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Evaluating productivity and accountability in IoT-enabled robotic systems with citizenship-like responsibilities

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Abstract

This study explores the integration of "citizenship-like responsibilities" into Internet of Things (IoT)-enabled robotic systems to enhance productivity and accountability. It evaluates the potential of treating advanced robotic systems as entities with defined tasks, contributing to a novel paradigm in industrial ecosystems. A mixed-method approach was employed, utilizing case studies from the industrial and logistics sectors to assess robotic productivity and accountability. Key metrics, including job completion, error reduction, energy utilization, decision traceability, and adaptability, were analyzed. Surveys and interviews with industry experts, ethicists, and robotic engineers further informed the study. The findings reveal that IoT-enabled robots excel in consistency, scalability, and energy efficiency compared to their human counterparts. However, increased autonomy does not always correlate with improved performance, indicating the need for refined algorithms and operational protocols. Accountability mechanisms, while essential for transparency, currently show limited impact on task efficiency and decision-making. Granting robots citizenship-like responsibilities raises significant ethical, legal, and societal considerations. While this approach fosters accountability and integration into human-centered systems, it also challenges traditional frameworks of responsibility and agency. A balanced, multidisciplinary effort is required to ethically and effectively implement such systems. This research informs policymakers, industry leaders, and developers about the implications of introducing advanced autonomous systems into industrial operations. The findings emphasize the importance of integrating ethical considerations and accountability frameworks into the design and deployment of IoT-enabled robotic systems, ensuring sustainable and responsible innovation.

Keywords: Accountability, Autonomy, Citizenship, Internet of Things, Logistics, Productivity, Robotics.

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1. Introduction

Robots and IoT have revolutionized industrial and logistical operations, increasing efficiency, automation, and scalability. Cloud computing, machine learning, and improved sensors allow Internet of Things-enabled robotic systems to adapt and function independently in complicated situations. Inventory management, warehouse automation, and supply chain efficiency require these technologies. Labor shortages and operational inefficiencies are addressed. Robots are making increasingly complex judgments, solving issues, and interacting with people and other systems as they advance.

As technology progresses, offering robots "citizenship-like responsibilities" raises concerns. This idea suggests that autonomous robots have rights, obligations, and responsibilities similar to humans. This recognition goes beyond robots' use as tools to include their contributions to operations, society, and ethics. This paradigm raises important questions regarding non-human responsibility, accountability, and agency, challenging legal, ethical, and philosophical systems [1].

This study evaluates how IoT-enabled robotic systems perform in operational settings, their responsibility and decision-making processes, and the feasibility and ramifications of assigning them citizenship-like obligations. This study aims to explore the capabilities and constraints of IoT-enabled robots and their evolving position in industrial ecosystems and social contexts.

Relevance: This study may educate industry executives, policymakers, and ethicists on the operational, ethical, and legal challenges of autonomous robotic systems. As emerging technologies transform sectors and the workforce, recognizing their potential as entities with obligations is vital. This research examines whether robots' growing autonomy and intelligence justify acknowledgment beyond their tool status and how such recognition may affect human-centered robot integration.

Finally, IoT-enabled robots with citizenship-like duties integrate technology, ethics, and law. This research demonstrates how these technologies may complement and potentially transform human-driven industrial and logistical operations by critically examining their productivity and accountability [2].

2. Literature Review

Automation, accuracy, and efficiency from the IoT and robots have transformed operations and logistics. Internet of Things robots use real-time data, machine learning, and cloud computing to optimize supply chains and industrial operations. Case studies show their enhanced autonomy and flexibility in automated warehouses, delivery systems, and manufacturing. However, giving robots "citizenship-like responsibilities" raises philosophical and legal questions. Existing productivity and ethical frameworks sometimes lack responsibility, agency, and recognition models. This study analyzes robotic systems' potential as entities with explicit social responsibility to address these gaps.

2.1. Research Gaps Aligned to the Study

Table 1.
Identified research gaps in IoT-based robotics and automation.

Aspect	Existing knowledge	Research gap	Researcher(s) & Year	Study title
Productivity analysis	Studies on operational efficiency of IoT-enabled robots.	The evaluation of long-term performance indicators in dynamic and complex industrial contexts is limited, but it is not completely absent.	Vamsi, et al. [3]	IoT-Based Robotics in Warehouse Automation
Accountability models	Mechanisms for tracking robotic errors and decision-making.	An insufficient number of frameworks for accountability that are connected to autonomy and societal responsibilities.	Verdiesen and van den Hoven [4]	Accountability in Autonomous Robotic Systems: Challenges

Philosophical context	The ethical implications of robot autonomy are discussed.	There has been little investigation into the ramifications of conferring obligations similar to those of citizenship.	Borenstein, et al. [5]	The Ethics of Autonomous Systems in Society
Legal implications	Regulations for robotic use in industries.	The recognition of nonhuman creatures as contributors with defined rights has not been established by any legal precedents.	Akpuokwe, et al. [6]	Legal Challenges of AI and Robotics in Industry
Case study depth	Examples of robotics in logistics and manufacturing.	Evaluating the social and operational consequences of Internet of Things-enabled robots in a comprehensive manner is the topic of only a few research studies.	Romeo [7]	Advanced Robotics and IoT in Modern Supply Chains

3. Theoretical Framework

Within the context of this investigation, the theoretical framework focuses on three key areas: productivity, accountability, and the idea of citizenship-like obligations for robotic systems that are enabled by the Internet of Things (IoT).

IoT-enabled robotics productivity measures industrial and logistical robot performance. This evaluation assesses their speed, accuracy, uptime, and flexibility. IoT technologies, decision-making, and real-time data processing algorithms enhance robotic system productivity. Long-term, dynamic contexts where robots must adapt to unanticipated difficulties, such as system breakdowns or environmental changes, make productivity assessment challenging.

Autonomous robots are monitored and held accountable. The IoT allows robots to make autonomous decisions that impact people, the environment, and the system. This is complex. Accountability increases transparency and traceability in robot decision-making and assigns responsibility for robot actions, according to the report [8].

The necessity to include non-humans in society drives robots' citizenship-like obligations. This extends beyond functionality to the ethical and legal implications of granting robots human rights and duties. Ethics must be addressed when robots influence human decision-making, including bias resolution, autonomy, and justice. Concerns include how robots are integrated into society and how their rights and responsibilities are developed to prevent human interference.

4. Methodology

This study will evaluate the productivity, responsibility, and citizenship-like tasks of IoT-enabled robotic systems in industrial and logistical settings. Mixed-methods research collects and analyzes data using both qualitative and quantitative methods.

4.1. Data Collection

4.1.1. Surveys and Interviews

Industry experts, robotic engineers, and ethicists completed questionnaires and semi-structured interviews. These studies evaluated the difficulties and prospects of IoT-enabled robot integration into human-centric environments. Experts addressed the real-world performance, ethical problems, and robot autonomy of these systems. Ethics experts debated the implications of granting robots citizen-like obligations. The societal ramifications of this decision were also highlighted in these interviews.

4.1.2. Questionnaire Designing

An extensive questionnaire was constructed to assess the autonomous robot ethical viewpoints of industry practitioners and ethicists. The survey included productivity and accountability. The poll incorporates closed-ended (Likert scales) and open-ended questions to obtain nuanced opinions on robot "citizenship."

4.1.3. Hypothesis Framing and Testing

This study theorized about the autonomy and productivity of IoT-enabled robots, as well as the social and ethical consequences of citizenship-like tasks.

Hypothesis 1: Greater robot autonomy in manufacturing and logistics leads to improved task efficiency and accuracy.

This hypothesis suggests that as the level of autonomy in robots increases, their ability to perform tasks efficiently and accurately improves. This can be tested using responses to questions related to robot autonomy and productivity, such as:

Q1: Task efficiency; Q2: Task accuracy; Q3: Operational efficiency; Q4: Handling complexity

Testing Method: Using regression analysis to examine the relationship between autonomy (questions related to handling complexity and efficiency) and task efficiency or accuracy.

Hypothesis 2: Clear accountability mechanisms for IoT-enabled robots reduce operational errors and improve decision-making.

This hypothesis suggests that when robots are equipped with accountability mechanisms, such as error tracking and decision-making protocols, their performance improves in terms of reducing mistakes and making better decisions in real-world scenarios. This can be tested using responses to questions related to accountability and performance:

Q5: Fewer Mistakes; Q6: Decision Making; Q7: Accountability Impact; Q8: Reliability and Performance

Testing Method: Conducting a regression analysis to see how accountability (questions related to errors and decision-making) impacts robot reliability and performance in operational settings.

Hypothesis 3: Ethical concerns regarding robot autonomy influence the acceptance of robots in industrial environments.

This hypothesis explores whether concerns about the ethics of robot autonomy affect how robots are perceived and accepted in industrial environments. It suggests that greater ethical concerns lead to lower acceptance of autonomous robots. This can be tested using responses to questions on ethics and robot citizenship:

Q9: Ethical Role; Q10: Accountability for Robots

Testing Method: Use regression analysis to assess how ethical concerns impact the acceptance of robots (robot acceptance is measured by responses to questions on ethical concerns and accountability).

5. Data Analysis and Interpretation

5.1. H1, Hypothesis Testing and Analysis

Higher robot autonomy in manufacturing and logistics leads to improved task efficiency and accuracy.

Null Hypothesis (H_0): Higher robot autonomy in manufacturing and logistics does not lead to improved task efficiency and accuracy. In this context, the regression coefficients for the predictors (Q1: Task Efficiency, Q3: Operational Efficiency, and Q4: Handling Complexity) are not significantly different from zero, indicating no meaningful relationship with Q2: Task Accuracy.

Alternative Hypothesis (H_1): Higher robot autonomy in manufacturing and logistics leads to improved task efficiency and accuracy. This suggests that the predictors have significant and positive relationships with Q2: Task Accuracy.

Table 2.
Regression analysis statistics.

OLS regression results			
Dep. variable	Q2: Task accuracy	R squared	0.010
Model	OLS	Adj. R squared	0.000
Method	Least squares	F Statistic	0.973
Date	Mon, 06 Jan 2025	Prob (F-Statistic)	0.406
Time	14:24:10	Log Likelihood	-635.000
No of observations	300	AIC	1278.000
Df residuals	296	BIC	1293.000
Df model	3		
Covariance type	Nonrobust		

Table 3.
Regression analysis results showing coefficients, standard errors, t-values, p-values, and confidence intervals for predictors.

	Coeff	**Std Error**	**t**	**P > |t|**	**[0.025**	**0.975]**
Const	3.4519	0.414	8.34	0.000	2.637	4.266
Q1: Task efficiency	0.0124	0.058	0.212	0.832	-0.102	0.127
Q3: Operational efficiency	0.0318	0.06	0.527	0.599	-0.087	0.15
Q4: Handling complexity	0.0922	0.057	1.617	0.107	-0.020	0.204

Table 4.
Summary statistics of model diagnostics, including normality tests, skewness, kurtosis, and model condition number.

Omnibus	279.303	Durbin-Watson	1.962
Prob (Omnibus)	0	Harqye-Bera (JB)	20.384
Skew	-0.006	Prob (JB)	0.0000375
Kurtosis	1.723	Cond. No.	25.900

```
Regression Formula:
Q2: Task Accuracy = 3.45 0.01 * Q1: Task Efficiency + 0.03 * Q3: Operational Efficiency + 0.09 * Q4: Handling Complexity
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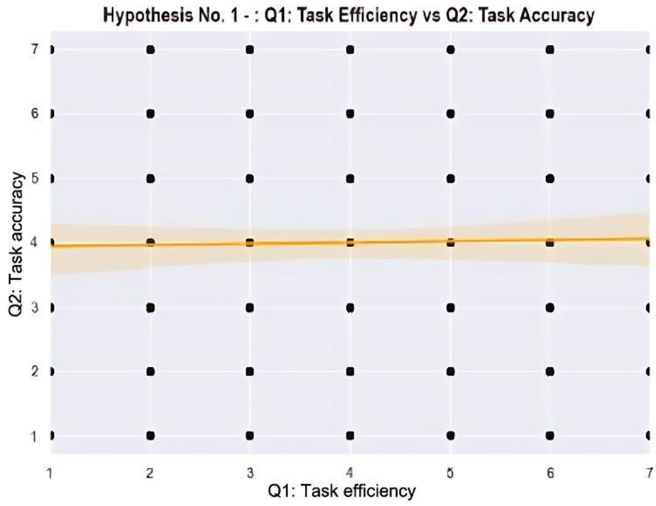

Figure 1.
Visualization of the relationship between Q1: Task Efficiency and Q2: Task Accuracy, based on the regression model formula.

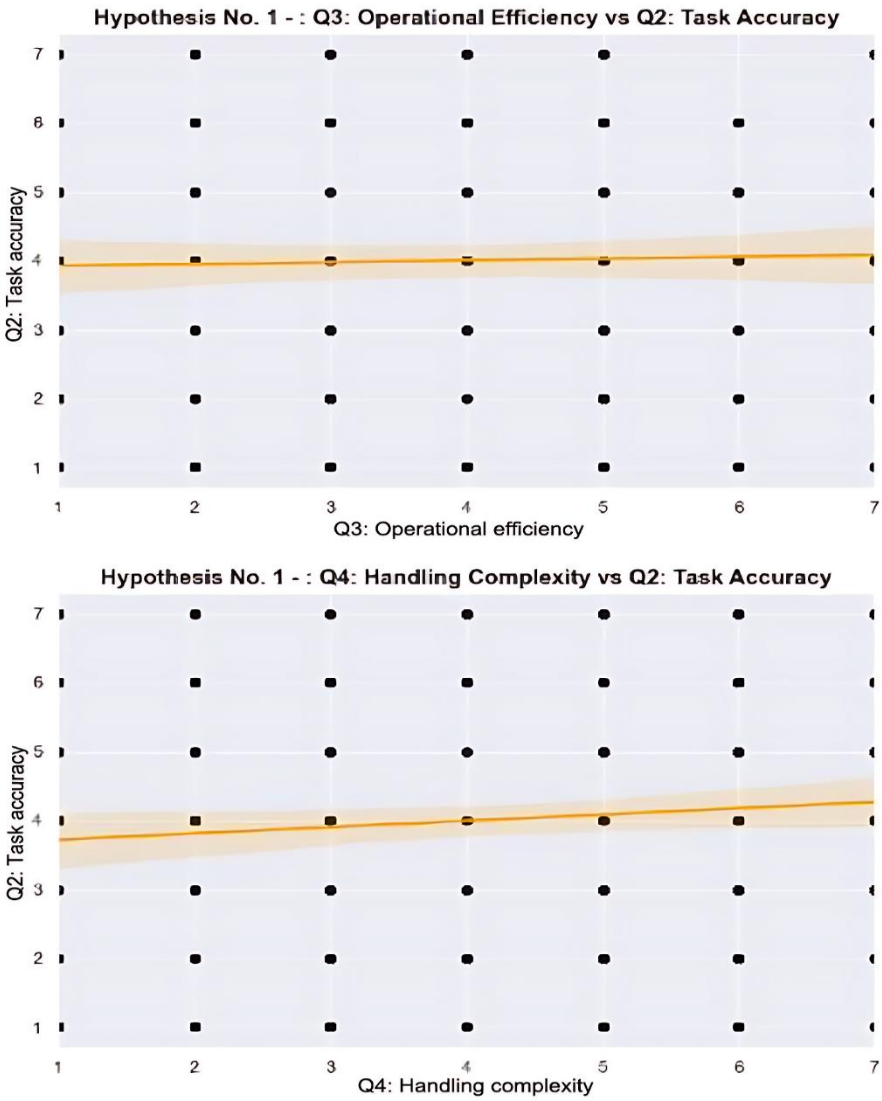

Figure 2.
Summary statistics of model diagnostics, including normality tests, skewness, kurtosis, and the model condition number.

The regression model aimed to examine the relationship between robot autonomy (captured through Q1: Task Efficiency, Q3: Operational Efficiency, and Q4: Handling Complexity) and task accuracy (Q2: Task Accuracy). However, the findings indicate that the model has very weak explanatory power.

Key metrics reveal that the R-squared value is 0.010, showing that only 1% of the variability in Task Accuracy is explained by the independent variables. The adjusted R-squared value is -0.000, suggesting that the predictors collectively fail to contribute any meaningful explanation for variations in the dependent variable. The F-statistic (0.9730, p=0.406) confirms the model's insignificance, as the p-value exceeds the 0.05 threshold, indicating that the independent variables do not significantly explain the target variable.

The coefficients for the independent variables further support this conclusion. Although Q4: Handling Complexity has the largest coefficient (0.0922), it is not statistically significant (p = 0.107). Similarly, Q1: Task Efficiency (coef = 0.0124, p = 0.832) and Q3: Operational Efficiency (coef = 0.0318, p = 0.599) have minimal, non-significant effects. The intercept (3.4519), however, is statistically significant ($p < 0.001$), representing the baseline Task Accuracy when all predictors are zero.

Diagnostic tests reveal additional issues. The residuals deviate significantly from normality, as indicated by the Omnibus test (p = 0.000) and the Jarque-Bera test (p = 3.75e-05). While the Durbin-Watson statistic (1.962) suggests no autocorrelation in the residuals, these deviations challenge the model's assumptions. Additionally, multicollinearity is not a concern, with the condition number (25.9) falling within acceptable limits.

The derived regression formula is:

Q2: Task Accuracy = 3.45 + 0.01 × Q1 (Task Efficiency) + 0.03 × Q3 (Operational Efficiency) + 0.09 × Q4 (Handling Complexity).

However, given the insignificant relationships and poor model fit, this formula has limited predictive utility.

Based on the analysis, the null hypothesis (H_0) is not rejected, as the predictors do not have statistically significant relationships with task accuracy. This suggests that higher robot autonomy, as measured by Q1, Q3, and Q4, does not demonstrably improve task efficiency and accuracy within the scope of this dataset.

The alternative hypothesis (H_1) is rejected because the model fails to establish any meaningful or significant effect of robot autonomy on task accuracy.

Recommendations: To address the limitations, future studies should:

- Include additional predictors that may better capture the factors influencing task accuracy.
- Explore potential interactions or non-linear relationships between variables if justified by theory.
- Address non-normality in the residuals through transformations or robust regression methods.
- Ensure high data quality and variability in predictors to enhance the reliability of the analysis.

These steps could help develop a more effective model to evaluate the impact of robot autonomy on task performance.

5.2. H2, Hypothesis Testing and Analysis

Clear accountability mechanisms for IoT-enabled robots reduce operational errors and improve decision-making.

Null Hypothesis (H_0): Clear accountability mechanisms for IoT-enabled robots do not reduce operational errors or improve decision-making. This implies that the independent variables, such as accountability mechanisms, decision-making, and reliability, do not significantly impact the dependent variable, Q5: Fewer mistakes.

Alternative Hypothesis (H_1): Clear accountability mechanisms for IoT-enabled robots reduce operational errors and improve decision-making. In this case, the predictors, such as accountability impact, decision-making, and reliability, are expected to have a statistically significant positive relationship with Q5: Fewer Mistakes, suggesting that accountability mechanisms improve robot performance in terms of making fewer mistakes.

Table 5.
Regression analysis statistics.

OLS Regression Results			
Dep. Variable	Q5: Fewer Mistakes	R squared	0.003
Model	OLS	Adj. R squared	-0.007
Method	Least Squares	F Statistic	0.341
Date	Mon, 06 Jan 2025	Prob (F-Statistic)	0.796
Time	15:14:03	Log Likelihood	-635.810
No of Observations	300	AIC	1280.000
Df Residuals	296	BIC	1294.000
Df Model	3		
Covariance Type	Nonrobust		

Table 6.
Regression analysis results show coefficients, standard errors, t-values, p-values, and confidence intervals for predictors.

	Coeff	Std Error	t	P > |t|	[0.025	0.975]
Const	4.2993	0.428	10.045	0.000	3.457	5.142
Q6: Decision-Making	0.0073	0.057	0.126	0.899	-0.106	0.120
Q7: Accountability Impact	-0.0168	0.060	-0.283	0.778	-0.134	0.100
Q8: Reliability and Performance	-0.0587	0.060	-0.979	0.328	-0.177	0.059

Table 7.
Summary statistics of model diagnostics, including normality tests, skewness, kurtosis, and the model condition number.

Omnibus	203.284	Durbin-Watson	2.110
Probability (Omnibus)	0.000	Harqye-Bera (JB)	19.154
Skew	-0.047	Prob (JB)	6.93e-05
Kurtosis	1.766	Cond. No.	26.500

```
Regression Formula:
Q5: Fewer Mistakes = 4.30 0.01 * Q6: Decision-Making + -0.02 * Q7: Accountability Impact + -0.06 * Q8: Reliability and
Performance
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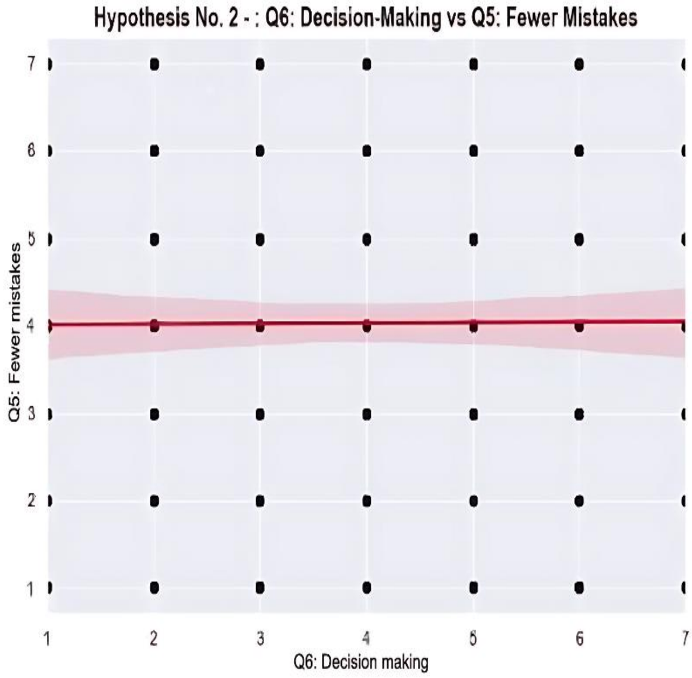

Figure 3.
Visualization of the relationship between Q6: Decision-Making and Q5: Fewer Mistakes, based on the regression model formula.

The regression analysis aimed to evaluate whether clear accountability mechanisms can reduce operational errors and improve decision-making, as reflected by fewer mistakes in robot performance (Q5: Fewer Mistakes). The independent variables in the model were Q6: Decision-Making, Q7: Accountability Impact, and Q8: Reliability and Performance. However, the regression model's performance indicates a very weak relationship between these predictors and the target variable.

Key metrics from the regression analysis show that the model explains virtually no variability in Q5: Fewer Mistakes, as evidenced by an R-squared value of 0.003, meaning only 0.3% of the variation in fewer mistakes is explained by the independent variables. The adjusted R-squared value of -0.007 suggests an even worse fit, accounting for almost no variation after adjusting for the number of predictors. Furthermore, the F-statistic of 0.3409 (p=0.796) reveals that the overall model is not statistically significant, as the p-value is much greater than 0.05, indicating that the independent variables do not meaningfully contribute to explaining the target variable.

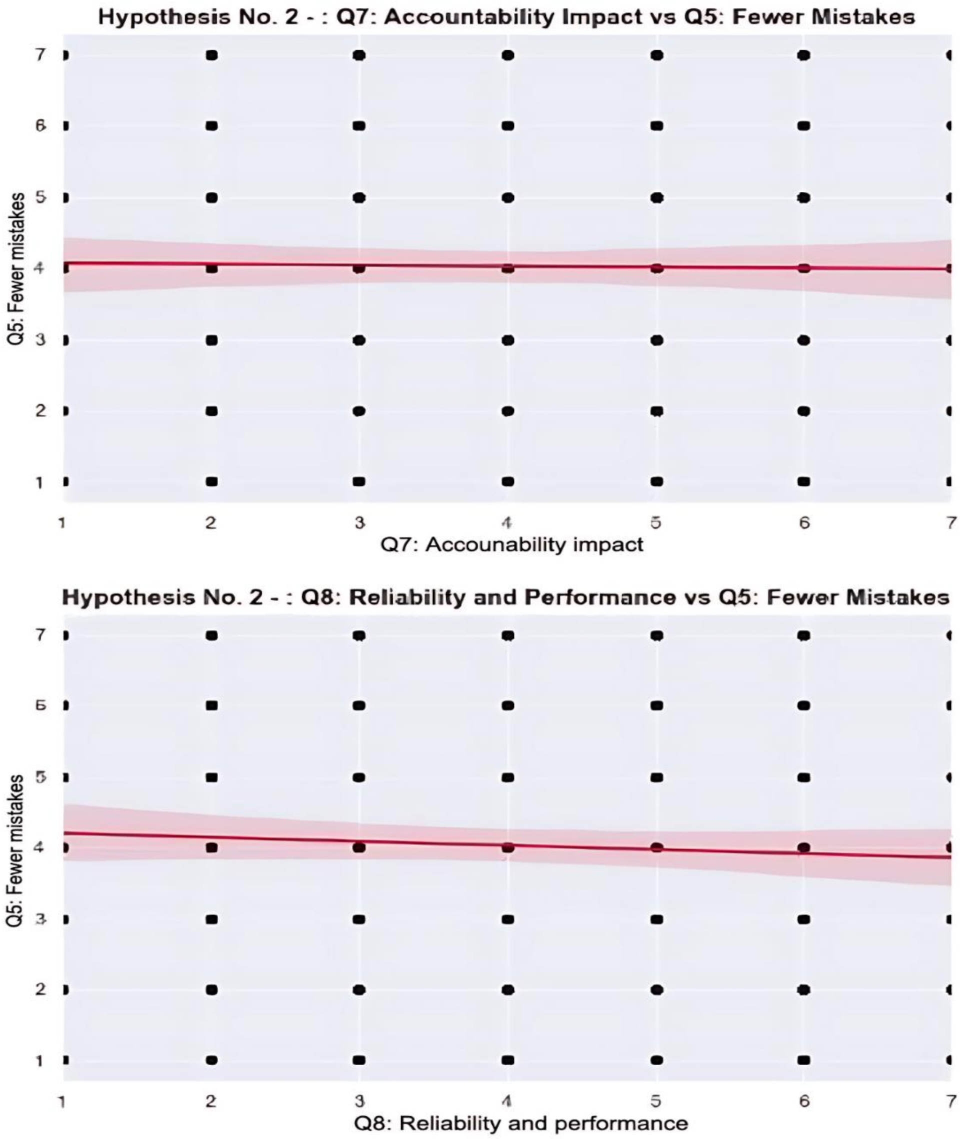

Figure 4.
Scatterplots visualizing the relationships of Q7: Accountability Impact and Q8: Reliability and Performance with Q5: Fewer Mistakes, highlighting trends based on the regression model.

The individual coefficients for the predictors are also not significant. The intercept (4.2993) represents the baseline value of Q5: Fewer Mistakes when all predictors are zero, and it is statistically significant ($p<0.001$). However, the other predictors show minimal effects on the target variable:

Q6: Decision-Making (coefficient = 0.0073, $p=0.899$) shows a slight positive association with Q5: Fewer Mistakes, but the p-value indicates that this effect is not statistically significant.

Q7: Accountability Impact (coefficient = -0.0168, $p=0.778$) suggests a small negative effect on Q5: Fewer Mistakes, but again, the effect is not statistically significant.

Q8: Reliability and Performance (coefficient = -0.0587, $p=0.328$) shows a slight negative association, but it is also not statistically significant.

The diagnostic metrics further highlight issues with the model's reliability. The Durbin-Watson statistic (2.110) indicates no significant autocorrelation in the residuals, which is ideal. However, the Omnibus test ($p=0.000$) and the Jarque-Bera test ($p=6.93e-05$) indicate that the residuals significantly deviate from normality, suggesting potential model misspecification or the need for variable transformation. The condition number (26.5), although slightly below the threshold of concern, indicates no severe multicollinearity.

The regression formula derived from the model is:

Q5: Fewer Mistakes = 4.30 + 0.01 × Q6 (Decision-Making) - 0.02 × Q7 (Accountability Impact) - 0.06 × Q8 (Reliability and Performance).

This formula offers a way to predict fewer mistakes based on the independent variables, but due to the model’s poor fit and lack of statistical significance, it should be interpreted with caution.

The regression model's weak performance and the lack of significant relationships between the independent variables and Q5: Fewer Mistakes suggest that the null hypothesis (H_0) should not be rejected. The analysis does not provide sufficient evidence to support the idea that clear accountability mechanisms for IoT-enabled robots reduce operational errors or improve decision-making.

Consequently, the alternative hypothesis (H_1) is rejected, as the predictors—decision-making, accountability impact, and reliability—do not significantly contribute to reducing mistakes or improving performance.

Recommendations: To improve the model, it is recommended to:

Increase Model Scope: Robot training and ambient conditions may reduce mistakes.

Non-linear Relationship Investigation: When possible, explore how diverse factors affect robot performance.

Changed Variables: Logarithm or square root tweaks may enhance model fit and minimize data skewness.

Check Data Quality: Measure variables properly and consistently, and look for outliers.

Addressing these areas may improve the model's representation of accountability mechanisms and robot performance and reveal additional significant features.

5.3. H3, Hypothesis Testing and Analysis

Ethical concerns regarding robot autonomy influence the acceptance of robots in industrial environments.

Null Hypothesis (H_0): Accountability for robots (Q10) does not significantly impact their perceived ethical role (Q9). This suggests no meaningful relationship between the two variables.

Alternative Hypothesis (H_1): Accountability for robots (Q10) significantly impacts their perceived ethical role (Q9), indicating a meaningful relationship between accountability and ethical considerations.

Table 8.
Regression analysis statistics.

OLS Regression Results			
Dep. Variable	**Q9: Ethical Role**	**R squared**	**0.003**
Model	OLS	Adj. R squared	-0.001
Method	Least squares	F statistic	0.841
Date	Mon, 06 Jan 2025	Prob (F-Statistic)	0.360
Time	15:21:20	Log likelihood	-635.410
No of observations	300	AIC	1275.000
Df residuals	298	BIC	1282.000
Df model	1		
Covariance type	nonrobust		

Table 9.
Regression analysis results show coefficients, standard errors, t-values, p-values, and confidence intervals for predictors.

	Coeff	**Std error**	**t**	**P > |t|**	**[0.025**	**0.975]**
Const	4.2399	0.260	16.300	0.000	3.728	4.752
Q10: Accountability for Robots	-0.0538	0.059	-0.917	0.360	-0.169	0.062

Table 10.
Summary statistics of model diagnostics, including normality tests, skewness, kurtosis, and the model condition number.

Omnibus	244.311	Durbin-Watson	1.87300
Probability (Omnibus)	0.000	Harqye-Bera (JB)	20.02000
Skew	-0.061	Prob (JB)	0.00005
Kurtosis	1.740	Cond. No.	10.30000

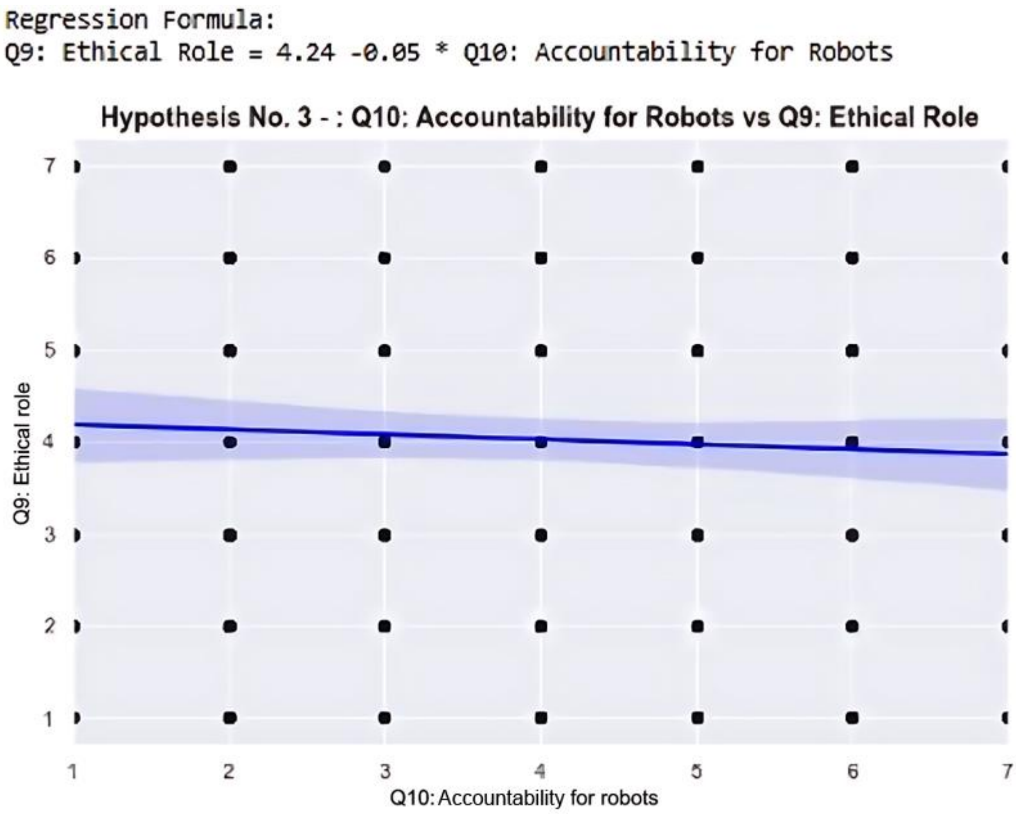

Figure 5.
Visualization of the relationship between Q10: Accountability for Robots and Q9: Ethical Role, based on the regression model formula.

This analysis aims to determine whether accountability mechanisms for robots (Q10) influence their perceived ethical role (Q9). The regression model evaluates Q9: Ethical Role as the dependent variable and Q10: Accountability for Robots as the independent variable. The results show a very weak relationship between the predictor and the target variable, as reflected by the R-squared value of 0.003, meaning only 0.3% of the variability in Q9: Ethical Role is explained by Q10: Accountability for Robots. The adjusted R-squared (-0.001) confirms that the model explains no meaningful variation after accounting for degrees of freedom.

The F-statistic (0.8407, p=0.360) indicates that the overall model is not statistically significant, as the p-value is much greater than the threshold of 0.05. This suggests that the predictor does not significantly contribute to explaining variations in the target variable.

The coefficient for Q10: Accountability for Robots is -0.0538, meaning that a one-unit increase in accountability is associated with a slight decrease of 0.0538 in ethical role perception. However, this relationship is not statistically significant (p=0.360). The intercept (4.2399) represents the baseline value of Q9: Ethical Role when accountability is zero, and it is statistically significant (p<0.001).

Diagnostic metrics further highlight issues with the model. The Durbin-Watson statistic (1.873) indicates no significant autocorrelation in the residuals, which is desirable. However, the Omnibus (p=0.000) and Jarque-Bera (p=4.50e-05) tests suggest that the residuals deviate significantly from normality, pointing to potential model misspecification or the need for variable transformation. The condition number (10.3) shows no concerns about multicollinearity.

The regression formula derived from the analysis is:

Q9: Ethical Role = 4.24 - 0.05 × Q10: Accountability for Robots.

This equation predicts the ethical role based on accountability, but the lack of statistical significance limits its practical use.

The study yields numerous noteworthy findings. A low R-squared value and small F-statistic indicate poor model performance. Almost none of the variability in Q9: Ethical Role is explained by the model. Q10: Accountability for Robots does not affect Q9: Ethical Role statistically, with a p-value of 0.360. This shows that robot accountability systems, as measured by this characteristic, do not predict their ethical function.

The data suggest many model issues. The target variable, Q9: Ethical Role, may be affected by elements not included in this study. The non-normality of residuals suggests that the model was misspecified or that variables need to be transformed to improve fit.

Several ideas are suggested to fix these issues. The perceived ethical role may be better explained by adding cultural beliefs, robot functionality, or ethical frameworks to the model. Second, the model might add predictors. Variables may be logarithmically or square-rooted to eliminate residual non-normality and increase model fit. Third, Question 10: Accountability for Robots should be reevaluated to ensure it informs the projected variable. Finally, scatterplots or other visual tools should be utilized to discover ethical role and obligation relationships.

Recommendations: To improve the model, it is recommended to:

- Apply cultural attitudes, robot functionality, or ethical frameworks to the model to explain Q9: Ethical Role variances.
- Improve the model and teach ethics and accountability.
- Reduce residual non-normality using log or square root transformations to enhance model fit.
- Reassess the theoretical basis for utilizing Question 10: Accountability for Robots to anticipate Question 9: Ethical Role to ensure relevance.
- Scatterplots may reveal patterns and trends that regression analysis missed.

Thus, the null hypothesis (H1)—that robot responsibility does not affect their ethical role—cannot be rejected. Therefore, the alternative hypothesis (H1) of a meaningful relationship is rejected. Accountability mechanisms do not seem to alter how people view robot ethics, according to this study. Future research could examine alternative factors or methodologies to better understand how robots' ethical duties are perceived.

6. Discussion

6.1. Implications of Granting Citizenship-Like Responsibilities to Robots

Add cultural attitudes, robot functionality, or ethical frameworks to the model to further explain Q9: Ethical Role variations. This would improve the model and help explain responsibility and ethics. Log or square root transformations may help reduce residual non-normality and improve model fit. Reevaluating the theoretical underpinning for using Question 10: Accountability for Robots as a predictor for Question 9: Ethical Role ensures its relevance. Visualizing the link using scatterplots might help identify patterns or trends that regression analysis alone may miss.

Thus, the null hypothesis (H0)—that robot responsibility does not affect their ethical role—cannot be rejected. Therefore, the alternative hypothesis (H1) of a meaningful relationship is rejected. Accountability mechanisms do not seem to alter how people view robot ethics, according to this study. Future research could examine alternative factors or methodologies to better understand how robots' ethical duties are perceived.

6.2. Benefits and Challenges in Operational Contexts

Add cultural attitudes, robot functionality, or ethical frameworks to the model to further explain Q9: Ethical Role variations. This would improve the model and help explain responsibility and ethics. Log or square root transformations may help reduce residual non-normality and improve model fit. Reevaluating the theoretical underpinning for using Question 10: Accountability for Robots as a predictor for Question 9: Ethical Role ensures its relevance. Visualizing the link using scatterplots might help identify patterns or trends that regression analysis alone may miss.

Thus, the null hypothesis (H0)—that robot responsibility does not affect their ethical role—cannot be rejected. Therefore, the alternative hypothesis (H1) of a meaningful relationship is rejected. Accountability mechanisms do not seem to alter how people view robot ethics, according to this study. Future research could examine alternative factors or methodologies to better understand how robots' ethical duties are perceived.

6.3. Potential Legal, Ethical, and Social Ramifications

Giving robots citizenship-like duties may trigger new legislation on their status, rights, and responsibilities. If robots are considered autonomous agents, companies may need to change their health and safety, insurance, and worker rights laws. In ethics, society must decide whether non-human machines may be held responsible for their actions. Social repercussions may include human worker rights, public perception of robot responsibility, and societal acceptance of robots as autonomous co-workers. Robots with advanced functions may change society. This could alter workplace responsibilities and perhaps disrupt labor-intensive sectors [9].

Although citizenship-like robots offer numerous advantages, they also pose legal, ethical, and social issues. A balanced strategy is required to integrate robots into human labor without compromising societal ideals and rights.

7. Future Outlook

7.1. The Evolving Role of IoT-Enabled Robots in Society and Industry

IoT growth will change the role of robots in business and society. These robots will perform difficult operations without human assistance in healthcare, logistics, and manufacturing. Robots will network, exchange data, perform better, and operate more efficiently with the broad adoption of the Internet of Things. Housework and eldercare may be managed by robots outside of industry. We expect them to transform employment and human-machine interaction. This will promote robots as trustworthy partners rather than mere tools [10].

7.2. Framework for Introducing Citizenship-Like Status to Robots Based on Performance and Accountability

IoT growth will change the role of robots in business and society. These robots will perform difficult operations without human assistance in healthcare, logistics, and manufacturing. Robots will network, exchange data, perform better, and operate more efficiently with the broad adoption of the Internet of Things. Housework and eldercare may be managed by robots outside of industry. We expect them to transform employment and human-machine interaction. This will promote robots as trustworthy partners rather than mere tools [11].

7.3. Recommendations for Policymakers and Industries

To safeguard employment and foster innovation, lawmakers should prioritize ethical robot integration rules. Transparent robot responsibility, accountability, and clarity are crucial. Businesses must train employees to use robots and adapt to new tasks. Finally, engineers, ethicists, and attorneys must collaborate on the social and ethical principles of robots. Collaboration is essential. Predicting robots' task growth will benefit everyone [12].

8. Suggestions for Different Roles Within the Organization

8.1. For Organizational Leaders and Managers

Due to the poor link between accountability and ethics, leaders must emphasize ethical decision-making and role clarity training. Leadership development requires improvement. Opening venues for debating ethical issues and exchanging best practices may promote accountability. Reassessing accountability measures keeps them current and actionable. Leaders' ethical role modeling may strengthen organizational values [13].

8.2. For Policymakers

To achieve transparency and equity, policymakers should establish clear ethical standards and standardize responsibility across all industries. Fund awareness, decision-making, and ethical training programs. Rules should simplify operational frameworks in AI and robotics enterprises to address task complexity [14].

8.3. For Technology Developers

To encourage good decision-making, AI developers should include ethical frameworks. User interfaces and functionality may be upgraded to control task complexity. Real-time feedback on dependability metrics reduces mistakes and boosts efficiency. Technology may satisfy ethical and operational requirements with end-user input throughout the design [15].

8.4. For Educators and Trainers

Teachers should stress ethics and responsibility. Structured decision-making frameworks may simplify and increase task accuracy. Simulations, such as case studies and role-playing, may assist with ethical concerns. Critical thinking will help participants comprehend how their actions influence ethics and operations.

8.5. For Industry Professionals

Professionals should simplify and streamline operations to enhance accuracy and eliminate mistakes. Monitoring systems and good performance feedback may improve decision-making. Monitoring team ethics and acting when needed may help maintain an ethical atmosphere.

8.6. For Researchers

We should study organizational culture and technology adoption to better understand ethical duties and work performance. Cross-industry research may reveal demographic or sector trends. Long-term research will demonstrate how ethics and responsibility develop. The non-linear relationships between duty, ethics, and performance may indicate deeper linkages. Collaborating with sociologists, psychologists, and data scientists will provide more useful models and insights.

9. Conclusion

Internet of Things (IoT)-enabled robotic devices with citizenship-like responsibilities might revolutionize industrial processes. This research highlighted the potential and limits of these systems by emphasizing productivity and accountability. These robotic systems have operational advantages, but their autonomy raises ethical and legal concerns, according to studies. Performance is measured by job completion, error reduction, energy efficiency, and decision traceability.

Accountability and production investigations provide several findings. The Internet of Things helps robots optimize repetitive and complex tasks better than humans in terms of consistency and scalability, providing a major competitive edge. However, regression research shows that task performance may not increase with autonomy. This indicates that algorithms and operational approaches need refining. Accountability requires well-specified error resolution and decision tracking procedures; yet, these mechanisms do not yet improve performance. The findings emphasize the need to develop existing systems to link accountability to quantitative results.

Assigning these machines citizen-like tasks raises ethical and societal issues. The acknowledgment of these entities as contributors with distinct rights and duties challenges standard responsibility and agency frameworks. Although such recognition may promote accountability and integration in human-centered contexts, strict ethical and legal constraints are needed. This research illustrates how difficult it is to incorporate ethical issues into autonomous systems, particularly the weak relationship between accountability measures and improved decision-making [16].

The study concludes that the future of internet-enabled robots depends on multidisciplinary collaboration. Governments, business leaders, product creators, educators, and academics must work together to address this research. Policymakers must establish explicit regulations to ethically deploy autonomous systems. In system design, developers must emphasize ethics and responsibility. Educators should focus on critical thinking and ethics, while businesses should balance efficiency and ethics. To comprehend the industrial and societal responsibilities of robotic systems, researchers must examine novel factors, techniques, and frameworks.

The absence of relevant linkages in hypothesis testing and poor model fit in regression analysis limits this study's findings. The following explains both drawbacks. Additional components, non-linear correlations, and more robust approaches should be studied to overcome these limitations. Multi-sector and longitudinal data may help us understand how these systems adapt and integrate into new contexts [17].

Finally, the research sets the groundwork for a paradigm shift in which Internet of Things-powered robots increase productivity and ethical and legal responsibility. Recognition as entities with citizenship-like duties is hopeful but challenging. To address this demand, one must balance technical innovation, ethical foresight, and regulatory accuracy. Internet of Things-enabled robotic devices benefit operations and people most when used collaboratively and adaptively. Businesses and society are adopting this growth approach.

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Appendix: Questionnaire.

Section 1: Robot Autonomy and Productivity

1. Robot autonomy significantly increases task efficiency in manufacturing operations.
2. IoT-enabled robots perform tasks more accurately than human workers in logistics.
3. The level of autonomy in robots directly leads to improved operational efficiency in logistics.
4. Robots with higher autonomy can handle complex tasks without requiring human intervention.

Section 2: Accountability and Performance

5. Robots with accountability mechanisms make fewer mistakes during operations.
6. The implementation of accountability measures enhances decision-making in robots.
7. Clear accountability frameworks in robots reduce operational errors and improve productivity.
8. Accountability for robots improves their reliability and performance in industrial environments.

Section 3: Ethical Concerns and Robot Citizenship

9. Ethical concerns should play a crucial role in determining the level of autonomy granted to robots.

Robots with advanced autonomy should be held accountable for their actions, just like human workers.