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Technology adoption and jobs: The effects of self-service kiosks in restaurants on labor outcomes☆

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ABSTRACT

This study explores how technology adoption affects labor. I investigate the effect of restaurants' adoption of self-service kiosks on labor outcomes, using survey data from Korea. I find that businesses' adoption of self-service kiosks had little impact on their number of full-time or part-time workers. However, restaurants with a self-service kiosk decreased both the wages of their part-time workers and the number of unpaid family members they employed. The results are driven by franchise restaurants. Independently owned restaurants that adopted kiosks increased the wages of their full-time workers. These findings provide support for the efficiency wage theory as well as the skill-biased technological change theory. The results suggest that when businesses adopt new technologies, these technologies do not replace unskilled labor, but rather raise the relative wages of skilled workers.

1. Introduction

Self-service technologies are not new, but they have become the new normal in the contactless era. For example, the use of self-service kiosks has become considerably more common in restaurants, and the technology itself has become more convenient and user friendly. Self-service technologies provide benefits to both consumers and businesses, but there are some concerns that the new technologies may take away jobs. A growing literature has examined the effect of industrial robots on employment, but little is known about the impact of self-service kiosk adoption on employment in the food service industry. These impacts could directly affect the economic sentiments of job seekers and small business owners.

In this study, I examine the impact of restaurants' adoption of self-service kiosks on labor outcomes. Specifically, I measure the effect of using a kiosk on firms' number of employees, hours worked per day, days worked per month, and monthly wages using survey data from restaurants in Korea from 2018 to 2021. The data include labor outcomes by employment status (full-time, part-time, or unpaid family member) and identify the ownership type (franchise or independently owned). This allows me to investigate the effects on labor outcomes across employment statuses and ownership types.

I find that the adoption of self-service kiosks is not related to firms' number of full-time or part-time workers. Restaurants with a kiosk did not decrease the number of employees whose tasks could be completed using a kiosk. However, restaurants with a kiosk paid lower wages to their part-time workers than other restaurants. This finding supports the skill-biased technological change theory, which suggests that new technology increases the marginal productivity and the wages of skilled workers, thus leading to wage inequality. In addition, the decrease in the wages of part-time workers is driven by franchise restaurants. Independently owned restaurants increased the wages of their full-time workers, marginally decreasing the wages of their part-time workers. This finding can be explained by the efficiency wage theory, which suggests that employers pay higher wages to improve workers' productivity and reduce shirking.

The adoption of self-service kiosks can be endogenous. The COVID-19 pandemic may have increased the chance of restaurants adopting such kiosks. To reduce the transmission of the coronavirus, many businesses implemented non–face-to-face interaction [1,2]. To address this issue, the number of new confirmed COVID-19 cases in the area is included in the model. Furthermore, I have implemented a coarsened exact matching (CEM) procedure [3] to help alleviate concern about the unpredictability of a restaurant adopting a kiosk in a specific year.

To the best of my knowledge, this study provides the first evidence of a relationship between self-service kiosk adoption and labor outcomes.

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This paper builds on several strands of the literature. First, a growing body of research has examined the extent and incidence of technology adoption, particularly the adoption of industrial robots and automation, and the labor market outcomes associated with such technology adoption. Previous studies have found that robot adoption leads to job losses, especially among low-skilled workers and production workers. While robots increase productivity and benefits for high-skilled workers, they reduce the wages and employment of low-skilled workers and incumbent workers [4–7]. Theoretical models have suggested that there is a negative relationship between technology adoption and labor demand [8–11]. In contrast to these findings, other studies have found that robot adoption results in increases in employment [12,13]. According to [14], firms with robots increased their employment, but robot adoption by a particular industry decreased overall employment in that industry. As explained above, previous research has produced mixed findings as to the relationship between robots and employment. Little is known about the impact the adoption of self-service kiosks may have on labor outcomes in the food service industry, a change that could directly impact the actual economic sentiments of consumers and small business owners. This paper adds to the literature by addressing this gap.

Another strand of the literature has explored how technological change affects labor demand. This study provides empirical evidence as to the relationships between technological change, employment, and wages. Many previous studies have focused on theoretical models of technological change. Skill-biased technological change (SBTC) describes an increase in the relative demand for skilled workers and a skill premium that explains wage differentials [15–17]. More recent studies have explained employment polarization via routine-biased technological change (RBTC) or routine-replacing technological change (RRTC) [18,19]. In addition, a large body of literature has examined the relationship between technology, particularly computerization and IT, and labor outcomes [20–24]. This study contributes to the literature by providing empirical evidence about the impact of self-service kiosk adoption on full-time and part-time workers' employment and wages.

Furthermore, this study explores the differential effect of technology adoption on labor outcomes among franchise businesses and independently-owned businesses. The existing literature has compared franchise outlets with company-owned outlets across several dimensions. Studies have found that franchise outlets are more likely to monitor their workers [25,26], fail to comply with minimum wage and overtime regulations [27], and use low-road practices such as offering employees low wages and menial tasks [28]. More recent works have shown that franchise outlets are less likely to invest in human resources and more likely to reduce costs [29,30]. However, few studies have documented the relationship between technology adoption and labor outcomes across different ownership structures. This study investigates the heterogeneous effects of technology adoption across franchises and independent businesses.

Finally, this study is closely related to the literature on self-service technology. Existing research has found that consumers who use self-service technologies report higher satisfaction [31–34]. [35] investigated how customer satisfaction and interactions with firms are associated with the use of self-service technology. Self-service technologies also have a positive effect on restaurant performance [36,37]. A number of qualitative studies have examined self-service technology focusing on customers' experiences and satisfaction [38,39]. Most previous studies have focused on the consumer side [40] or on restaurant performance metrics such as sales and profits. Instead, this research provides evidence as to the effect of self-service technology on both the supply side of the labor market, explained by businesses' number of employees, and the demand side of the labor market.

The rest of this paper is organized as follows. Section 2 explains the conceptual framework of the study and summarizes previous studies. Section 3 describes the data and presents summary statistics. Section 4 outlines my empirical methods and presents the results. Section 5 draws conclusions and discusses the implications of the findings.

2. Conceptual framework

2.1. Adoption of technology and employment

A growing body of research has investigated the relationship between robots and employment. [5] have examined the impact of imports of robots on firm outcomes using French firm-level data, and found a positive relationship between robot imports and employment, but a negative effect of exposure to robots on employment. They have also documented that robots improve productivity and the employment share of high-skilled workers, but have no impact on sales. [6] has investigated the effect of robot adoption on firm outcomes using administrative data from Denmark. The study finds that robot adoption increases firm output, layoffs of production employees, and the hiring of tech employees. [4] have measured the effect of automation on incumbent workers using Dutch micro-data, finding that automation increases the likelihood that workers will leave and decreases their days worked and wage income, while their wage rates are largely unaffected. [7] have suggested that robots lead to labor productivity gains while also raising total factor productivity and reducing output prices. They found that robots did not decrease total employment, but did decrease the employment share of low-skilled workers.

[8] have investigated the relationship between new technologies and the labor market. Their theoretical model implies that automation could decrease employment, the labor share, and wages. More recently, they have theorized a negative effect of automation on the labor share and labor demand, but a positive effect on productivity [9]. They have shown that the negative effects are offset by new labor tasks that provide a comparative advantage. They have also presented a conceptual framework [10] in which robots decrease both employment and wages. Most recently, [11] have created a theoretical model that explains the relative wage decreases among workers who perform routine tasks in industries experiencing automation.

[12] have found that robots are associated with increases in total employment but declines in total management employment, a finding that contrasts with previous research that has found decreases in overall employment. They have argued that robot adoption is motivated by a desire to enhance product and service quality rather than to reduce labor costs, and that robots reduce the need for managers to supervise workers' activities to assure production quality. [13] have also found that robot adoption results in significant output gains, reductions in the labor cost share, and net job creation. [14] have found that robot adoption by French firms decreased the labor share and the employment share of production workers while increasing productivity. Firms with robots increased their overall employment, but robot adoption decreased overall employment at the industry level. [41] have also studied the effect of artificial intelligence (AI) on labor markets. Firms that adopt AI reduce their non-AI positions and change the skill criteria for new hires.

More specifically, this research adds to the literature on self-service technology. There is a substantial corpus of literature devoted to the impact of such technologies on customers. [33] have found that consumers who used a tabletop payment device gave positive feedback regarding its ease of use and their credit card security. [34] also found that customers who used self-service kiosks reported higher levels of satisfaction but lower levels of hospitableness. [32] have documented that consumers' judgments of the service quality of self-service kiosks is associated with their retail patronage intentions. [40] describe various values expressed by customers using self-service kiosks and the components of these values. [42] have explored how social distancing, individualistic culture, self-identification as technology users, and innovativeness affect consumers' use of SSTs, and identify four segments of users of a smart locker self-collection service. Their research emphasizes the effects of the COVID-19 pandemic on the consumption environment and individuals' self-perceptions, which have led to behavioral changes in SST usage. [31] have examined how waiting time

satisfaction and the use of self-service technology affect customer loyalty in the airport industry. The study highlights how customer satisfaction with waiting times and self-service technologies affects customer loyalty, and indicates that waiting time satisfaction mediates the relationship between self-service technology use and loyalty. [39] found that customers' past experiences such as wait times, task complexity, and the presence of a companion influenced their attitudes toward self-service technology. [38] investigated the co-creation of value by organizations and consumers through the use of self-service technology, and argued that shifting responsibility for service production toward self-service brings potential risks and managerial challenges.

Another body of literature investigates the impact of self-service technologies on businesses. [37] have examined the effect of tabletop devices on restaurant performance, finding that tabletop devices increase the average sale and decrease meal duration. [36] have developed a theoretical model to explain the impact of self-order technologies. The model suggests that self-order technologies decrease customers' waiting costs and increase their demand and restaurants' profits. The model also implies that these technologies increase employment, even when labor costs are high. A growing body of research has examined the role of non–face-to-face interaction and self-service technology (SST) in the COVID-19 pandemic response. [1] have shown that small restaurants that used Uber Eats significantly increased their total activity, orders per day, and orders per hour in response to COVID-19 lockdowns. [2] have investigated how banks' servicescapes influence the adoption of SST. Their findings suggest that the servicescape can have a positive effect on customers' intentions to use SST, which is mediated by their attitude.

Based on the previous studies, it is unclear whether the adoption of SST can be expected to lead to a decrease in employment. While some studies have found that the adoption of robots and AI can lead to a decrease in employment, others have suggested that such technologies increase employment or at least do not decrease it. Given the lack of direct evidence as to the effect of SST on employment, I propose the following hypothesis:

H1. The adoption of SST will negatively influence employment

2.2. Skill-biased technological change

The classical skill-biased technological change (SBTC) theory suggests that a shift in the production function for skilled workers increases marginal productivity and the wages of skilled workers. This leads to wage inequality between high-skilled and low-skilled workers, also known as the skill premium. According to SBTC, a new technology increases the demand for skilled workers. Routine-biased technological change (RBTC) and routine-replacing technological change (RRTC) both imply that new technologies decrease the employment of workers who perform routine tasks, but increase the employment of workers who perform non-routine tasks [15–19].

To be specific, [15] have examined the effect of skill-biased technological change (SBTC) on wage differentials. The paper shows an increasing relative demand for skilled workers in response to computerization. [16] has shown that the increasing productivity of skilled workers using skill-complementary technologies leads to a short-run decrease in the skill premium, but in the long run it encourages skill-biased technological change (SBTC) and the skill premium. [17] have found that in low-skill service occupations where workers perform routine tasks, technological change is associated with employment polarization and wage polarization. Employment polarization can be explained by the reallocation of low-skilled workers into service occupations, and wage polarization can be seen in earnings growth at the distribution tails.

[18] have explained employment polarization via routine-biased technological change (RBTC) and offshoring. [19] have measured the impact of routine-replacing technological change (RRTC) on employment. RRTC decreased the employment of workers who performed routine tasks but created new occupations, leading to net employment increases. [43] has developed a model where labor scarcity encourages labor-saving technology, but discourages labor-complementary technology. [23] has shown that workers who use a computer at work have a higher wage rate than those who do not use a computer. [20] have shown that computerization is associated with lower labor input for routine manual tasks and higher labor input for nonroutine tasks. [22] have studied the relationships between personal computer adoption, educational attainment, and the returns to skills using US city-level panel data. [24] have examined the impact of information and communication technologies (ICT) on labor market inequality. They find that industries that have adopted ICT show increased demand for highly educated workers rather than middle-educated workers. [21] have identified a positive effect of IT adoption on productivity.

Based on the skill-biased technological change theory, the adoption of new technologies increases the demand for skilled workers, resulting in higher marginal productivity and wages for skilled workers. This causes wage inequality between high-skilled and low-skilled workers. Given these findings, it is reasonable to expect that the adoption of SST will differentially impact the employment and wages of workers with different skill levels and employment statuses. Specifically, SST will have different effects on the demand and wages of full-time employees (FTE) compared with part-time employees (PTE) or family member employees (FME). Therefore, I propose that:

H2. The adoption of SST will have a positive effect on the demand for full-time employees (FTE), but a negative effect on the demand for part-time employees (PTE) or family member employees (FME).

H3. The adoption of SST will increase the wages of full-time employees (FTE), but decrease the wages of part-time employees (PTE) or family member employees (FME).

2.3. Efficiency wage theory

The efficiency wage theory can help explain the differential effects of self-service kiosk adoption across franchise outlets and independently-owned businesses. Some firms pay higher wages than other firms in order to improve worker productivity and reduce shirking. Independent owners cannot rely as much on name recognition, thus are more likely to invest in motivation-enhancing human resource practices such as performance-related pay. However, franchise restaurants are likely to pay low wages, minimize their labor costs, and underinvest in human resources [25,26,28–30].

[26] has documented that company-owned outlets have less incentive to monitor employees than franchise outlets and offer higher employee compensation. Freedman and Kosov'a (2014) have also found that company-owned hotels have less incentive to supervise employees than franchisee-owned hotels. [27] have found that franchise outlets were more likely to violate minimum wage and overtime regulations than company-owned outlets. [28] have shown in descriptive statistics that franchise operations more often engage in low-road practices such as offering employees low wages and only menial tasks, but these findings disappear when control variables are employed. [29] have found that franchisee-owned units are less likely to invest in human resource practices and are more likely to reduce costs when they do not receive organizational routines from the chain franchisor. [30] has also documented that franchisee-owned hotels underinvest in human resource practices compared to company-owned hotels.

According to the efficiency wage theory, franchise restaurants are likely to pay low wages, minimize labor costs, and underinvest in human resources, while non-franchise restaurants may invest in motivation-enhancing practices such as performance-related pay. Therefore, the adoption of SST may have differential effects on the employment and wages of workers in franchise and non-franchise restaurants. Hence, the

following hypothesis is proposed:

H4. The adoption of SST will have a negative effect on the employment and wages of workers in franchise restaurants, but a positive effect on the employment and wages of workers in non-franchise restaurants.

2.4. Contributions

This study contributes to the literature on the relationship between technology adoption and employment. It fills a gap in the existing literature by examining the impact of self-service technology on labor outcomes in the food service industry, an area that has received relatively little attention in previous studies. While previous research has primarily focused on the manufacturing sector, this study's findings are particularly relevant given the significant impact that self-service technology adoption can have on the economic sentiments of consumers and small business owners. Specifically, the study aims to investigate whether restaurants that adopt self-service kiosks substitute low-skilled workers with kiosks and skilled workers, and how this affects the number and wages of both full-time and part-time workers, something the literature has not yet examined.

Furthermore, this study contributes to the literature on the efficiency wage theory and business ownership by exploring the heterogeneous effects of self-service kiosk adoption across franchises and independently-owned restaurants. Little is known about the differential effects of technology adoption across different types of business ownership. By comparing the impact of kiosk adoption on the number and wages of full-time and part-time workers across these two ownership types, the study sheds light on the differential effects of technology adoption on different types of businesses.

The empirical evidence has implications for ongoing debates about the skill-biased technological change theory and efficiency wage theory. While most previous studies have focused on the customer side or on restaurant performance indicators such as sales and profits, this study sheds light on self-service technology's impact on employees and employers by examining employment and wages. The findings generated by this research can be useful for policymakers, business owners, and other stakeholders who are interested in understanding the potential impacts of self-service technology adoption on labor outcomes, particularly in this new era of contactless business.

3. Data

3.1. Sample

This study makes use of annual survey data from the food service industry collected by the Korea Rural Economic Institute (KREI). The population comprises all 657,086 businesses in the food service industry, as identified in the 2015 National Business Survey. In order to calculate statistics for each category of food (such as Korean, Chinese, Japanese, etc.), a sample selection procedure was employed. The survey encompassed all businesses with more than 100 employees, or all businesses in a category if the population size of that category was less than 30 businesses. Interviewers conducted in-person surveys by visiting the restaurants.

The sample used in this study from 2018 to 2021 cover firms' use of technologies and services such as self-service kiosks, POS (point of sale) devices, delivery apps, or delivery agencies; rent; year of establishment; and other business data such as annual sales, annual profits, visitors per day, and deliveries/takeout orders per day. The dataset also includes employment data including each firm's number of employees, their hours worked per day, days worked per month, and monthly salary by employment status (full-time, part-time, or unpaid family member). This allows me to investigate the effect of self-service kiosk use on labor outcomes by employment status, while controlling for business data and other characteristics. It should be noted that the annual surveys consist of repeated cross-sectional data rather than panel data. In the empirical analysis section, I explain in depth how I assess the given effects using this data.

3.2. Dependent variables

The dependent variables in the analysis are the labor outcomes, which are restaurants' numbers of full-time employees (FTE), part-time employees (PTE), and family member employees (FME). The number of employees is used as a measure of labor input. It is possible for business owners to be self-employed without having employees. Table 1 provides summary statistics for the number of employees, including the average number of hours worked per day, the number of days worked per month, and the average monthly earnings. According to the table, full-time employees work an average of 9.5 h per day, 25.3 days per month, and earn an average of 218.2 ($1963.8) every month. Compared with part-time employees, full-time employees work 3 more hours per day and 5 more days per month, and earn twice as much. Family member employees (FME), on the other hand, are defined as those who work for a family member's restaurant without pay. They work as much as full-time employees but are not compensated.

3.3. Independent variable

The independent variable in this study is whether or not a restaurant has a self-service kiosk. Self-service kiosks are a customer-facing technology that allows patrons to order and pay for their food without the assistance of an employee. In this study, the presence or absence of self-service kiosks was used to compare restaurants over a period of time.

Table 1 shows that between 2018 and 2021, around 3.7% of restaurants used self-service kiosks. There was a significant increase in the percentage of restaurants using self-service kiosks over this period, from 1.7% in 2018 to 5.5% in 2021, indicating a more than threefold growth in the use of self-service technology in the restaurant industry.

3.4. Summary statistics and balance check

Table 1 reports the summary statistics on the data used in the analysis. The sample covers 12,224 restaurants that were surveyed between

Table 1
Summary statistics.

	Mean	SD	Observations
A. Characteristics			
Kiosk (%)	3.7	18.8	12,224
POS device (%)	88.3	32.2	12,224
Delivery app (%)	20.2	40.2	12,224
Delivery agency (%)	14.3	35.0	12,224
Rental (%)	87.5	33.1	12,224
Year of establishment	2012.0	6.3	12,222
Annual sales (in 10 k KRW)	24,620.0	62,522.5	12,224
Annual profit (in 10 k KRW)	3255.6	8849.4	12,224
Visiting customers per day	67.6	234.0	11,958
Deliveries/takeouts per day	26.0	78.2	12,220
B. Employment			
Full-time employee (FTE)	1.5	4.9	12,224
FTE hours worked per day	9.5	1.9	6,836
FTE days worked per month	25.3	3.6	6,836
FTE wages per month (in 10 k KRW)	218.2	60.3	6,836
Part-time employee (PTE)	0.5	1.9	12,224
PTE hours worked per day	6.4	2.4	2,630
PTE days worked per month	20.5	6.7	2,630
PTE wages per month (in 10 k KRW)	113.1	63.9	2,630
Family member employee (FME)	0.4	0.6	12,224
FME hours worked per day	9.4	2.4	4,809
FME days worked per month	25.7	4.6	4,846

Notes: This table describes summary statistics from a survey on restaurants in Korea for years 2018–2021. The data comes from the Korea Rural Economic Institute (KERI).

2018 and 2021. Approximately 3000 restaurants were surveyed each year. The restaurants' annual sales and profits are reported in 10 k KRW. Given the average exchange rate of 0.0009 in 2018, the average annual sales of 24,620 (in 10 k KRW) and annual profits of 3255.6 (in 10 k KRW) correspond to about 221,580 USD and 29,300 USD, respectively. The data include a total of 18 different categories of restaurants. Approximately 29% of the restaurants serve Korean cuisine.[1] The geocoding is at the metropolitan city or province level. Specifically, around 24% of the restaurants in the sample are located in Seoul.[2]

To isolate the impact of self-service kiosks, the characteristics of restaurants with and without kiosks must not differ significantly. Table 2 describes the differences between the characteristics of the treatment and control groups. Restaurants with kiosks are more likely to utilize POS devices, delivery apps, and delivery agencies, and have higher profits than restaurants without kiosks. The differences between the two groups become negligible when region-year fixed effects and category fixed effects are controlled. Given the *p*-value of the joint F-test, there is no significant difference between the treatment and control groups.

4. Empirical strategy and results

4.1. Baseline estimates

The empirical analysis examines the effect of using a self-service kiosk on labor outcomes. Specifically, I compare restaurants that use a kiosk with those without such a kiosk. The econometric model takes the following form:

$$Y_{ijct} = \beta\ \text{Kiosk}_{it} + \gamma_j + \tau_{ct} + X_{it} + \varepsilon_{ijct} \quad (1)$$

Table 2
Balance checks between treatment and control groups.

	Kiosk	No kiosk	*p*-value (no controls)	*p*-value (controls)
	(1)	(2)	(3)	(4)
POS device (%)	97.8	87.9	0.01	0.62
Delivery app (%)	46.9	19.2	0.00	0.88
Delivery agency (%)	36.4	13.5	0.01	0.32
Rental (%)	87.3	87.5	0.28	0.38
Year of establishment	2012.8	2012.0	0.83	0.55
Sale (in 10k KRW)	62278.3	23187.3	0.03	0.07
Profit (in 10k KRW)	5397.2	3174.1	0.33	0.55
Visiting customers per day	195.4	62.7	0.21	0.08
Deliveries/takeouts per day	103.4	23.1	0.00	0.13
p-value (joint F-test)			0.00	0.20
Observations	448	11,776	12,224	12,224

Notes: Columns 1 and 2 show the mean values. The *p*-value reported in column 3 is derived from a regression of each variable on a kiosk dummy, and the *p*-value in column 5 is obtained from a regression, controlling for region-year fixed effects and category fixed effects. The *p*-value (joint F-test) reports aggregate orthogonality test in a regression of a kiosk dummy on covariates.

[1] Korean (29.4%), Chinese (5.1%), Japanese (3.8%), Western (3.7%), other countries (2.3%), cafeteria (3.5%), catering (2.0%), bakery (5.0%), pizza and hamburger (4.7%), chicken (6.4%), kimbap (6.7%), lightfood (3.4%), bar (3.2%), nightclub (2.2%), pub with draft beer (3.7%), other pub (6.9%), coffee (5.3%), and other beverage restaurants (2.8%).

[2] Seoul (23.6%), Busan (7.3%), Daegu (4.5%), Incheon (6.5%), Gwangju (5.2%), Daejeon (4.7%), Ulsan (3.1%), Sejong (0.5%), Gyeonggi-do (19.1%), Gangwon-do (2.3%), Chungcheongbuk-do (3.7%),Chungcheongnam-do (3.9%), Jeollabuk-do (1.9%), Jeollanam-do (2.1%), Gyeongsangbuk-do (4.4%), Gyeongsangnam-do (6.5%), and Jeju-do (0.8%).

where Y_{ijct} is the labor outcomes of restaurant i in category j located in area c in year t: its number of employees, hours worked per day, days worked per month, or wages per month by employment type (full-time employee, part-time employee, or family member employee). Kiosk_{it} is a dummy variable that takes the value of one if restaurant i has a kiosk in year t. Category fixed effects γ_j are included. There are 18 different types of restaurants. Area-year fixed effects τ_{ct} are also included in the model. To isolate the impact of kiosk use on labor outcomes, controls for variables other than labor outcomes X_{it} are included: POS device, delivery app, delivery agency, rent, year of establishment, annual sales, annual profit, customers per day, and delivery/takeout orders per day. Coefficient β therefore measures the effect of using a self-service kiosk on labor outcomes.

The identification strategy has both advantages and disadvantages. The fact that the surveys provide repeated cross-sectional data rather than panel data means that I cannot include restaurant fixed effects that control for all time-invariant restaurant characteristics. Instead, category fixed effects and controls help address potential concerns about missed factors or uncontrolled events that coincide with kiosk use and affect labor outcomes. Area-year fixed effects also control for any economic trends that could influence restaurants in specific areas.

Table 3 reports the results from this specification. The results suggest that restaurants with kiosks did not differ significantly from those without a kiosk except for the monthly wages of part-time workers and the number of family member workers. Kiosk use had no association with the number of full-time or part-time employees. Hours worked per day and days worked per month also did not differ. However, using a kiosk decreased the monthly wages of part-time employees by about 16 ($14.4) and significantly reduced the number of family member employees by 0.125.

To measure the magnitude of the impact, I also apply the logarithmic form of the dependent variables. The estimated coefficients reported in Table 4 are consistent with the results reported in Table 3. In particular, using a kiosk decreased the monthly wages of part-time employees by 14.7% and decreased the number of family member employees by 8.1%.

Table 3
Effect of kiosk on labor outcomes.

Dependent variable	Number of workers	Hours worked per day	Days worked per month	Wages per month
	(1)	(2)	(3)	(4)
A. Full-time employee				
Kiosk	0.908	−0.178	−0.128	3.495
	(1.299)	(0.235)	(0.368)	(5.308)
Observations	11,952	6,770	6,770	6,770
B. Part-time employee				
Kiosk	0.331	0.402	−1.190	−16.420**
	(0.444)	(0.402)	(1.325)	(6.701)
Observations	11,952	2,580	2,580	2,580
C. Family member employee				
Kiosk	−0.125***	−0.079	0.593	
	(0.042)	(0.248)	(0.505)	
Observations	11,952	4,688	4,725	
Category fixed effects	Yes	Yes	Yes	Yes
Area-year fixed effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The sample consists of restaurants between 2018 and 2021. Kiosk is an indicator that equals to one if a restaurant uses a kiosk. Controls for POS device, delivery app, delivery agency, rental, year of establishment, annual sales, annual profit, visiting customers per day, and delivery/takeouts per day are included. Standard errors in parentheses are clustered at the category.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 4
Effect of kiosk on labor outcomes in log form.

Dependent variable	Number of workers	Hours worked per day	Days worked per month	Wages per month
	(1)	(2)	(3)	(4)
A. Full-time employee				
Kiosk	0.101	−0.020	−0.007	0.013
	(0.069)	(0.025)	(0.022)	(0.027)
Observations	11,952	6,770	6,770	6,770
B. Part-time employee				
Kiosk	0.058	0.015	−0.061	−0.147**
	(0.061)	(0.026)	(0.091)	(0.053)
Observations	11,952	2,580	2,580	2,580
C. Family member employee				
Kiosk	−0.081***	−0.001	0.030	
	(0.025)	(0.026)	(0.029)	
Observations	11,952	4,688	4,725	
Category fixed effects	Yes	Yes	Yes	Yes
Area-year fixed effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The dependent variables in logarithmic form are used. The sample consists of restaurants between 2018 and 2021. Kiosk is an indicator that equals to one if a restaurant uses a kiosk. Controls for POS device, delivery app, delivery agency, rental, year of establishment, annual sales, annual profit, visiting customers per day, and delivery/takeouts per day are included. Standard errors in parentheses are clustered at the category.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

4.2. Addressing additional concerns

I have controlled for unobservable variations in restaurant type and observable restaurant characteristics in the previous section, but there could still be potential concern about the likelihood of other possible unknown or unobservable variations related to restaurants' adoption of self-service kiosks. Specifically, the COVID-19 pandemic may have increased the likelihood that restaurants would adopt such kiosks. Many businesses adopted non–face-to-face interaction to reduce the spread of the coronavirus. To address this issue, I include new confirmed COVID-19 cases in the area and the log of the population in the model in place of area-year fixed effects. The estimation results from this specification are shown in Table 5. They are consistent with the main findings.

In the balance check, I verified that there is no statistical difference between restaurants with a kiosk and those without a kiosk, but the adoption of a kiosk is an endogenous variable. The results might reflect the impact of restaurant characteristics other than their adoption of a kiosk because restaurants with a kiosk may differ from those without a kiosk across several dimensions, even though I have controlled for category fixed effects, area-year fixed effects, and restaurant characteristics.

To mitigate this potential endogeneity problem, I implemented a coarsened exact matching (CEM) procedure [3], which is a nonparametric alternative to a propensity score matching procedure. CEM is appropriate because the probability of a restaurant adopting a kiosk in a particular year is unpredictable. In the CEM procedure, the control restaurants are culled from the 11,776 restaurants without kiosks. The control group is chosen such that the treated restaurants exhibit no differential trends in restaurant characteristics relative to the controls, such as their use of an app or POS device, their sales, profits, customers, or delivery/takeout orders. The results from this matched sample are presented in Table 6. The results are robust and consistent with the main results. A matched sample analysis alleviates the concern that restaurants with kiosks differ from those without kiosks.

I also conduct a falsification test in which the treatment groups and treatment periods are randomly selected. In the sample, 448 restaurants used a kiosk. I randomly choose 448 other restaurants as a placebo treatment group, without replacement, and construct a new independent variable. I then re-estimate the regression and report the effect of the placebo treatment on the monthly wages of part-time workers. I repeat this test 10,000 times with random shuffles. Fig. 1 shows the distribution of the coefficients resulting from every iteration. The solid

Table 5
Effect of kiosk on labor outcomes with additional controls.

Dependent variable	Number of workers	Hours worked per day	Days worked per month	Wages per month
	(1)	(2)	(3)	(4)
A. Full-time employee				
Kiosk	0.099	−0.015	−0.007	0.025
	(0.066)	(0.024)	(0.023)	(0.039)
Observations	11,952	6,771	6,771	6,771
B. Part-time employee				
Kiosk	0.050	0.008	−0.062	−0.132*
	(0.062)	(0.036)	(0.085)	(0.074)
Observations	11,952	2,581	2,581	2,581
C. Family member employee				
Kiosk	−0.078**	0.005	0.029	
	(0.028)	(0.031)	(0.038)	
Observations	11,952	4,689	4,726	
Category fixed effects	Yes	Yes	Yes	Yes
Area fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Area controls	Yes	Yes	Yes	Yes

Notes: The dependent variables in logarithmic form are used. The sample consists of restaurants between 2018 and 2021. Kiosk is an indicator that equals to one if a restaurant uses a kiosk. Controls for POS device, delivery app, delivery agency, rental, year of establishment, annual sales, annual profit, visiting customers per day, and delivery/takeouts per day are included. Log of population and COVID- 19 cases per thousand population are controlled. Standard errors in parentheses are clustered at the category.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 6
Matched sample analysis.

Dependent variable	Number of workers	Hours worked per day	Days worked per month	Wages per month
	(1)	(2)	(3)	(4)
A. Full-time employee				
Kiosk	0.061	−0.012	−0.014	0.033
	(0.061)	(0.026)	(0.039)	(0.029)
Observations	848	592	592	592
B. Part-time employee				
Kiosk	0.039	0.001	−0.198	−0.243**
	(0.073)	(0.065)	(0.143)	(0.108)
Observations	848	222	222	222
C. Family member employee				
Kiosk	−0.060**	−0.017	0.000	
	(0.026)	(0.045)	(0.027)	
Observations	848	258	263	
Category fixed effects	Yes	Yes	Yes	Yes
Area-year fixed effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The table reports the matched sample results using coarsened exact matching (CEM). Kiosk is an indicator that equals to one if a restaurant uses a kiosk. Controls for POS device, delivery app, delivery agency, rental, year of establishment, annual sales, annual profit, visiting customers per day, and delivery/takeouts per day are included. Standard errors in parentheses are clustered at the category.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

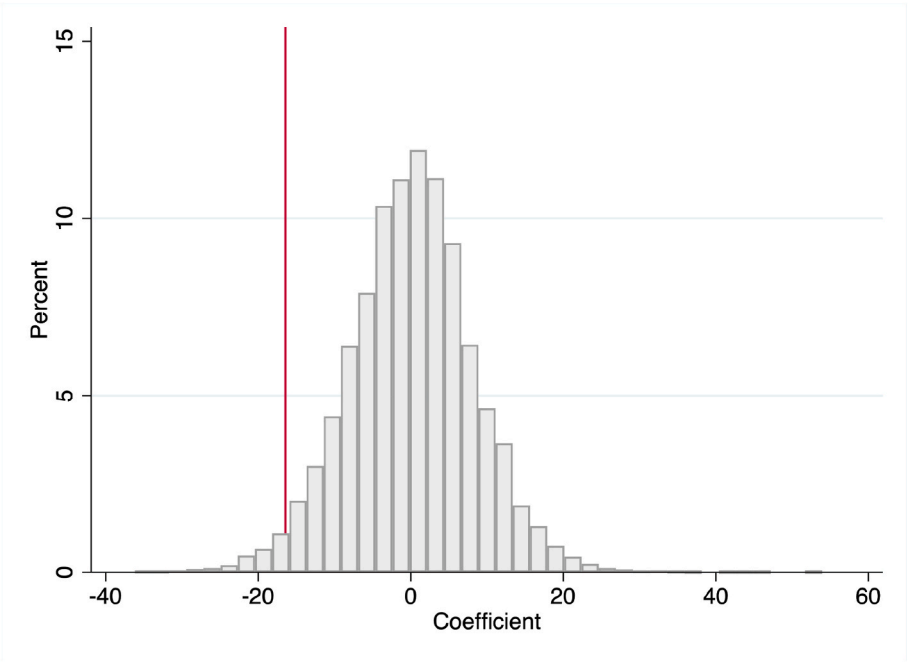

Fig. 1. Placebo test.
Notes: The figure plots the coefficient estimates conducted as a placebo treatment test. There are 448 restaurants which uses a kiosk in the sample. To perform one iteration of the placebo test, I randomly choose 448 restaurants, without replacement, and construct the placebo treatment for the effect of kiosk on part-time employee's wages. I re-estimate the regression and record the coefficient estimate with this new placebo treatment variable by doing this 10,000 times with different random shuffles. The distribution of coefficient estimates from the 10,000 iterations is shown. The solid vertical line depicts the actual causal effect using the true data. I finally calculate a p value by computing the proportion of the 10,000 iterations with the coefficient estimate smaller than the actual coefficient estimate ($p < 0.01$).

line shows the actual causal effect using the true data. If I calculate a p-value using the proportion of the 10,000 iterations where we find coefficients smaller than the true estimate, this p-value is < 0.01. Together, the CEM procedure and the placebo test alleviate any concerns that the results are driven by spurious correlations.

4.3. Heterogeneous effects among franchises and independent businesses

In the previous section, I demonstrated that restaurants with a kiosk decreased the monthly wages of part-time employees and the number of family member employees. The results support the previous findings that technology adoption is associated with low-skilled labor. The decrease in wages for part-time workers explains the reduced productivity of low-skilled labor. Furthermore, the decrease in the number of family member workers suggests that unpaid workers can be replaced by adopting a kiosk. I investigate the mechanisms by which using a kiosk influenced labor outcomes by examining the heterogeneous impacts by business type, that is, whether a business is a franchise or independently owned. Independently owned restaurants use different human resources management practices than franchise restaurants.

Tables 7 and 8 report the results using respective subsamples of franchise restaurants and independently owned restaurants. These suggest that the results are driven by franchise restaurants. Consistent with the previous literature in which franchises pay lower wages, franchise restaurants paid lower monthly wages to their part-time workers compared with independently owned restaurants. To earn profits from their operations, franchise owner-managers must keep their labor costs low. On the other hand, non-franchises increased the monthly wages of their full-time employees. This result is consistent with efficiency wage theory. The non-franchises were likely to pay higher wages in an effort to improve the productivity of their full-time workers and to reduce their shirking.

Table 7
Effect of kiosk on labor outcomes in franchise.

Dependent variable	Number of workers	Hours worked per day	Days worked per month	Wages per month
	(1)	(2)	(3)	(4)
A. Full-time employee				
Kiosk	0.042	−0.021	−0.021	0.010
	(0.057)	(0.018)	(0.015)	(0.020)
Observations	3,292	2,079	2,079	2,079
B. Part-time employee				
Kiosk	0.098	0.011	−0.075	−0.139*
	(0.067)	(0.053)	(0.110)	(0.068)
Observations	3,292	898	898	898
C. Family member employee				
Kiosk	−0.080***	−0.033	0.048	
	(0.022)	(0.030)	(0.055)	
Observations	3,292	1,097	1,110	
Category fixed effects	Yes	Yes	Yes	Yes
Area-year fixed effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The sample consists of franchise restaurants between 2018 and 2021. The dependent variables in logarithmic form are used. Kiosk is an indicator that equals to one if a restaurant uses a kiosk. Controls for POS device, delivery app, delivery agency, rental, year of establishment, annual sales, annual profit, visiting customers per day, and delivery/takeouts per day are included. Standard errors in parentheses are clustered at the category.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

5. Conclusion

This paper examines the mechanisms underlying the relationship between the adoption of self-service kiosk technology and various labor outcomes in the food service industry. The study's findings reveal four main results. Firstly, the use of self-service kiosks had little effect on the number of full-time or part-time workers in the restaurants. This indicates that the adoption of self-service technology did not lead to a significant reduction in the number of employees in the food service industry. Secondly, the study found that restaurants with a self-service kiosk tended to lower the wages of part-time workers. This suggests that the adoption of self-service technology may have a negative impact on the wages of part-time workers in the food service industry. Thirdly, the study found that the adoption of self-service kiosks in restaurants was associated with a decrease in the number of unpaid family member workers. This implies that in the food service industry, the adoption of

Table 8
Effect of kiosk on labor outcomes in non-franchise.

Dependent variable	Number of workers	Hours worked per day	Days worked per month	Wages per month
	(1)	(2)	(3)	(4)
A. Full-time employee				
Kiosk	0.207*	0.010	0.036	0.045*
	(0.105)	(0.031)	(0.043)	(0.022)
Observations	8,659	4,689	4,689	4,689
B. Part-time employee				
Kiosk	−0.083	−0.031	−0.026	−0.179
	(0.050)	(0.097)	(0.104)	(0.134)
Observations	8,659	1,677	1,677	1,677
C. Family member employee				
Kiosk	−0.056**	0.031	0.009	
	(0.020)	(0.040)	(0.029)	
Observations	8,659	3,586	3,610	
Category fixed effects	Yes	Yes	Yes	Yes
Area-year fixed effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The sample consists of non-franchise restaurants between 2018 and 2021. The dependent variables in logarithmic form are used. Kiosk is an indicator that equals to one if a restaurant uses a kiosk. Controls for POS device, delivery app, delivery agency, rental, year of establishment, annual sales, annual profit, visiting customers per day, and delivery/takeouts per day are included. Standard errors in parentheses are clustered at the category.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

self-service technology may lead to a reduction in reliance on unpaid family labor. Finally, the study found that the effects of self-service kiosk adoption varied depending on the type of restaurant ownership. Franchise restaurants tended to drive the negative effects of kiosk adoption, while non-franchise restaurants with kiosks tended to increase the wages of full-time workers. This suggests that the impact of self-service technology adoption on labor outcomes may differ depending on the specific context in which it is implemented.

5.1. Theoretical contributions

This study makes theoretical contributions to the literature on technology adoption and its impact on employment, specifically related to the skill-biased technological change theory. The study fills a gap in the existing literature by examining the impact of self-service technology on labor outcomes in the food service industry, a topic that has received relatively little attention in previous research. This study's findings provide insight into how the adoption of self-service technology affects the employment of both low- and high-skilled workers in the food service industry.

The empirical evidence generated in this study is consistent with the skill-biased technological change theory. According to the theory, a shift in production that favors skilled labor over unskilled labor raises the relative marginal productivity and the relative wages of skilled laborers. Unskilled labor wages fell in response to the adoption of self-service kiosks, a technology that can substitute for unskilled labor. These empirical findings contribute to the literature by adding support for the skill-biased technological change theory.

The study also contributes to the literature on the efficiency wage theory and business ownership by examining the heterogeneous effects of self-service kiosk adoption across franchises and independently-owned restaurants. By exploring the differential impact of such technology adoption on different types of businesses, the study sheds light on how these businesses adapt to new technologies and what impact such technology adoption may have on employment outcomes. The efficiency wage theory suggests that employers are likely to pay higher wages to enhance the productivity of workers and reduce their shirking. The empirical findings suggest that independently owned restaurants increased the relative wages of skilled workers over unskilled workers, while franchise outlets reduced their labor costs by lowering the wages of unskilled workers.

This research not only contributes to our understanding of the impact of technology adoption on employment and wages in the food service industry but also enhances our knowledge of the skill-biased technological change theory and the efficiency wage theory.

5.2. Managerial implications

The findings of this study have several managerial and practical implications for policy makers and restaurants considering the adoption of self-service kiosk technology. Firstly, the adoption of self-service kiosks in the food service industry does not necessarily lead to a significant reduction in the number of employees. Therefore, policy makers considering subsidies or support for business owners considering adopting SST should consider such SST adoption as a means of improving efficiency without worrying about a potential loss of jobs.

However, the study also found that restaurants with self-service kiosks tended to lower the wages of part-time workers. Restaurants should consider this implication and carefully evaluate the impact of wage reductions on employee morale and turnover rates. Furthermore, the study found that in the food service industry, the adoption of self-service technology may lead to a reduction in reliance on unpaid family labor. Therefore, restaurants that currently rely on unpaid family labor can consider adopting self-service kiosks as a means of reducing this dependence. Policy makers can also consider incentives or subsidies to encourage restaurants to adopt self-service kiosks, particularly small businesses that rely on unpaid family labor.

Finally, the study found that the impact of self-service technology adoption on labor outcomes may differ depending on the specific context in which it is implemented. Franchise restaurants tended to drive the negative effects of kiosk adoption, while non-franchise restaurants with kiosks tended to increase the wages of full-time workers. Therefore, when assessing the potential impact of self-service kiosk adoption on labor outcomes, policy makers should take into account the specific context, including the type of businesses adopting such technology. For instance, if policy makers support the adoption of SST for non-franchise restaurants, employers may be more likely to increase the wages of full-time employees rather than significantly reducing their number of employees.

The results of this study can be useful for policy makers, business owners, and other stakeholders who seek to understand the potential impacts of self-service technology adoption on labor outcomes, particularly in this new era of contactless business. By shedding light on the effects of technology adoption, this research can inform future discussions and decision-making such that both businesses and their employees may benefit.

5.3. Limitations and future research

This research offers policy implications and insights into the effects of self-service kiosk adoption on labor outcomes in the food service industry. However, there are still some limitations of the study and avenues for future research to explore. One limitation is that this study only examines the short-term impacts of self-service kiosk adoption on labor outcomes: the number of full-time and part-time workers, their wages, and the employment of unpaid family members. Future research could investigate the long-term effects of such technology adoption and explore other labor market outcomes such as job satisfaction, job quality, employee turnover, and the overall financial performance of restaurants.

It is important to recognize that the implications of self-service kiosk adoption may vary across industries. The influence of self-service kiosks on labor outcomes can be shaped by contextual factors and labor market

dynamics unique to each industry. It would be valuable for future research to explore the effects of kiosk use in different industry settings to understand the broader implications of the adoption of such technology. While this paper uses survey data and a quantitative method, a qualitative research design could offer insights into restaurant-industry employers' and employees' responses to self-service technology. Future research that incorporates qualitative methods could further enhance our understanding of the effect of self-service technology adoption.

Another limitation is that the study did not investigate the specific reasons for employee turnover, which could potentially confound the results. Future research could examine the underlying reasons for turnover, which could help to better isolate the effects of self-service technology adoption on layoffs and employee retention. Furthermore, while this study provides policy implications based on the relationship between self-service kiosk adoption and labor outcomes, it does not explore the broader implications of such technological advancements. Future research could investigate the potential impact of self-service technology adoption on broader issues, such as income inequality, economic mobility, and the future of work. This would provide a more comprehensive understanding of the effects of technology adoption.

Author statement

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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