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The Effects of a Sudden Stop in Low-Skilled Immigration: Evidence from Korea's Guest Worker Program

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ABSTRACT

As workforces in high-income countries age and shrink, immigrants increasingly fill entry-level, low-skilled jobs. We examine what happens when this labor supply is abruptly reduced, exploiting South Korea's sudden suspension of its low-skilled guest worker program following the 2020 COVID-19 border closure. Using policy-driven variation in firms' pre-pandemic reliance on immigrant labor, we show that the collapse in inflows led to a significant increase in firm exit. Among surviving firms, greater pre-pandemic dependence on immigrant workers resulted in production disruptions and operational delays. Firms did not respond by expanding domestic hiring to replace missing guest workers. Instead, they adjusted by reallocating incumbent Korean employees toward lower-skilled tasks, contributing to occupational downgrading and significant wage declines. These findings suggest that low-skilled immigrant workers were not easily substitutable in the short run and that tighter immigration constraints can impose substantial adjustment costs on both firms and native workers.

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1 Introduction

The labor market for low-wage, manual occupations has undergone notable transformations in recent years, primarily driven by demographic shifts. As the working-age population in many high-income countries has aged, incoming cohorts of young workers have become numerically smaller and, on average, more highly educated than the cohorts exiting the labor force. Consequently, low-wage manual entry-level positions have become increasingly difficult to staff. Labor markets for unskilled entry-level employment have tightened as the supply of new workers willing to take such jobs has declined. This has led to longer vacancy durations and persistent unfilled job openings.¹

In many high-income countries, young immigrants without tertiary education enter through temporary visa channels and guest worker programs. They work in physically demanding, low-skilled jobs across agriculture, manufacturing, personal services, hospitality, and construction (Peri and Sparber, 2009).² Despite political rhetoric that immigrants displace native workers, and rising anti-immigrant sentiment in Europe and the United States, even conservative governments continue to rely on guest worker programs and occupation-specific visas.³ This paper studies whether low-skilled immigrant workers are "essential" to production and difficult to replace in the short run, or whether firms easily adjust by hiring native workers or changing production practices.

South Korea offers a useful setting to study this question. The country experienced a rapid and sudden fertility decline during the 1980s and 1990s, which led to a sharp contraction in the size of younger cohorts beginning in the 2010s, together with a decline in the supply of new workers, particularly non-college-educated individuals willing to take unskilled jobs (Kim and Lee, 2021). As a result, South Korea introduced a series of reforms beginning in the mid-2000s to admit different groups of immigrants targeting these occupations (see Dong, Lee, and Yang (2024) and Kim, Lee, and Peri (2025)). One of these programs, the Employment Permit System (EPS), was introduced in 2004 to provide temporary entry-level workers, primarily to the manufacturing sector. These workers were largely employed as machine operators, an important occupation in this sector, and were assigned simple and repetitive tasks typical of entry-level jobs. They were complementary to the more advanced tasks performed by Korean workers. Firms' reliance on these workers varied substantially, and a mechanical feature of the policy design allowed some establishments to employ a larger share of EPS workers than others.

In our analysis, we exploit the disruption to the inflow of EPS immigrant workers caused by COVID-19, which in Korea produced a halt in international travel and resulted in virtually no new visas being issued during

¹In the U.S., the ratio of unemployed people relative to job openings has been lower than—or very close to—one since June 2021, while this number before 2019 was well above one. See U.S. Bureau of Labor Statistics, Unemployment Level, retrieved from FRED, Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/LNU03000000>, December 19, 2025.

²Examples of comparable visa programs include the H-2A and H-2B seasonal worker visas in the U.S., the Temporary Foreign Worker Program (TFWP) and Seasonal Agricultural Worker Program (SAWP) in Canada, and visa routes tied to occupations on the "Immigration Salary List" in the UK.

³See the recent article "The migration schemes even populist love," *The Economist* October 23, 2025.

most of 2020 and 2021, as a quasi-random sudden shock. We interact the post-January 2020 shock with the policy-established EPS quota, which had been set in earlier years before the pandemic and generated variation in employment shares of EPS workers in a strictly exogenous and quasi-random way across establishments once we control for employment size. Specifically, the policy prescribed a fixed cap on EPS workers within each firm according to employment size bins. Because firms using the program tended to hire close to the cap, within each size bin the employment share of EPS workers declined from the lower to the higher end of the bin and then jumped when the firm moved into a new size category. After controlling for employment-bin size dummies, the within-bin variation in pre-COVID EPS employment shares depended on within-bin variation in firm size, which, as we show, does not appear to be correlated with pre-COVID observable firm characteristics or trends. This idiosyncratic pre-COVID variation in EPS shares captures differential dependence on immigrant workers across establishments and represents the identifying variation in our analysis. Using the quasi-random variation in firms' pre-pandemic EPS employment shares introduced above, we analyze how firms responded to the decline in immigrant labor supply in terms of survival probabilities and, among surviving firms, production outcomes and the employment and wages of Korean workers.

The paper makes three novel contributions. First, we exploit policy-driven cross-firm variation in reliance on low-skilled immigrant workers, combined with a sudden and unexpected shock to their supply during COVID-19, to analyze firms' responses, including survival, native employment, and wages. The specific policy schedule governing the allowed number of EPS workers as a function of total employment generated local idiosyncratic variation in EPS employment shares across firms.

Second, an original firm-level survey conducted before and after COVID-19 provides detailed information on variables not available in administrative or census data. The data were collected through a survey implemented by the Korea Development Institute (KDI) and the World Bank, covering a nationally representative group of Korean firms, primarily in the manufacturing sector. Notably, the survey provides rare access to small firms; more than 40 percent of the sample consists of firms with fewer than ten employees. The survey includes standard variables such as wages, employment, location, and sector, as well as detailed questions on business outlook, management practices, hiring experiences, and task assignments across worker groups. The survey, covering approximately 1,000 firms, was conducted in August 2019, before the COVID-19 pandemic, and again in 2021, after the peak of the pandemic. In the second wave, the survey collected information referring to January 2020, at the onset of the pandemic. An important outcome recorded in 2021 is firm survival, as several firms exited during the period. This allows us to analyze firms' responses to the decline in immigrant labor supply in substantially greater detail.

Third, this paper contributes to the small but growing literature that studies the effects of a *decline* rather than an increase in low-skilled immigrant labor. While many studies examine sudden surges of low-skilled im-

migrants to identify their effects, far fewer analyze sudden drops in immigrant supply, and our paper contributes to this emerging line of research.⁴

Our main identification approach uses the policy-predicted share of EPS workers in firm employment in August 2019 as a measure of exposure to the COVID shock (treatment) that each firm experienced starting in January 2020. Firms with a larger predicted share of foreign workers experienced a larger decline in labor supply as a percentage of employment. Specifically, we interpret the main shock during this period as the sharp reduction in the supply of foreign workers, whose entry was essentially halted during 2020–2021. We first verify that predicted pre-COVID dependence on EPS workers was not correlated with pre-COVID trends in firm employment, supporting the validity of our approach. We then examine whether the decline in EPS workers (instrumented by the pre-COVID policy-predicted measure) was associated with (i) firm survival; (ii) perceived setbacks, labor shortages, and business disruptions among surviving firms; and (iii) wages and employment outcomes of Korean workers in surviving firms.

Our main results show that greater dependence on EPS workers, and therefore a larger decline in that group as a share of employment, was associated with a higher probability of market exit by 2021. Among surviving firms, greater reliance on EPS workers was associated with a higher probability of reporting revenue declines and production setbacks, as well as stronger intentions to hire additional EPS workers in post-2020 survey responses. Firms with greater EPS dependence also reported reducing operations and attempting to extend the contracts of existing EPS workers.

A second set of results for surviving firms concerns the effects of higher EPS dependence on the wages and employment of Korean workers. Among surviving firms, greater reliance on EPS workers was associated with lower wages paid to Korean employees after 2020 and higher retention of incumbent Korean workers, but not with increased hiring of new Korean workers to replace lost EPS workers. This pattern is consistent with a downgrading of more skilled Korean incumbents in firms that lost a larger share of EPS workers. The results suggest that Korean workers filled tasks previously performed by immigrant workers while accepting lower wages and less desirable positions. This adjustment may have reflected stronger bargaining power among surviving firms, which could require Korean workers to downgrade in order to maintain operations. As a result, surviving firms appear to have shifted part of the productivity loss onto the wages of Korean workers, with larger effects in firms that had previously relied more heavily on EPS workers. Surviving firms were able to remain in business despite the decline in foreign labor supply, but they did so at the cost of downgrading native workers and reducing wages.

This set of findings is consistent with difficulties in replacing EPS workers and limited substitutability between Korean and EPS workers, at least in the short run. The evidence suggests that, prior to COVID, foreign

⁴Notable examples examining reductions in immigration include Lee, Peri, and Yasenov (2022), which studies deportations in the U.S. in 1929, and Clemens and Lewis (2022), which analyzes immigration restrictions following the end of the Bracero program.

workers supplied basic skills by performing entry-level tasks in manufacturing firms. Their presence allowed native workers to specialize in more advanced activities, promoting a more efficient task-to-skill allocation. Firms showed limited ability to substitute between the two groups of workers. This evidence of a hard-to-replace and essential role for low-skilled foreign workers within firms is consistent with the findings of Clemens and Lewis (2022), who use lottery variation in the U.S. to show that increases in low-skilled seasonal workers raise firm productivity without reducing native employment.

The rest of the paper proceeds as follows. Section 2 describes the institutional framework and immigration policy we study and highlights key characteristics of EPS workers. Section 3 presents the survey data and defines the main variables and units of analysis. Section 4 outlines the empirical strategy, identification, and validity tests. Section 5 presents the main results, while Section 6 reports robustness checks. Section 7 concludes.

2 Institutional Framework and EPS Workers

South Korea is one of the fastest-aging countries in the world, characterized by a highly educated population, very low fertility rates, and long life expectancy. The fertility rate has remained below replacement level since the 1970s and has fallen below one since 2020. This demographic transition has led to a substantial decline in the size of cohorts of young workers entering the labor market over recent decades, together with a rapid reduction in the supply of workers willing and able to engage in physically demanding, manual, low-skilled occupations. As a result, the country has experienced a growing number of unfilled vacancies in sectors such as low-skilled manufacturing, construction, and agriculture.

To address declining labor supply in low-skilled sectors, South Korea introduced the Employment Permit System (EPS) in 2004. The EPS is a government-to-government labor migration program that allows low-skilled workers from 16 designated Asian countries to work in specific industries across South Korea. Eligibility to hire foreign workers under the EPS is restricted to small and medium-sized enterprises (SMEs) with fewer than 300 employees.

Although the EPS formally covers manufacturing, agriculture, and fisheries, the vast majority of EPS employment is concentrated in manufacturing. According to Employment Trends published by the Ministry of Employment and Labor of Korea, approximately 78 percent of EPS workers were employed in the manufacturing sector as of 2019. Within manufacturing, EPS firms are disproportionately concentrated in low-skilled, labor-intensive industries compared with the national average. Appendix Table A1 shows that the food products sector represents the largest share of our sample at 22 percent, substantially higher than the national average of 8 percent. Similarly, the leather, luggage, and footwear sector accounts for 13 percent of EPS firms, far exceeding its 1 percent share in the national distribution.

Manufacturing firms participating in the EPS differ from typical manufacturing firms in two key respects.

First, EPS firms are characterized by their small scale and relatively low productivity. As illustrated in Table A2, the size distribution is heavily skewed toward smaller operations; specifically, 41 percent of the surveyed firms employ fewer than 10 workers, and a cumulative 92 percent have fewer than 50 employees. Reflecting this smaller scale and lower productivity, these firms offer significantly lower compensation than the industry average. For instance, in 2019, the average monthly wage in the overall manufacturing sector was 3.4 million KRW, compared to only 2.5 million KRW in EPS-participating firms.

Manufacturing firms participating in the EPS differ from typical manufacturing firms in two key respects. First, EPS firms are characterized by smaller scale and relatively low productivity. As illustrated in Table A2, the size distribution is heavily skewed toward smaller operations; specifically, 41 percent of the surveyed firms employ fewer than 10 workers, and a cumulative 92 percent have fewer than 50 employees. Reflecting their smaller scale and lower productivity, these firms offer significantly lower compensation than the industry average. For instance, in 2019, the average monthly wage in the overall manufacturing sector was 3.4 million KRW, compared to only 2.5 million KRW in EPS-participating firms.

Second, in addition to these structural characteristics, these firms face persistent difficulties in filling job vacancies. Table 1 highlights the severity of this issue in production roles. While the rate at which job openings were filled in the previous year (that is, employed workers relative to job postings during the year) for clerical support and sales workers was relatively high, ranging from 90.9 to 100 percent, the vacancy-filling rate for “Plant and machine operators,” the core workforce in manufacturing, was only 68.6 percent. This rate is even lower than that observed for managers and professionals (76.5 percent), occupations that arguably require scarcer and more specialized skills. Difficulties in hiring low-skilled manual workers are widespread across the sector: 53 percent of the surveyed firms (408 firms) explicitly reported challenges in recruiting the targeted number of new Korean workers. Among these firms, 90 percent identified “Plant and machine operators and assemblers” as the most difficult occupation to fill. Crucially, the primary reason cited for these difficulties was “no applicants,” indicating a fundamental shortage of domestic labor supply for these positions. Taken together, these statistics suggest that these firms face a limited supply of workers willing to perform these jobs and encounter substantial challenges in attracting Korean workers at prevailing market wages.

The tight labor markets for these elementary occupations suggest that EPS workers are primarily hired to fill these positions. This pattern is confirmed when we compare how foreign workers are employed within firms relative to their domestic counterparts. Panel A of Table 2 shows that the occupational distribution of EPS workers is almost entirely concentrated in “plant and machine operators” (98.5 percent). While Korean workers in these firms are also largely employed as “plant and machine operators” (approximately 89 percent), a non-negligible share is employed as clerks (6.4 percent) and managers (3.5 percent).

Table 1: Planned vs. Actual Hiring of New Korean Workers by Occupation

Occupation	# Planned	# Actual	% Filled
Managers/Professionals	0.17	0.13	76.5%
Clerical support workers	0.33	0.30	90.9%
Service workers/Sales workers	0.04	0.04	100.0%
Plant and machine operators	2.10	1.44	68.6%
Elementary occupation	0.05	0.04	80.0%

Notes: Figures report the average number of new Korean workers per firm that were planned and hired over the previous year. % Filled denotes the ratio of actual hires to planned hires.

Source: The Survey on the Employment Permit System (KDI and World Bank, 2019)

Table 2: Occupational and Task Characteristics of EPS and Korean Workers

	EPS (%)	Korean (%)
Panel A. Major Type of Occupation		
Managers/Professionals	0.0	3.5
Clerical support workers	0.0	6.4
Service workers/Sales workers	0.0	0.7
Plant and machine operators, and assemblers	98.5	89.1
Elementary occupation	1.5	0.3
Total	100.0	100.0
Panel B. Task Characteristics		
Simple, repetitive tasks	79.0	19.0
Tasks requiring basic skills	13.0	37.4
Tasks requiring considerable skills	6.6	31.3
Tasks requiring expert-level skills	1.4	12.3
Total	100.0	100.0

Notes: Panel A reports the distribution of major occupational categories. Panel B reports the distribution of task characteristics.

Sources: Panel A uses The Survey on the Employment Permit System (KDI and World Bank, 2019). Panel B uses A Study on the Implementation of a Pre-Announcement System for Employment Visa Quotas (Ministry of Justice Korea and Migration Research and Training Center, 2024).

An even more striking difference between EPS and Korean workers emerges when we examine the specific tasks performed by these two groups within firms. According to a 2024 survey conducted by the Migration

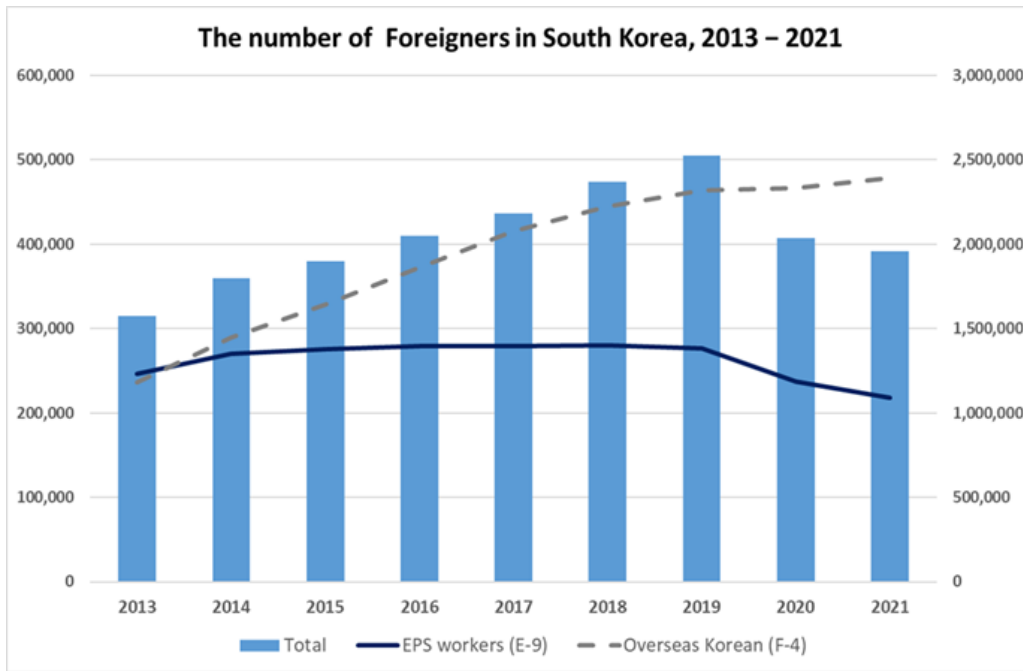
Research and Training Center (Panel B of Table 2), employers reported that more than 79 percent of EPS workers were primarily assigned to simple, repetitive tasks requiring neither specific knowledge nor technical skills. In contrast, only 19 percent of Korean workers were reported to be engaged in such tasks. In addition, a substantial share of Korean workers was reported to perform tasks requiring basic (37 percent), considerable (31 percent), or expert-level (19 percent) skills. By contrast, only 13 percent of EPS workers performed tasks requiring basic skills, 6.6 percent performed tasks requiring considerable skills, and a very small 1.4 percent performed tasks requiring expert-level skills. This difference is also reflected in the wage gap between EPS and Korean workers. In 2019, the average monthly wage of EPS workers across firms was 2.26 million KRW, whereas that of Korean workers was 2.6 million KRW, a 15 percent difference that partly reflects the more skilled nature of tasks typically performed by Korean workers.

The more basic occupations, simpler tasks performed, and lower wages received by EPS workers suggest that they primarily filled entry-level, low-skilled positions. The limited tenure of these workers, who are granted an initial employment term of three years, extendable up to four years and ten months, further implies that firms may have limited incentives to provide extensive training, keeping them in simpler and more basic tasks. Taken together, these factors suggest that, within production-related activities, EPS workers tend to be engaged in less-skilled roles compared with their Korean counterparts, and that their production roles, while less remunerated, are distinct from and complementary to those of most Korean workers. In a ladder of tasks within firms, where lower-rung tasks must be performed for production to occur but are less remunerated and simpler than upper-rung tasks, EPS workers tend to occupy the lower rungs while Korean workers occupy the higher ones.

The supply of this group of workers experienced a sudden and substantial decline in 2020. During the global COVID-19 pandemic, Korea implemented strict travel restrictions to curb the spread of the virus. As a result, the inflow of new EPS workers nearly halted, while a substantial number of existing EPS workers returned to their home countries. This led to a significant reduction in the total number of EPS workers, as illustrated in Figure 1.

The number of other types of foreign residents, such as overseas Koreans, remained relatively stable between 2019 and 2021, after having increased for several years. However, the number of EPS workers experienced a dramatic drop, from 276,000 in 2019 to 217,000 in 2021, a decrease of approximately 22.2 percent in the EPS workforce. The overall decline in foreign workers in Korea between 2019 and 2021 was entirely driven by the reduction in EPS workers.

Figure 1: The number of Foreigners, 2013–2021



Source: Statistics on Immigration and Foreign Residents, Ministry of Justice Korea.

The loss of EPS workers represents a significant negative labor supply shock affecting production workers with lower skill levels who specialize in simple tasks and receive relatively low wages. If one were to abstract from the differences between EPS and Korean low-skilled workers described above and instead treat the two groups as substitutable, the standard theoretical framework would predict Korean workers to replace EPS workers, potentially at higher wages, following the reduction in labor supply as discussed in Borjas (2003) and Borjas (2017).

However, if this group of workers is differentiated from and imperfectly substitutable with Korean workers, their sudden decline, by reducing the supply of tasks complementary to those performed by the average Korean worker, could disrupt firm production, lower the productivity of complementary Korean workers, and reduce overall employment and firm size. In this case, firms that relied heavily on EPS workers, where these workers constituted a large share of pre-COVID employment, may have faced substantial difficulties replacing them with Korean workers. These positions paid lower wages, were less desirable, and the supply of Korean entry-level low-skilled workers was very limited. As a result, firms may have experienced production setbacks, declines in output and revenues, and some may even have been forced to exit the market.

We examine whether the empirical evidence on Korean workers' employment and wages, as well as firms' performance and survival, supports a hypothesis of easy substitution, in which Korean workers replaced EPS workers and gained employment, or instead points to complementarity, with potential productivity losses and

wage declines for Korean workers following the reduction in EPS labor supply.

3 Data

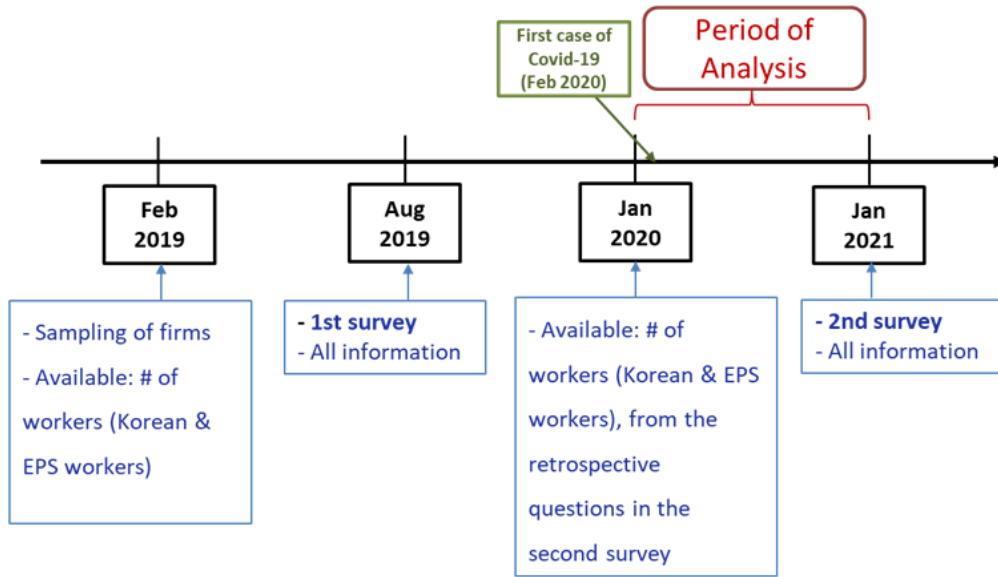
The data used in this paper come from two waves of the original “Survey on the Employment Permit System,” conducted by KDI in collaboration with the World Bank in August 2019 and January 2021.⁵ For the first survey, conducted in February 2019, 1,000 firms were sampled to be representative of the full population of 51,619 firms participating in the EPS program. The sampling followed a stratified design based on 144 strata defined by region, industry, and firm size.⁶ In the August 2019 survey, selected EPS employers were interviewed on a wide range of topics, including business outlook, hiring experiences with both Korean and EPS workers, task assignments across worker groups, wage levels, and overall evaluations of the EPS. The dataset also includes information on firms’ industries, locations, and other basic characteristics.

To examine how the COVID-19 crisis affected EPS-participating firms, the same team, KDI and the World Bank, re-surveyed these firms in January 2021, approximately 16 months after the first wave. The final panel sample for the second wave consists of 682 firms, as some firms had closed, declined to participate, or were unreachable for follow-up interviews. The second survey replicated the questions from the first wave and additionally collected retrospective information on firm conditions as of January 2020 to construct a more accurate pre-COVID baseline. Figure 2 summarizes the timeline of the two survey waves together with other key dates, including the sampling period and the confirmation of the first COVID-19 case in Korea.

⁵The fieldwork was carried out by the KDI Public Opinion Analysis.

⁶For more details on the survey sampling, see Dong et al. (2024).

Figure 2: Timeline of Events and Survey



Using the panel dataset of EPS employers, the post-treatment period in our analysis spans from January 2020 to January 2021, approximately one year, allowing us to assess the short-run impacts of EPS worker loss on firm survival and on outcomes among surviving firms. In the analysis, we control for several firm characteristics measured in August 2019 and examine pre-trends in Korean worker employment between February and August 2019.

For consistency, we restrict the analysis to firms in the manufacturing sector, as firms in agriculture and fisheries differ markedly in the composition of EPS workers and in administrative oversight. After applying this restriction, the final sample consists of 761 manufacturing firms.⁷ In the initial analysis using the full sample of 761 firms, we investigate whether the sudden and unexpected decline in foreign guest workers affected firm survival during the study period. Out of the 761 firms, 33 firms (4.3 percent) closed during the period. When we broaden the definition of “closed” to include firms that became unreachable because of contact errors, which likely indicates business closure, this number increases to 59 firms (7.8 percent). Finally, 185 firms declined to participate in the second survey, resulting in a balanced panel of 517 surviving firms. Focusing on this subset, we examine a range of firm-level outcomes beyond firm closure status, including production disruptions, labor shortages, firm responses, and changes in wages and employment for both EPS and Korean workers.

To examine the impact of the decline in EPS workers, we first construct a firm-level measure capturing the reduction in the number of EPS workers as a fraction of total firm employment. Specifically, the measure is

⁷Out of the 772 manufacturing firms initially surveyed, 12 firms with no Korean workers were dropped due to the lack of Korean wage data.

defined as follows:

$$\text{Drop_EPS}_i = -\frac{\Delta\text{EPS}_i^{2020-21}}{\text{Kor}_i^{2020} + \text{EPS}_i^{2020}}, \quad (1)$$

where Kor_i^{2020} and EPS_i^{2020} denote the numbers of Korean and EPS workers in firm i , respectively, and $\Delta\text{EPS}_i^{2020-21}$ represents the change in the number of EPS workers in firm i between January 2020 and January 2021. The change is normalized by total firm employment in January 2020 to avoid mechanical endogeneity arising from changes in firm size in 2021. The negative sign ($-$) ensures that larger values of Drop_EPS_i correspond to larger declines in EPS employment during the period.

Panel A of Table 3 reports the mean and standard deviation of the decline in EPS workers. On average, EPS-participating firms experienced a 5.7 percent reduction in EPS employment relative to their total workforce as of January 2020. This variable is measured only for firms that remained in operation through January 2021, yielding 517 observations. We also report summary statistics for the pre-COVID share of EPS workers, which serves as our main source of identifying variation. In January 2020, the average share of EPS workers across firms was approximately 36.9 percent. Although the sample includes only firms that used the EPS program, there is substantial heterogeneity in the intensity of use, with pre-COVID EPS shares ranging from values close to zero to levels above 0.8.

Panels B and C of Table 3 present summary statistics for firm-level control variables and outcome variables, respectively. In Panel B, all variables are measured as of August 2019, except for the sales decline indicator (covering January 2020 to January 2021) and the change in Korean employment during the pre-period (February to August 2019). In Panel C, the number of observations is again 517, except for firm closure status, as most outcome variables are available only for firms that survived the analysis period. Because wage information for Korean workers is missing for some firms, the corresponding variable capturing changes in wages has fewer observations.

Table 3: Summary Statistics

	Observations	Mean	Std. Dev.
Panel A: Key Variables			
Drop of EPS workers (Jan 2020 – Jan 2021)	517	0.057	0.133
Share of EPS workers (Jan 2020)	761	0.369	0.207
Panel B: Firm-level controls and pre-period changes			
The number of workers	761	20.781	30.288
Firm age	761	14.323	9.783
Exporter (indicator)	761	0.170	0.375
Positive outlook (indicator)	761	0.130	0.337
Hiring difficulties of Korean (indicator)	761	0.535	0.499
EPS participation (relative to firm age)	761	0.749	0.662
Employer: female (indicator)	761	0.134	0.341
Age of employer	761	55.957	8.877
Employer: college graduates (indicator)	761	0.560	0.497
EPS helped in expansion (indicator)	761	0.547	0.498
Average wage	761	246.581	42.519
Pre-period change in Korean workers	761	0.066	0.680
Panel C: Firm-level outcomes			
Firm closed	761	0.043	0.204
Firm closed (extended definition)	761	0.078	0.268
Revenue decreased, 2020–2021 (indicator)	761	0.422	0.494
Setback	517	0.362	0.481
Labor shortage	517	0.485	0.500
Business exacerbated	517	0.588	0.493
Additional hiring of EPS (intention)	517	0.072	0.308
Hire local workers (intention)	517	0.221	0.415
Automation (intention)	517	0.019	0.138
Change in Korean workers	517	0.019	0.168
# of New hires (Korean)	517	2.174	5.995
Change in wages (Korean)	512	0.028	0.173
Change in wages (EPS)	517	0.049	0.161

Source: The Survey on the Employment Permit System (KDI and World Bank)

4 Empirical Framework

4.1 Pre-COVID-19 Exposure and Firm-level Imputed EPS Quotas

Our empirical analysis aims at identifying how firms’ differential dependence on EPS workers before the onset of COVID-19 in early 2020 affected post-COVID firm outcomes, beginning with firm survival. The loss of EPS workers following international border closures was proportionally larger in firms where they represented a higher share of employment. A natural starting point for examining the impact of EPS worker loss on firm survival is to regress firm exit status in 2021 on the pre-COVID share of EPS workers, a predetermined measure capturing each firm’s exposure to the nationwide decline in foreign labor supply.

However, this share is likely correlated with unobserved firm characteristics and depends inversely on firm size because of the structure of legally determined quotas. To address this concern, we use statutory EPS quotas together with each firm’s size bracket, as described in Table 4, to construct an imputed EPS share based on the maximum statutory number of EPS workers allowed. For example, a firm with three Korean workers was allowed to hire up to five EPS workers, implying a predicted share of $5/(3 + 5)$. Similarly, for a firm with 20 Korean workers, the predicted EPS share is $10/(20 + 10)$. We then control flexibly for firm size, either using a polynomial or dummies for size-bins, so that identification comes from variation in statutory quotas across size bins and from within-bin variation near bin thresholds.

Table 4: Maximum EPS Permission by Firm Size

(1) Number of Koreans (category)	(2) Maximum EPS permission
1–5	5
6–10	7
11–30	10
31–50	12
51–100	15
101–150	20
151–200	25
201–300	30

Notes: This table outlines the maximum number of EPS workers a firm is allowed to hire, contingent on the number of native Korean employees. These quotas apply to the manufacturing sector.

This firm-level predicted exposure, after controlling for firm size, predicts the actual EPS share and is driven by local differences in firm size and statutory quota changes at discrete employment thresholds. Hence, predicted exposure conditional on size can serve as a valid instrument for the decline in EPS workers as a share of employment during the COVID-19 pandemic, as shown below. This measure can also be interpreted as capturing treatment intensity within a treatment–control framework. Specifically, we estimate the following

regression, which can be interpreted as a reduced-form specification in which exposure to treatment proxies for the actual decline in EPS workers:

$$Closed_i = \beta Exposure_i + F(Size_i) + \Gamma X_i + \lambda_r + \lambda_g + \varepsilon_i, \quad (2)$$

where $Closed_i$ is a binary indicator equal to one if firm i closed between January 2020 and January 2021. The key explanatory variable, $Exposure_i$, is the predicted share of EPS workers based on Table 4 and the number of workers in the firm prior to 2020, and $F(Size_i)$ is a cubic polynomial in firm size measured before 2020, capturing the systematic relationship between firm size and statutory quotas. The model includes a vector of firm-level control variables X_i and region fixed effects λ_r for 17 administrative regions to account for regional trends.⁸ As an alternative, we implement a nonparametric control for firm size by including firm size fixed effects (λ_g) based on the number of Korean workers in August 2019, mirroring the statutory quota bins (0–10, 11–30, 31–50, 51–100, 101–150, 151–200, and 201–300). Under this specification, identification comes from within-bin variation in imputed EPS shares. Finally, ε_i denotes the error term.

The coefficient β captures the relationship between firms’ reliance on EPS workers and the probability of closure. A positive β indicates that firms more dependent on EPS workers were more likely to close between 2020 and 2021, suggesting that the loss of immigrant workers adversely affected firm survival. Conversely, a negative β implies that firms with higher EPS reliance were more likely to remain in operation despite larger proportional employment losses.

4.2 Power and Validity Tests

For a causal interpretation of coefficient β as the effect of EPS dependence on firm survival, two key assumptions must hold. First, the exposure variable ($Exposure_i$) must strongly predict the actual decline in EPS workers, which we verify empirically. Second, and more importantly, conditional on controls, $Exposure_i$ must be uncorrelated with unobserved firm characteristics that independently affect survival and performance during the pre-period and persist into the post-COVID period. In the following section, we provide evidence that the exposure variable has strong predictive power for the decline in EPS workers and is not correlated with pre-2020 trends in key firm outcomes.

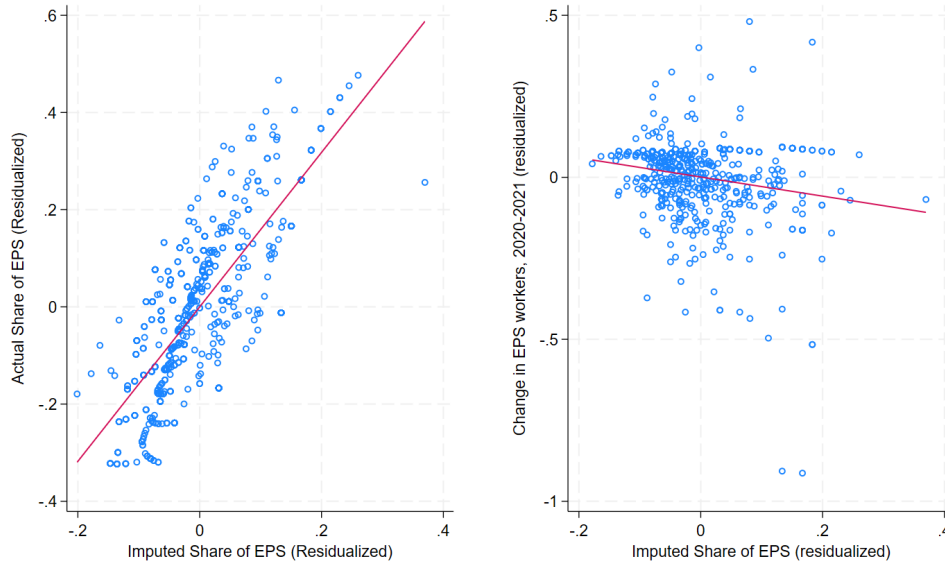
Figure 3 illustrates the first condition. The left panel plots the relationship between a firm’s actual share of EPS workers and its pre-COVID predicted share, showing that the exposure measure strongly predicts actual EPS intensity prior to the pandemic. The right panel plots the change in the number of EPS workers between January 2020 and January 2021, expressed as a share of total employment in January 2020, against the pre-

⁸Control variables include: firm age, a dummy for exporting status, a dummy for positive business outlook, a dummy for difficulties in hiring Korean workers, number of EPS participation per year, the average number of EPS workers in 2019, employer characteristics (gender, age, and education), and average wage, all measured as of August 2019.

COVID predicted share. Firms with higher predicted exposure experienced significantly larger subsequent declines in EPS employment, satisfying the relevance condition of the instrumental variable strategy. Each variable is residualized with respect to firm size, so that even after accounting for size, the exposure measure explains both actual dependence on EPS workers and the subsequent decline in EPS employment.

At the same time, the right panel reveals substantial heterogeneity in firm responses: while most firms experienced large contractions in EPS employment, a nontrivial subset recorded increases. This pattern is consistent with a reallocation of EPS workers toward less affected surviving firms in the post-COVID period. Such reallocation highlights the potential endogeneity of directly using realized changes in EPS employment as a treatment variable and motivates our reliance on the predetermined imputed exposure measure for identification.

Figure 3: Change in EPS workers and Share of EPS



Notes: The figure displays scatter plots of residualized variables after controlling for a cubic polynomial of firm size (including linear, quadratic, and cubic terms). The left panel plots the relationship between the actual share of EPS workers and the pre-COVID predicted share of EPS workers in January 2020. The right panel plots the relationship between the change in the number of EPS workers from January 2020 to January 2021 (normalized by total employment in January 2020) and the pre-COVID predicted share of EPS workers. Each dot represents a firm.

Columns (1) through (3) of Table 5 report the first-stage regression results. Column (1) reports estimates including firm-level controls measured in 2019 and region fixed effects that capture region-specific shocks or trends. In column (2), we additionally include firm size fixed effects using dummy variables corresponding to the statutory bins reported in Table 4, further accounting for the mechanical relationship between firm size and imputed EPS dependence, as well as potential correlations between firm size and other determinants of survival, such as access to credit or buffers against negative shocks. In column (3), we instead control for a

cubic polynomial in firm size. Standard errors are clustered across 68 groups defined by the interaction between region and firm size, based on the number of Korean workers, to account for potential within-group correlation.

The exposure variable is a statistically significant predictor of the post-COVID decline in EPS employment during 2020–2021, even when controlling flexibly for firm size either nonparametrically or through a polynomial specification. The estimated coefficients are positive because the drop in EPS workers is defined with a negative sign. Specifically, in columns (2) and (3), a one percentage point increase in the predicted pre-pandemic EPS worker share is associated with a reduction in EPS employment equal to 0.3 percentage points of total employment during the pandemic, relative to pre-pandemic employment levels. This effect is statistically significant. These results indicate that firms more exposed to EPS workers experienced a substantial labor supply shock due to pandemic-induced restrictions on the inflow of foreign workers.

Table 5: First-Stage Power and Validity

	(1)	(2)	(3)	(4)	(5)
Outcome:	Drop EPS (1st stage)	Drop EPS (1st stage)	Drop EPS (1st stage)	Δ Korean (pre-trends)	Δ Korean (pre-trends)
Sample:	Panel firms	Panel firms	Panel firms	All firms	Panel firms
<i>Exposure_i</i>	0.255*** (0.064)	0.298*** (0.098)	0.296** (0.117)	-0.319 (0.220)	-0.529 (0.375)
1st-stage <i>F</i>	15.92	9.22	6.38	2.11	2.00
2019 Controls	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Firm-size FE		Yes		Yes	Yes
Size (Cubic)			Yes		
Observations	517	517	517	761	517
R-squared	0.154	0.156	0.154	0.057	0.085

Notes: The dependent variable is the decline in EPS workers relative to firm size. The key explanatory variable is the pre-COVID predicted share of EPS workers. Standard errors are clustered by region and firm size. Baseline controls include total employment, firm age, an export-status dummy, a dummy for whether the firm reported a good business outlook, EPS participation intensity, employer age, gender, and education, a dummy for whether EPS participation contributed to firm expansion, the average wage (all measured as of 2019), and a dummy for whether firm revenue decreased.

**p < 0.01, *p < 0.05, *p < 0.1

Next, we assess the validity of our identification strategy by examining whether the constructed firm-level

exposure variable is correlated with pre-COVID employment trends, conditional on firm size. Although our regressions include an extensive set of firm-level controls as well as region and size-group fixed effects, concerns about endogeneity, particularly reverse causality and pre-existing trends correlated with EPS exposure, may remain. A higher share of EPS workers could itself reflect differential firm performance in employment or productivity prior to COVID. If so, our estimates could capture the continuation of pre-existing trends rather than the causal impact of the pandemic-induced decline in EPS workers. To evaluate this concern, we conduct a validity test by regressing pre-pandemic changes in the number of Korean workers between February and August 2019 on the exposure variable, defined as the predicted EPS share based on Table 4. If the instrument were correlated with these pre-COVID trends, this would suggest the presence of underlying confounders already operating before 2020.

Columns (4) and (5) of Table 5 report the results of these validity checks. All regressions include firm-level controls and size fixed effects. Column (4) uses the full sample of firms, including those that closed after 2020, whereas column (5) restricts the sample to firms that survived and are included in the panel analysis of outcomes. In both specifications, we find no statistically significant association between the exposure measure and pre-period changes in Korean employment. These results indicate that the identifying variation is not systematically related to pre-existing trends, strengthening our interpretation that the post-2020 relationship between EPS dependence and firm outcomes reflects the effects of the unexpected decline in EPS labor supply. To further alleviate concerns regarding pre-trends, we include pre-period changes in Korean employment as additional controls in all regressions.

Another potential concern in our analysis is that large firm-specific demand shocks correlated with EPS exposure may drive the results, given that the study period coincides with the short-run response to the COVID-19 pandemic. For example, if pandemic-related production declines were concentrated among goods produced by firms with high EPS employment, our estimates could partly reflect demand-side shocks rather than labor supply disruptions. However, the manufacturing sector in Korea was substantially less affected than the service sector during the pandemic (Lee and Yang, 2022). In addition, we address this concern in two ways. First, because exporting firms were disproportionately affected by the pandemic, we exclude exporters in some specifications to test whether the results are driven by this subset of firms. Second, as a robustness check, we exclude firms located in Daegu and Gyeongbuk, regions that were among the most severely affected during the early stages of the pandemic (Aum, Lee, and Shin, 2021). As shown in the following section, the results remain highly robust across these alternative specifications.

4.3 Alternative Identification Strategy: Matching

Our sample consists of relatively homogeneous manufacturing firms that use the EPS program to varying degrees. The main identification strategy exploits variation in statutory quotas across firms to generate policy-driven exposure and evaluate its impact. Nevertheless, omitted unobserved factors and the continuous nature of our treatment measure may still bias the estimates. To address these concerns, we complement the regression analysis with a nearest-neighbor matching approach. This method relies less on parametric assumptions and selects control firms that are highly comparable to treated firms, requiring a discretization of treatment intensity into highly exposed and minimally exposed firms. Finding consistent results using this matching strategy strengthens the credibility of our findings under alternative identification assumptions.

We classify EPS-participating firms into treated and control units and match each treated firm to its closest counterpart in the control group using standard matching methods (Imbens, 2015). Treatment status is defined based on the exposure variable, namely the predicted share of EPS workers implied by statutory quotas. Specifically, firms with a predicted pre-COVID EPS share above the median (50 percent), or above the 75th percentile (62.5 percent) as a robustness check, are classified as treated. Control units consist of firms in the bottom quartile, corresponding to the lowest 25 percent of the predicted pre-COVID share. To ensure clear separation between groups, we exclude firms with intermediate exposure levels, namely those in the second and third quartiles. This procedure yields 330 (or 171) treated firms and 191 control firms.

We adopt the potential outcomes framework, where Y_i^1 denotes the survival status of firm i if it is in the treated group, and Y_i^0 denotes its status if it is in the control group. For each firm, only one of these potential outcomes is observed. For treated firms we observe Y_i^1 , while the counterfactual Y_i^0 is missing and must be imputed; for control firms, the opposite holds. The matching estimator imputes the missing counterfactuals by averaging outcomes among the most similar firms in the opposite group.

The main parameter of interest is the average treatment effect (ATE), defined as the expected difference in outcomes between the treated and control states:

$$ATE = \mathbb{E}[Y_i^1 - Y_i^0].$$

It is estimated using the sample analog:

$$\widehat{ATE} = \frac{1}{N} \sum_{i=1}^N (Y_i^1 - Y_i^0).$$

Robust standard errors are computed following Abadie and Imbens (2006, 2011, 2016).

This identification strategy relies on the conditional independence assumption: conditional on observed

covariates, treatment assignment is as good as random. Under this framework, matched treated and control firms are assumed to be comparable in all relevant dimensions except for their predicted share of EPS workers. To promote comparability, we implement a granular matching procedure based on a vector of pre-COVID characteristics. These include baseline firm size (a cubic polynomial in the number of workers pre-2020) to account for scale effects and pre-treatment employment dynamics (the change in Korean worker employment from February to August 2019). The latter is particularly important because it matches firms on pre-treatment trends in labor demand that could otherwise confound the impact of the labor supply shock.

4.4 Instrumental Variables Approach for Surviving Firms

After estimating the impact of the negative labor supply shock from guest workers on firm survival, we focus on firms that remained in operation through January 2021. Using this subsample, we estimate the effects of the decline in EPS workers on a range of firm-level outcomes. As before, we use the pre-COVID predicted share of EPS workers ($Exposure_i$) as an instrument for the firm-specific decline in EPS employment.

$$y_i^j = \delta^j \text{Drop_EPS}_i + \Theta^j X_i + \phi_r^j + \phi_g^j + \epsilon_i^j, \quad (3)$$

where y_i^j denotes the outcome variable j for firm i , and Drop_EPS_i is the endogenous explanatory variable of interest. The coefficient δ^j captures the effect of the decline in EPS workers on outcome j . X_i includes the firm-level control variables described earlier. The terms ϕ_r^j and ϕ_g^j represent region and size-group fixed effects, respectively, and ϵ_i^j is the error term.

We report instrumental variables estimates so that the coefficient δ^j can be interpreted as the effect of a one-percentage-point decline in EPS employment relative to total firm employment. Estimates from reduced-form specifications can be interpreted as rescaled versions of the corresponding 2SLS coefficients.

In the second part of the analysis, we examine several firm-level outcomes, including five qualitative indicators and two firm responses:

- **Revenue decreased:** Indicator for whether firm revenue in 2021 declined relative to August 2019.
- **Setback:** Indicator for whether the firm experienced production delays due to staffing constraints.
- **Shortage:** Indicator for whether the firm identified non-citizen worker shortages as the most significant personnel management challenge following COVID-19.
- **Business exacerbated:** Indicator for whether the firm reported a deterioration in current business conditions.
- **Additional EPS:** Number of EPS workers the firm would be willing to hire in the absence of restrictions.

- **Hire local workers:** Indicator for whether the firm’s primary response to worker shortages was to hire local workers.
- **Automation:** Indicator for whether the firm’s primary response to worker shortages was the adoption of automation systems (machinery).

We also examine employment and wage effects for Korean workers.

5 Main Results

5.1 Firm Survival and Exit

We begin by examining firm survival in response to the sudden and unexpected loss of EPS workers. In our sample of 761 manufacturing firms, 33 firms (4.3 percent) closed during the analysis period. When we broaden the definition of “closed” to include firms that became unreachable because of contact errors, which likely indicate but do not definitively confirm business closure, this number increases to 59 firms (7.8 percent). Because EPS-participating firms are typically small and medium-sized businesses facing persistent labor shortages, a reduction in EPS workers may have had stronger negative effects on firms more reliant on such workers, potentially leading to exit. This is the first outcome we analyze.

In Table 6, we formally examine firm survival using two outcome variables: actual business closures (indicated as *closed* in column (1)) and an extended definition that includes unreachable firms (indicated as *closed2* in column (2)). As shown in the second row of the table, the average probability of closure during the period was 0.044 (4.4 percent) under the narrower definition and 0.078 under the broader definition. These regressions include the full set of pre-2020 control variables introduced earlier, together with region fixed effects. Standard errors are clustered across 68 groups defined by the interaction between region and firm size.

Our findings indicate that pre-pandemic dependence on foreign guest workers, proxied by the pre-COVID policy-driven employment share of EPS workers, significantly affects firm survival. Specifically, in columns (1) and (2), a one-unit increase in the imputed exposure measure, corresponding to a shift from zero to full exposure, is associated with a 12.4 to 17.7 percentage point increase in the probability of closure. Given that the sample means for closure are only 4.4 and 7.8 percent, respectively, these estimates imply economically large effects, approximately two to three times the baseline exit rate. Importantly, this negative relationship persists when restricting the analysis to non-exporting firms, alleviating concerns that the results may be driven by export-related disruptions during COVID-19 rather than labor supply shocks. The estimates remain robust when controlling for firm-size bin fixed effects or including a cubic polynomial in firm size, as shown in columns (4) and (5).

Table 6: The shortage of EPS workers and Survival of Firms

	(1)	(2)	(3)	(4)	(5)
Outcome:	<i>closed</i>	<i>closed2</i>	<i>closed</i>	<i>closed</i>	<i>closed</i>
Sample:	All firms	All firms	Non-exporters	All firms	All firms
<i>Exposure_i</i>	0.124** (0.052)	0.177*** (0.057)	0.151* (0.079)	0.154** (0.073)	0.150* (0.075)
\bar{y}	0.044	0.078	0.044	0.044	0.044
2019 Controls	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Firm size FE				Yes	
Size (Cubic)					Yes
Observations	761	761	632	761	761
R-squared	0.069	0.086	0.066	0.074	0.070

Notes: Each column reports a regression of the indicated outcome on the pre-COVID predicted share of EPS workers. Standard errors are clustered by region and firm size. Full controls include total employment, firm age, indicators for whether the firm exports and whether it reported a positive business outlook, EPS participation intensity, employer age, gender, and education, an indicator for whether EPS participation contributed to firm expansion, the average wage (all measured as of 2019), and a dummy for whether firm revenue decreased.

*p < 0.1, **p < 0.05, ***p < 0.01

Table 7 examines the heterogeneous impact of the decline in EPS workers on firm survival by stratifying firms according to their pre-pandemic average wage, which serves as a proxy for firm productivity and value added per worker. For firms in the lower half of the wage distribution, a higher policy-driven pre-COVID reliance on EPS workers is associated with a large and statistically significant increase in exit probability. Specifically, in column (2), firms in the lower 50 percent of the wage distribution experience an increase in closure probability of 0.238 percentage points per one percentage point increase in EPS exposure. The effect becomes even more pronounced among the lowest-wage firms: column (4) shows that firms in the bottom 25 percent of the wage distribution exhibit an increase in exit probability of 0.398 percentage points.

Table 7 examines heterogeneity in the impact of the decline in EPS workers on firm survival by stratifying firms according to their pre-pandemic average wage, which proxies for firm productivity and value added per worker. Among firms in the lower half of the wage distribution, higher policy-driven pre-COVID reliance on EPS workers is associated with a large and statistically significant increase in exit probability. Specifically, in column (2), firms in the bottom 50 percent of the wage distribution experience an increase in closure probability

of 0.238 percentage points for each one-percentage-point increase in EPS exposure. The effect is even larger among the lowest-wage firms: column (4) shows that firms in the bottom 25 percent of the wage distribution exhibit an increase in exit probability of 0.398 percentage points per one-percentage-point increase in exposure.

In contrast, firms in the upper segments of the wage distribution display small and statistically insignificant responses to the same labor supply shock. Columns (1) and (3) show that among firms in the top 50 percent and top 75 percent of the wage distribution, the estimated coefficients remain close to zero and are statistically indistinguishable from no effect.

Table 7: Survival of Firms by Wage-Level

	(1)	(2)	(3)	(4)
Average Wage (2019):	Upper 50%	Lower 50%	Upper 75%	Lower 25%
<i>Exposure_i</i>	0.063	0.238*	0.066	0.398***
	(0.114)	(0.123)	(0.084)	(0.112)
Full Controls	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	387	374	571	190

Notes: Each column reports a regression of firm survival on the pre-COVID predicted share of EPS workers, estimated separately for subsamples defined by firms' pre-pandemic average Korean worker wage levels. Standard errors are clustered by region and firm size. Full controls include total employment, firm age, indicators for whether the firm exports and whether it reported a positive business outlook, EPS participation intensity, employer age, gender, and education, an indicator for whether EPS participation contributed to firm expansion, the average wage (all measured as of 2019), and a dummy for whether firm revenue decreased.

*p < 0.1, **p < 0.05, ***p < 0.01

This pattern suggests that the adverse effects of the EPS labor drop were stronger and more significant among low-wage, low-productivity firms, which are typically more reliant on routine, manual, and entry-level tasks, which were predominantly performed by EPS workers. These firms appear substantially less capable of absorbing immigrant labor supply disruptions, leading to higher exit rates. By contrast, higher-wage firms may have greater operational margins, financial buffers, and organizational capacity, allowing them to survive the shock, often by reallocating tasks and downgrading native workers, as shown in subsequent tables.

Finally, Table 8 presents alternative estimates based on a nearest-neighbor matching approach to assess the robustness of our primary findings. Across the columns, we employ two alternative definitions of treatment status to capture the intensity of firms' reliance on EPS workers. The variable *Treated1* identifies firms whose pre-COVID share of EPS workers exceeds the median, while *Treated2* applies a more stringent threshold, identifying firms in the top quartile (above the 75th percentile). For both specifications, the control group is

restricted to firms in the bottom 25 percent of the predicted EPS share distribution.

Table 8: Matching Results on Survival of Firms

	(1)	(2)
Treated1	0.033*** (0.009)	
Treated2		0.025** (0.012)
Observations	521	362

Notes: Robust standard errors are reported in parentheses.
 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Columns (1) and (2) report the estimated impact of these negative labor supply shocks on firm survival using matching estimators. The outcome variable in all specifications is a binary indicator for business closure (*closed*), which takes a value of one if the firm ceased operations between 2019 and 2021, and zero otherwise. The coefficients in the table suggest that treated firms—those that experienced a loss of EPS workers—are significantly more likely to close down their businesses.

In particular, under the stricter treatment definition (*Treated2*), the probability of business closure among treated firms increases by 2.5 percentage points relative to their matched counterparts in the control group (column (2)). This is a sizable difference given the baseline closure rate of 4.4 percent during this period; it implies that the labor supply shock increased the likelihood of exit by more than 50 percent of the average. These results are consistent with the regression evidence reported in Table 6 and confirm that firms with high pre-pandemic reliance on EPS workers were significantly more vulnerable to the sharp contraction in foreign labor supply, with the resulting labor shortages acting as a critical determinant of firm mortality.

Taken together, the negative effect of the labor supply shock on firm survival points to an important and relatively underexplored mechanism through which reductions in immigrant labor can worsen local labor market conditions even in the short run, consistent with evidence in Lee et al. (2022) and East, Hines, Luck, Mansour, and Velásquez (2023). Firm closures and the associated loss of local physical capital are likely to displace native Korean workers as well. In our sample, firms that exited during the period employed on average eight Korean workers, suggesting that labor supply shocks affecting immigrant workers may indirectly reduce native employment through firm exit. Although we do not observe aggregate labor market outcomes and therefore cannot quantify the total employment effect of these closures, the results are consistent with a decline in local labor demand for natives following firm exit. These findings also align with Mahajan (2024), who shows that immigrant inflows helped prevent firm closures and supported local employment outcomes. Moreover, because closures are concentrated in manufacturing, the associated income losses may reduce demand in local service sectors, potentially generating negative local employment spillovers (Moretti, 2010).

5.2 Outcomes Among Surviving Firms

The short-run negative effect of the decline in EPS workers on firm survival documented in the previous subsection suggests that this group of workers may have played an important role in production and may have been difficult to replace within the relatively short time frame we analyze. As a result, the disruption caused by the sudden reduction in EPS workers may also have affected firms that remained in operation. This mechanism is particularly plausible given that EPS-participating firms already faced persistent difficulties in filling vacancies even prior to the COVID-19 crisis. To explore this channel, we examine a set of qualitative firm-level outcomes together with firms' stated adjustment responses collected in our survey. It is important to emphasize that this part of the analysis focuses exclusively on firms that survived through the post-COVID period; therefore, the estimated effects should be interpreted as capturing additional impacts beyond firm closures when assessing the overall consequences of the sudden decline in EPS workers for Korean labor outcomes.

Table 9 examines how the contraction in EPS employment during the COVID-19 period affected qualitative outcomes among firms that survived until January 2021. Panel A reports 2SLS estimates of the causal effect of a decline in EPS workers on firm-level outcomes in specifications where the firm-specific drop in EPS workers is instrumented with the quota-predicted pre-COVID EPS share, controlling for firm size. The first-stage F-statistics, reported at the bottom of Panel A, are approximately 9.6 across specifications, indicating that the pre-COVID statutory exposure provides a reasonably strong predictor of the subsequent decline in EPS employment.

Table 9: Qualitative Outcomes of Surviving Firms (2SLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcome:	Revenue drop	Setback	Shortage	Business exacerbated	Additional EPS (intention)	Hire local workers	Automation
Panel A: Qualitative Outcomes (2SLS)							
Drop_EPS _{<i>i</i>}	1.705*** (0.552)	1.365* (0.708)	0.713 (0.527)	0.796 (0.564)	1.990*** (0.375)	0.259 (0.485)	0.167 (0.232)
1st stage <i>F</i>	9.55	9.55	9.55	9.55	9.55	9.55	9.55
Panel B: Qualitative Outcomes (Reduced-form)							
<i>Exposure_i</i>	0.511** (0.253)	0.409** (0.171)	0.214 (0.185)	0.239 (0.221)	0.596*** (0.191)	0.078 (0.167)	0.050 (0.061)
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm size FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	517	517	517	517	517	517	517

Notes: Each column reports a regression of the indicated outcome on the change in the number of EPS workers, instrumented by the pre-COVID predicted share of EPS workers in Panel A, and on the pre-COVID predicted share of EPS workers directly in Panel B. Standard errors are clustered by region and firm size. Full controls include total employment, firm age, indicators for whether the firm exports and whether it reported a positive business outlook, EPS participation intensity, employer age, gender, and education, an indicator for whether EPS participation contributed to firm expansion, the average wage (all measured as of 2019), and a dummy for whether firm revenue decreased.

**p < 0.01, *p < 0.05, *p < 0.1

The results indicate that the reduction in EPS labor had economically meaningful adverse effects on firm performance, as reported by firms themselves. In Panel A, a larger decline in EPS employment significantly increased the likelihood of experiencing revenue losses and production setbacks between 2020 and 2021. The 2SLS estimates imply that a one-percentage-point larger drop in EPS workers is associated with a 1.7 percentage-point higher probability of reporting a revenue decline and a 1.36 percentage-point higher probability of experiencing production setbacks. These estimates suggest that EPS workers played an important role in the production process of surviving manufacturing firms, and that the sudden contraction of this labor force during the pandemic disrupted normal business operations. A plausible mechanism consistent with these patterns is that EPS workers performed routine production tasks that complemented Korean workers, so that their sudden absence generated bottlenecks in production rather than triggering straightforward substitution toward domestic labor. While the point estimates for “shortage” (identifying non-citizen worker shortages as the main personnel man-

agement challenge) and “business exacerbated” (a deterioration in overall business conditions) in columns (3) and (4) are positive, they are not statistically significant.

At the same time, the estimates reveal a notable pattern in firms’ adjustment responses. Despite facing significant operational distress, firms did not respond by significantly increasing the hiring of local workers (column (6)) or accelerating automation investments (column (7)). Instead, firms exhibited a strong and statistically significant increase in their intended demand for additional EPS workers (column (5)). A one-unit decline in EPS employment is associated with an increase of approximately two additional EPS workers in desired hiring, reflecting unmet labor demand under existing restrictions. This pattern suggests that, at least in the short run, EPS workers were not easily substitutable with domestic labor or capital, and that replacing them through local hiring or automation was not viewed as a feasible adjustment margin.

Panel B presents the corresponding reduced-form results based on pre-pandemic exposure to the EPS system, and the estimates closely mirror the 2SLS findings. Firms with higher pre-pandemic imputed exposure to EPS workers were significantly more likely to experience revenue losses and production disruptions, and they expressed substantially stronger demand for additional EPS employment. By contrast, the effects on reported non-citizen worker shortages and on the indicator for deteriorated business conditions (columns (3) and (4)) remain positive but statistically insignificant, consistent with the imprecision observed in Panel A. The consistency between the 2SLS and reduced-form estimates supports a causal interpretation based on the exogenous variation in pre-COVID quota-driven dependence on EPS workers.

Taken together, Table 9 provides evidence that EPS labor shortages during the pandemic imposed meaningful constraints on firm performance. Firms’ limited adjustment through local hiring or automation further highlights the difficulty of substituting away from migrant labor in the short run within Korean manufacturing production processes.

5.3 Employment and Wage Effects

Lastly, we examine how the pandemic-induced decline in EPS workers affected the employment and wages of Korean workers in firms that survived through 2021. In a standard competitive framework with perfect substitutability between EPS and Korean workers, a reduction in EPS labor supply would be expected to increase both employment and wages for Korean workers through direct replacement. By contrast, if the two types of workers are complementary, a reduction in EPS labor may lower productivity and reduce both employment and wages among Korean workers, potentially leading to occupational downgrading for those who move into tasks previously performed by EPS workers.

Table 10 examines how firms adjusted their Korean workforce in response to the decline in EPS workers

between January 2020 and January 2021.⁹ The 2SLS estimates in columns (1)–(3) indicate that a larger EPS worker decline is associated with a statistically significant increase in Korean employment (column (1)), with a coefficient of 0.716, suggesting partial, less-than-one-to-one substitution. However, focusing explicitly on the variable “new hires” in column (2), there is no evidence that firms increased new hiring of Korean workers to replace EPS workers. The coefficient on new hires is negative and statistically insignificant.

Instead, the primary adjustment margin appears to operate through the retention of incumbent Korean workers. Firms experiencing larger EPS declines exhibit significantly higher average tenure among Korean workers (column (3)), with a coefficient of 2.523, consistent with reduced separations or longer employment durations. The reduced-form estimates in columns (4)–(6) corroborate this pattern: firms with higher pre-pandemic EPS exposure retained more Korean workers with longer tenure but did not significantly increase new hiring.

⁹The wage effects refer to the period between August 2019 and January 2021.

Table 10: The Impact on Employment and Wages (Korean)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2SLS				Reduced-Form			
Outcome:	Δ Empl.	New Hire	Tenure	Wage	Δ Empl.	New Hire	Tenure	Wage
Drop_EPS _{<i>i</i>}	0.716*	-4.677	2.523***	-0.619**				
	(0.380)	(9.266)	(0.622)	(0.285)				
<i>Exposure_i</i>					0.215**	-1.402	0.686***	-0.168***
					(0.082)	(2.691)	(0.191)	(0.061)
1st stage <i>F</i>	9.55	9.55	9.58	9.58				
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm size FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	517	517	512	512	517	517	512	512
R-squared		0.359		0.109	0.080	0.367	0.109	0.248

Notes: Columns (1)–(4) report regressions of the indicated outcome on the change in the number of EPS workers, instrumented by the pre-COVID predicted share of EPS workers. Columns (5)–(8) report reduced-form results using the pre-COVID predicted share of EPS workers. Standard errors are clustered by region and firm size. Full controls include total employment, firm age, indicators for whether the firm exports and whether it reported a positive business outlook, EPS participation intensity, employer age, gender, and education, an indicator for whether EPS participation contributed to firm expansion, the average wage (all measured as of 2019), and a dummy for whether firm revenue decreased.

**p < 0.01, *p < 0.05, *p < 0.1

These results indicate that firms did not expand domestic recruitment in response to the EPS worker shortage. Rather, adjustment occurred mainly through retention of existing Korean workers and internal reallocation of labor. This pattern is consistent with limited short-run substitutability between EPS and Korean workers and with constraints in the local supply of domestic labor. In addition, Korean workers experienced a substantial decline in average wages following larger EPS reductions. Column (4) shows a negative and statistically significant effect on average wages. This finding is consistent with complementarity between EPS and Korean workers and with firms responding to the shock by reallocating Korean workers toward lower-paying tasks or retaining relatively less-skilled workers at lower wages.

Overall, the evidence suggests that immigration restrictions did not improve outcomes for native workers within surviving firms. Firms were largely unable to offset the loss of EPS workers through domestic hiring and instead adjusted by retaining incumbent workers, reallocating tasks internally, and reducing wages. While some Korean workers remained employed at surviving firms, they appear to have done so at the cost of lower wages and potential occupational downgrading, while others likely lost employment when firms exited the market. The combined evidence points to adverse effects on native workers along both intensive and extensive margins.

6 Robustness Checks

In this section, we assess the robustness of our main findings on firm closure and on Korean workers' outcomes, including employment and wages. Table 11 reports two sets of robustness exercises. Columns (1)–(3) re-estimate the main specifications after excluding firms located in Daegu and Gyeongbuk, the regions most severely affected during the initial COVID-19 outbreak. Columns (4)–(6) repeat the same specifications after excluding firms with a pre-pandemic EPS share above 0.8. In columns (1) and (4), the outcome variable is *Closed*, and the key regressor is $Exposure_i$ (the pre-pandemic predicted EPS share). In columns (2)–(3) and (5)–(6), the endogenous regressor is $Drop_EPS_i$ (the decline in EPS workers), instrumented by $Exposure_i$.

The first three columns of Table 11 address the concern that our estimates may be confounded by the direct effects of the COVID-19 outbreak itself, as the analysis period overlaps with the early phase of the pandemic in Korea. In particular, the Daegu and Gyeongbuk regions were disproportionately affected at the onset of COVID-19 and experienced substantial disruptions in production and exports. To mitigate this concern, we exclude firms located in these two regions and re-estimate the baseline specifications. The results remain consistent with our main findings: firms with greater pre-pandemic exposure to EPS workers continue to exhibit a higher probability of closure, and the 2SLS estimates indicate that a larger pandemic-induced decline in EPS workers is associated with changes in Korean employment and statistically significant wage declines.

Table 11: Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)
	Dropping Daegu & GB			Dropping Share EPS > 0.8		
	(Reduced-Form)	(2SLS)	(2SLS)	(Reduced-Form)	(2SLS)	(2SLS)
Outcome:	Closed	Employment	Wage	Closed	Employment	Wage
<i>Exposure_i</i>	0.165** (0.075)			0.149* (0.087)		
Drop_EPS _i		0.779* (0.410)	-0.687** (0.299)		0.801** (0.398)	-0.738*** (0.284)
1st stage <i>F</i>	-	11.38	11.22	-	11.15	11.93
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm size FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	712	486	481	737	500	495
R-squared	0.074		0.061	0.077		0.083

Notes: Columns (1)–(3) report robustness checks excluding firms located in Daegu and Gyeongbuk. Columns (4)–(6) report robustness checks excluding firms whose pre-pandemic EPS share exceeds 0.8. In columns (1) and (4), the outcome is firm closure, and the key regressor is the pre-COVID predicted share of EPS workers. In columns (2)–(3) and (5)–(6), the regressor is the change in the number of EPS workers, instrumented by the pre-COVID predicted share of EPS workers. Standard errors are clustered by region and firm size. Full controls include total employment, firm age, indicators for whether the firm exports and whether it reported a positive business outlook, EPS participation intensity, employer age, gender, and education, an indicator for whether EPS participation contributed to firm expansion, the average wage (all measured as of 2019), and a dummy for whether firm revenue decreased.

*p < 0.1, **p < 0.05, ***p < 0.01

The last three columns of Table 11 also examine sensitivity to firms with exceptionally high reliance on EPS workers by excluding firms whose pre-pandemic EPS share exceeds 0.8. Reassuringly, both the reduced-form and 2SLS estimates remain similar in magnitude and statistical significance, and the first-stage F-statistics remain comfortably above conventional thresholds. These results indicate that the findings are not driven by a small number of firms with extremely high exposure. Overall, the robustness checks suggest that our main conclusions are unlikely to be driven either by localized COVID shocks or by a small subset of firms with unusually high EPS dependence.

7 Discussion and Conclusions

As populations in advanced economies age and the supply of young native workers willing to perform physically demanding manual jobs continues to decline, less-skilled immigrant workers have increasingly become an essential input in many production processes. Although these workers are often employed in entry-level occupations, our results demonstrate that they play a critical role in sustaining firm productivity, supporting the employment of native workers in complementary occupations, and ensuring firm operations.

This paper studies the short-run consequences of a sudden and exogenous contraction in the inflow of immigrant guest workers into the Korean manufacturing sector in 2020 following COVID-19 border closures. Exploiting policy-driven variation in firms' pre-pandemic quotas for immigrant labor, we show that this source of variation is uncorrelated with pre-COVID trends and therefore provides causal evidence on how firms adjust when the supply of a key labor input is abruptly reduced.

Two central findings emerge. First, firms that relied more heavily on guest workers experienced significantly larger production disruptions and a substantially higher probability of exit. The lost labor input was not easily substitutable in the short run, leading to measurable declines in operational performance and firm survival. Second, among surviving firms, the reduction in immigrant labor did not translate into increased domestic hiring. Instead, firms primarily adjusted by retaining incumbent Korean workers and reallocating them toward lower-skilled tasks, resulting in significant wage declines and occupational downgrading. While retention of incumbents may have partly offset employment losses due to firm closures, it came at the cost of lower wages and task downgrading.

Overall, our findings highlight the role of less-skilled immigrant workers as complementary inputs in industrial production and suggest that sudden immigration restrictions can impose substantial short-run costs on both firms and native workers. These results are consistent with recent evidence by Clemens and Lewis (2022) for the United States. They also have important implications for immigration policy in aging economies, suggesting that restricting access to immigrant labor may generate unintended negative consequences for firm dynamics and worker welfare. Future research examining longer-run adjustments by firms and workers following sustained declines in immigrant labor would be especially valuable. More broadly, understanding how labor shortages interact with firm organization and task allocation remains a key avenue for future research in aging labor markets.

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Appendix

Table A1: Comparison of Industry Distribution: Survey Sample vs. National Average

Industry (KSIC)	Our Survey	National Average
Food products	22%	8%
Beverages	0%	0%
Tobacco products	0%	0%
Textiles, except apparel	6%	4%
Wearing apparel, clothing accessories and fur articles	7%	3%
Leather, luggage and footwear	13%	1%
Wood and of products of wood and cork; except furniture	2%	1%
Pulp, paper and paper products	0%	3%
Printing and reproduction of recorded media	0%	2%
Coke, briquettes and refined petroleum products	0%	0%
Chemicals and chemical products; except pharmaceuticals	3%	4%
Pharmaceuticals, medicinal chemical and botanical products	0%	1%
Rubber and plastic products	4%	9%
Other non-metallic mineral products	1%	4%
Basic metals	4%	4%
Fabricated metal products, except machinery and furniture	11%	14%
Electronic components, computer, radio, TV and communication equipment	5%	5%
Medical, precision and optical instruments, watches and clocks	2%	4%
Electrical equipment	5%	6%
Other machinery and equipment	8%	14%
Motor vehicles, trailers and semitrailers	2%	6%
Other transport equipment	1%	2%
Furniture	4%	2%
Other manufacturing	1%	2%
Repair of industrial machinery and equipment	0%	1%

Notes: Values represent the proportion of firms in each industry. Data for “Our Survey” are drawn from The Survey on the Employment Permit System (KDI and World Bank, 2019). Data for “National Average” are drawn from The Mining and Manufacturing Survey (Statistics Korea, 2019).

Table A2: Comparison of Firm Size Distribution: Survey Sample vs. National Average

Number of Workers	Our Survey	National Average
Less than 10 workers	41%	-
10 to 19 workers	26%	51%
20 to 49 workers	25%	34%
50 to 99 workers	4%	9%
100 to 199 workers	2%	4%
200 to 299 workers	1%	1%
300 to 499 workers	0%	1%
500 or more workers	0%	0%

Notes: Values represent the proportion of firms in each industry. Data for “Our Survey” are drawn from The Survey on the Employment Permit System (KDI and World Bank, 2019). Data for “National Average” are drawn from The Mining and Manufacturing Survey (Statistics Korea, 2019).