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Does Self-Checkout Service Really Improve Customer Service in Systems Subject to Congestion? – An Empirical Investigation in the Retail Industry

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Abstract: Self-checkout services have gained popularity across various industries, offering customers the convenience of completing transactions without human interactions. The global self-checkout systems market is projected to grow steadily, driven by the potential benefits such as faster checkout times, increased efficiency, and improved accuracy. However, challenges associated with technical difficulties, theft and fraud, and reduced human interaction also exist. This paper aims to investigate the preferences and potential future replacement of traditional checkouts by self-checkout services. Building upon prior research, a retest of the causal relationships between self-checkout attributes, customer satisfaction, and retail patronage is conducted. Data from an online survey conducted among college students are analyzed. The results differ from previous findings, highlighting the significance of sample characteristics and the inclusion of additional determining factors. This study contributes to the understanding of self-checkout services and their implications in different contexts. It is expected that adding self-checkout options in service systems with waiting lines can improve the customer service in several aspects including reducing the queues/waiting times and operating cost.

Keywords: Customer preferences, empirical analysis, queueing, retail patronage, self-checkout, traditional checkouts.

1. Introduction

Self-checkout services, allowing customers to complete service without human interactions, are becoming more popular in various industries, including retail, airports, and some fast-food restaurants. Self-checkout services intend to provide customers with a faster and more efficient checkout experience while reducing labor costs for businesses. According to a report by ResearchAndMarkets.com, the global self-checkout systems market is expected to grow at a CAGR of 10.5% from 2020 to 2027. There are many potential benefits of self-checkout services. Three obvious benefits include (1) Faster

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checkout times (from customer's perspective): Self-checkout services can reduce wait times for customers, which can improve their overall shopping experience; (2) Increased efficiency (from server provider's perspective): Self-checkout services can reduce the need for human cashiers, which can save businesses on labor costs; and (3) Improved accuracy: Self-checkout services can reduce errors in pricing and change calculations, which can benefit both customers and businesses. On the other hand, there are also some potential challenges of self-checkout services. These include (1) Technical difficulties: Self-checkout services can be prone to technical difficulties, such as barcode scanning errors or payment processing issues; (2) Theft and fraud: Self-checkout services can be more susceptible to theft and fraud, as it can be easier for customers to manipulate the system; and (3) Reduced human interaction: Self-checkout services can reduce the amount of human interaction in retail environments, which can have negative impacts on customer service and personal connections between customers and employees. It's worth noting that the potential benefits and challenges of self-checkout services can vary depending on the specific industry and context in which they are implemented.

We observe that most retail stores providing self-checkout services also keep the traditional checkouts served by their employees. But why do some people prefer to use self-checkout? And would self-checkouts replace traditional checkouts completely in the future?

Many scholars have done research in this field. For example, Fernandes and Pedroso [2] use regressions to test three casual relationships regarding self-checkout service. First, consumers evaluate service quality based on five attributes: speed, ease of use, control, reliability, and enjoyment; Second, consumers obtain satisfaction based on their perceived quality; Third, consumers' retail patronage is determined by their satisfaction. They find all relations are significant. A large Portuguese supermarket chain offering self-checkout was chosen for this study. Self-checkouts were introduced as an alternative to traditional checkouts, with customers having the option of choosing either. Data were collected through a self-administered cross-sectional survey. Each question was based on the existing literature and, with the exception of the initial questions regarding consumer characteristics and frequencies of use, respondents were asked to express their opinion using a seven-point Likert scale. Data collection was similar to a mall-intercept method, with randomly chosen respondents filling out the questionnaire on-site during self-checkout, resulting in 294 usable responses. Although the study of Fernandes and Pedroso [2] concludes the existence the significant relations, testing the robustness of their results is worthwhile under different circumstances such as different countries and surveyed subjects. This becomes one of the goals of our study.

In this paper, we use data collected from an online survey to retest the results of Fernandes and Pedroso [2]. The survey was conducted in February and March 2023, and most respondents are college students at West Washington University. Besides the questions in the survey conducted by Fernandes and Pedroso [2], we added more questions to test if there exists other determining factors, including user-friendly, waiting time, purchase content, human/non-human feature, and pandemic factor. Our regression outputs are inconsistent with those of Fernandes and Pedroso ([2], [3]), and the impacts of reliability and perceived control are insignificant. The sample characteristics may account for the difference as most respondents are young and well-educated.

The remainder of this paper is organized as follows. Section 2 is the literature review. Section 3 is the problem description. Section 4 is the analysis. Section 5 concludes.

2. Literature Review

Several studies have examined the factors that influence consumers' choice of using self-checkout services. As mentioned as the most relevant study to this paper, Fernandes and Pedroso [2] found that consumers evaluate service quality based on five attributes: speed, ease of use, control, reliability, and enjoyment. Their multivariate regression analysis showed that all five attributes significantly influence the perceived quality of the self-checkout service. In addition, they found that perceived quality and satisfaction significantly influence consumers' intention to repatronize. Other studies have identified additional factors that may affect consumers' choice of using self-checkout services. For example, Liao et al. [6] and Duarte et al. [1] found that consumers' decision to use self-checkout services is influenced by their level of technological expertise, the availability of human cashiers, and the amount of time they have available to complete their purchase. Similarly, Lee and Huang [5] and Huang et al. [4] found that consumers' choice of using self-checkout services is influenced by their age, gender, and previous experience with self-checkout technology. The effect of self-checkout services on customer service is a topic of debate among researchers and industry professionals. While self-checkout services can improve efficiency and reduce wait times, they may also lead to reduced human interaction and a less personalized shopping experience. Some studies have found that self-checkout services can improve customer satisfaction and loyalty. For example, Meuter et al. [8] and Martin and Turley [7] found that consumers who use self-checkout services have higher levels of satisfaction and loyalty than those who do not use these services. However, other studies have found that self-checkout services can have negative effects on customer service. For example, Ramanathan and Othman [9] found that self-checkout services can lead to longer wait times, frustration, and decreased satisfaction among customers. Similarly, Sun et al. [10] found that self-checkout services can reduce the amount of human interaction and personalized service in retail environments.

In conclusion, the factors that affect consumers' choice of using self-checkout services are multifaceted and may include attributes such as speed, ease of use, control, reliability, enjoyment, technological expertise, availability of human cashiers, and time constraints. While self-checkout services have the potential to improve efficiency and customer satisfaction, they may also lead to reduced human interaction and a less personalized shopping experience. Therefore, it is important for businesses to carefully consider the potential benefits and challenges of self-checkout services and to design these services in a way that maximizes their benefits while minimizing their potential drawbacks. The inconsistency of the past studies motivates us to conduct this research on the effect of self-checkout options on the customer service in the retail setting. To achieve our research goals, we focus on testing the results reported in Fernandes and Pedroso [2]. Using the regression approach, they mainly test three casual relationships regarding self-checkout service. First, consumers evaluate service quality based on five attributes: speed, ease of use, control, reliability, and enjoyment; Second, consumers obtain satisfaction based on their perceived

quality; Third, consumers' retail patronage is determined by their satisfaction. Their multivariate regression output indicates that all five attributes are determinants of the perceived quality of the self-checkout service. The coefficient of determination is 0.518, and the coefficients of all five attributes are significant since their P-values are close to zero. The simple regressions testing the second and third causalities suggest that the perceived quality of self-checkout affects consumers' satisfaction significantly, and so does satisfaction affect consumers' intention to repatronize.

3. Problem Description

We intend to retest the outcome produced by Fernandes and Pedroso [2]. We keep their hypotheses while we extend their research framework. The research framework is shown in Figure 1.

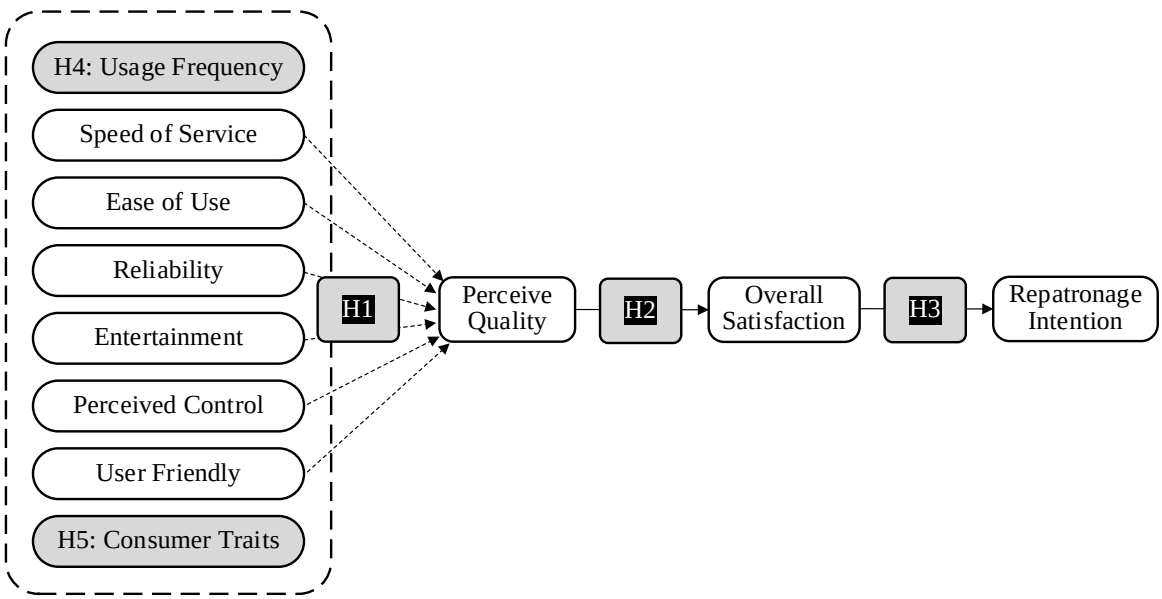

Figure 1: Research model

The same hypotheses as Fernandes and Pedroso [2] are stated as follows, with slight modifications to Hypothesis 1.

Hypothesis 1 (H1): Self-checkout attributes, including speed, ease-of-use, reliability, entertainment, perceived control, and user friendly, will have a positive effect on the service-perceived quality.

Hypothesis 2 (H2): Self-checkout perceived quality will have a positive effect on customer overall satisfaction.

Hypothesis 3 (H3): Overall customer satisfaction will have a positive effect on repatronage intention.

Hypothesis 4 (H4): Frequency of use will influence self-scanning checkout attribute evaluations.

Hypothesis 5 (H5): Consumer characteristics, namely age, gender, and education, will influence self-scanning checkout attribute evaluations.

4. Analysis

4.1. Data

We designed the survey questions and used google forms to collect the responses. We have 23 questions categorized into different groups. There are three sections in the survey. The first section asks for the identity, name, and email address (optional) of the respondents. The second section asks for demographic characteristics and shopping experiences, including age, gender, education, shopping frequency, etc. In the third section, our survey includes all questions in Fernandes and Pedroso [2], and we also add more questions to examine other possible determinants. All these questions are categorized into different groups. The questions adopted from Fernandes and Pedroso [2] measure speed, ease of use, control, reliability, and enjoyment, while some new questions measure user-friendly, waiting time, purchase content, human/non-human feature, and pandemic factor. We use a seven-point rating system asking for responses. The survey questions are summarized in Appendix A. The survey was conducted in February and March 2023, and most respondents are students at Western Washington University. Their characteristics are shown in Appendix B. As we see, most respondents are young people. Almost 64% are below 20, and 99% are below 30. 54.6% declared to be male, and 42.3 claimed to be female. The remaining prefer to keep their gender as private information. 97% of respondents have undergraduate degrees or undergraduate degrees-in progress. Only 4% of respondents claimed that they never use the self-checkout service before.

4.2. Regression analysis

4.2.1. Perceived quality

First, we mimic the multivariate regressions used by Fernandes and Pedroso[2]. They have three regressions to test three relationships. The first relationship is between perceived quality and attributes, and the equation is:

$$\widehat{quality}_i = \hat{\beta}_0 + \hat{\beta}_1 Ease_i + \hat{\beta}_2 Speed_i + \hat{\beta}_3 Reliability_i + \hat{\beta}_4 Control_i + \hat{\beta}_5 Entertainment_i \quad (1)$$

We use several specifications to test this relationship. First, we use five attributes, the same as in Fernandes & Pedroso [2]. Since each attribute is measured by two questions, we choose to use the average score of the two questions to quantify each attribute. As Q4 asks the question in an unfavorable way, which is opposite to Q1, we adjust its scores by subtracting the response score from seven. Second, we add one more attribute, user-friendly, to the regression. Third, we add another regressor, waiting time, in the regression. Fourth, we keep adding another regressor, content, in the regression. The regression output report of the above equation is shown in Table 1. We run a regression by using all questions as regressors, as shown in Appendix C. We also change the way of the measurement and use geometric mean to test the effects of five attributes. We compared its outcome with the one using a simple average in Table 2.

Table 1 suggests that only ease of use and entertainment can affect perceived quality significantly in all specifications. In all regressions, the coefficients of ease of use are significant at a 5% level of significance, and the coefficients of entertainment are significant at a 1% level of significance. However, only speed is significant at a 10% level of significance in the first regression, and none of the other coefficients are. This result is not the same as those in Fernandes & Pedroso [2], where the coefficients of all five attributes are significant. We also notice that the coefficients of the five attributes do not change much after we add more regressors, suggesting that the regression using five attributes is robust. Meanwhile, we do not observe a significant change in R-squared, especially after adding content. Instead, the adjusted R-squared decreases after adding it to the regression, suggesting content is a redundant variable determining the perceived quality.

Table 1: The regressions testing relationship between perceived quality and attributes

	Dependent variable:			
	quality			
	(1)	(2)	(3)	(4)
Ease	0.362**	0.318**	0.310**	0.309**
	(0.138)	(0.142)	(0.142)	(0.143)
Speed	0.226*	0.182	0.159	0.157
	(0.124)	(0.129)	(0.130)	(0.133)
Reliability	0.156	0.148	0.160	0.160
	(0.119)	(0.119)	(0.119)	(0.120)
Control	0.139	0.130	0.123	0.124
	(0.119)	(0.118)	(0.118)	(0.119)
Entertainment	0.327***	0.303***	0.301***	0.300***
	(0.107)	(0.109)	(0.109)	(0.109)
Friendly		0.184	0.210	0.211
		(0.148)	(0.150)	(0.151)
Waiting_time			0.088	0.089
			(0.076)	(0.077)
content				-0.008
				(0.074)
Constant	-2.030**	-2.269**	-2.654***	-2.612**
	(0.845)	(0.864)	(0.924)	(0.999)
Observations	94	94	94	94
R2	0.534	0.542	0.549	0.549
Adjusted R2	0.507	0.510	0.512	0.506
Residual Std. Error	1.157 (df = 88)	1.153 (df = 87)	1.151 (df = 86)	1.158 (df = 85)
F Statistic	20.133***	17.136***	14.938***	12.923***
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 2 suggests that this result does not change much if we change the measurement of the five attributes from using arithmetic means to geometric means. And speed turns out to be insignificant after changing the measurement.

Table 2: Geometric mean vs. arithmetic mean

	Dependent variable:	
	quality	
	(1)	(2)
Ease	0.362**	0.347**
	(0.138)	(0.132)
Speed	0.226*	0.182
	(0.124)	(0.121)
Reliability	0.156	0.141
	(0.119)	(0.114)
Control	0.139	0.147
	(0.119)	(0.114)
Entertainment	0.327***	0.355***
	(0.107)	(0.102)
Constant	-2.030**	-1.747**
	(0.845)	(0.817)
Observations	94	94
R2	0.534	0.547
Adjusted R2	0.507	0.522
Residual Std. Error	1.157 (df = 88)	1.140 (df = 88)
F Statistic	20.133*** (df = 5; 88)	21,282*** (df = 5; 88)
Note:		*p<0.1; **p<0.05; ***p<0.01

Unlike Fernandes & Pedroso [2], our regression results suggest that the impacts of reliability and perceived control are insignificant. To test the impacts of each trait, we run a regression of perceived quality on all survey questions individually, as shown in Appendix C. We pay attention to Q9 and Q10, which account for perceived control. We notice that the coefficients of Q9 and Q10 are significant, but the coefficient of Perceived Control, the combination of Q9 and Q10, is not. We then try to reveal the relations between them and the dependent variables. First, we find the correlation between Q9 and Q10 is 0.8540, the correlation between Q9 and perceived quality is 0.4940, and the correlation between Q10 and perceived quality is 0.5870. We run regressions of Perceived quality on Q9, Q10, and both of them and the output are reported as follows.

Table 3: The test for perceived control

	Dependent variable:		
	quality		
	(1)	(2)	(3)
Q9	0.556**		0.347**
	(0.102)		(0.184)
Q10		0.486***	
		(0.093)	
Constant	1.684***	1.337**	1.416**
	(0.613)	(0.529)	(0.578)
Observations	94	94	94
R2	0.244	0.345	0.345
Adjusted R2	0.236	0.337	0.330
F Statistic	29.700***	48.375***	23.946***
Note:			*p<0.1; **p<0.05; ***p<0.01

Interestingly, the coefficients of regressors are positive and significant when we run regressions on Q9 or Q10, respectively, while the sign of coeffect of Q9 turns negative if Q10 is added. Moreover, the values of R-squared are almost the same if we add Q9 to the regression with Q10 as the regressor. The adjusted R-squared value is even smaller, implying Q9 is a redundant variable.

We try to test the effects on perceived quality in different gender groups. As the survey question lists three options for gender: female, male, and prefer not to say, we have three dummy variables describing gender. When we run the regression with R, it drops the female dummy automatically, and the output is as follows. The coefficient of male dummy is -0.43, and it is significant at 10% level of significance. It suggests that male respondents have worse perceived quality than female respondents.

Table 4: The effects on perceived quality in different sex groups

	Dependent variable:
	quality
Ease	0.351**
	(0.137)
Speed	0.243*
	(0.124)
Reliability	0.170
	(0.118)
Control	0.107
	(0.119)
Entertainment	0.299***
	(0.107)
Your.genderMale	-0.430*
	(0.249)
Your.genderPrefer not to say	-0.968
	(0.707)
Constant	-1.558*
	(0.868)
Observations	94
R2	0.554
Adjusted R2	0.518
Residual Std. Error	1.144 (df = 86)
F Statistic	15.285*** (df = 7; 86)
Note:	*p<0.1; **p<0.05; ***p<0.01

We also try to test the effects on perceived quality in groups with different shopping frequency. As the survey question lists six options for shopping frequency: everyday, every two days, twice a week, once a week, every two weeks, and others. However, no one chooses everyday. When we run the regression with R, it drops the “every two days” dummy automatically, and the output is as follows. The output is shown in Table 5. It suggests that shopping frequency does not affect people’s perceived quality of self-scan service.

Table 5: The effects on perceived quality in different shopping frequency groups

	Dependent variable:
	quality
Ease	0.345**
	(0.148)
Speed	0.214
	(0.136)
Reliability	0.138
	(0.132)
Control	0.100
	(0.123)
Entertainment	0.363***
	(0.112)
How.often.do.you.go.to.a.grocery.store.every.two.weeks	0.214
	(1.469)
How.often.do.you.go.to.a.grocery.store.once.a.week	0.259
	(1.442)
How.often.do.you.go.to.a.grocery.store.others	-1.048
	(1.668)
How.often.do.you.go.to.a.grocery.store.twice.a.week	0.332
	(1.444)
Constant	-1.948
	(1.412)
Observations	94
R2	0.546
Adjusted R2	0.498
Residual Std. Error	1.168 (df = 84)
F Statistic	11.231*** (df = 9; 84)
Note:	*p<0.1; **p<0.05; ***p<0.01

4.2.2. Satisfaction

Next, we test the relationship between satisfaction and perceived quality by using the following equation:

$$\widehat{Satisfaction}_i = \hat{\beta}_0 + \hat{\beta}_1 quality_i \quad (2)$$

Table 6 illustrates the regression output. The coefficient of quality is 0.597, and significant at a 1% level of significance, suggesting perceived quality can affect customers' satisfaction significantly. This result is the same as in Fernandes & Pedroso [2]. The R-squared is 0.572, suggesting that 57.2% of the variation in satisfaction can be explained by the variation in perceived quality. This number is a little bigger than 0.488, as found in Fernandes & Pedroso [2].

Table 6: The regressions testing relationship between satisfaction and perceived quality

	Dependent variable:
	satisfaction
quality	0.597***
	(0.054)
Constant	2.601***
	(0.279)
Observations	94
R2	0.572
Adjusted R2	0.568
Residual Std. Error	0.855(df = 92)
F Statistic	123.191*** (df = 1; 92)
Note:	*p<0.1; **p<0.05; ***p<0.01

4.2.3. Repatronage intention

We test the relationship between repatronage intention and by using the following equation:

$$\widehat{intention}_i = \hat{\beta}_0 + \hat{\beta}_1 Satisfaction_i \quad (3)$$

Table 7 illustrates the regression output. The coefficient of satisfaction is 0.582, and significant at a 1% level of significance, suggesting satisfaction can affect customers' repatronage intention significantly. This result is the same as in Fernandes & Pedroso [2]. The R-squared is 0.360, suggesting that 36% of the variation in satisfaction can be explained by the variation in perceived quality. This number is similar to 0.385, as found in Fernandes & Pedroso [2].

Table 7: The regressions testing relationship between repatronage intention and satisfaction

	Dependent variable:
	repatronage
satisfaction	0.582***
	(0.081)
Constant	2.996***
	(0.461)
Observations	94
R2	0.360
Adjusted.R2	0.353
Residual.Std.Error	1.016 (df = 92)
F.Statistic	51.670*** (df = 1; 92)
Note:	*p<0.1; **p<0.05; ***p<0.01

5. Conclusion

We use regression analysis to test the first three hypotheses in Fernandes & Pedroso [2]. We have the same results for hypotheses 2 and 3 as in Fernandes and Pedroso [2], that perceived quality can affect customers' satisfaction significantly, and satisfaction can affect customers' repatronage intention significantly. However, we have a different result for hypothesis 1. Fernandes & Pedroso [2] find that all five attributes, including speed, ease of use, control, reliability, and enjoyment, significantly affect the perceived quality of self-checkout service. However, our data only confirm the significant effects of ease of use, speed, and entertainment. Reliability and perceived control seem not to be determinants of the perceived quality of self-checkout service. We assumed that user friendly might be another determinant of the perceived quality, while our regression outputs do not support this claim. Our regression outputs also suggest that male respondents have worse perceived quality than female respondents, and shopping frequency does not affect people's perceived quality.

The difference between our results and Fernandes and Pedroso[2] may attribute to the different populations of interest. As we mentioned in Section 4.1, most of our respondents are students from Western Washington University in USA. In addition, country difference, which may imply the cultural difference, there are two typical characteristics in our sample: young and well-educated. A well-educated young person may know how a self-checkout machine works and therefore is not concern about the reliability. Compared with some online shopping and playing games, a young person may not feel that "user-friendly" feature is needed. Moreover, young people may not have a bad experience of lack of self-control as senior people may do. Thus, they don't take self-control as an important factor. We will keep collecting more data to update our results. The managerial implication of our findings in this paper that in a store with self-checkout facilities, a staff should pay attention to senior people and offer more assistance to them if needed. Based on the author's observations, in local several supermarkets in USA/Canada, most self-checkout users are young people

while most senior people line up for the regular checkout cashiers. During the rush hours, the self-checkout option does reduce the waiting line significantly. A future research topic could be finding an effective approach to encouraging senior shoppers to use the self-checkouts during the busy hours. A queueing model with multi-type service channels and modulated arrival streams can be established to study the congestion reduction effect quantitatively of using check-out service.

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Appendix

A: Survey Questions

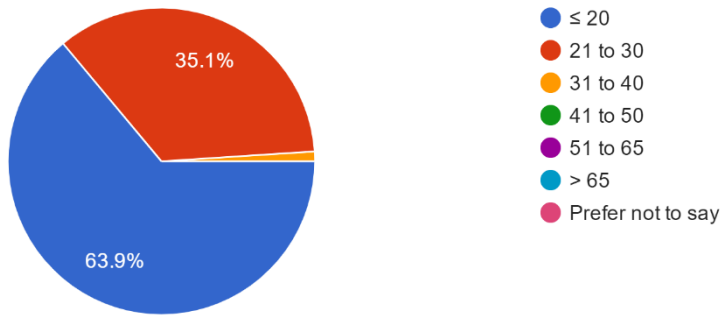
Categories	Questions
Ease of use	Q2*: The self-scan is easy to use. Q3*: The self-scan does not take much effort.
Speed	Q5*. The self-scan saves me time. Q6*. The self-scan let me checkout quickly.
Reliability	Q7*. The self-scan is accurate Q8*. The self-scan is reliable
Perceived control	Q9*. The self-scan gives me control Q10*: The self-scan lets the customer be in charge
Entertainment	Q11*: I enjoy using the self-scan Q12*: It is fun to scan the items yourself.
User Friendly	Q1: Most self-checkout machines are customer friendly. Q4: I won't use self-checkout if there is no helper.
Waiting time	Q13: Only the length of the line matters when I choose the checkouts Q14: I roughly compare the number of customers waiting for self-checkouts with the number of customers in line served by the cashiers before making my checkout decisions
Purchase content	Q15: I won't use self-checkout if some items need to be weighted. Q16: I won't use self-checkout if some items are oversized. Q17: I won't use self-checkout if I purchase more a certain number of items.
human/non-human feature	Q18: I use more self-checkout if I shop alone. Q19: I don't like self-checkout because no human interactions.
pandemic factor	Q20: I use more self-checkout since COVID pandemic started.
Perceived quality	Q21: I feel that the service quality of using self-check-out is very high
Satisfaction	Q22: My overall satisfaction is really high.
Repatronage intention	Q23: I will certainly come back again to use the self-checkout in future.

The questions with * are identical to those in Fernandes & Pedroso [2].

B: Respondents' Characteristics

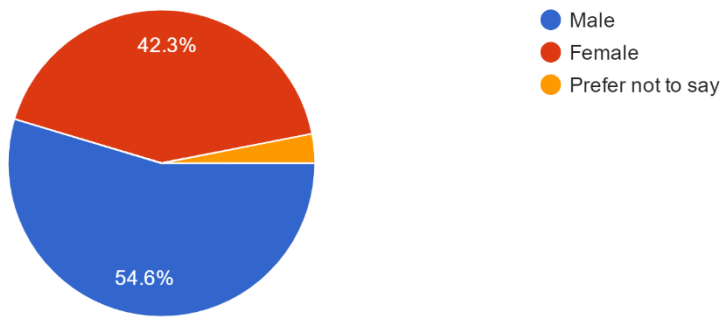
Your age

97 responses



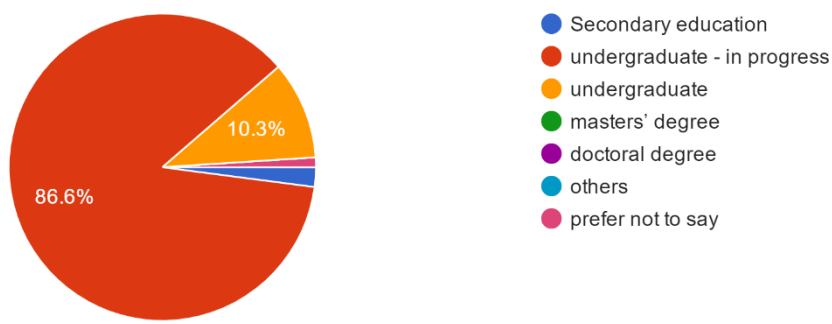
Your gender

97 responses



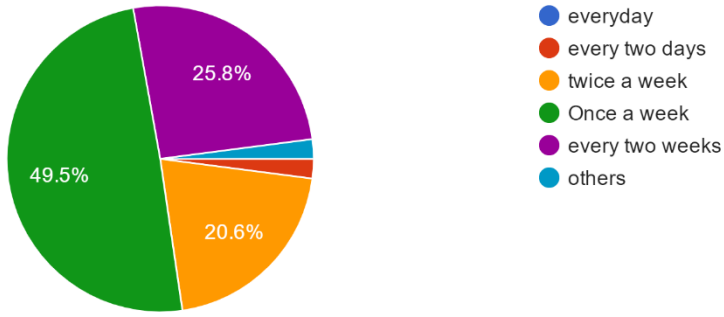
Your education

97 responses



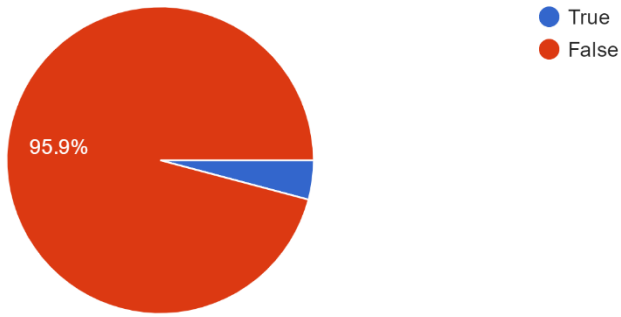
How often do you go to a grocery store?

97 responses



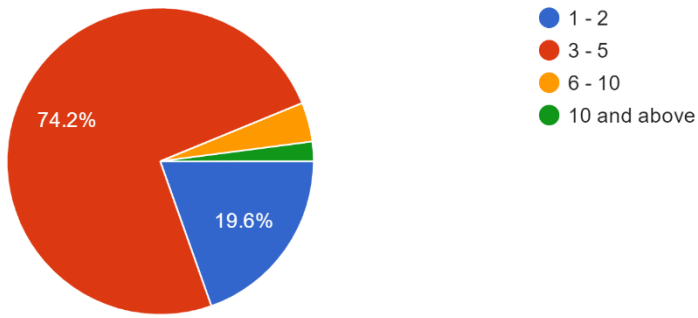
I never use self checkout before.

97 responses



What is the size of your households?

97 responses



C: Regression on All Survey Questions

	Dependent variable:
	quality
Q1	0.302*
	(0.167)
Q2	-0.044
	(0.206)
Q3	0.258
	(0.189)
Q4	-0.023
	(0.099)
Q5	-0.111
	(0.208)
Q6	0.264
	(0.230)
Q7	0.137
	(0.195)
Q8	0.061
	(0.170)
Q9	-0.347*
	(0.180)
Q10	0.501***
	(0.189)
Q11	-0.052
	(0.146)
Q12	0.234**
	(0.095)
Q13	0.188**
	(0.074)
Q14	-0.066
	(0.069)
Q15	0.061
	(0.084)
Q16	-0.007
	(0.076)
Q17	-0.089
	(0.061)
Q18	-0.050
	(0.071)
Q19	-0.138
	(0.105)
Q20	0.095
	(0.066)
Constant	-1.873*
	(1.048)
Observations	94

R2	0.653
Adjusted R2	0.558
Residual Std. Error	1.096 (df = 73)
F Statistic	6.867*** (df = 20; 73)
Note:	*p<0.1; **p<0.05; ***p<0.01