatigue and other physical and psychological issues. Job demands turn into stressors when employees exert excessive effort without adequate recovery [16].

A key concern is that using service robots may increase employees' fears about job replacement. Employees might worry that robot performance could diminish their perceived value and skills, leading to fears of replacement [4]. This notion could result in inefficiencies and reluctance to work with SRs. Huang and Rust [5] proposed a theory outlining the stages of job replacement in the context of AI advancements, providing strategies for fostering positive co-existence between humans and robots. Similarly, Frey and Osborne [25] analyzed the potential for various jobs, particularly in hospitality and tourism, to be replaced by robots, identifying front-line roles like tourist guides, waitstaff, and food service specialists as high-risk positions for automation. Other research [26] focuses on new roles emerging in robot-based industries, with concerns around the loss of traditional skills, dependence on robots, and potential job loss.

H1: *Fear of job replacement has a positive impact on the perceived perception of burdensomeness.*

Another factor is the increased cognitive load required to constantly monitor, troubleshoot, and adapt to robot functions. Unlike traditional tasks, which employees may master over time, working with robots demands continuous mental engagement to ensure smooth operation [8]. This cognitive demand intensifies when employees must manage both robot tasks and their regular responsibilities, heightening the complexity and mental effort in daily routines [9].

Recent studies underscore the cognitive strain posed by advanced technologies. For instance, Wang et al. (2023) found that technostress in digital work environments raises work exhaustion, particularly when paired with diverse knowledge demands, thus increasing stress and reducing well-being [27]. Similarly, Tarafdar et al. (2019) highlighted that the continuous need to monitor and adapt to new technologies can lead to cognitive strain, particularly when these demands coincide with employees' regular workload [28]. These findings confirm that increased cognitive load is a significant source of mental strain [9], which may reduce job satisfaction and contribute to perceived burdensomeness.

H2: *Increased cognitive load has a positive impact on the perceived perception of burdensomeness.*

A reduction in social interaction is another critical factor contributing to perceived burdensomeness. Social interactions foster camaraderie and a supportive environment, but introducing robots can disrupt these dynamics. As robots assume roles involving customer interactions or collaboration, employees may have fewer opportunities for meaningful interactions, leading to feelings of isolation and reduced job satisfaction [29]. This shift can weaken the social fabric in the workplace, impeding teamwork and communication, and increasing burdensomeness. Li et al. [29] found that service robots can alter workplace social structures, potentially degrading the quality of employee relationships, especially in customer-facing industries like hospitality, where interaction is essential for satisfaction and performance [30]. The resulting decrease in emotional support from colleagues can increase stress and make coping with job demands more challenging [31].

H3: *Social interaction reduction has a positive impact on the perceived perception of burdensomeness.*

Conversely, job resources are valuable workplace assets that help employees achieve their goals, reduce stress, and promote personal growth [14]. These resources include administrative, psychological, social, and physical support systems, which are essential not only for meeting job demands but also for fostering well-being. Chowhan and Pike [32] assert that job resources facilitate task completion, alleviate physical and psychological costs, and support self-development. Fernandes and Martins [33] define personal resources within the JD-R model as self-regulatory capacities, like resilience and self-efficacy, which empower employees to manage job demands effectively, invest their energies, and remain engaged even under high stress.

One such job resource, Perceived Organizational Support (POS), reflects employees' beliefs about how much their organization values their contributions and cares about their well-being [34]. High POS levels can mitigate the adverse effects of job demands by offering emotional and practical support, helping employees cope more effectively with workplace stressors [35]. In the context of job demands like fears of job replacement, technological challenges, and reduced social interaction, POS can act as a buffer, reducing these stressors' impact on perceived burdensomeness [36–38].

Studies show that POS can diminish the negative effects of automation in the workplace by bolstering employees' resilience and coping skills. Employees who feel supported by their organization tend to experience lower stress and show a greater willingness to engage with new technologies, including service robots [39–41]. This indicates that when employees feel valued, they are less likely to perceive job demands as overwhelming or threatening, thus reducing stress and discomfort. For example, employees with high POS may feel confident that their organization will provide the necessary resources, training, and emotional support to adapt to environments involving SRs [40], thereby alleviating feelings of burdensomeness.

H4: *Perceived organizational support moderates the relationship between (a) fear of job replacement, (b) increased cognitive load, (c) social interaction reduction, and perceived perception of burdensomeness.*

2.3. Employee's Perceived Burdensomeness and the Willingness to Collaborate with Service Robots

In the tourism sector, collaboration is fundamental to achieving high productivity and service quality. Organizations emphasize teamwork as essential for meeting shared goals, which often relies on seamless cooperation and effective peer interactions [42]. Tourism employees must work closely with colleagues to provide a cohesive guest experience, especially in roles that require constant communication and coordination [43,44].

The introduction of service robots (SRs) into the workplace, however, can challenge these dynamics. While SRs can offer operational and financial benefits, such as cost savings and enhanced efficiency, they also introduce concerns among employees about job security and workplace dynamics. As South Korea leads in workplace automation, SR use in

tourism-related sectors is accelerating, bringing SRs into roles previously held by humans, particularly in customer service [30,44].

This shift toward automation raises anxieties, as employees worry that robots might replace them in the long term, increasing the perceived burden of adapting to new technologies. These concerns can affect employees' willingness to collaborate with SRs, as they feel their own value and job stability are under threat [3,43,45,46].

H5: *Perceived burdensomeness negatively impacts employees' willingness to collaborate with SRs.*

2.4. The Moderating Role of Personal Resources: Self-Esteem and Self-Development

Personal resources are characteristics that enhance resilience and an individual's sense of control over their environment [47]. This study focuses on two specific personal resources: self-esteem and self-development.

Self-esteem reflects a person's overall sense of personal worth. It influences their confidence, motivation, and ability to face challenges in both personal and professional contexts [47]. Employees with high self-esteem typically have a positive self-concept, boosting their confidence in their skills and workplace contributions [48]. This self-assurance helps them view workplace challenges, including the introduction of SRs, as less threatening or burdensome. High self-esteem acts as a psychological buffer, reducing the perception of SRs as threats to job security and fostering a more optimistic view of workplace changes [24,46].

Research suggests that employees with elevated self-esteem are more likely to view SRs as complementary tools that enhance their roles rather than diminish them [3]. These individuals are generally more open to innovation, confident in their ability to adapt, and inclined to see SR collaboration as an opportunity for growth rather than a source of anxiety [30,49]. In contrast, employees with lower self-esteem often feel uncertain about their ability to contribute effectively to an automated workplace [45]. For them, SRs may heighten feelings of inadequacy, leading to increased perceptions of burdensomeness and reduced willingness to work with new technologies [16]. Lacking the psychological resilience that high self-esteem provides, these employees may perceive SRs as direct threats, further hindering SR adoption [13].

Therefore, self-esteem not only influences perceptions of burdensomeness but also significantly impacts employees' readiness to collaborate with SRs. Organizations can support this by creating a positive environment that fosters self-esteem through recognition, training, and skill-building opportunities [48]. This approach can alleviate automation-related fears and create a resilient workforce open to technological advancement.

Self-development involves actively improving one's skills, knowledge, and attributes through learning and challenges [49]. In tech-driven workplaces with SRs, self-development is crucial for adaptability. Employees committed to self-improvement are more likely to view SRs as growth opportunities rather than threats [50,51]. High self-development employees often see SRs as career-enhancing tools that reduce burdensomeness and foster collaboration [46]. In contrast, employees with low self-development levels may view SRs as job risks, resulting in anxiety and reluctance to engage [50,52].

Thus, we propose that self-development moderates the relationship between perceived burdensomeness and willingness to collaborate. Employees with higher self-development are likely to embrace SRs, while those with lower levels may resist. Organizations should encourage continuous learning to support SR integration.

Based on these insights, we propose the following hypotheses:

H6: *Self-esteem moderates the relationship between perceived burdensomeness and willingness to collaborate with SRs.*

H7: *Self-development moderates the relationship between perceived burdensomeness and willingness to collaborate with SRs.*

Figure 1 illustrates the relationships among the research variables.

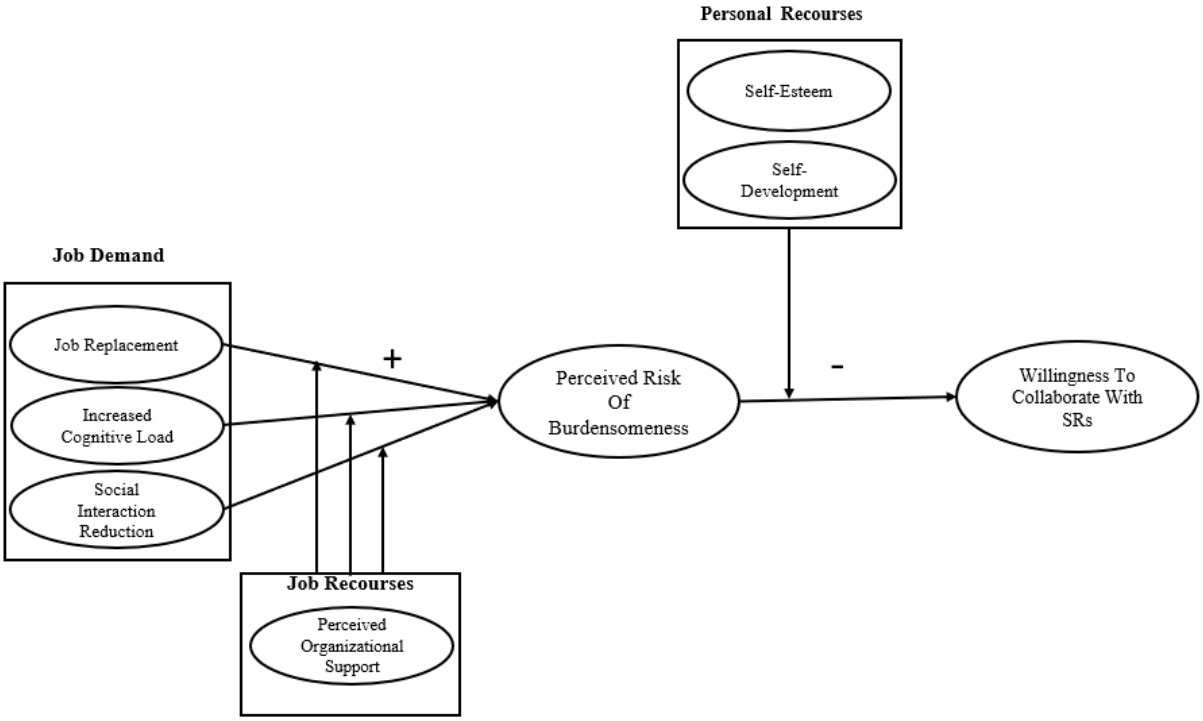


Figure 1. The proposed model.

3. Method

3.1. Survey Design

The survey was carefully designed to ensure clarity, ease of use, and accuracy in capturing participants' responses. To avoid any ambiguity and ensure respondents understood the questions, the survey was pre-tested with a small group of employees in the service industry who had some experience with SRs. Feedback from the pre-test was used to refine the wording of several items to improve clarity and relevance. The final survey was divided into sections that aligned with the key constructs under investigation, ensuring that respondents could navigate the survey easily without experiencing survey fatigue.

The survey also included a section on demographic information, which captured details about respondents' age, gender, employment status, length of experience in their current role, and previous exposure to SRs. These demographic data were used to ensure diversity in the sample and control for any potential confounding factors in the analysis. To avoid response bias, especially social desirability bias, the survey was designed to be anonymous, and participants were informed that their responses would remain confidential.

3.2. Measurement Items

To ensure this study's construct validity and reliability, we utilized previously validated scales from the existing literature to measure key variables such as perceived burdensomeness, organizational support, fear of job replacement, and willingness to collaborate with service robots (SRs). These constructs were carefully chosen based on their relevance to this study's theoretical framework and context of SR integration. While perceived burdensomeness items were adapted from Kim et al. [20], items measuring job replacement were derived from Huang and Rust [5]. Additionally, cognitive load items were based on Tarafdar et al. [28], and social interaction reduction items were sourced from Li et al. [29]. The self-esteem items were derived from Tharenou's Self-Esteem Scale [48], while self-development was assessed using items from studies on skill acquisition and personal growth, such as those by Robitschek et al. [53]. Finally, willingness to collaborate with service robots was measured using items reflecting themes in technology acceptance, based on Paluch [3].

The measurement items used in this study are listed in Appendix A. Respondents indicated their agreement with each statement using a seven-point Likert scale, ranging from 1 (Strongly Disagree) to 7 (Strongly Agree).

3.3. Data Collection and Sample Characteristics

Data were collected through an online survey distributed to employees working in service sectors where interaction with service robots is relevant. The survey was conducted in December 2022 through Embrain, a leading research firm widely used in previous studies for its reliability and extensive panel reach [54,55]. Embrain's platform enabled us to target a large and diverse sample of respondents across various service sectors, ensuring both data accuracy and broad demographic representation.

A convenience sampling technique was employed to efficiently recruit participants who met this study's criteria. This method was selected due to its practicality in accessing a large number of respondents within a limited timeframe, especially when targeting employees with specific experiences, such as those working with service robots. The use of convenience sampling via Embrain also ensured a diverse demographic representation, reflecting a range of job roles, locations, and experience levels with service robots.

A total of 200 valid responses were collected, after excluding incomplete submissions. The sample included almost equal numbers of female and male participants, with a mean age of 29.2 years. Most respondents held a bachelor's degree as their highest educational qualification, and the majority were full-time employees. A significant portion of the participants reported having direct experience working with service robots, with nearly one year of interaction on average. Detailed demographic information is provided in Table 1.

Table 1. Demographic information.

Variable	Category	Distribution	Valid Percentage
Gender	Male	94	47%
	Female	106	53%
Age	Mean	29.2	
Marital Status	Single	178	88%
	Married with children	12	7%
	Married without children	10	5%
Educational Background	High school or below	40	23%
	Bachelor's degree	130	60%
	Master's degree	26	15%
	Doctorate	4	2%
Job Position	Full-time	140	65%
	Part-time	44	25%
	Contract	16	10%
Experience with SRs	3 months	4	2%
	6 months	30	14%
	9 months	28	13%
	1 year	104	52%
	More than 1 year	34	19%
Workplace Experiencing Labor Shortages	Yes	152	77%
	No	48	23%
Personal Income Per Year	35–49 M	81	35%
	50–74 M	89	40%
	75–99 M	8	10%
	100–149 M	14	15%
	More than 150 M	8	10%

4. Results

4.1. Confirmatory Factor Analysis (CFA)

Data screening was conducted before CFA to look for potential violations of fundamental presumptions. The skewness ratings ranged from −0.799 to 0.872. The ratings for

kurtosis ranged from −0.841 to 0.800. Hence, outliers were not found, and there was no breach of data normality.

Confirmatory Factor Analysis (CFA) was conducted to validate the measurement model and assess the constructs' validity and reliability. The analysis showed that the model fit the data adequately, with the following fit indices: $\chi^2 = 682.215$, df = 480, $p < 0.01$, $\chi^2/df = 2.42$, RMSEA = 0.058, CFI = 0.915, IFI = 0.916, PCLOSE = 0.04, and GFI = 0.870. These indices indicate an acceptable model fit, suggesting that the proposed model is suitable for explaining the relationships among the variables.

The factor loadings for all items were significant, demonstrating good convergent validity. Moreover, the Average Variance Extracted (AVE) for each construct was above the recommended threshold of 0.50, indicating that the constructs captured a significant portion of the variance. Table 2 provides a summary of the factor loadings and Eigenvalues for each construct.

Table 2. Summary of Factor Analysis results: reliability.

Construct	Measurement Item	Factor Loading	Eigenvalue
Perceived Perception of Burdensomeness	Item 1	0.82	2.10
	Item 2	0.81	
	Item 3	0.80	
	Item 4	0.83	
	Item 5	0.79	
	Item 6	0.80	
Fear of Job Replacement	Item 1	0.78	2.50
	Item 2	0.82	
	Item 3	0.83	
	Item 4	0.80	
Increased Cognitive Load	Item 1	0.79	2.80
	Item 2	0.82	
	Item 3	0.81	
	Item 4	0.80	
	Item 5	0.77	
	Item 6	0.80	
Social Interaction Reduction	Item 1	0.83	1.80
	Item 2	0.84	
Perceived Organizational Support	Item 1	0.81	2.60
	Item 2	0.82	
	Item 3	0.80	
	Item 4	0.79	
	Item 5	0.78	
Willingness to Collaborate with SRs	Item 1	0.76	1.70
	Item 2	0.78	
	Item 3	0.75	
Self-Esteem	Item 1	0.83	2.40
	Item 2	0.82	
	Item 3	0.84	
	Item 4	0.80	
Self-Development	Item 1	0.82	2.20
	Item 2	0.84	
	Item 3	0.83	
	Item 4	0.81	

Table 3 presents the correlations between constructs along with the AVE values, demonstrating discriminant validity. The squared root of the AVE values, which are presented along the diagonal in bold, are greater than the correlations between the constructs, indicating that the constructs are distinct from one another.

Table 3. Summary of CFA results (correlation).

	PPB	POS	FJR	ICL	SIR	WC	SE	SD	AVE
PPB	**0.846** [a]								0.715
POS	0.250 *[b]	**0.804**							0.647
FJR	0.230 **	0.310 **	**0.822**						0.676
ICL	0.360 **	0.290 **	0.350 **	**0.821**					0.674
SIR	0.290 **	0.230 **	0.200 **	0.310 **	**0.788**				0.621
WC	−0.220 **	0.360 **	−0.240 **	−0.260 *	−0.280 *	**0.800**			0.640
SE	0.200 **	0.380 **	0.210 **	0.250 **	0.270 **	0.300 **	**0.763**		0.582
SD	0.320 **	0.400 **	0.230 **	0.300 **	0.260 **	0.340 **	0.320 **	**0.819**	0.671

Note 1: χ^2 = 682.215, df = 480, $p < 0.01$, χ^2/df = 2.42, RMSEA = 0.058, CFI = 0.915, IFI = 0.916, PCLOSE = 0.04, and GFI = 0.870. * $p < 0.05$; ** $p < 0.01$. Note 2: PPB = perceived burdensomeness, POS = perceived organizational support, FJR = job replacement, ICL= cognitive load, SIR = social interaction reduction, WC = willingness to collaborate, SE = self-esteem, and SD = self-development. Note 3: [a] = Squared root of AVE; diagonal values in bold. [b] = Correlations between constructs.

4.2. Structural Equation Modeling (SEM)

Following the CFA, Structural Equation Modeling (SEM) was employed to test the hypothesized relationships between the constructs. The model fit indices indicated a good fit: χ^2 = 699.217, df = 490, χ^2/df = 2.72, RMSEA = 0.056, CFI = 0.930, IFI = 0.929, TLI = 0.921, NFI = 0.905, and GFI = 0.850. As shown in Table 4, all the direct hypothesized paths were statistically significant, supporting the theoretical framework proposed in this study. See Table 4.

Table 4. Summary of the Structural Equation Modeling results.

			Standardized Estimate	t-Value	Hypothesis
H1: Fear of job replacement	⟶	Perceived perception of burdensomeness	0.480	8.532 ***	Supported
H2: Increased cognitive load	⟶	Perceived perception of burdensomeness	0.420	7.103 ***	Supported
H3: Social interaction reduction	⟶	Perceived perception of burdensomeness	0.360	6.258 ***	Supported
H5: Perceived perception of burdensomeness	⟶	Willingness to collaborate with SRs	−0.320	−6.037 ***	Supported
Goodness-of-fit statistics (final model): χ^2 = 699.217, df = 490, χ^2/df = 2.72, RMSEA = 0.056, CFI = 0.930, IFI = 0.929, TLI = 0.921, NFI = 0.905, and GFI = 0.850. *** $p < 0.001$		Total variance explained: R^2 of PPB = 0.482 R^2 of WC= 0.320	Total impact on willingness to collaborate with SRs FJR= 0.480 ICL = 0.420 SIR = 0.360 PPB = −0.320		

Note: FJR = fear of job replacement, ICL = increased cognitive load, SIR = social interaction reduction, PPB = perceived perception of burdensomeness, and WC = willingness to collaborate.

4.3. Indirect Effects of Perceived Perception of Burdensomeness

The indirect effects of perceived burdensomeness on various outcomes were analyzed to understand how this construct influences employees' willingness to collaborate with service robots through other mediating variables. The results are summarized in Table 5.

Table 5. Summary of indirect effect assessment results.

Indirect Effect	WC
FJR	−0.154 **
ICL	−0.134 **
SIR	−0.115 **

Note: PPB = perceived burdensomeness, WC = willingness to collaborate, FJR = job replacement, ICL = cognitive load, and SIR = social interaction reduction. ** $p < 0.01$.

4.4. Multi-Group Moderation Analysis

The moderating effects of Perceived Organizational Support, self-esteem, and self-development were examined using multi-group analysis to understand their influence on the relationships between the perceived perception of burdensomeness and other constructs, such as fear of job replacement, increased cognitive load, social interaction reduction, and willingness to collaborate.

Perceived Organizational Support (POS): The analysis revealed that POS significantly moderated the relationship between perceived burdensomeness and both job replacement fears and cognitive load. In the high POS group, the relationship between perceived burdensomeness and job replacement fears was stronger (t-value = 0.126) compared to the low POS group (t-value = 0.367), with a significant chi-square difference ($\Delta\chi^2(1) = 2.483$, $p < 0.05$). This result indicates that higher POS weakens the negative effects of job replacement fears on perceived burdensomeness. Additionally, the moderation effect of POS on the cognitive load–burdensomeness relationship was also more pronounced in the high POS group (t-value = 0.241) compared to the low POS group (t-value = 0.412), with a significant chi-square difference ($\Delta\chi^2$ (1) = 3.912, $p < 0.05$). However, no significant moderation was observed for the relationship between social interaction reduction and perceived burdensomeness ($\Delta\chi^2$ (1) = 0.827, $p > 0.10$) (Table 6).

Table 6. Summary of multi-group invariance test results (Perceived Organizational Support). Measurement Invariance Model for high (n = 133) and low (n = 67) POS.

Models	χ^2	df	$\Delta\chi^2$ (df)	Full-Metric Invariance
Non-restricted model	704.327	365	$\Delta\chi^2$ (21) = 39.488, $p < 0.05$	Not Supported
Full-metric invariance	740.100	386		
Model fit statistics for the non-restricted model: RMSEA = 0.054, CFI = 0.938, TLI = 0.931, IFI = 0.939. **Model fit statistics for the full-metric model:** RMSEA = 0.055, CFI = 0.933, TLI = 0.929, IFI = 0.934.				
Paths	**High POS t-Values**	**Low POS t-Values**	**Nested Model (Equally Restricted)**	**Chi-Square Difference Test**
H4a: FJR ⟶ PPB	0.126 *	0.367 ***	χ^2 (369) =741.983	$\Delta\chi^2$ (1) = 2.483, $p < 0.05$
H4b: ICL ⟶ PPB	0.241 *	0.412 ***	χ^2 (369) = 745.795	$\Delta\chi^2$ (1) = 3.912, $p < 0.05$
H4c: SIR ⟶ PPB	0.345	0.355	χ^2 (369) = 727.283	$\Delta\chi^2$ (1) = 0.827, $p > 0.10$

Baseline model fit: χ^2 = 720.000, df = 368, χ^2/df = 1.957, RMSEA = 0.051, CFI = 0.945, TLI = 0.940, and IFI = 0.946. Note 1: *** $p < 0.001$, * $p < 0.05$. Note 2: High POS indicates high Perceived Organizational Support; low POS indicates low Perceived Organizational Support.

Self-Esteem: The moderation analysis indicated that self-esteem did not significantly influence the relationship between perceived burdensomeness and willingness to collaborate with service robots. Both the high self-esteem group (t-value = −0.174) and the low self-esteem group (t-value = −0.185) showed no substantial difference in their willingness to collaborate, with the chi-square difference test ($\Delta\chi^2(1) = 1.029$, $p > 0.10$) indicating no significant moderating effect (Table 7).

Table 7. Summary of multi-group invariance rest results (self-esteem). Measurement Invariance Model for high (n = 125) and low (n = 75) self-esteem.

Models	χ^2	df	$\Delta\chi^2$ (df)	Full-Metric Invariance
Non-restricted model	690.500	360	$\Delta\chi^2$ (21) = 32.500, $p < 0.05$	Not supported
Full-metric invariance	722.000	381		
Model fit statistics for the non-restricted model: RMSEA = 0.052, CFI = 0.939, TLI = 0.932, IFI = 0.940. **Model fit statistics for the full-metric model:** RMSEA = 0.053, CFI = 0.935, TLI = 0.930, IFI = 0.936.				
Paths	**High Self-Esteem t-Values**	**Low Self-Esteem t-Values**	**Nested Model (Equally Restricted)**	**Chi-square Difference Test**
H6: PPB ⟶ WTC	−0.174	−0.185	χ^2 (367) = 722.000	$\Delta\chi^2$ (1) = 1.029, $p > 0.10$

Baseline model fit: χ^2 = 718.000, df = 366, χ^2/df = 1.962, RMSEA = 0.051, CFI = 0.940, TLI = 0.935, and IFI = 0.941. Note 1: High self-esteem indicates high levels of self-esteem; low self-esteem indicates low levels of self-esteem.

Self-Development: The results showed that self-development significantly moderated the relationship between perceived burdensomeness and willingness to collaborate. In the high self-development group, the negative impact of burdensomeness on willingness to

collaborate was weaker (t-value = −0.154) compared to the low self-development group (t-value = −0.289), with a significant chi-square difference ($\Delta\chi^2$ (1) = 9.743, $p < 0.05$). This suggests that individuals with higher self-development levels are better able to cope with the negative effects of perceived burdensomeness on collaboration (Table 8).

Table 8. Summary of multi-group invariance test results (self-development). Measurement Invariance Model for high (n = 140) and low (n = 60) self-development.

Models	χ^2	df	$\Delta\chi^2$ (df)	Full-Metric Invariance
Non-restricted model	702.327	360	$\Delta\chi^2$ (21) = 30.400, $p < 0.05$	Not supported
Full-metric invariance	732.800	381		
Model fit statistics for the non-restricted model: RMSEA = 0.050, CFI = 0.940, TLI = 0.933, IFI = 0.941. **Model fit statistics for the full-metric model:** RMS RMSEA = 0.051, CFI = 0.938, TLI = 0.932, IFI = 0.939.				
Paths	**High Self-Development t-Values**	**Low Self-Development t-Values**	**Nested Model (Equally Restricted)**	**Chi-square Difference Test**
H7: PPB ⟶ WTC	−0.154	−0.289	χ^2 (367) = 710.000	$\Delta\chi^2$ (1) = 9.743, $p < 0.05$

Baseline model fit: χ^2 = 705.000, df = 366, χ^2/df = 1.926, RMSEA = 0.048, CFI = 0.945, TLI = 0.938, and IFI = 0.946. Note 1: High self-development indicates high levels of self-development; low self-development indicates low levels of self-development.

5. Discussion

The findings of this study provide significant insights into the psychological and emotional strain experienced by employees working with service robots (SRs), specifically emphasizing perceived burdensomeness as a key factor influencing their willingness to collaborate. This study validates certain established concepts but also extends existing knowledge by offering a refined view of how SR-induced job demands shape employee perceptions.

A central contribution is the introduction of perceived burdensomeness as a specific construct for understanding the emotional and cognitive strain associated with SRs. Previous research has largely examined job stress or performance impacts in broader automation contexts, focusing on generic technological anxiety [6,21]. However, this study hones in on SR-specific stressors, particularly in industries where human roles are essential, such as hospitality and customer service. Unlike general automation studies, this targeted analysis reveals how SR-induced job replacement fears amplify perceived burdensomeness, providing a detailed understanding of how SRs uniquely impact job security concerns in human-centered fields. This refinement offers valuable specificity, highlighting that SRs, rather than generic automation, intensify these anxieties in sectors requiring direct human interaction.

Additionally, this study extends established connections between cognitive load and stress associated with technological demands [24,25] by situating cognitive load specifically within SR management. Unlike previous studies that identify technological demands as broad stressors, this research provides a focused analysis of SR-related cognitive load, including responsibilities like overseeing robotic tasks and troubleshooting. These findings clarify the mental strain associated with SR roles, contributing to a deeper understanding of cognitive challenges specific to human–robot collaboration.

This research also addresses the impact of social interaction reduction on perceived burdensomeness, which aligns with studies showing automation's disruptive effect on workplace social dynamics, often resulting in isolation and diminished job satisfaction [19,20]. By expanding on these insights, this study demonstrates that the effects of social interaction reduction are especially severe in service sectors, where meaningful interactions are critical to employee well-being. This context-specific analysis provides a nuanced perspective on how SRs affect employee connectivity and satisfaction, illustrating that the burden is heightened in roles traditionally enriched by social engagement.

Examining moderating factors such as Perceived Organizational Support (POS), self-esteem, and self-development, this research offers new perspectives. Prior studies often assert that POS buffers job demands' impact on stress [28,36,37], but this study identifies limitations in POS's ability to alleviate burdens associated with reduced social interaction in SR contexts. This suggests that in automated settings, POS alone may be insufficient, requiring supplementary social and emotional resources to address employees' evolving needs. This finding refines our understanding of POS's role, highlighting that in SR-integrated workplaces, support mechanisms need to be expanded.

Notably, this study finds that while self-esteem did not significantly moderate the relationship between perceived burdensomeness and willingness to collaborate, self-development did. This distinction reveals that employees who engage in self-development are better able to view SRs as growth opportunities rather than threats, emphasizing the value of continuous learning in adapting to technological change [48,50]. This finding underscores the importance of fostering self-development within organizations as a strategy for enhancing employee adaptability to SRs, contributing new insights into the role of personal resources in mitigating SR-related challenges.

Overall, this study not only confirms certain aspects of previous research but also extends and refines our understanding of how SRs affect employees, providing valuable insights that can guide future research and practice in managing the integration of automation in the workplace.

6. Implications

6.1. Practical Implications

The findings of this study offer practical and innovative ways for organizations to integrate service robots (SRs) effectively while keeping employee well-being front and center. One creative approach is to make SR integration a participative journey by involving employees in defining how SRs will support their roles. For instance, allowing employees to suggest tasks that robots could handle or to participate in testing SR functions could help them feel like co-creators of this transition rather than passive observers. This involvement can make SRs feel like empowering tools instead of replacements.

To address fears around job replacement, companies could create "career adaptation plans" that outline new skills employees can learn and the growth paths available as SRs are introduced. Regular workshops on skill-building for robot operation and management, paired with open conversations about evolving job roles, can shift the perception of SRs from a potential threat to a gateway for career progression.

To reduce cognitive overload, organizations could introduce short, focused training sessions spread out over time rather than one long session to help employees gradually adapt to using SRs in a low-stress way. Additionally, integrating quick-access support (like a helpdesk or mobile app for SR troubleshooting) could alleviate any technical frustrations, keeping the learning curve manageable and engaging.

Preserving social bonds is also essential as SRs enter the workspace. Organizations might consider arranging team activities that include SRs in creative ways, such as collaborative projects where employees and SRs tackle different parts of a task. Even simple practices, like assigning certain tasks to human–robot teams, can maintain the social flow and help employees see SRs as collaborative partners.

Encouraging personal growth alongside SR integration can further ease concerns about automation. By offering courses in new skill areas that go beyond SR interactions such as leadership or creativity workshops, companies can show they value each employee's development holistically. This not only boosts confidence but also makes employees feel that the organization sees their potential beyond specific technologies.

Lastly, fostering a supportive environment where employees feel heard and respected during the transition is key. This might include monthly "feedback forums" where employees share their SR experiences and management addresses questions or concerns openly.

Such forums can create a culture of continuous improvement and adaptation, helping employees feel empowered and positive about working alongside SRs.

6.2. Theoretical Implications

This study presents several meaningful theoretical implications for understanding organizational behavior, human–robot interaction, and automation in the workplace. By examining unique stressors like job replacement fears and increased cognitive load, this study enhances the Job Demands–Resources (JD-R) model, showing that automation-related demands have a distinct impact on employee well-being. Incorporating these SR-specific demands, such as the pressure to adapt quickly to technology or the fear of being replaced, expands the JD-R model's scope and emphasizes that new forms of technology bring their own set of emotional and cognitive challenges.

The findings also shed new light on Perceived Organizational Support (POS) by questioning its traditional role in reducing job-related stress. While POS is generally seen as essential for buffering stress, this study highlights its limitations in fully addressing the social and emotional impacts of working with SRs. This suggests a need to rethink and refine current frameworks to better capture how organizational support can be adapted to help employees manage the unique challenges posed by SRs, including potential feelings of isolation or role displacement. Future theoretical models could explore ways for POS to evolve, incorporating specific supports that address the emotional aspects of automation.

Additionally, this study underscores the value of personal resources, especially self-development, as essential moderators in adapting to automation. By showing that self-development can reduce perceived burdensomeness and improve willingness to collaborate with SRs, this study encourages an expanded JD-R model that includes personal growth and adaptability as critical factors. This shift emphasizes that individual development, such as learning new skills or engaging in personal growth activities, is not just a support but a vital strategy for thriving in a technology-integrated workplace.

Finally, by focusing on service industries, this study enriches our understanding of human–robot collaboration in fields where social interaction and emotional labor are essential. It suggests that theories of human–robot interaction need to be adapted to address the unique pressures of maintaining social bonds and managing emotional labor in highly automated environments. As SRs increasingly join the workforce, refining human–robot interaction theories to prioritize social cohesion and emotional support will be essential for sustaining a balanced and resilient workplace.

7. Limitations and Future Research

This study is not without its limitations. Firstly, its focus on service-oriented industries may limit the applicability of the findings to other sectors. Expanding future research to include a variety of industries would help assess the broader relevance of the results. Additionally, the reliance on self-reported data introduces potential biases, such as social desirability, suggesting that more objective methods, like behavioral observations or longitudinal studies, should be employed in future research.

Moreover, cross-sectional design limits the ability to establish causality, emphasizing the need for longitudinal studies to understand how perceptions of burdensomeness and collaboration with robots develop over time. Other important factors, such as organizational culture and leadership styles, should also be considered to provide a more comprehensive understanding of robot–employee relationships.

Lastly, ethical issues surrounding robot integration, such as job displacement and dehumanization, were not thoroughly explored. Future research should delve deeper into these concerns to strike a balance between technological advancement and maintaining ethical work environments. Despite these limitations, this study serves as a solid foundation for further exploration of robot–employee interactions in the workplace.

8. Conclusions

This study reveals how job demands, such as cognitive load and reduced social interaction, contribute to perceived burdensomeness in workplaces where service robots (SRs) are integrated. The findings show that organizational support and personal resources, such as self-development, significantly mitigate this burdensomeness, promoting employee willingness to collaborate with SRs. By fostering self-development and resilience, organizations can achieve a more sustainable integration of automation, ensuring long-term workforce adaptability and satisfaction. These insights contribute to the broader discourse on sustainability by emphasizing the need for a balanced approach to technological advancements that enhance operational efficiency while safeguarding employee well-being. Addressing these socio-economic challenges ensures that human–robot collaboration can thrive, driving both productivity and workforce stability in the context of sustainable development.

Author Contributions: Conceptualization, E.A. and C.H.L.; methodology, E.A. and C.H.L.; validation, E.A.; formal analysis, E.A. and C.H.L.; data curation, E.A. and C.H.L.; writing—original draft preparation, E.A. and C.H.L.; writing—review and editing, E.A. and C.H.L. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Institute of Information & Communications Technology Planning & Evaluation (IITP) under the metaverse support program to nurture the best talents (IITP-2024-RS-2023-00254529) grant funded by the Korean government (MSIT). Additionally, this work was supported by the Ministry of Korea and the National Research Foundation of Korea (NRF-2022S1A5A2A03054930).

Institutional Review Board Statement: This study was approved by the Institutional Review Board (IRB) of Sejong University, ensuring compliance with ethical guidelines.

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Measurement Items.

Constructs	Measurement Items
Perceived Perception of burdensome	Service robots force me to work harder to keep up the work pace with the service robots. Working with service robots requires dealing with more uncertainty. Working with service robots is not as efficient as I had expected. It takes me extra time and energy to work with service robots. Service robots often make mistakes, which makes my work more passive. It frustrates me that service robots are not so intelligent.
Fear of job replacement	Service robots help reduce high labour turnover in the hospitality industry. Service robots will replace my position in the future. Service robots will replace what I do now in my job. Service robots will replace human employees in this industry.
Increased cognitive load	The tasks I had to complete while working with the service robot were very complex. Collaborating with the service robot required me to process a lot of information simultaneously. The instructions for collaborating with the service robot were clear and easy to follow. I had to invest extra effort to understand how to work with the service robot. I invested significant mental effort into learning how to effectively collaborate with the service robot. I put extra effort into understanding how to perform my job tasks alongside the service robot.

Table A1. *Cont.*

Constructs	Measurement Items
Social interaction reduction	Service robots reduce social relationships with my human colleagues. Service robots destroy the social order and structure in my workplace.
Perceived Organizational Support	My organization values my contributions to its well-being. My organization really cares about my well-being. My organization takes pride in my accomplishments. My organization strongly considers my goals and values. Help is available from my organization when I have a problem.
willingness to collaborate with SRs	When service robots are employed, the company would like me to collaborate with service robots. It will give a good impression to my supervisor if I work with service robots. I would not work with service robots if I were given an option to choose.
Self-esteem	I feel that I am a person of worth. I feel I have several good qualities. I take a positive attitude toward myself. Overall, I am satisfied with myself
Self-development	Working with service robots helps me acquire additional job skills. Service robots provide opportunities to develop professional skills or technological knowledge. I view my work with service robots as contributing to my personal growth. My work helps me make sense of the world around me.

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