Information Systems Research

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Abstract. The literature often explains female labor force participation through factors such as schooling, wage gaps, and fertility. In this study, we identify how technology-induced time savings from household chores increase female labor force participation in South Korea. Using a leads-and-lags difference-in-differences model, we find that entry of an online food delivery platform significantly increased the female employment rate in the three years following the platform's entry, and the results still hold after excluding employment in the food and beverage sector. Our further analyses show that such digital platforms offered a pathway for women to break free from traditional household roles, thus granting them more time and the opportunity to decide whether to join the labor market or stay at home. We examine the positive externalities generated by the online food delivery platform and find that this new technology-induced female employment accounted for 0.27% of South Korea's GDP, or 17 times the platform's direct revenue.

1. Introduction

Gender equality remains a significant challenge in modern society as women continue to face lower pay and limited representation in the workforce. Although the value of housewives is invaluable to their families and communities, increasing female labor force participation has important social and economic benefits. The World Bank reports that countries with higher female labor force participation have less international conflict and that countries with a lower percentage of women in the labor force are much more likely to experience internal conflict.[1] A McKinsey Global Institute report finds that advancing women's equality can add $12 trillion to the global gross domestic product (GDP).[2] Increasing growing female labor force participation can increase the size of the workforce and thus boost economic growth.[3]

The primary objective of this paper is to analyze the indirect impact of a technology-driven business model on social welfare, with a specific focus on the female labor market. We show that technology reduces the amount of time spent by women on onerous household chores, thus granting them more time and opportunity to decide whether to join the labor market or stay at home rather than be restrained by domestic drudgery. The freedom to join the labor force is of great significance for women in East Asia, who are usually responsible for the majority of household chores.

The literature has identified a few critical drivers of female labor force participation, such as education, gender wage gap, fertility, marriage and divorce rates, child-rearing costs, and social norms. In this paper, we identify a link between technology-induced time savings for women and their labor force participation. Specifically, we find that the entry of an online food delivery platform in South Korea has significantly increased the female employment rate in three years following its entry, and the results still hold after excluding employment that is directly related to the food delivery sector. Furthermore, we show that the income from this newly generated female employment accounted for 0.27% of South Korea's GDP, which was 17 times the total revenue of the platform. In other words, the online food delivery platform created major positive externalities.

We contribute to the growing literature on the impact of information technology (IT) on society (Goldfarb and Tucker 2019) by quantifying how a technology-driven

business model can indirectly increase female labor force participation. Such externalities are often difficult to measure. For instance, by charging zero price, platforms such as Facebook and YouTube typically generate much greater social value (through consumer surplus) than what is indicated by their revenue. Another example is of digital content platforms such as Wikipedia and Quora. com, which, by contributing to online public goods, can help increase people's knowledge, self-esteem, well-being, and happiness, especially for unemployed individuals (Slivko et al. 2020). Unfortunately, the nature of free user access makes it difficult to identify and quantify these positive externalities through the use of GDP statistics (Brynjolfsson et al. 2019).

We estimate the positive externalities of a technology-driven business model on employment by examining the staggered introduction of an online food delivery platform in different provinces of South Korea. We show that the economic benefits and social value of the new technology have been underestimated. We also demonstrate that the positive externalities dwarf the direct revenue generated by the platform. Furthermore, we investigate the mechanisms through which this technology-driven business model affects the labor market by enabling women who wish to join the labor force to work outside their homes rather than being forced to stay at home.

Online food delivery is a business model that has experienced fast worldwide growth over the past decade. DoorDash, the largest U.S. meal-delivery company, was valued at $15 billion in 2020.[4] Compared with conventional offline channels for ordering food, online food delivery platforms have four unique channel capabilities: low search costs, low entry costs, large consumption choice sets, and higher product differentiation. Online food delivery platforms reduce customers' search costs of obtaining information about restaurants and provide them with easy access to prices and food from a wide variety of restaurants. Besides, online food delivery platforms reduce the entry costs of offering delivery food by developing delivery infrastructure for restaurants to use, which enables many more restaurants to enter the market. Furthermore, online food delivery platforms broaden the choice set for consumers by aggregating information on restaurants that have entered the market. It allows people to order food from restaurants that are far from their residences and from those that offer niche foods. The platforms provide online ratings and reviews of food delivery, which offer useful reputation information, build trust in users, and serve to differentiate products, thus encouraging people to use these food delivery services on a daily basis.

Online food delivery platforms in South Korea provide a good setting with which to study the externality of new technology-driven business models on social welfare. First, the rollout of such platforms has been staggered both geographically and temporally. Therefore,

we can leverage a leads-and-lags difference-in-differences (DID) design (Autor 2003, Wolfers 2006, Gentzkow et al. 2011, Burtch et al. 2018) to study its impact. In addition to the benefits of standard DID models, such as controlling for time-invariant, location-specific heterogeneity and macroeconomic trends, the leads-and-lags DID design allows us to check the parallel pretreatment assumption and explore heterogeneous effects across time.

Second, South Korea is ranked among the worst countries by the Organization for Economic Cooperation and Development (OECD) in terms of the glass-ceiling index, which is a measure of gender equality in the workplace. Both female labor force participation and employment rates are far below the OECD average in South Korea. An official survey (further details are provided in Section 3) from South Korea reveals that household chores are the main activity of nearly half of the South Korean women who do not join the labor force. In addition, another official survey, the *Time Use Survey*[5] (further details are provided in Section 3), shows that cooking occupies a significant portion of the time (52.3%) spent by women on household chores in South Korea; that is, the time spent by women on all other chores (e.g., cleaning, laundry) combined is less than the time they spend on cooking. Thus, cooking duties may serve as an obstacle that prevents women from joining the labor force. Online food delivery services can potentially free up women's time from domestic chores (e.g., food preparation) significantly and give them the freedom to choose whether to work outside their homes or stay at home. In this manner, food delivery platforms can enable women with a higher willingness to work to join the labor market and thereby increase the overall female employment rate.

Third, employment data are readily available for analysis because South Korea conducts nationwide employment surveys and publishes the statistics online. We consolidate a longitudinal data set of regional quarterly employment information covering the period from 2009 to 2017. We also collect regional quarterly population statistics (e.g., migration, birth, death, marriage, divorce) and regional economic indicators (e.g., GDP, consumer price index (CPI), consumption). Importantly, a large fraction of such employment and population data are stratified by gender.

Our results show that employment, especially female employment, in South Korea increased significantly following the entry of an online food delivery platform. Half a year later, the total employment rate had increased by 4.8%, whereas the male employment rate had not been affected by the entry of the platform. In contrast, the female employment rate rose by a significant 6.5%. The income generated by these newly employed women accounted for 0.27% of South Korea's total annual GDP, whereas the platform's sales represented only 0.016% of the total GDP.

To investigate the mechanisms that underlie this increase in the female employment rate, we first rule out the possibility of the impact of policy implementation on female employment. We then find that the increased number of employed women was driven by more women joining the labor force. We find a significant increase of 6.3% in female labor force participation. We then discover that the increased female labor force participation rate was driven by a lower degree of participation in household chores by women during our sample period. We find that women in South Korea significantly reduced their participation in household chores after the entry of the food delivery platform, whereas there was no such change for men. In addition, we show that the time women spent on meal preparation indeed decreased and rule out the possibility that women came to spend less time on other types of household chores. We further show that there was no shock from other business platforms that served to relieve women from household chores during this time period. Rather, we find that women spent even more time on other household chores (e.g., cleaning and organizing) during our sample period. These results suggest that technology-induced time savings reduced women's need to stay at home and attend to food preparation and thus enabled more women to choose their own lifestyles (working vs. staying at home). In this way, the platform's entry served to increase the female employment rate.

Furthermore, we analyze the impact of the online food delivery platform on occupations, working hours, and employment status. The results show that the platform increased the employment rates of service workers. In addition, the number of people whose weekly working hours ranged from 15 to 35 hours, temporary employees, and daily workers increased significantly with the introduction of the food delivery platform. Moreover, we discuss the impact of the food delivery platform on labor demand and show that our results hold even after excluding employment in the food and beverage industries.

We then conduct various tests to rule out alternative explanations and potential confounding factors, including shocks from other industries (e.g., childcare, ride-sharing platforms, microjob platforms, or freelancer platforms), changes in dietary habits, the adoption of mobile devices or mobile Internet, and the impact from economic trends. We also conduct a series of robustness checks to alleviate concerns of reverse causality, serial correlation in the standard errors, provincial differences in the platform's economic trajectory, and the effect of market entry by other food delivery platforms. We further conduct additional tests related to the heterogeneous treatment effect, city- and county-level analysis, and alternative dependent variables. The results are consistent and are displayed in the Appendix.

Our paper makes the following contributions to the field. First, it adds to our knowledge on the externalities of new technology-driven digital goods and services (Gentzkow et al. 2011, Chan and Ghose 2014, Burtch et al. 2018, Allcott et al. 2020). We place a fresh emphasis on the positive externalities of new technology-driven goods and services on both the labor market and economy. Our results suggest that the indirect benefits of an increased female employment rate are several orders of magnitude greater than the direct benefits of the revenue generated by such technology-enabled platforms. Second, we identify a different approach to promote female labor force participation. Our findings suggest that we can achieve it by supporting individual households and enabling more freedom for women with the help of IT-enabled new business models. We find that the time savings enabled by such business models helped remove the constraints faced by housewives, thereby enabling them to choose their own lifestyles (working vs. staying at home). Third, previous information system (IS) literature shows mixed findings regarding the relationship between technology development and employment. This paper improves our understanding of the topic by showing that the net effect of new technology on the aggregate-level employment rate can be positive in an economy-wide manner.

Below, we first introduce the literature regarding the impact of technology on the labor market. We then discuss the background of female labor force participation and food delivery platforms. We next describe the data used and our empirical strategy. Then, we report the main results, the economic impact, and the mechanism underlying it and conduct additional analysis. Next, we rule out alternative explanations and potential confounding factors. Finally, we conclude with a discussion.

2. Literature Review
2.1. Effect of Technology on the Labor Market
There is vigorous debate concerning whether technological advancement will lead to mass layoffs and a jobless society because advanced machines have the potential to replace workers and lower wages, resulting in unemployment. John Maynard Keynes coined the term "technological unemployment" in his 1930 essay to refer to the disappearance of jobs as a result of technological progress (Keynes 2010). Other economists, however, have held different perspectives. They claim that technology is likely to increase employment on both the demand and supply sides. From the demand side, technology can change the business structure and alter the ways in which firms conduct business. New jobs will emerge, and obsolete jobs will die out. Technological advancement can also create tremendous opportunities on the supply side. For example, the Industrial Revolution has long been regarded as a vital historical turning point in the working lives of women. Prior to industrialization, women were often confined to traditional

household jobs such as cooking, mending clothes, and raising children. After the Industrial Revolution, women began to leave their houses and join the labor force (Berg and Hudson 1992).

The ongoing development of technology creates various new business models (e.g., social media, gig economy, e-marketing, cloud computing), which directly generate thousands of new jobs in fields such as marketing, strategic and operations management, and information systems (Laudon and Traver 2016). In addition to these direct jobs, technology also exerts a spillover effect on the labor market. Hathaway and Kallerman (2012) showed that technology creates far more indirect jobs than any other industry. In addition to creating new jobs, technological advances can increase the labor force supply by making people's daily lives easier and sparing them from household chores. For example, Dinkelman (2011) showed that electronic labor-saving technology developed to perform household chores enables households to supply more female labor to the market.

Drawing on the literature regarding new home economics (Becker 1965, Michael and Becker 1973, Berk 1980), a household can be seen as a small factory that both produces and consumes goods (e.g., food) and services (e.g., childcare), with household members seeking to maximize their utility. The production process requires inputs of time and raw materials and is subject to household income constraints, opportunity costs, and production technology. This framework implies that the time allocated for any activity conducted at home depends on the value of both the time and the activity. For some families, as the means of obtaining meals changes from cooking at home or phone-based delivery to online food delivery platforms, the time they spent on preparing meals is reduced, and the opportunity costs of cooking at home become higher. Therefore, a substitution effect may occur as people shift their time from cooking to more valuable activities (e.g., joining the labor force). Therefore, some housewives may allocate their time to activities that they believe are more valuable (e.g., outside employment). At the same time, for some women, the utility of staying at home can be higher than that of joining the workforce. Under this context, the convenience brought about by online food delivery platforms may decrease female labor force participation rates. Thus, whether online food delivery platforms increase or decrease employment rates remains an open question.

2.2. IS Studies on the Impact of IT on the Labor Market

Table 1 summarizes the IS literature regarding the impact of IT on the labor market. These papers are presented chronologically to reveal the general transition of research topics.

Some of these papers examine how IT investment (Brynjolfsson et al. 1994), IT use (Im et al. 2013, Atasoy

et al. 2016), and IT training (Mehra et al. 2014) relate to the labor market at the firm level. The remaining studies analyze how new technology, that is, Internet communities (Huang and Zhang 2016), online social networks (Garg and Telang 2017), enterprise systems (Greenwood et al. 2019), IT skills (Atasoy et al. 2021), and social media platforms (Chen et al. 2021), affects the labor market at the individual level. These studies focus on sample firms or sample individuals but fail to explore the role of technology in economy-wide or society-level employment. We aim to fill this gap by studying the effect of technology on aggregate-level employment using official employment statistics.

In addition, empirical evidence concerning the effect of technology on employment is mixed at both the firm and individual levels, implying that technology development can either increase or decrease employment. At the firm level, Brynjolfsson et al. (1994) and Im et al. (2013) found that greater IT investment and greater IT use reduce the number of employees because of a labor substitution effect. In contrast, Mehra et al. (2014) and Atasoy et al. (2016) found that more IT training and IT use result in a greater number of employees because technology creates more job opportunities. At the individual level, some researchers have found that social media platforms (Chen et al. 2021) and IT skills (Atasoy et al. 2021) lead to better job market outcomes such as increased job candidate performance. However, others have found that the new technology has mixed impacts on the labor market based on the characteristics of the specific technology. Huang and Zhang (2016) found that contributions to online knowledge communities increase the probability of job-hopping, whereas learning from online knowledge communities increases the probability of retention. In the context of online social networks, Garg and Telang (2017) found that strong social ties improve job search outcomes, whereas weak social ties have no effect. Moreover, Greenwood et al. (2019) suggested that complementary enterprise systems reduce the likelihood of job change, whereas noncomplementary technology increases the level of job mobility. Although it is abundantly clear that technology enhances convenience, it remains unclear whether it increases or decreases employment rates. Our study contributes to this stream of IS research by examining the net effect of new technology, that is, the impact of online food delivery platforms on the labor market at the societal level.

In summary, our paper contributes to the IS literature in two ways. First, the existing studies focus on either the firm or individual level. The data used are taken from sample firms or sample individuals who have adopted the corresponding technologies. However, our paper leverages official employment data and analyzes research questions at the societal level. Second, previous empirical evidence on the effect of IT on the labor market is mixed. The adoption of new technologies can either

Table 1. Information Systems Studies on the Impact of Information Technology (IT) on the Labor Market

Study	Unit of analysis	Independent variable	Outcome variable	Relationship
Brynjolfsson et al. (1994)	Firm	IT investment	Number of employees	Negative
Im et al. (2013)	Firm	IT use	Number of employees	Negative
Mehra et al. (2014)	Firm	IT training	Number of employees	Positive
Atasoy et al. (2016)	Firm	IT use	Number of employees	Positive
Huang and Zhang (2016)	Individual	Internet communities	Job-hopping and retention	Mixed
Garg and Telang (2017)	Individual	Online social network	Job search outcome	Mixed
Greenwood et al. (2019)	Individual	Enterprise systems	Job change	Mixed
Atasoy et al. (2021)	Individual	IT skills	Employment	Positive
Chen et al. (2021)	Individual	Social media	Employment	Positive

increase or decrease employment. We show that the net effect of new technology on employment is positive for women but not significant for men.

2.3. IS Studies on Digital Platforms
Academic research on digital platforms has advanced along a variety of fronts, covering topics that include the adoption, diffusion and usage of digital platforms (see, e.g., Davis 1989, Zhang and Zhu 2011, Catalini and Tucker 2017, and Wang et al. 2018), the design and governance of digital platforms (see, e.g., Oh and Lucas Jr. 2006, Animesh et al. 2011, Ghose et al. 2019, Cui et al. 2020, Kim et al. 2022, Wang et al. 2022), and the broader economic and societal effects of digital platforms (see, e.g., Chan and Ghose 2014, Greenwood and Agarwal 2016, Greenwood and Wattal 2017, Burtch et al. 2018, Chan et al. 2019, Allcott et al. 2020, Park et al. 2021, Han et al. 2021, Wang and Overby 2022). This research area has drawn increasing attention over the past several years.

Scholars have also studied the various economic and societal impacts of digital platforms. One such category is the influence of digital platforms on diseases and crime in society. For example, research has shown that the online personal ad site Craigslist increased HIV cases by 15.9% (Chan and Ghose 2014, Greenwood and Agarwal 2016) and prostitution cases by 17.58% (Chan et al. 2019). Moreover, researchers have documented that the home-sharing platform Airbnb leads to an increase in crime incidences (Han et al. 2021). In contrast, the ridesharing platform Uber is found to decrease alcohol-related motor vehicle fatalities (Greenwood and Wattal 2017) and sexual assault cases (Park et al. 2021). Another such category is the financial impact of digital platforms. For instance, Xu and Zhang (2013) found that Wikipedia improves the information environment of the financial market. Chen et al. (2014) revealed that opinions on the social media platform Seeking Alpha can be used to effectively predict future stock returns and earnings surprises. Wang and Overby (2022) showed that the peer-to-peer lending platform Lending Club increases bankruptcy filings. In addition to the health, crime, and financial impacts of digital platforms, other researchers have investigated how digital platforms affect entrepreneurial activities

(Burtch et al. 2018), public transit use (Babar and Burtch 2020), subjective well-being (Allcott et al. 2020), etc. Our paper contributes to the literature on the economic and societal effects of digital platforms by studying the influence of online food delivery platforms on the labor market, which are relatively underexplored in the literature.

3. Background
3.1. Female Employment
Housewives create great value for both their families and society. On the other hand, female employment exerts a significantly positive impact on both economic development and social welfare. Eckstein and Lifshitz (2011) found that increasing female employment contributed to a 2.12% annual growth rate in the U.S. GDP per capita in 1964. Using a simple Solow-style calculation, the increase in female employment accounted for 16% of the U.S. GDP per capita during the period ranging from 1964 to 2007. Hsieh et al. (2019) showed that approximately 15% of growth in U.S. GDP per capita can be attributed to the reduction in occupational barriers faced by women in the country that occurred from 1960 to 2010.

Aside from the economic impact, increasing female employment also benefits social welfare in the following aspects. First, it improves company performance. Inagami (2007), for example, showed that companies with a high degree of gender equality perform better than other companies in the same industry in terms of sales, profit, and productivity. Second, it benefits the next generation. Jensen (2012) found that households invest more in the health and education of their children when female earnings increase. Third, it enhances women's empowerment. Jensen (2012) and Majlesi (2016) showed that women paid for work outside their homes have a greater "voice" at home and stronger presence in society.

These benefits make the increase in the female labor force participation rate particularly important in developed economies because they have both aging and shrinking population issues (Elborgh-Woytek et al. 2013). Many countries have implemented policies that aim to reduce the barriers to female labor force entry. For example, the South Korean government has implemented various policies

since 1995 to improve female labor force participation (Table S1 in the online appendix) and address its huge gender inequality problem.[6] Despite these efforts, South Korea ranked 127th out of 153 countries on the Global Gender Gap Index in 2020 because its female labor force participation rate (approximately 50% at the time) was still very low. South Korea also suffers from the largest gender wage gap among the OECD countries. Note that during the period when online food delivery platforms were being introduced in a staggered manner (2010–2014) across South Korea, no influential policies regarding female employment had been implemented. Moreover, such policies have been adopted nationwide with no variation in policy adoption across provinces. Thus, our results are unlikely to be driven by a specific policy change during our sample period.

One crucial factor that prevents South Korean women from entering the labor market may be the burden of household chores. The official *Economically Active Population Survey* conducted by Statistics Korea[7] in 2009 reports that 52% of the country's economically inactive female population (those who are above the working age of 15 years but are neither employed nor actively seeking a job) largely perform household chores, followed by attending school (19%) and performing childcare duties (16%).[8] The Statistics Korea 2009 *Time Use Survey* also investigated the time spent by women on household chores, and the majority of such time (52.3%) was devoted to food preparation.[9] Note that the time spent on food preparation was twice that spent on family care.[10] These data suggest that cooking responsibilities are the strongest barrier preventing South Korean women who want to work outside their homes from doing so. These statistics also indicate that if technology can ease the household chores or food preparation burdens of women, then more women will escape from their kitchens and enjoy the freedom of living their lives in a manner of their choosing, and some of them may choose to join the labor force.

3.2. Online Food Delivery Platforms

In recent years, the advancement of digital technology has reshaped the food delivery industry and introduced a new channel through which food can be ordered during the daily lives of residents. These new platforms enable consumers to compare menus and prices from a wide range of restaurants. Users can check these restaurants' ratings and browse the reviews left by previous consumers and then order food on a unified interface through a single click. In addition, online food delivery platforms often develop logistic networks, thus removing the need for individual restaurants to build their own food delivery infrastructure, such as procuring delivery vehicles and personnel. These advances have overturned the conventional business models of food delivery.

Given that conventional offline channels have provided food delivery services for several decades, the question remains as to what sets online food delivery platforms apart? Drawing on the notion of channel capabilities (Avery et al. 2012), we identify four unique benefits that distinguish food delivery platforms from conventional offline channels, which comprise phone-based food delivery services or the offline purchasing of prepackaged meals.

The first benefit of online food delivery platforms is their lower search costs (Brynjolfsson and Smith 2000). The technical characteristics of the Internet that lower consumer search costs are compared with those of phone-based orders (Bakos 1997) through two channels. First, online food delivery platforms reduce the incremental costs of obtaining restaurant information. For example, if people want to try a new restaurant, then they must make an effort to find and retain new information related to that restaurant (e.g., menu, pricing, address). However, with online food delivery platforms, users do not need to seek out any information about restaurants because the platforms gather and list all the essential information for consumers. Second, online food delivery platforms provide customers with easy access to a wide variety of restaurants and the means of comparing prices and food. It is much easier to obtain pricing and product information from online platforms than by phone. Therefore, online food delivery platforms significantly reduce consumer search costs.

In addition to low search costs, another unique characteristic of online food delivery platforms is low entry and operational costs (Brynjolfsson and Smith 2000). In the absence of online food delivery platforms, restaurants have to build their own food delivery infrastructure (e.g., delivery cars, delivery people, and delivery packages) to deliver food, and thus, not all restaurants have the capability to offer food delivery services. Food delivery platforms, however, enable nearly all restaurants to enter the delivery market because restaurants can leverage the delivery infrastructure offered by the platforms. The economies of scale reduce the costs of shared delivery infrastructure for each restaurant, thus motivating them to join the platforms.

Third, the consumption choice sets for users that are provided by online food delivery platforms are much larger than those provided by phone-based food delivery services. Because lower entry costs increase the entry of restaurants into the delivery market (Salop 1979), online food delivery platforms aggregate information on a variety of restaurants in the market. Customers can then gather information on many more restaurants than they could by phone. Specifically, through online food delivery platforms, people can order food from restaurants located far away from their residence and from restaurants that offer niche foods. Thus, the consumption choice sets that are provided by online food delivery

platforms are significantly larger than those of other food delivery mechanisms.

Last, online reviews and ratings provided by online food delivery platforms decrease the customer costs of differentiating among products and restaurants (Pavlou and Dimoka 2006). Such feedback conveys useful reputational information about the restaurant's prior transactions that cannot be captured by phone-based orders. Therefore, online reviews and ratings made available through online food delivery platforms help build trust among users.

These unique channel capabilities have increased the user base of online food delivery services at an extraordinary speed, with the industry having received more than $30 billion in investments between 2014 and 2019.[11] The global online food delivery services market was valued at $23 billion in 2018 and is expected to reach $200 billion by 2025.[12] South Korea is estimated to be the world's fourth-largest market for online food delivery services, with an estimated market size of $6 billion as of 2019. TrendMonitor documents reveal that 73.4% of South Koreans report having used a food delivery app. Many such apps have emerged since 2010; Baedal Minjok (Baemin), the earliest online food delivery platform introduced in South Korea, occupies a 55% share of the market, with the remainder split between Yogiyo (34%) and Baedaltong (10%). Baemin's monthly user number reached 10 million in 2019, which accounted for approximately one-fifth of the total population of the country; the app processed 29 million monthly orders in 2019, with sales reaching $260 million in 2018, constituting 0.016% of South Korea's total GDP. In addition to considering the largest online food delivery platform (Baemin) in our main analysis, we also conduct a robustness check that uses the entry times of all of the platforms in the market. The results are consistent with that of the main analysis, as reported in Table S24 in the online appendix.

4. Methods
4.1. Data and Descriptive Statistics
To empirically assess Baemin's impact on the labor market, we first construct a panel data set of quarterly province-level aggregate variables over eight years, that is, 2009–2017 (Table S2 in the online appendix).[13] We then collect the platform's different entry (*entry*) dates in each province (Table 2). This section offers an overview of the data sources, variable definitions, and summary statistics.

In South Korea, provinces are the first-level divisions within the country (similar to states in the United States). There are eight "normal" provinces and one special autonomous province: Gyeonggi-do, Gyeongsangbuk-do, Gyeongsangnam-do, Jeollabuk-do, Jeollanam-do, Chungcheongbuk-do, Chungcheongnam-do, Gangwon-do, and Jeju Special Self-Governing Province. We do not

Table 2. Baemin's Entry by Province

Province	Entry
Gyeonggi-do	September 2010
Gyeongsangnam-do	February 2014
Jeollabuk-do	April 2014
Gyeongsangbuk-do	May 2014
Chungcheongnam-do	June 2014
Chungcheongbuk-do	August 2014
Gangwon-do	September 2014
Jeollanam-do	December 2014

include Jeju in our analysis because this island is very different from the other eight provinces. The Association of North East Asia Regional Governments reports that because of the island's geographic isolation, the people in Jeju have developed their own culture, language, and customs, and they are quite different from those of mainland South Korea. In addition, tourism contributes to a significant proportion of Jeju's economy, and the province houses only a few other industries, such as agriculture and fishing, which makes the economic structure very different from that of the other eight provinces. South Korea also contains megacities such as Seoul and Busan that do not belong to any of the provinces. For ease of comparison, we exclude these megacities because their areas, population growth, and economic development are markedly different from those of the provinces.[14] In the following analysis, we focus only on the eight normal provinces.[15]

The province-level variables are obtained from Statistics Korea's data portal, the Korean Statistical Information Services (KOSIS; http://kosis.kr/eng/index/index.do). KOSIS is a central government organization that regularly publishes national and regional statistics. The employment statistics are collected from the *Economically Active Population Survey*,[16] which is conducted by Statistics Korea. In our main analysis, the dependent variable is *employment rate* (total, male, and female), which is defined as the ratio of the employed population to the working-age population. KOSIS defines employed people as "people of 15 years or older who (i) work for 1 hour or longer per week to earn income, (ii) work for 18 hours or longer per week with no pay for a business or farm run by a household member (unpaid family worker), and (iii) can resume work once the causes that prevent them from working, such as temporary diseases, accidents, leave, and education, are resolved (taking absence temporarily)." Based on this definition, employment includes full-time, part-time, and self-employed workers. We also collect a range of other regional variables representing the provinces' population characteristics (net immigration, births, deaths, marriages, divorces, and age at first marriage), economic growth factors (GDP, consumption, and CPI), and education levels (the number of people who hold a university degree or

above). Most variables are provided on a quarterly basis, except for regional GDP and consumption data, which are collected annually. Table S3 in the online appendix reports the summary statistics of the data, which show that the employment rates for women are much lower than those for men.

To assess the effects of platform entry, it is necessary to determine the entry time of the online food delivery platforms. On the national level, we were able to obtain the exact entry dates. At the province level, we supplemented the platforms' official website announcements with Google Trends data.[17] The online food delivery platform that we mainly focus on is Baemin (배달의 민족 in Korean) because it is the first and largest food delivery platform in South Korea (with the largest market share). Later, we also conduct a robustness check that used the entry time of the top three food delivery platforms in South Korea; in aggregate, these platforms occupied more than 99% of the market share during our analysis period. Official websites and other public information report the entry time of online food delivery platforms in South Korea at the national level. The actual entry times of these platforms are exactly the same as the entry dates inferred from the Google Trends Index.[18] Thus, we further infer the provincial entry times by using the Google Trends Index. Table 2 shows that the platform entered most of the provinces during different months in 2014, but in Gyeonggi-do, its first entry happened in 2010.

4.2. Econometric Specification

Some may argue that a food delivery platform cannot randomly enter different provinces because the features of a particular location (e.g., GDP, consumption, population) can affect entry decisions. Ignoring this aspect and conducting a simple DID can lead to misspecifications (Wolfers 2006). We take several measures to safeguard against possible misspecifications. First and most importantly, we employ a leads-and-lags DID model (Autor 2003, Wolfers 2006, Gentzkow et al. 2011, Burtch et al. 2018) to evaluate the parallel-trends assumption and validate our estimates. Because the platform entered different provinces at different time points, this model allows us to use observational data to conduct a quasi-experiment. Therefore, we can compare the untreated provinces (in which the food delivery platform has not yet entered) as controls for the treated provinces. The longitudinal nature of the data allows us to test whether the parallel pretreatment trend assumption holds for employment. Thus, we can examine whether our untreated provinces can serve as valid controls. The parallel pretreatment ensures that untreated provinces can be used as valid controls for treated provinces. Second, we include quarter-fixed effects and province-specific fixed effects to control seasonality and any time-invariant unobserved factors that can be used to characterize specific locations. Third, we control the time-varying

characteristics of the local economy such as GDP, CPI, consumption, and education levels. Finally, we conduct various robustness checks.

Our unit of analysis is province-quarter. The model specification is shown in Equation (1). Our main dependent variables $Y_{i,t}$ are *employment rates* in province i during quarter t. The independent variables of interest are a set of time dummies $\phi_{i,t}$, which indicate the chronological distance j with respect to the time of entry of the online food delivery platform into province i. The time dummy variable equals 1 if the time period between quarter t and the quarter in which the online food delivery platform enters province i is $\frac{j}{2}$ years.[19] This model allows us to intuitively observe employment trends and capture the relative differences before and after treatment (online food delivery platform entry) for both the treated and control provinces. Following previous studies (Burtch et al. 2018, Cheng et al. 2020), we use the time just before entry as the baseline. The reference time of the model is 0–0.5 years prior to treatment. We collapse all of the pretreatment periods greater than three years before treatment into one dummy and all of the posttreatment periods greater than three years after treatment into another dummy. The treatment effects relative to the reference time are captured by β_j:

$$Y_{i,t} = \sum_j \beta_j(\phi_{i,t}) + \alpha_i + \tau_t + X_{i,t} + \epsilon_{i,t} \qquad (1)$$

In addition to the province fixed effect α_i and quarter fixed effect τ_t mentioned above, we include a set of control variables $X_{i,t}$ that might affect employment, which can be further classified into three categories. First, we include population-related control variables. Migration between provinces can affect employment (Dinkelman 2011), so we include the quarterly net migration for province i at time t, which is defined as the number of people who move into the province less the people who leave. We also include the number of births and deaths in a province to control for the change in population and family fertility decisions (Hyslop 1999). In addition, people's decisions to work are closely related to whether and when they marry, when they give birth, and whether they are divorced (Hyslop 1999, Goldin and Katz 2000, Jensen 2012, Greenwood et al. 2016). Therefore, we also include the number of marriages, number of divorces, mean age of women at first marriage, and mean age of men at first marriage as control variables. Second, we include economy-related variables that can control the time-varying characteristics of the local economy, such as regional GDP, CPI, and the level of private consumption. Wages also play a role in people's decisions to join the workforce. However, South Korea does not provide regional wage information. To control the possible effects of wages, we include private consumption as a control variable because it is strongly correlated with people's earnings. Additionally, a minimum wage

policy applies nationwide in South Korea, with no regional variations. This policy narrows the level of variation in people's wages across different provinces to a certain extent, thereby reducing the impact of wages on the decision to work. Third, we control education factors by including the number of people who have received university degrees or higher, which is another factor that influences people's employment decisions (Eckstein and Lifshitz 2011, Guvenen and Rendall 2015, Greenwood et al. 2016).

Note that we use a generalized linear model (GLM) for the employment rate, which is a fractional variable that ranges from 0 to 1, with a binomial link function. In this manner, the exponential forms of the coefficients e^{β_j} for the employment rate represent the ratio between the difference in employment rate and difference in reference time.

5. Results
5.1. Main Results
Table 3 reports our main findings. The estimated effects of the online food delivery platform's entry on the female employment rate are significantly positive, whereas the effects are not significant for the male employment rate. Table 3 shows the results of the estimated coefficients, significance levels, and robust standard errors after executing the DID estimation with leads and lags, as proposed by Autor (2003). We incorporate pre-entry and post-entry dummies into our leads-and-lags DID model to observe the relative effects before and after platform entry (treatment) on a six-month basis. We also conduct robustness checks on a quarterly and yearly basis, as shown in Tables S4 and S5 in the online appendix. The results remain consistent.

Columns (1)–(3) represent the effect of the online food delivery platform on the employment rate, which is defined as the ratio of the number of employed people to the working-age population. Row (7) displays the results for six months before platform entry, with its employment rate level set as a reference and omitted from regressions. We choose the reference time period based on previous studies (Burtch et al. 2018, Cheng et al. 2020). Leads-and-lags estimators represent the relative effects of platform entry on the employment rate compared with that at the reference time. Rows (1)–(6) show the estimates of the effect before platform entry. None of the coefficients from rows (1)–(6) are statistically significant, indicating that the parallel pretreatment trend holds and that platform entry was not correlated with previous labor market conditions.

Rows (8)–(14) show the estimates of the impact of the entry of the online food delivery platform on the labor market. The posttreatment trends in columns (1)–(3) indicate that platform entry had a statistically significant positive effect on both the total employment and female

Table 3. Online Food Delivery Platform's Impact on Employment Rate

	Employment rate		
	Total (1)	Male (2)	Female (3)
Pre-entry (≤3 years)	−0.008	−0.039	0.014
	(0.059)	(0.085)	(0.067)
Pre-entry (2.5–3 years)	0.027	0.003	0.046
	(0.064)	(0.083)	(0.071)
Pre-entry (2–2.5 years)	0.013	−0.008	0.030
	(0.049)	(0.074)	(0.054)
Pre-entry (1.5–2 years)	0.039	0.024	0.053
	(0.032)	(0.038)	(0.046)
Pre-entry (1–1.5 years)	−0.002	−0.023	0.013
	(0.022)	(0.029)	(0.028)
Pre-entry (0.5–1 years)	0.019	0.007	0.030
	(0.020)	(0.019)	(0.029)
Pre-entry (0–0.5 years)	Baseline of dummy		
Entry (0–0.5 years)	0.047**	0.033	0.063***
	(0.018)	(0.033)	(0.016)
Post-entry (0.5–1 years)	0.033	0.016	0.049*
	(0.028)	(0.042)	(0.023)
Post-entry (1–1.5 years)	0.064**	0.052	0.082***
	(0.023)	(0.030)	(0.023)
Post-entry (1.5–2 years)	0.049*	0.021	0.079***
	(0.021)	(0.029)	(0.023)
Post-entry (2–2.5 years)	0.077**	0.055	0.104**
	(0.025)	(0.030)	(0.034)
Post-entry (2.5–3 years)	0.081***	0.049	0.117***
	(0.023)	(0.048)	(0.029)
Post-entry (≥3 years)	0.152**	0.108	0.210***
	(0.055)	(0.091)	(0.046)
Time fixed effect	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes
Control variables	Yes	Yes	Yes
Observations	256	256	256
Adjusted R^2	0.8904	0.8752	0.886

Notes. The dependent variables are employment rate by gender. The control variables are birth rate, death rate, marriage rate, divorce rate, net migration rate, GDP rate, consumption rate, consumer price index (CPI), university rate, wife's age, and husband's age. The models are obtained from a generalized linear model (GLM) regression. Robust standard errors are displayed in parentheses and clustered at the province level.

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

employment rates but no significant impact on the male employment rate. Moreover, the female employment rate benefited immediately following platform entry. Because of this short-term relative effect, six months after entry the female employment rate was 1.065 (i.e., $e^{0.063}$) times the female employment rate six months before entry, and the total employment rate was 1.048 (i.e., $e^{0.047}$) times the total employment rate at the reference time. Therefore, the female employment rate increased by 6.5%, and the total employment rate increased by 4.8% six months after the entry of the online food delivery platform. Platform entry also positively affected female employment and total employment rates over longer time periods. However, it did not significantly improve the male employment rate.

Figure 1 is a graphical representation of the female employment rate as shown in column (3) of Table 3. The x-axis shows the time points relative to the entry of the online food delivery platform in years, and the y-axis represents the relative effect of platform entry on the female employment rate compared with that at the reference time. The presence of black dots above the line $y = 1$ indicates that the female employment rate has increased with respect to that at the reference time. The black dashed line around the dots indicates the 95% confidence interval. This figure shows that before platform entry, the female employment rate was stable and did not change. Afterward, the female employment rate increased significantly.

There is a concern that the difference in entry time between Gyeonggi-do and that of other provinces is large and that our leads-and-lags DID may capture other effects that increased the female employment rate during this period. To alleviate this concern, we conduct a simple DID (with a dummy representing province entry) with provinces whose entry times was 2014 only; the results are displayed in Table S25 in the online appendix in the robustness check section. The simple DID shows that the female employment rate increased by 6% within a single year, which is consistent with the magnitude reported in Table 3, column (3).

5.2. Economic Impact

The increase in employment because of the online food delivery platform contributes greatly to economic growth. The income generated by these new female employees accounted for at least 0.27% of the total GDP,[20] whereas Baemin's sales accounted for only 0.016% of the total GDP. The vast difference between these two values suggests that Baemin exerts substantial positive externalities for society, with the newly generated female employment directly contributing 17 times the annual GDP created by the platform. Such indirect benefits and value of online food delivery platforms had previously been largely unaccounted for. As a comparison, the government surplus of South Korea in 2017 was 1.4% of GDP.

Broadly speaking, these results provide strong and significant evidence for the positive impact exerted by the entry of online food delivery platforms on local labor markets and economic growth. Specifically, such entry significantly increased female employment numbers and rates. This increased employment exerts a strong positive externality for economic growth.

5.3. Mechanism

After establishing the main results, we identify the mechanism underlying the observed effect. We formally test whether the increase in the employment rate is driven by the fresh employment of people who were not in the labor force in the past. Then, we analyze the effect of online food delivery platforms on the principal activities of people's daily lives. This helps us to confirm that the online food delivery platform relieves women from certain household chores. Finally, we calculate the change in the amount of time women spent on meal preparation and other household chores during our analysis period. We rule out the possibility that other business models that outsource other types of household chores (e.g., laundry, cleaning, and organizing) serve to free up women's time as well.

5.3.1. Why Does the Employment Rate Increase? In this section, we provide a formal analysis of whether the increase in the female employment rate is indeed driven by the entry of previously economically inactive people joining the labor force. The data shown in Table 4 answer this question. The dependent variables are the labor force participation rates. The participation rate measures the percentage of people who participate in the labor force

Figure 1. (Color online) Effect of the Online Food Delivery Platform on Female Employment Rate
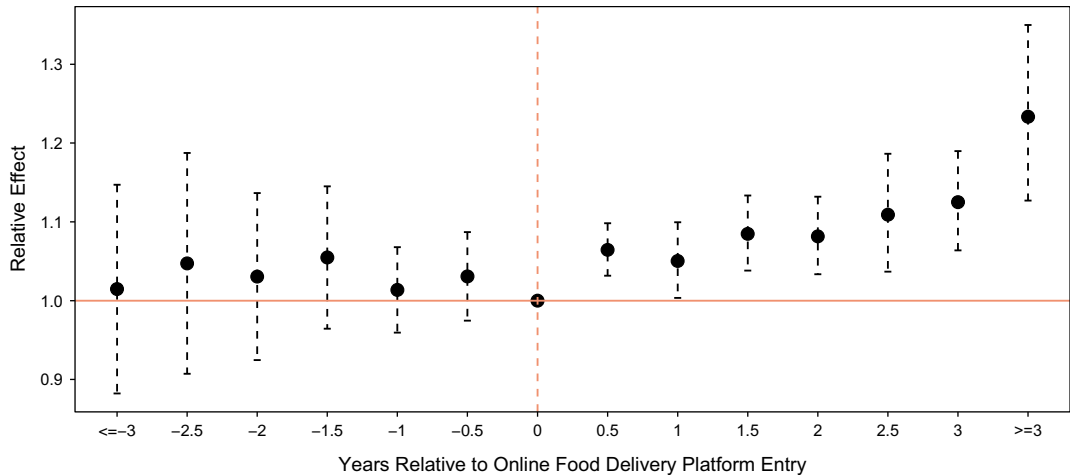
Table 4. Online Food Delivery Platform's Impact on Participation Rate

	Participation rate		
	Total (1)	Male (2)	Female (3)
Pre-entry (≤3 years)	0.006	−0.016	0.022
	(0.054)	(0.086)	(0.064)
Pre-entry (2.5–3 years)	0.036	0.019	0.051
	(0.057)	(0.075)	(0.068)
Pre-entry (2–2.5 years)	0.025	0.009	0.038
	(0.049)	(0.075)	(0.056)
Pre-entry (1.5–2 years)	0.046	0.035	0.058
	(0.031)	(0.041)	(0.044)
Pre-entry (1–1.5 years)	0.003	−0.017	0.017
	(0.025)	(0.034)	(0.028)
Pre-entry (0.5–1 years)	0.020	0.007	0.030
	(0.019)	(0.015)	(0.029)
Pre-entry (0–0.5 years)	Baseline of dummy		
Entry (0–0.5 years)	0.044*	0.027	0.061***
	(0.019)	(0.035)	(0.016)
Post-entry (0.5–1 years)	0.027	0.005	0.045
	(0.032)	(0.048)	(0.028)
Post-entry (1–1.5 years)	0.063*	0.060	0.072**
	(0.026)	(0.033)	(0.026)
Post-entry (1.5–2 years)	0.045	0.018	0.072**
	(0.024)	(0.033)	(0.026)
Post-entry (2–2.5 years)	0.066**	0.033	0.098**
	(0.023)	(0.026)	(0.034)
Post-entry (2.5–3 years)	0.057*	0.003	0.108**
	(0.022)	(0.039)	(0.037)
Post-entry (≥3 years)	0.126*	0.060	0.196***
	(0.049)	(0.085)	(0.044)
Time fixed effect	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes
Control variables	Yes	Yes	Yes
Observations	256	256	256
Adjusted R^2	0.9007	0.9039	0.8802

Notes. The dependent variables are participation rate by gender. The control variables are birth rate, death rate, marriage rate, divorce rate, net migration rate, GDP rate, consumption rate, consumer price index (CPI), university rate, wife's age, and husband's age. The models are obtained from a generalized linear model (GLM) regression. Robust standard errors are displayed in parentheses and clustered at the province level.

   *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

as either working or actively looking for jobs but have not yet been employed. We further examine how this effect varies by gender.

We observe that both the total and female participation rates significantly increased immediately after the online food delivery platform entered a province, whereas the male participation rate remained unaffected. Half a year after platform entry, the female participation rate increased by 6.29%. Recall that the female employment rate increased by approximately 6.5% (Table 3, column (3)), which indicates that most of the increase in the female employment rate came from the increase in the female participation rate. Figure 2 presents a graphical representation of the results displayed in Table 4. The x-axis displays the time relative to

online food delivery platform entry in years, the y-axis shows the ratio of the participation rate relative to the reference level, and y = 1 indicates that the participation rate is the same as that when the food delivery platform first entered the province. If y > 1, then the participation rate is higher than that at the time of platform entry and vice versa. The dashed black lines on each dot represent the 95% confidence interval. We can see that the black dots before platform entry are clustered around y = 1. After entry, the female participation rate exhibits a clear increase.

Both Table 4 and Figure 2 suggest that platform entry affected the female participation rate. Therefore, we conclude that the platform-induced increase in the employment rate was driven by a greater number of women who were previously neither employed nor actively seeking jobs prior to platform entry started to actively join the labor force, presumably because online food delivery services had relieved their need to cook at home.

5.3.2. Are Women Relieved of Household Chores by the Entry of Online Food Delivery Platforms? We show that the increase in the female employment rate was driven mainly by the increase in the female participation rate. In this section, we investigate whether women actually reduced their participation in household chores after platform entry.

Because the data from Statistics Korea on the economically inactive population do not include gender information, we also collect data from the Korea Labor and Income Panel Study (KLIPS), which is hosted by the Korea Labor Institute, to examine the behavioral changes in residents (both employed and non-employed) caused by the entry of the online food delivery platform.[21] We use the dummy variable *housework* to indicate employment status, which is set to 1 when a resident's main activity in addition to paid work is household chores. For non-employed individuals, *housework* is set to 1 if a resident's main activity is the performance of household chores.[22] In addition, we collect individual information on residential province, age, level of education, marriage status, possession of social insurance, health status, life satisfaction, family income satisfaction, and family cohabitation status. These variables serve as controls when conducting analyses using KLIPS. The sample consists of 38,970 employed individuals and 28,948 non-employed individuals from eight provinces and covers the period from 2009 to 2017, including 35,508 women and 32,410 men. The variable definition and summary statistics can be found in Tables S6 and S7 in the online appendix.

With KLIPS, we can investigate whether women performed household chores less often after the entry of the online food delivery platform. Table S8 in the online appendix displays the results, which show that the percentage of employed women (column (1)) who perform mainly household chores in addition to working outside

Figure 2. (Color online) Effect of Online Food Delivery Platform on Female Participation Rate
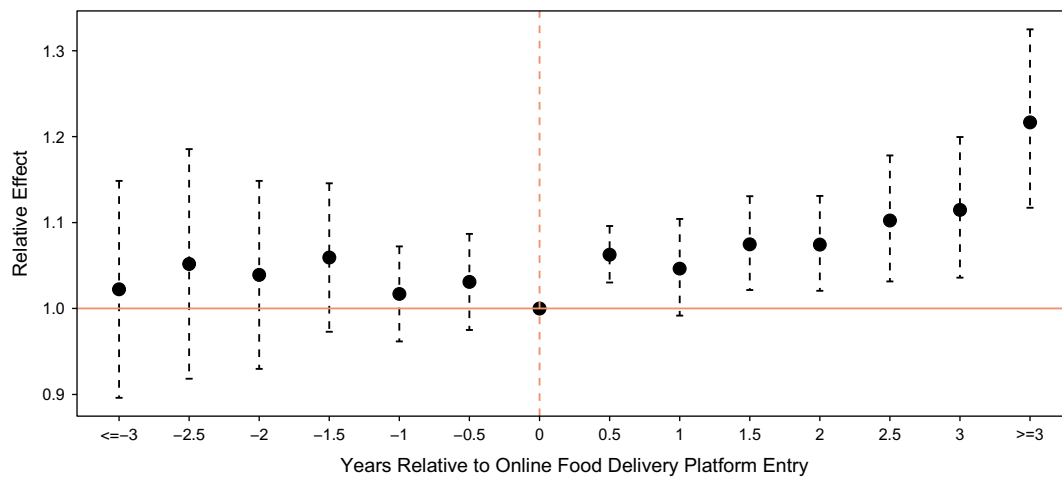
had decreased by 41.61% two years after platform entry. However, the behaviors of employed men (column (3)) did not notably change. In addition, the percentage of non-employed women (column (2)) who consider household chores to be their main activity was significantly reduced by 34.95% two years after platform entry, whereas such an effect was also absent for non-employed men (column (4)). The pre-trend coefficients are not significant, which confirms the validity of our leads-and-lags DID design. These results indicate that fewer women considered household chores their main activity after the emergence of the online food delivery platform. Therefore, we confirm that the entry of the online food delivery platform indeed freed women from performing burdensome household chores.

5.3.3. Has the Time Spent on Cooking Been Reduced for Women? We show that fewer women considered household chores as their main activity following the entry of the online food delivery platform. However, women still generally perform multiple household chores, including laundry, cleaning, and organizing. It is possible that other platforms designed to assist people in their errands and household chores may exist. We alleviate this concern in two ways.

First, home-cleaning services are not popular in South Korea. The founder of Merry Maids, the largest home-cleaning services firm in South Korea, says that the demand for residential cleaning services in South Korea is low because South Koreans are reluctant to request services for such chores, because they are hesitant to allow outsiders into their homes.[23] In addition, households in the highest income bracket (top 10th percentile) are the primary users of home-cleaning services in South Korea. Therefore, the effects of such services on ordinary families and working people are quite limited, and South Koreans tend to rely heavily on family members for cleaning.

Second, we calculate the change in the time allocated for different household chores based on individual data collected from the *Time Use Survey*. Statistics Korea surveyed people regarding the ways that they spent 24 hours during their daily lives in 2009 and 2014 (http://kostat.go.kr/portal/eng/surveyOutline/5/4/index.static). Unfortunately, we cannot conduct a DID analysis with only two years of observation. Therefore, we report only the ordinary least squares regression results using the time spent on different household chores as dependent variables and set a dummy variable indicating the year 2014 as the independent variable. The variable definitions and summary statistics are reported in Tables S6 and S7 in the online appendix. The results for the change in the amount of time spent by people on different household chores are shown in Table S9 in the online appendix.

These results show that the time people spend on meal preparation was significantly reduced for those who lived in regions that had access to the online food delivery platform (column (1)), but the change was not significantly different from zero for those who lived in regions without access to the platform (column (2)). In addition, the reduction in time spent on meal preparation was higher for women (panels A and B) than for men (panels C and D).

Furthermore, the time spent by people on other household chores was either increased or approximately zero, with two notable exceptions being clothing care (columns (5) and (6)) and home repairs (column (8)). The time spent by employed women on clothing care was reduced for women in regions with (column (5)) and without (column (6)) the online food delivery platform; the reduction was greater for regions without access to the online food delivery platform, which suggests that clothing-care-related services do not affect our results. Home repairs refer to activities such as home/equipment repair and vehicle maintenance. We are not concerned that the decrease in

time allocated for home repairs will confound our main findings for two reasons. First, home repairs account for only a small percentage of the time spent by women on household chores (less than 1%). Second, the surveyed items for this specific category changed between 2009 and 2014, and thus the data regarding home repairs may not be comparable between these two years. In contrast, the surveyed items for other household chores were consistent across both years.

In addition, it can be seen that the time spent by women on cleaning and organizing (column (7)) and purchasing goods (column (9)) increased significantly. This increase in time allocation confirms that home-cleaning services did not confound our main results. Actually, the increase in the time costs of these activities may be an obstacle for women and may have reduced their likelihood of joining the labor force, which may offset the increase in the female employment rate resulting from the entry of the online food delivery platform.

Snack preparation refers to the preparing of snacks and emergency food (e.g., stored food); we find that the time spent on snack preparation remained unchanged (column (4)). This result excludes the possibility of women shifting to the consumption of more ready-to-eat food and thereby reducing their cooking time.

Furthermore, we conducted an additional survey (Korean language) on a South Korean survey platform, that is, Surveasy (https://gosurveasy.com/). We successfully collected 182 responses from South Korean females, among which 113 passed the attention-check question. We asked respondents to indicate their level of agreement with the statement "a food delivery platform enables nonworking females to have more time and freedom, which allows them to join the workforce." The survey showed that 35.4% of Korean females either agreed (20/113) or partially agreed (20/113) with the statement. In the survey, we also asked respondents whether they have ever known of a woman who did not have a job previously but started a part-time or a full-time job as a result of the entry of a food delivery platform. A total of 36.3% of respondents answered yes to this question. In addition, respondents could voluntarily share their story with us in the survey. Some respondents said "I'm freed because of food delivery platform," and some reported that their acquaintances were thus freed and subsequently took a part-time job. The results of this survey further support our findings.

In summary, these results suggest that only the time spent on meal preparation was decreased for women as a result of the market entry of the online food delivery platform. Therefore, we eliminate the possibility of other domestic chores confounding our results.

In this section, we investigate the mechanisms underlying our main results. We first show that the increase in the female employment rate was driven mostly by the increase in the female labor force participation rate. We then show that women indeed participated less in household chores following treatment. Finally, we show that among all household chores, only meal preparation saw a reduction in necessary time commitments from 2009 to 2014. In summary, we provide evidence that the online food delivery platform freed women from cooking, thus allowing more women to join the labor force if they intended to do so.

5.4. Additional Analyses

In this section, we go beyond the average effect on female employment and provide a more nuanced picture of the impact of the online food delivery platform on the labor market. Specifically, we investigate the impact of the platform on different occupations, working hours, and types of employment status.

We collect employment statistics for the different occupations, working hours, and types of employment status from KOSIS. The data are available only at an annual level and do not distinguish workers by gender. KOSIS categorizes people into nine occupations (managers, professional and related workers, clerks, service workers, sales workers, skilled agricultural workers, forestry and fishery workers, craft and related trade workers, and equipment, machine operation, and assembly workers, as well as defining elementary occupations).[24] KOSIS also provides employment rates for those whose weekly working hours fall in the ranges of 1–14, 15–35, 36–52, and 53 hours and above. For employment status, KOSIS provides the employment rate of self-employed workers, regular employees, and temporary employees and daily workers.

We find that only the employment rate of service workers (e.g., police, firefighters, and security-related service occupations; cosmetology, wedding, and medical-assistance service workers; transport and leisure service occupations; and cooking and food service occupations) (see Table S10 in the online appendix, column (4)) increased after the entry of the online food delivery platform. We find that the employment rates of people whose working hours are 15–35 hours per week (Table S11 in the online appendix, column (2)) increased significantly following the entry of the online food delivery platform. Moreover, the employment rates of temporary employees and daily workers (Table S11 in the online appendix, column (7)) increased after the entry of the platform. These results suggest that the platform disproportionately attracted more people to work in service and temporary jobs.

We also investigate the potential for heterogeneity in the impact of the online food delivery platform (Table S12 in the online appendix), and we find that the impact is not heterogeneous.

5.5. Impact from Labor Demand

Online food delivery platforms can affect the labor market not only through labor supply but also through labor

demand by providing more job opportunities and thus directly employing a greater number of people. In this section, we systematically discuss the potential impact of the labor demand of the online food delivery platform.

Following the entry of the online food delivery platform, more restaurants were established, which increased the need for workers. The platform itself also hires people (e.g., delivery people). This could lead to a significant increase in labor demand in the food and beverage industries. To address the potential effect of this labor demand, we collect data on the number of establishments, annual average wage, and number of employees in the food and beverage sectors from KOSIS. The food and beverage sectors include restaurants, drinking places, nonalcoholic beverage places, and food service activities. We consider these data on the food and beverage sectors to be capable of capturing the impact of the online food delivery platform on labor demand. We repeat our main analysis by controlling the number of establishments and annual average wage in the food and beverage sectors. The results are shown in Table S13 in the online appendix, columns (1)–(3), and they are consistent with our main results. Furthermore, we calculate the employment rate after excluding employment from the food and beverage sectors to capture the effect of the online food delivery platform purely through labor supply.[25] The coefficients (Table S13 in the online appendix, column (4)) are similar to those in our main analysis, indicating that most of the increase in the employment rate can be attributed to labor supply.

We additionally analyze the potential impact of the online food delivery platform on the food and beverage industry as a whole, which captures the effect of the platform on labor demand. We obtain the number of employees in the food and beverage sectors from KOSIS by occupation type (regular or temporary employees). The results displayed in Table S14 in the online appendix show that the introduction of the online food delivery platform had a temporary effect on the total employment rate (column (1)) and the employment rate for regular employees (column (2)) in the food and beverage service sectors. In addition, the entry of the platform increased the employment rate of temporary employees (column (3)) in the food and beverage sectors.

5.6. Alternative Explanations

In this section, we briefly explain how we rule out alternative explanations (details in Appendix A).

Because childcare is the second most time-consuming activity for women at home, there is a concern over whether our main effect is driven by shocks originating in the childcare industry in South Korea. The results in Table S15 in the online appendix suggest that our effect does not capture the entry of new childcare businesses.

Our main results are also unlikely to capture the effects of ridesharing platforms, microjobs, or freelancer

platforms. Ridesharing services are unavailable in South Korea because the South Korean government legally prohibits them (Choi et al. 2022). Microjob platforms such as Amazon MTurk affect different provinces of South Korea simultaneously, and thus, our results are unlikely to capture the effect of microjob platforms. Moreover, Table S16 in the online appendix suggests that the treatment and control provinces are indistinguishable in terms of the probability of an individual becoming a freelancer, especially among females. Therefore, our estimates are unlikely to capture the differential effect of freelancer platforms.

Another concern is that our results may be driven by changes in eating habits. The results in Table S17 in the online appendix indicate that the level of fast food consumption did not differ between the treatment and control provinces during our sample period for both men and women.

The results in Table S18 in the online appendix show that the treatment and control provinces did not differ in terms of the number of light food restaurants (e.g., bakeries and those that serve pizza, hamburgers, sandwiches, fried chicken, seaweed rolls, and other light foods). Therefore, our results are unlikely to be driven by changes in these restaurants.

Another concern is that mobile networks and smartphones, upon which online food delivery platforms rely, may be the main drivers of the observed effect. Table S19 in the online appendix suggests that the treated provinces were indistinguishable from the control provinces in terms of mobile device penetration and mobile Internet access methods, which rules out this alternative explanation.

Another concern is that the increase in employment might be driven by economic development (Slivko et al. 2020). To rule out this possibility, we conduct a standard DID model for the shorter time period of 2013–2015, during which the economy was stable. The results, displayed in Table S20 in the online appendix, are consistent with those of our main analysis.

Finally, we conduct various robustness checks to address concerns related to reverse causality, serial correlation in the standard errors, differences in economic trajectory among provinces with online food delivery platforms, and the potential effect of other food delivery platforms. We further conduct additional tests related to the heterogeneous treatment effect, city- and county-level analysis, and alternative dependent variables. The results of these tests are all consistent with our main findings and can be found in Appendix B.

6. Conclusion

The development of technology fosters new business models and the creation of new digital platforms (e.g., Facebook, Airbnb, and Uber). Some of these new business

models have the potential to generate significant positive externalities that are difficult to detect and quantify using traditional economic indices.

We measure the externalities of a digital platform on social welfare. Specifically, we provide evidence of the effects of platform entry on female labor market participation in South Korea. To measure the externalities, we employ a leads-and-lags difference-in-differences model that compares the changes in employment rates before and after the introduction of the online food delivery platform. We first show that the food delivery platform's entry had a positive impact on the female employment rate. Furthermore, this effect was immediate and long-lasting (lasting longer than three years following platform entry). In the short term, the female employment rate increased by 6.5%, whereas the total employment rate increased by 4.8%. We then measure the economic impact of the online food delivery platform by quantifying the income produced by the increased female employment. The aggregate income generated by the increase in female employees accounted for 0.27% of the total GDP in 2015. Considering that the sales made by the online food delivery platform accounted for merely 0.016% of the total GDP, this significant gap in contributions indicates that the platform exerted a strong positive externality on the economy; that is, the increase in female employment contributed 17 times the direct value created by the platform itself.

We then investigate the mechanisms through which these positive effects manifest and rule out any potential confounding factors. We first show that the increase in the female employment rate was driven mainly by an increase in the female labor force participation rate. We then show that women indeed participated less in household chores following platform entry. Finally, we show that among the many household chores, meal preparation was the only duty whose time demands on women decreased from 2009 to 2014. We then conduct additional analyses on the impact of the platform on different occupations, working hours, and types of employment status. Next, we rule out several alternative explanations and conduct a series of robustness tests, as shown in the Appendix.

This study empirically assesses the indirect impact of online food delivery platforms on the labor market. The platform reduces women's cooking time and thus enables them to choose whether to participate in the labor force. Our results show that a substantial number of these hitherto housebound women have chosen to join the labor force. We quantify the externalities generated by this online business model and measure its social welfare and economic value. The results indicate that the economic benefits and social value of this technology-driven business model would be largely underestimated if we consider only its direct revenue. We show that in countries where gender equality is a social issue, the provisioning of digital platforms can potentially remove or reduce the barriers faced by women.

Our paper has important implications for public policy and practice. First, we identify a different approach to promote female labor force participation. Female labor force participation is a critical component of gender equality and women's empowerment. Governments, as well as organizations such as IMF and OECD, place a very strong emphasis on encouraging female labor force participation. Such measures may include reducing job discrimination, equalizing female and male wage rates, and promoting a minimum percentage of female employees in organizations. These measures are often costly and difficult to implement. Different from the measures that require obtaining commitments from hiring organizations, our findings suggest that these measures can be achieved by assisting individual households and enabling more freedom for women. This finding may not be directly generalizable to other countries, but the estimated impact of the technology-induced reduction of cooking time on female employment is substantial and meaningful in South Korea.

Secondly, this work establishes and measures the positive impact of a technology-driven business model on employment. Such indirect effects of technology are often poorly measured (Brynjolfsson et al. 2019). Policymakers may find it is necessary to consider these spillover effects when estimating the economic and societal effects impacts of these technology-driven business models and deciding whether to accommodate or to regulate these platforms. Different from Brynjolfsson et al. (2019), who argued that the value of free Internet applications is inadequately measured through GDP statistics, our work identifies externalities as a new source of value created by innovative technology platforms. At the same time, given the indirect link between technology and female labor force participation, GDP statistics may not be properly attributed to capture the externalities of technology. Compared with the platform's limited direct GDP contribution derived from its revenue, the increase in female labor force participation and associated GDP gains are exponentially greater in scale and importance.

This work is subject to several limitations. First, our estimates do not capture every dimension of the externalities created by the online food delivery platform regarding social welfare. The long-run spillover effects may be larger than those identified in this study and transcend the job market and economy. Access to employment can improve women's status in the household and the level of household access to health and education services. Additional research on these other potential impacts would be valuable. Second, although the main finding of this research is a positive externality, it is possible that there exist negative externalities. For example, these platforms may leverage their market power to take advantage of restaurants and delivery personnel. The

overall social effect of such platforms needs to be carefully established in future research. Third, data limitations have forced us to use aggregate-level data and official surveys in examining these trends. The use of individual-level panel data would allow future researchers to track individuals over time and observe individual family and career choices. Finally, the effect of online platforms on labor participation may be different in different countries; thus, a cross-country comparison would be a useful and fruitful future research direction.

Acknowledgments

Endnotes

[1] https://blogs.worldbank.org/dev4peace/can-gender-equality-prevent-violent-conflict.

[2] https://www.mckinsey.com/~/media/mckinsey/industries/public%20and%20social%20sector/our%20insights/how%20advancing%20womens%20equality%20can%20add%2012%20trillion%20to%20global%20growth/mgi%20power%20of%20parity_executive%20summary_september%202015.pdf.

[3] https://trumpwhitehouse.archives.gov/articles/relationship-female-labor-force-participation-rates-gdp/.

[4] https://www.marketwatch.com/story/doordash-close-to-funding-deal-that-would-value-company-at-15-billion-pre-infusion-2020-06-11.

[5] http://kostat.go.kr/portal/eng/surveyOutline/5/4/index.static.

[6] These national policies are unlikely to drive our results because we employ a leads-and-lags DID framework to leverage the different times of introduction of the platform in different provinces.

[7] Statistics Korea is a central government organization that maintains statistics in South Korea.

[8] Statistics Korea publishes major employment statistics based on the *Economically Active Population Survey*, which assesses approximately 35,000 households every year (http://kostat.go.kr/portal/eng/surveyOutline/4/1/index.static). The survey also releases data on the major activities carried out by economically inactive people. Thus, we can determine the factors that prevent economically inactive people from being employed. In addition to housekeeping (52%), childcare duties (16%), and attending school (19%), reasons for not seeking jobs are being elderly (6%), being disabled (1%), and other (6%).

[9] The proportions of time spent by women and girls on cleaning and organizing (22.8%), purchasing goods and services (11.4%), laundry and clothes (9.4%), home repairs (less than 1%), and other household management (3%) are all less than the time they spent on food preparation (52.3%).

[10] If we sum up the time for all household chores and family care (childcare and elderly care), then food preparation accounts for 42% of the total time, whereas family care accounts for only 21% of the total time.

[11] See https://www.economist.com/business/2019/08/01/the-foodoo-economics-of-meal-delivery.

[12] https://www.forbes.com/sites/sarwantsingh/2019/09/09/the-soon-to-be-200b-online-food-delivery-is-rapidly-changing-the-global-food-industry/#522b4837b1bc.

[13] We conduct a robustness check later to examine the entry of all three major platforms.

[14] Ideally, we would conduct an additional analysis on these megacities. As mentioned in a later section, we use the Google Trend Index to infer the adoption time of food delivery platforms. Unfortunately, the Google Trend Index has monitored city-level search trends in South Korea only since July 2016, and we have no search trend information before July 2016 for these cities. Therefore, we cannot infer the earliest time when people searched for Baemin in these megacities.

[15] We also conduct analyses at the city and county levels. These results are shown in Table S26 in the online appendix and are consistent with our main results.

[16] See http://kostat.go.kr/portal/eng/surveyOutline/4/1/index.static.

[17] Statcounter, a Web traffic analysis company, reveals that Google's search engine market share in South Korea is 68.2%. The search trend index of another popular search engine in South Korea (Naver) is strongly correlated with the search trend index of Google.

[18] We infer the local entry time as the earliest time at which the Google Trend Index of the platform's name is greater than zero for three consecutive months in that province. The assumption is that people will not search for a platform name over three consecutive months if that platform has not entered a given province. Although people might search for the platform before its entry, they would do so only occasionally. For example, in Jeollanam-do, the first time a Google Trend Index greater than zero appeared was in June 2012, but it was zero in the following two years (until December 2014). Thus, the restriction to three consecutive months helps us avoid mistakenly identifying the entry time. As a validity check of the method, we acquire information on the "Shake Shack" entry time in South Korea from their official website. The Google Trends Index correctly identifies the launch time of Shake Shack. As another validity check, we retrieve Uber X's entry time in the United States directly from the Uber blog. The Google Trend Index also correctly identifies the entry time of Uber X into various cities (e.g., Chicago, Miami, Minneapolis, Atlanta, Boston, and San Diego).

[19] To check whether our results are sensitive to the use of a half-year as the unit of analysis, we also examine our treatment effect on a yearly and quarterly basis. The results are consistent and are displayed in the online appendix Tables S4 and S5.

[20] The aggregate annual income generated by the increase in female employees = annual increase in female employment number × minimum annual income in 2015 = increase in female employment rate × female employment rate in 2014 × number of working-age women in 2014 × minimum annual income in 2015 = $(e^{0.049} - 1) \times 49.7\% \times 9{,}986{,}000 \times \$15{,}125.4 = \$3{,}769{,}941{,}061.69$.

[21] KLIPS does not distinguish unemployed people from economically inactive people. Here, the category "non-employed" includes both unemployed and economically inactive people.

[22] For employed people, KLIPS asks, "Which of the following best describes your current situation?" The response options are working, working and housework, working and attending school, working and activities other than housework, and attending school. For non-employed people, KLIPS asks "What did you mainly do during the past week?" The available options are household chores, childcare, attending school, being elderly, mental/physical illness, preparation for military services, preparation for marriage, resting, and others.

[23] http://www.koreatimes.co.kr/www/news/biz/2013/08/326_141246.html.

[24] Detailed definitions of each occupation can be found in the note in Table S10 in the online appendix.

[25] Because employment in the food and delivery sector is not categorized based on gender, we can calculate only the total employment rate after excluding the food and delivery sectors.

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