

Cost Shocks and Firm Productivity: Evidence from Minimum Wage Introduction

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Abstract

We study firm adjustment to labor cost shocks using the first nationwide introduction of a minimum wage in Korea. Using plant-level manufacturing data and variation in policy exposure based on pre-reform wage distributions, we estimate effects on employment and productivity. More exposed firms experience significant increases in labor costs and declines in employment, but also substantial improvements in both labor productivity and total factor productivity. These findings indicate that firms respond to cost shocks along multiple margins, including efficiency-enhancing adjustments to production. The results suggest that productivity gains may partially offset the impact of higher labor costs.

Keywords: Cost Shocks, Minimum Wage Introduction, Employment Effect, Firm Productivity, Difference-in-differences with heterogenous trends

JEL Classification Code: J23, J31, J38, L60

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1 Introduction

A large literature has studied the effects of minimum wage policies on various economic outcomes, including employment, prices, profits, and market structure through entry and exit.¹ We examine how firms respond to the first nationwide introduction of the minimum wage. Korea introduced a national minimum wage in 1988, about a year after the minimum wage law was enacted in December 1986, although legal provisions for such a policy had existed since the 1953 Labor Standards Act. This provides a useful setting to examine minimum wage effects, as the 1988 reform represents the first nationwide minimum-wage policy shock in Korea.

We focus on the effects of the minimum wage on employment and firm productivity. While a large literature has examined employment effects, there remains little consensus regarding their sign or magnitude. Specifically, some empirical studies point towards a positive employment effect of the minimum wage or no effect at all, contrary to what is predicted by the standard model of the labor market (e.g., see Neumark and Wascher (2008) and Card and Krueger (2015) for the survey of mixed evidence). Even when the impact is negative, the size of the employment effects of minimum wages is also debatable, often described by the phrase “elusive” coined by Kennan (1995) and Manning (2021).

Firms may respond to cost shocks in several ways. When minimum wages bind and labor costs rise, firms may adjust their wage structure, increase prices to offset profitability losses, or substitute away from now more expensive labor toward other inputs such as capital. Firms may also attempt to improve labor productivity or production efficiency to mitigate the cost increase.

Despite the large literature on the effects of minimum wages on various economic outcomes, one important but less studied margin of adjustment is firm productivity. Depending on how strongly the minimum wage binds, firms may adjust their provision of on-the-job training or

¹There exists a voluminous literature on the employment effects of the minimum wage, e.g. Addison et al. (2009), Dube et al. (2010), Mela et al. (2009), Harasztosi and Lindner (2019), Doh et al. (2024), and many other studies surveyed by Neumark and Wascher (2008). Other studies have contributed to the debate about whether prices are raised as the minimum wage is passed on to consumers, or whether firms endure the policy’s impact by lowering profits (Katz and Krueger (1991), Card and Krueger (1994), Aaronson and French (2007), Aaronson et al. (2008), Allegretto and Reich (2018), and Draca et al. (2011), among others). The literature on the effect of minimum wage on entry and exit includes Rohlin (2011), Aaronson et al. (2018), and Luca and Luca (2019).

implement organizational changes, such as restructuring management or adopting new technologies, to improve production efficiency.² Minimum wages may also affect labor quality, such as the effort exerted by non-managerial workers or the costs of monitoring them.³ Firm-level productivity is, in many cases, not directly observable. As a result, empirical research on the effects of minimum wages on productivity is relatively limited and confined to a handful of settings in which relevant information is available. We examine firm-level productivity using detailed firm-level data. Furthermore, in contrast to most previous studies that focus on specific aspects of firm productivity—such as worker effort, job training, R&D investment, or managerial structure—we consider a composite measure of these components that jointly determine overall firm productivity as well as labor productivity.⁴

We use firm-level data on employment, wages, and input demand collected by the annual Mining and Manufacturing Survey (MMS) to examine how the introduction of the national minimum wage affects employment and firm productivity. Our analysis focuses on the manufacturing sector, which has been subject to the minimum wage policy since its introduction in 1988. We use two distinct measures of firm productivity to examine the productivity effects of minimum wages. Total factor productivity (TFP) is obtained by estimating firm-level production functions, while labor productivity is measured as value added per worker. The production function estimates are obtained separately for each of the nine manufacturing sectors using firm-level data covering the period 1982–1995.⁵

We identify the effects of the minimum wage using a difference-in-differences specification that allows for heterogeneous trends driven by both observed and unobserved factors. Using

²The possibility that minimum wages reduce training investment, initially raised by Rosen (1972) and Feldstein (1973), is evidenced by Hashimoto (1982), Schiller (1994), and Neumark and Wascher (2001), whereas no clear evidence of reduced training is found by Grossberg and Sicilian (1999), Acemoglu and Pischke (1999), and Arulampalam et al. (2004).

³Studies predicated upon the efficiency wage theory associate wages with the productive quality of employees through shirking or supervision costs (Shapiro and Stiglitz, 1984; Georgiadis, 2013), quitting and turnover costs (Salop, 1984), and workers’ sentimental association with firms or a conception of fair wages (Akerlof, 1982; Akerlof and Yellen, 1990).

⁴Notable exceptions which use the estimates of unobservable productivity shocks are recent studies by Rizov et al. (2016) and Riley and Bondibene (2017).

⁵Biases arising from potential endogeneity of observed inputs have been a pervasive problem in estimating firm level production functions to recover productivity. See the literature, including recent work addressing concerns about robust estimation (Olley and Pakes, 1996; Levinsohn and Petrin, 2003; Akerberg et al., 2015; Kim et al., 2019; Akerberg et al., 2023).

data on 188,479 plants in Korea from 1982 to 1995, we construct a measure of minimum wage exposure based on firm-level average labor costs and estimate regressions of outcome changes around the policy introduction on this measure with augmented controls. We then estimate minimum wage effects by comparing the evolution of outcomes at affected firms with those at firms that are barely or not affected.

Our main findings are as follows. First, we find a significant disemployment effect of the minimum wage. Baseline estimates indicate that employment at affected firms declines by 4–9 percent relative to unaffected firms during the first three years after implementation. The implied employment elasticity with respect to wages or labor costs ranges from -0.13 to -0.19 , consistent with previous studies. Our estimates of wage effects also support the existing literature showing that minimum wages increase labor costs for low-paid workers. We conduct several robustness checks for our baseline employment results. First, our findings are robust to potential measurement issues arising from sampling attrition in the MMS. Firms with fewer than five workers are excluded from the survey, so firms falling below this threshold cannot be distinguished from exiting firms. We also find that our disemployment results are robust to varying the cutoff for average labor costs used to define the treatment group. Our results are also robust to potential threats to the validity of the treatment status in our empirical setting.

Second, we find that both labor productivity and TFP increase at firms more exposed to the minimum wage relative to less exposed firms. Labor productivity rises by 20–50 percent more at affected firms during the first three years after implementation. The change in TFP at more exposed firms peaks about three years after the policy at roughly 46 percent above that of less exposed firms and diminishes in the following year. The implied elasticities with respect to wages range from 0.6 to 0.9 for labor productivity and from 0.6 to 0.8 for TFP. These productivity effects are robust to alternative comparison groups and to production function estimates that allow for a structural break around the policy introduction.

Lastly, we document substantial industry heterogeneity. Disemployment effects are concentrated in light industries, while productivity gains appear in both light and heavy industries. These patterns suggest that the minimum wage binds more strongly for labor-intensive firms, whereas the smaller labor share in heavy industries limits employment responses.

Related Literature

This paper relates to three strands of the literature: studies of firm responses to minimum wage policies, research exploiting firm-level data to examine minimum wage reforms, and work examining productivity effects.

Our analysis relates to a growing empirical literature that uses firm-level data to study the effects of minimum wage policies. Recent contributions exploit large policy shifts or institutional reforms to examine how firms adjust to higher wage floors. For instance, Harasztosi and Lindner (2019) analyze the large minimum wage increase in Hungary in the early 2000s and show that the policy raised wages substantially while generating modest employment losses. Their results emphasize the importance of product market conditions in determining firm responses, with employment adjustments being more pronounced in sectors exposed to stronger competitive pressures. While their study focuses on a sizable increase in an already existing minimum wage system, our setting differs in that we examine the initial implementation of a nationwide minimum wage, which represents a distinct type of policy shock.

Another related strand of research studies the introduction or expansion of minimum wage policies using detailed micro data. Dustmann et al. (2022), for example, examine the introduction of the German nationwide minimum wage in 2015 using matched employer–employee data. Their analysis documents substantial wage gains for low-paid workers with limited evidence of aggregate employment losses and emphasizes the role of worker reallocation toward more productive firms. Because our data do not link workers to firms, we cannot directly evaluate such reallocation mechanisms. Instead, we focus on changes in firm-level productivity, examining whether firms adjust their production processes when faced with higher labor costs.

Our work is also related to studies that examine minimum wage policies in emerging economies. Engbom and Moser (2022) study Brazil using administrative firm data and find strong wage compression but limited evidence of employment effects. Compared with these studies, the institutional context we examine provides a particularly useful setting for analyzing firm responses. The Korean reform in 1988 introduced a national minimum wage for the first time, creating a sharp policy change affecting firms that previously operated without a statutory wage floor. This allows us to analyze how firms respond when a wage regulation becomes binding for the

first time rather than when an existing minimum wage is adjusted.

Our work is also related to Doh et al. (2024), who study the rapid increase in the Korean minimum wage between 2017 and 2019 using firm-level manufacturing data. They document a significant negative employment effect associated with the large and unexpected wage increases and show that labor productivity rises more strongly among firms more exposed to the policy. While their analysis focuses on a sharp increase in an already existing minimum wage system, our study examines the initial introduction of the nationwide minimum wage in 1988. By analyzing this earlier institutional episode, we provide more direct evidence on how firms respond when a statutory wage floor is introduced for the first time rather than when it is subsequently raised. Moreover, our analysis examines not only labor productivity but also total factor productivity, which we measure by estimating firm-level production functions.

More broadly, our paper contributes to the literature on firm adjustments to labor cost shocks. Much of the existing work focuses primarily on employment outcomes, but firms may also respond by altering production methods, input combinations, or organizational practices. Using detailed plant-level data from the manufacturing sector, we examine both employment adjustments and productivity responses, measuring productivity through labor productivity and total factor productivity. By jointly analyzing these outcomes, our study provides evidence on how firms adapt their production processes following the introduction of a nationwide minimum wage. The results suggest that firms partially offset higher labor costs through productivity improvements.

The remainder of the paper is organized as follows. Section 2 describes the institutional background and the data. In Section 3, we outline the empirical identification strategy. Section 4 presents the estimation results and discusses their implications. Section 5 concludes.

2 Institutional Background and Data

2.1 Institutional Background

The minimum wage in Korea was first introduced in 1988, about one year after the minimum wage law was enacted in December 1986. Though legislation for implementing minimum wages

was passed in 1953 with the enactment of the Labor Standards Act, the Korean government has not introduced the minimum wage until 1988. This was because the government posited that the minimum wage and the foreseeable spike in labor costs as its consequence would impede the Korean economy's spurt of rapid industrialization and growth in the 1960-1970s. When the policy was first implemented, it was applied to firms in the manufacturing industry with more than 10 full-time employees, which covered about 20 percent of all employees in the economy. Then, the target group of the minimum wage was gradually extended to other sectors including the mining and construction industries. The minimum wage has been applied to every employees of the entire economy since November 2000.

The Korean economy entered a period of maturity in the 1980s following rapid growth and industrial restructuring in the 1970s. During this period, the manufacturing sector underwent a significant structural transformation, shifting from light industries toward heavy and chemical industries and the production of capital goods. While Korean manufacturing was initially concentrated in textiles and footwear, the 1970s saw expansion into steel, heavy machinery, shipbuilding, and petrochemicals, followed by further diversification into electronics and automobiles in the 1980s.

Figure 1 plots the evolution of several key macroeconomic variables around the time of the reform.⁶ The Korean economy maintained strong growth throughout the late 1980s and early 1990s, with no major macroeconomic disruptions coinciding with the policy introduction. As shown in the bottom panel, GDP growth was about 13 percent in 1987, declined to 12 percent in 1988 and 7 percent in 1989, and then recovered to about 10–11 percent during 1990–1991. Consistent with this favorable macroeconomic environment, aggregate labor market conditions also improved, with the unemployment rate falling from about 4 percent to 3 percent in 1987 and remaining near 2.5 percent through 1991. Inflation, measured by the CPI, remained low and stable at around 1.5 percent before rising modestly to about 2 percent in 1990.

[Figure 1 about here]

Overall, these patterns suggest that the introduction of the minimum wage did not coincide

⁶The source of data is Economic Statistics System (ECOS) by the Bank of Korea.

with major macroeconomic shocks or deteriorating labor market conditions, alleviating concerns that concurrent aggregate trends confound the estimated effects of the policy.

2.2 Data and Construction of Variables

The data set at our disposal includes detailed information about 188,479 plants in Korea from 1982 to 1995. The data were collected from the annual Mining and Manufacturing Survey (MMS) conducted by Statistics Korea, and they cover all manufacturing establishments with more than five workers.⁷ The data provide firm-level accounting information from balance sheets and income statements, along with employment records. These data enable us to construct a firm-level panel including revenue, value added, factor inputs, and labor costs.

The data cover nine industrial sectors associated with 2-digit codes of the Korean Standard Industrial Classification (KSIC). The KSIC system has been revised twice, in 1984 and 1991, during the data periods. The revision in 1991 diversified the 2-digit KSIC code from 13 to 28 industry groups, while the 1984 revision led the lower level classification to be more fragmented. We used the 1984 version of 2-digit codes to classify the sample firms' industries, and modified the 2-digit codes of the years of 1982-1983 and 1991-1995 accordingly. The nine industry sectors include Fabricated Metals, Machinery, Equipment (38), Plastics and Rubber Products (35), Textiles and Leather (32), Primary Metals (37), Papers and Printing (34), Food and Tobacco Products (31), Non-metallic Mineral Products (36), Wood Products (33), Other Manufacturing (39), in the order of total output over the sample periods, where the numbers in parentheses are the 2-digit KSIC code.

In estimating the plant-level production functions described in the Appendix, we use value added as the measure of output and include labor, capital, and (non-energy) intermediate inputs as production factors. Labor input is measured as the monthly average of total employment. Capital input is measured using the mid-year capital stock, constructed as the average of capital balances at the beginning and end of each year. The data report capital separately for buildings,

⁷Statistics Korea, the national statistical agency, has conducted the Mining and Manufacturing Survey (MMS) annually since 1967. The MMS is a census of manufacturing establishments that operated for at least one month during the survey year. Beginning in 2008, the employment threshold for inclusion increased from five to ten employees.

machinery, and vehicles, and we construct the capital measure by aggregating these components. Value added, capital, and intermediate inputs are deflated to constant 2000 Korean won (KRW) using industry-level price deflators. The construction of output and input deflators follows the methodology of the Korean National Income Accounts and the Bank of Korea. In particular, real capital is obtained by deflating nominal capital stock using industry-specific deflators for nonresidential buildings, machinery, and transport equipment provided by the Bank of Korea.

Table 1 presents descriptive statistics for the variables used in our analysis. Panel A reports summary statistics for the variables used in the estimation of the production functions. The variables exhibit large standard deviations, with coefficients of variation ranging from 6.1 to 21.1 (not reported), suggesting substantial dispersion in both inputs and output. Most of this variation is attributable to cross-firm or cross-industry differences rather than within-firm variation over time. The average coefficient of within-firm variation, which measures the extent of time-series variation within firms, ranges from 0.23 to 0.61 and accounts for only 2.5–4.0% of the overall variation. The large cross-industry variation further supports our approach of estimating production functions separately by industry group.

Panel B in Table 1 reports industry-level descriptive statistics for the sample used to estimate the production functions. Average firm size, measured by output, is largest in the sector of primary metals (37), which also has the fewest firms, followed by food and tobacco products (31) and plastics and rubber products (35). While the sector of fabricated metal products, machinery, and equipment (38) also exhibits relatively high average output, output is more dispersed across firms in this industry.⁸ Labor cost is defined as the real value of total labor compensation (wages, retirement allowances, and employee benefits) divided by average monthly employment. The capital–labor ratio also varies substantially across industries, being relatively low in traditionally labor-intensive industries (e.g., textiles, leather, and wood products) and high in heavy and chemical industries.

[Table 1 about here]

In estimating minimum wage effects, we use data from the four years before and after its

⁸Cross-firm output dispersion, measured by the coefficient of variation, is highest in food and tobacco products (31), followed by primary metals (37) and fabricated metal products, machinery, and equipment (38).

introduction (1984–1987 and 1988–1991). Because the policy initially applied only to firms with at least 10 employees, we exclude firms with fewer than 10 employees in 1987.⁹ We also exclude firms in the top and bottom 1 percent of the output growth distribution between 1984 and 1991 to limit the influence of outliers. The sample is further restricted to firms operating continuously during 1984–1990. The resulting sample consists of 12,649 firms, accounting for about 56 percent of total manufacturing employment over 1984–1991.

[Table 2 about here]

Table 2 presents summary statistics of firm-level characteristics in 1987, one year prior to the introduction of the national minimum wage. The average annual wage is 6.8 million KRW. Workers at firms in the top quartile of the labor cost share earn about 1.9 million KRW less per year, on average, than workers at firms in the bottom quartile. Firms with lower labor costs employ 197 workers on average, whereas those with higher labor costs employ 60 workers. For both groups, employment varies substantially across firms. On average, firms in heavy and chemical industries exhibit higher capital–labor ratios and lower labor shares than firms in light industries. About one quarter of the firms in our sample exported in 1987, and among these firms the average export share is 51 percent.

To capture exposure to the minimum wage, we construct an indicator that equals one if a firm’s average labor cost falls below a threshold percentile of the 1987 distribution of average labor costs, and zero otherwise. We use the eighth percentile as the cutoff, corresponding to the range in which the minimum wage is most likely to bind (see Section 3.1 for details and Section 4.1 for alternative definitions used in robustness checks). Based on this definition, 4.6 percent of firms in the high labor-cost-share group are classified as affected by the minimum wage, compared to 2.8 percent of firms in the low labor-cost-share group.

⁹The employment threshold was reduced to five employees in 1999 and eliminated in 2001, after which the policy applied to all firms.

3 Identification Strategy

3.1 The Minimum Wage Effects

Empirical models— We estimate the effects of the minimum wage on various economic variables by regressing changes in the relevant outcome variables on an indicator for whether the firm is strongly affected by the introduction of the minimum wage.

In doing so, we compare the evolution of the outcome variable between firms for which the minimum wage binds strongly and those that are barely affected by its introduction. To this end, we estimate the following difference-in-differences regression equation, building on the empirical frameworks of Draca et al. (2011) and Harasztosi and Lindner (2019). An important difference, following recent developments in the treatment effects literature (e.g., Wooldridge (2023), Wooldridge (2025), and Deb et al. (2024)), is that we account for differential trends that may depend on both observed and unobserved heterogeneity:

$$\begin{aligned} \frac{Y_{it} - Y_{i,1987}}{Y_{i,1987}} &= \beta_t MW_i + \gamma'_t X_{i,1987} + \theta'_t (X_{i,1987} - \bar{X}_{MW_i=1,1987}) \cdot MW_i + \lambda_{t,j(i)} \\ &+ \eta((t - 1987) \cdot MW_i) + \pi'((t - 1987) \cdot MW_i) \cdot (X_{i,1987} - \bar{X}_{MW_i=1,1987}) + \varepsilon_{it}, \end{aligned} \quad (1)$$

where Y_{it} denotes the outcome variable of interest for firm i in year t such as employment, total labor costs, and firm productivity, MW_i is a binary treatment indicator of the minimum wage introduction, $X_{i,1987}$ is a vector of firm characteristics for the pre-policy period 1987, $\bar{X}_{MW_i=1,1987}$ denotes the average of $X_{i,1987}$ for the treated group, and $\lambda_{t,j(i)}$ are industry-year fixed effects that accommodate overall trends in industry $j(i)$ to which firm i belongs. This specification allows for differential trends depending on both observed and unobserved heterogeneity, as well as group-specific linear time trends. The effects of the minimum wage and other covariates, including industry fixed effects, are also allowed to vary over time. The dependent variable is the percentage change in the outcome variable in each post-policy year relative to its 1987 level. To limit the influence of outliers, outcome variables are winsorized at the 1st and 99th percentiles.

The treatment indicator of the policy, MW_i , equals 1 if firm i is more strongly affected by the 1988 minimum wage introduction, and 0 otherwise. The coefficient for MW_i , β_t , then captures

the effect of the minimum wage on the outcome variable. To estimate the regression coefficient β_t separately for each of the post-policy years allows us to quantify the evolution of the minimum wages effects. The vector of covariates, $X_{i,1987}$, includes the labor cost share of output, the depreciation share of output, the value-added share of output, the share of fixed assets, and the share of non-wage benefits in labor costs, all measured in the pre-policy year 1987. We use the logarithm of the output in 1987 as weights in our regressions following Harasztosi and Lindner (2019) and Card and Krueger (1994).¹⁰

It is worth noting that the empirical specification in (1) is closely related to standard difference-in-differences and event-study designs with a common treatment timing. As in a DID framework, we compare changes in outcomes before and after the introduction of the minimum wage between treated and control firms. The treated firms are those paying relatively low wages prior to the policy and are therefore more exposed to the minimum wage. These firms experience larger post-policy wage increases relative to control firms.

Our specification is also related to an event-study design in that we estimate treatment effects that vary over event time. The time-varying coefficients on minimum wage exposure capture the dynamic pattern of anticipation and post-treatment effects. Estimating these coefficients separately for each post-policy year provides additional flexibility relative to a standard event-study specification by allowing the effects of regressors to vary over time.

Definition of treatment group— Splitting firms into treatment and control groups in a DID framework is less than ideal, since firms’ exposure to the minimum wage may differ depending on their within-firm wage distributions. Firms with a larger share of employees earning below the minimum wage would be more strongly affected by the policy than firms with a smaller share of such workers. However, due to the lack of information on individual worker compensation or within-firm wage distributions, a more detailed measure of minimum wage exposure is often not feasible in empirical applications.¹¹

¹⁰We use the logarithm of output as weights instead of the level of output to avoid the potential problem of highly skewed weights. As a robustness check, we ran the same regressions without the weights and found no qualitative changes in the estimation results (not reported).

¹¹There are a few exceptions that use continuous measures of exposure intensity to minimum wage policies as treatment variables. Harasztosi and Lindner (2019) calculate the fraction of workers earning less than the minimum wage using worker-level wage data, while Doh et al. (2024) use fitted values of the fraction of affected workers based on information on firm-level wage distributions.

Because we do not observe firm-level information on the fraction of workers affected by the minimum wage, we follow Draca et al. (2011) and use average firm wages to define the treatment group. We compute each firm's average annual labor cost by dividing total annual labor costs by the number of employees. We then define a threshold for average labor costs, below which firms are assumed to employ a relatively large share of low-wage workers and thus be more strongly affected by the minimum wage policy. Under this assumption, firms below this threshold are expected to experience increases in average wages following the policy introduction.¹² In our baseline analyses, we define a firm as a member of the treated group if its average remuneration in 1987 is lower than the eighth percentile of the average labor cost distribution. This threshold is equivalent to the average labor cost of 3,281 thousand KRW in 1987.

To provide support for our definition of the treatment group, we examine whether average wages in the treatment group increased substantially following the minimum wage introduction. Panel A of Figure 2 shows the change in firms' average labor costs from 1987 to 1988, the years immediately before and after the policy introduction in January 1988, across percentiles of the 1987 average labor cost distribution. The solid red line shows the change in average labor costs around the actual policy introduction, while the dotted blue line shows the corresponding change around a placebo policy introduction in 1987. Firms with average labor costs below the eighth percentile in the pre-policy year experienced the largest increases in average labor costs (solid red line). The increase becomes smaller and plateaus at higher percentiles of the labor cost distribution.

[Figure 2 about here]

In contrast, firms that paid low average labor costs in 1986, the year immediately preceding the placebo policy, did not experience any clear change in the following year (dotted blue line). This suggests that the introduction of the minimum wage had a discernible impact on labor costs among treated firms. As an alternative measure of compensation to define the treatment group, we also use average wages excluding non-wage benefits. Average wages exhibit similar

¹²Draca et al. (2011) examine the relationship between low-wage incidence and average wages using worker-level wage data for a subsample of firms and validate the treatment indicator based on average wages. Specifically, they show that employees earning below the minimum wage are concentrated in firms at the lower end of the average wage distribution.

patterns, and the same percentile cutoff is selected for defining the treatment group (Panel B of Figure 2). In Section 4, our estimates of the minimum wage effects on labor costs and wages further confirm a substantial increase in labor costs among treated firms following the policy introduction.

3.2 Measure of Firm-Level Productivity

One of the key outcome variables in our analysis of minimum wage effects is firm-level productivity. We consider two measures of productivity: labor productivity and total factor productivity (TFP). Labor productivity, a widely used measure due to its ease of computation, is defined as value added per worker. Total factor productivity is typically measured as the component of output not explained by input use and requires the estimation of firm-level production functions. We estimate production functions using the control function approach (e.g., Olley and Pakes (1996) and Levinsohn and Petrin (2003)) and construct firm-level productivity measures accordingly.

Estimates of firm-level TFP — Production functions are estimated separately for each of the nine manufacturing industries using firm-level data between 1982 and 1995 (See details in Appendix A). We used the intermediate input of non-energy materials as a proxy of the control for unobserved productivity shocks. Given that the minimum wage introduction may have engendered a structural change in the production process or efficiency, as a robustness check, we estimated production functions separately for the pre- and post-policy periods (i.e., 1982-1987 and 1988-1995) and computed firm-level TFPs accordingly.

[Table 3 about here]

Table 3 presents labor productivity and TFP over the sample years by wage quartiles. In both panels, the first four columns are unweighted averages of productivity, and the last column is unweighted averages of wages. The biennial growth rates of firm-level productivity are in parenthesis. For both measures of productivity, the higher average wages, the greater are productivity and its growth rate. Productivity has grown steadily through the years, but firms in all wage groups experience the highest growth of productivity in the first year of the reform.

4 Estimation of Minimum Wage Effects

4.1 Employment Effects of the Minimum Wage

The estimates of the employment effects of the minimum wage from regressions of equation (1) are reported in Panel A of Table 4. The first two columns present the short-run effects on employment for the first two years following the policy introduction, while the next column reports the effect after three years. The results show that employment declines more among low-wage firms following the introduction of the minimum wage. In the first year after the policy introduction, employment at firms classified as low-wage in 1987 declines by 4.1 percent more than at firms that paid higher wages. This difference approximately doubles in the second year but becomes smaller and statistically insignificant by the third year. This pattern is illustrated in Panel A of Figure 3, which shows the evolution of employment effects in the years before and after the policy.

[Table 4 about here]

The coefficient in the last column of Table 4 captures the change in employment of low-wage firms between 1986 and 1987 relative to the control group. This specification corresponds to a placebo policy introduction prior to the actual policy implementation. We reverse the sign of the estimated coefficient for the change between 1987 and the preceding year, since the dependent variable is defined as the change relative to 1987 in regression (1). The estimated pre-policy employment change for treated firms is smaller in magnitude and statistically insignificant. This result supports a causal interpretation of our estimates by ruling out the presence of differential pre-policy employment trends.¹³ The presence of pre-trends would imply that employment growth was already lower for low-wage firms prior to the policy introduction, which could lead our estimates to overstate the disemployment effects of the minimum wage.

[Figure 3 about here]

¹³Our placebo analysis is closely related to the parallel trends test proposed by Borusyak and Jaravel (2024), as our pre-trend test, based on the coefficient estimate of β_t for $t < 1987$, is separated from the estimation of treatment effects while allowing for group-specific linear time trends.

We next estimate the wage effects of the minimum wage using equation (1). The results are reported in Table 5 and Panel B of Figure 3. We use both wages and labor costs as dependent variables, where the latter includes not only wages but also non-wage benefits such as retirement allowances and other employee benefits. The results reaffirm the established finding in the literature that minimum wages increase pay for low-wage workers.¹⁴

The short-run wage effects are substantial for both compensation measures. Firms affected by the minimum wage experience increases in wages and labor costs of 28–31 percent in the first year relative to unaffected firms. The effects persist over the following years, with magnitudes increasing over time. The cumulative increase in wages and labor costs reaches 54–58 percent by the third year.

[Table 5 about here]

Because firms employing low-wage workers adjust labor demand in response to the wage shock, the employment elasticity with respect to wages or labor costs provides a natural measure of the employment effect. We compute this elasticity using the estimated employment and wage responses. This elasticity can be interpreted as a firm-level proxy for the employment elasticity with respect to the minimum wage, or equivalently the induced wage changes for affected workers. If labor demand adjustments are concentrated among workers initially paid below the minimum wage, this measure provides a reasonable approximation of the employment elasticity for directly affected workers.¹⁵

If information on the distribution of employees by wage level were available, it would be possible to obtain a more precise approximation of the employment elasticity with respect to the minimum wage for directly affected workers. We compute the employment elasticity as the ratio of the estimated employment and wage effects. The resulting elasticity ranges from -0.13 to -0.19 based on both wage and labor cost measures. Our estimates of the employment elasticity are similar to those from the previous studies. Neumark and Wascher (2006) document, based on a comprehensive review of the literature, that estimated employment elasticities range

¹⁴See Machin et al. (2003), Stewart (2004), and Draca et al. (2011), among others.

¹⁵Note that our estimate of the employment elasticity is not directly comparable to estimates reported in the previous literature, which typically focus on specific groups such as teenagers. An exhaustive review of empirical studies on the employment effects of minimum wages can be found in Neumark and Wascher (2006, 2008).

between -0.1 and -0.2 for teenagers and between -0.15 and -0.2 for young workers. More recently, Harasztosi and Lindner (2019) find that the employment elasticity with respect to wages or labor costs ranges between -0.13 and -0.23 for firms in Hungary.

Note that the estimated placebo effect on wages is negative and statistically significant. This indicates that average wages and labor costs at affected firms were declining relative to those at unaffected firms prior to the introduction of the minimum wage. However, this difference in wage growth between the two groups reverses after the policy is implemented. The statistically significant pre-policy coefficient suggests that the parallel trends assumption may not hold perfectly, which may limit a strict causal interpretation of the DID estimates. That said, the observed time-series pattern of wages suggests that this placebo effect is unlikely to account for the sharp post-policy increase in wages among treated firms. Because wages at treated firms were declining relative to control firms prior to the policy, the post-policy wage increases cannot be attributed to favorable pre-trends and may, if anything, represent a conservative estimate of the wage effects.

[Figure 4 about here]

Specifically, Figure 4 plots the evolution of average real wages over time by quartiles of the firm-level wage distribution in 1987, one year prior to the policy introduction. The treatment group in our DID analysis consists of firms in the lowest quartile of the 1987 wage distribution (0–25th percentile), for which the minimum wage is most likely to bind. The average wage of firms in the first quartile (solid line) remains largely unchanged during the pre-policy period and even declines from 1986 to 1987. In contrast, the average wages of firms in the higher quartiles (dotted and dashed lines) increase steadily prior to 1987. This contrast disappears following the introduction of the minimum wage, after which the average wage of firms in the first quartile increases sharply. This pattern is consistent with our DID estimates. In particular, wages at low-wage firms relative to their 1987 levels are lower than those at higher-wage firms prior to the policy, but this pattern reverses after the minimum wage introduction.

Robustness Checks for the Employment Effect

We first examine the robustness of our employment effect estimates to sample attrition in the MMS data. As noted, the MMS includes only firms with at least five employees.¹⁶ Firms may leave the sample in the post-policy period either due to firm exit or because employment falls below the sampling threshold. These cases cannot be separately identified in the data.

The employment decline following the minimum wage can be decomposed into extensive margin effects (firm exit) and intensive margin effects (layoffs). Our baseline sample includes only firms that operate continuously from 1984 to 1990, which may understate the disemployment effects by excluding firms that exit or fall below the MMS sampling threshold. Because employment at these firms is unobserved, we construct lower and upper bounds on the employment effects by imputing plausible employment levels.

Given that the MMS employment cutoff is five workers, employment at firms that drop out of the sample must lie between 0 and 4. That is, when a firm is excluded from the MMS after the minimum wage introduction, its employment would be zero if the firm exited the market or between 1 and 4 if it reduced its workforce below the sampling threshold. Assigning zero employment to excluded firms in the post-policy period therefore provides an upper bound on the disemployment effect due to sample attrition, while assigning 4 employees provides a lower bound.

In addition, we can further tighten the lower bound of the estimate by accounting for differences in the conditional probability of firm closure by employment size. Doh et al. (2024), who also use the MMS data, utilize a supplementary data source that allows them to identify firm exits and find that, conditional on dropping out of the MMS sample, firms with employment levels closer to the cutoff (10–15 workers in their study) are less likely to have exited than firms with larger workforces. Following their evidence on the relationship between closure probability and firm size, we derive a tighter lower bound for the disemployment effect by assigning employment of 4 workers to excluded firms with fewer than 15 employees in 1987, one year prior to the policy, and assigning zero employment otherwise.

¹⁶The MMS sampling threshold is five employees during our sample period and was increased to 10 employees in 2009.

[Table 6 about here]

Table 6 presents the lower and upper bounds of the estimated employment effects. Panel A reports the lower bound estimates of the employment decline, while Panel B presents a tighter lower bound that accounts for differences in closure probabilities. Panel C reports the upper bound of the disemployment effect obtained by assigning zero employment to excluded firms. The results show that the estimated employment effects do not differ qualitatively across the upper and lower bounds for the extensive margin, suggesting that our baseline estimates are robust to sample attrition in the MMS data.

Second, we check the robustness of our results to alternative definitions of the treatment indicator. Specifically, we raise or lower the cutoff level of average labor costs for the definition of the treatment group. Panel D of Table 6 shows the estimates with the varied thresholds of labor costs. The results suggest that our estimates of employment effects are robust to alternative definitions for the treatment indicator.

Next, we examine the Stable Unit Treatment Value Assumption (SUTVA), an important identifying assumption underlying our empirical strategy. This assumption requires that any spillover effects on firms not directly exposed to the minimum wage are limited. We provide indirect evidence against violations of SUTVA in two ways. First, we verify that including KSIC industry fixed effects in regression (1) does not qualitatively change the estimated employment effects. Estimates from the specification without industry fixed effects are reported in Panel B of Table 4. This suggests that potential cross-industry spillovers are minimal. Second, examining the evolution of the wage distribution over time, we find no evidence that the cost shock to low-wage firms affects the upper tail of the wage distribution (see Figure 5).

4.2 Effects of the Minimum Wage on Firm Productivity

We next examine the effects of the minimum wage on firm productivity. Table 7 and Figure 6 report changes (relative to 1987) in firm-level productivity for firms highly exposed to the minimum wage relative to less exposed firms. Labor productivity at affected firms increases by 19.5 percent more than at unaffected firms in the first year following the policy introduction, and the effect grows over time, ranging from 36.2 to 50.3 percent in subsequent years.

[Table 7 about here]

The change in TFP for more affected firms is 17.4 percent in the first year and peaks at 46.2 percent in the third year. The implied elasticities of firm-level productivity with respect to minimum wage-induced wage changes range from 0.62 to 0.86 for labor productivity and from 0.55 to 0.79 for total factor productivity over the three years following the policy. Placebo estimates are small in magnitude and statistically insignificant, supporting the plausibility of the parallel trends assumption and strengthening a causal interpretation of the post-policy divergence in productivity.

[Figure 6 about here]

These results suggest that firms adjust to higher labor costs not only through employment reductions but also through efficiency-enhancing adjustments to production. One possible explanation is consistent with efficiency wage theories, which predict that higher wages may improve worker effort, reduce turnover, or increase morale, thereby raising productivity (Akerlof (1982), Shapiro and Stiglitz (1984)). Alternatively, higher labor costs may induce firms to reorganize production, adopt more efficient input combinations, or eliminate organizational slack. Such responses are consistent with recent firm-level evidence showing that minimum wage increases can induce productivity improvements through adjustments in firm behavior rather than solely through employment reductions (see e.g. Rizov et al. (2016), Riley and Bondibene (2017), Dustmann et al. (2022), and Harasztosi and Lindner (2019)). Our results therefore suggest that firms respond to minimum wage shocks along multiple adjustment margins, combining reductions in labor demand with improvements in efficiency.

Robustness Checks for the Productivity Effect

Our identification strategy relies on comparing changes in outcomes before and after the policy between firms more strongly affected by the minimum wage and less affected firms. As a robustness check, we adopt a tighter definition of these groups by restricting the control group to firms with average labor costs in 1987 above the treatment threshold (3,281 thousand KRW) but below the median (6,343 thousand KRW). We conduct this robustness check to allow for

the possibility that firms above the median labor cost may differ systematically from treated firms and may therefore follow different unobserved productivity trends.

Panels A and B of Table 8 present the estimated effects of the minimum wage on labor productivity and TFP, respectively, using the tighter definition of the control group. The results indicate that the estimated productivity effects do not qualitatively change under this alternative specification. The estimates using the tighter control group are slightly smaller in magnitude than those from the baseline specification in Table 7, by about 16 percentage points on average over the three post-policy years for labor productivity and by about 6 percentage points for TFP. However, the implied productivity elasticities with respect to wages are larger when using the narrower control group. This reflects the fact that the estimated wage response to the minimum wage is smaller when the control group is defined using a tighter upper bound on average labor costs, which mechanically leads to larger elasticity estimates.

[Table 8 about here]

We further examine the robustness of our productivity results to the construction of TFP. Because the baseline TFP measure is obtained from production functions estimated over the full sample period (1982-1995), the estimates may be affected if the minimum wage policy altered firms' production technologies or input choices. To address this possibility, we re-estimate production functions separately for the pre-policy and post-policy periods.¹⁷

Panel C of Table 8 reports the estimated minimum wage effects on firm-level productivity when TFP is constructed allowing for a structural break at the time of the policy introduction. The estimated elasticities of TFP with respect to wages are higher by about 17.2 percentage points on average over the three post-policy years relative to those based on the baseline TFP measure. The results, however, remain qualitatively similar when allowing for this structural break, suggesting that the observed productivity improvements are not driven by the specific construction of TFP.

¹⁷Note that our approach to estimating production function parameters is based on a dynamic model of firm behavior that allows for firm-specific efficiency differences (see, e.g., Olley and Pakes, 1996; Levinsohn and Petrin, 2003). Differences in firm-level efficiency are an important determinant of firm growth and thus an integral part of how firms adjust to changes in their economic environment. Allowing production functions to differ between the pre- and post-minimum wage periods therefore provides a less restrictive approach to modeling production technology over the sample period.

4.3 Heterogeneous Responses to the Minimum Wage

We examine heterogeneity in the responses to the minimum wage policy across firms by industry. Table 9 shows the effects of minimum wages on employment and productivity for firms in the light and heavy industries. We focus here on the elasticities of employment and productivity with respect to wage.

The results indicate that the disemployment effect of minimum wages emerges among firms in light industries, and productivity improvements are similarly strong between light and heavy industries though the improvement appears from the second year among firms in light industries. The results for employment suggest that the minimum wage would have bitten much harder for labor-intensive firms in the light industries, hence a larger impact on employment, and that the cost shock of minimum wages in the heavy industries is not sufficiently aggravated to be passed through to the employment decision due to a limited importance of labor inputs.

[Table 9 about here]

Figure 7 and 8 illustrate heterogeneity in responses to the minimum wage introduction across industries. We report the employment elasticity with respect to wages (Figure 7) and the elasticities of labor productivity and TFP (Figure 8). The 2-digit KSIC industries considered are also divided into two groups according to factor intensity, heavy and light industries. Light industries include four sectors in our sample (KSIC 31-34), of which production technologies are characterized as labor-intensive, such as manufacturing of food and tobacco, textiles, leather, and papers. Heavy industries involve a capital-intensive production process and include manufacturing of metals, chemicals, machinery, and plastics in our sample (KSIC 35-38).¹⁸ Elasticities are computed for the mid-term responses, that is, the second year of the policy introduction.

[Figure 7 about here]

[Figure 8 about here]

¹⁸The ratio of capital to labor is about 1.4 times higher and the labor cost share in output is 0.8 times lower for heavy industries than for light industries.

Rows 1 and 6 in the figures report the elasticities for the light and heavy industries, respectively. Rows 2-5 present the elasticities for the four light industries, and rows 7-10 show the elasticities for the four heavy industries. Figure 7 indicates that the disemployment effects are substantially evident for light industries, whereas the effects are statistically insignificant for heavy industries except the sector of fabricated metals, machinery, equipment (38). The results also show that the disemployment effects vary slightly across industries. Productivity improves for both light and heavy industries. Elasticities of labor productivity with respect to wages are greater by 0.13 and those of TFP are greater by 0.2 for light industries than for heavy industries. Heterogeneity in productivity improvements emerges for both labor productivity and TFP. The elasticity of labor productivity range between 0.09 and 1.15 and that of TFP ranges between 0.05 and 1.34, the highest for food and tobacco products (31) and the lowest for plastics and rubber products (35) for both productivity measures.

Our empirical results in this section indicate that firms adjust to minimum wage increases along multiple margins. While employment declines among the most affected firms, productivity improvements suggest that firms partially offset higher labor costs through efficiency-enhancing adjustments. This pattern is consistent with recent firm-level evidence in the literature showing that firms respond to labor cost shocks through a combination of employment adjustments and productivity improvements rather than through employment responses alone.

5 Conclusion

This paper studies how firms adjust to the introduction of a national minimum wage using plant-level data from Korean manufacturing. Exploiting differences in firms' exposure to the policy based on pre-reform wage distributions, we estimate the effects of the minimum wage on employment and productivity. We find that firms more strongly exposed to the policy experience substantial increases in labor costs and significant employment declines relative to less affected firms. At the same time, these firms exhibit sizable gains in both labor productivity and total factor productivity.

The results suggest that firms respond to labor cost shocks along multiple margins. In

addition to reducing employment, firms also appear to adjust their production processes in ways that improve efficiency, partially offsetting higher labor costs. The evidence further points to important heterogeneity in these responses. The disemployment effects of the minimum wage are concentrated among firms in light industries, while productivity improvements are observed in both light and heavy industries. However, productivity gains among firms in light industries tend to emerge with a lag, becoming more pronounced from the second year after the policy introduction.

Several limitations should be noted. Our measure of exposure to the minimum wage relies on average firm wages because information on the within-firm wage distribution is not available. In addition, while our empirical design closely follows a difference-in-differences framework, some evidence of differential pre-trends suggests that the estimates should be interpreted with appropriate caution.

Overall, our findings highlight that the impact of minimum wage policies on firms extends beyond employment effects alone. Policies that raise labor costs may induce firms to reorganize production, adopt efficiency-enhancing adjustments, or change input use. These results suggest that firm productivity responses may partially mitigate the cost increases associated with minimum wage policies. Understanding these firm responses is therefore important for evaluating the broader economic consequences of minimum wage regulations.

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Appendix

A Estimation of Production Functions and Productivity

Estimating production functions raises concerns about simultaneity arising from the endogeneity of input demands (e.g., Olley and Pakes, 1996; Levinsohn and Petrin, 2003; Akerberg et al., 2015). We adopt the proxy variable approach of Levinsohn and Petrin (2003), using materials as a proxy for unobserved productivity, to estimate the production function parameters and obtain a measure of firm-level productivity.¹⁹

We consider a Cobb-Douglas production function in logs, given by

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \nu_{it}, \quad (2)$$

where y_{it} is the output (value added) of plant i at year t , and l_{it} and k_{it} denote its labor and capital input, respectively. The Hicks neutral shock ν_{it} is decomposed into a productivity shock (ω_{it}) and an idiosyncratic shock (ε_{it}), $\nu_{it} = \omega_{it} + \varepsilon_{it}$, and this ω_{it} is a state variable (along with the fixed input, k_{it}) which influences the input decision of firms.

Assuming that the intermediate input demand function, $m_{it} = f(\omega_{it}, k_{it})$, is monotonic in ω_{it} for any k_{it} and has no error component, it can be inverted into $\omega_{it} = f^{-1}(m_{it}, k_{it})$.²⁰ Then, by plugging this term, the production function (2) can be rewritten as

$$y_{it} = \beta_l l_{it} + g(m_{it}, k_{it}) + \varepsilon_{it}, \quad (3)$$

where the second term can be decomposed as follows

$$g(m_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + f^{-1}(m_{it}, k_{it}). \quad (4)$$

The parameters of the production function can be estimated in two-stages. The first stage identifies the labor input coefficient β_l by estimating the partially linear model (3) with a third-order polynomial in m_{it} and k_{it} in place of $g(m_{it}, k_{it})$. In the second stage, we estimate β_k using moment conditions based on the timing assumption that, in firms' dynamic input choice problem, past input choices are not directly affected by the current component of unobserved productivity shocks.²¹

Once the production function is estimated, the measure of plant-level productivity is obtained using the parameter estimates as the following

$$p_{it} = \exp(\omega_{it}) = \exp(y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it}). \quad (5)$$

¹⁹Our data include information on intermediate inputs of materials and energy (electricity and fuels). We used among these the variable materials as intermediate input in our analysis because the energy variable has more zero values than the materials variable. Nonetheless, we find that using the energy variable as an alternative measure of intermediate input does not change the results qualitatively.

²⁰Levinsohn and Petrin (2003) argue that the input demand function of m_{it} can be shown to be monotonically increasing in ω_{it} by making mild regularity conditions on $f(\cdot)$.

²¹This identification restriction follows Olley and Pakes (1996), assuming unobserved productivity shock is first-order Markovian so that $\omega_{it} = E[\omega_{it} | \omega_{i,t-1}] + \xi_{it}$, where ξ_{it} is an innovative or unpredictable component in productivity. They also posit that capital is uncorrelated with the innovation term, i.e., $E[k_{it} \xi_{it}] = 0$. Additionally, Levinsohn and Petrin (2003) assume that ξ_{it} is uncorrelated with the lagged decisions of intermediate input demand given that firms choose $m_{i,t-1}$ before ξ_{it} is realized.

Firm-level productivity shock obtained this way is defined as the residual from the relationship between deflated value-added and inputs. Since the industries accounted for by the sample firms have differentiated products and the deflators used here are specific to industries, as noted by Olley and Pakes (1996), the measured productivity is interpreted as the residual from the reduced form output equation—specific to an industry, which is assumed to be unchanged over the period.

B Tables and Figures

Figure 1. Macroeconomic Trends in Korea: 1983-1991

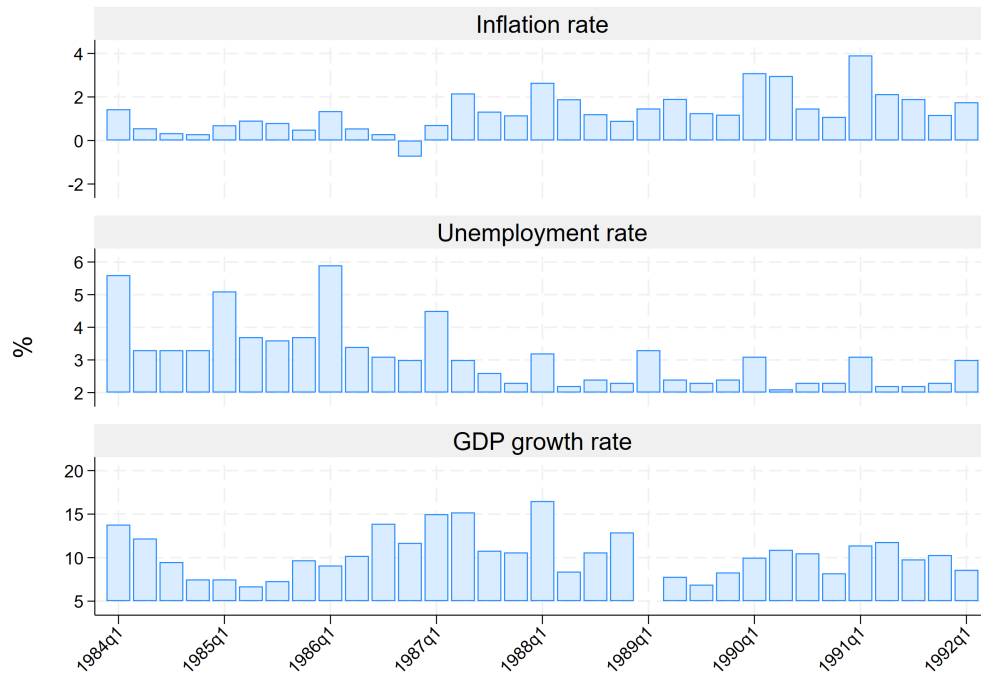


Table 1. Summary Statistics on Korean Manufacturing

Panel A: Variables in production function

	Mean	Std	Median	Min	Max
Value added	1010.1	14523.0	152.2	0.0001	3608967
Capital	1269.7	26718.2	92.2	0.62	5972582
Employment	42.5	265.6	13	1	33553
Materials	2402.4	42984.1	174.6	0.03	8674000

Note: Value added, capital, and materials are in millions of 2000 KRW. Employment is the monthly average of payroll employees.

Panel B: Descriptive statistics by industry

Industry (KSIC 2-digit code)	Sample average			
	No. firms	Output	Labor cost	K/L ratio
Food and tobacco products (31)	11,458	1896.6	6.57	20.11
Textiles and leather (32)	55,393	671.1	7.85	9.30
Wood products (33)	15,776	368.1	8.74	9.52
Papers and printing (34)	15,992	717.9	9.13	14.87
Plastics and rubber products (35)	19,137	1731.0	9.29	23.48
Non-metallic mineral products (36)	9,713	877.6	8.61	21.90
Primary metals (37)	3,777	3203.4	10.58	26.15
Fabricated metals, machinery, equipment (38)	74,925	995.9	9.66	14.84
Other manufacturing (39)	5,302	621.5	7.07	7.77

Note: Statistics are calculated for the sample used for estimating production functions. Value added and wage are in millions of 2000 KRW. Labor cost is the real value of total labor costs divided by the monthly average of payroll employment. K/L ratio is the ratio of capital input to labor input.

Table 2. Summary Statistics of Firm-Level Attributes in 1987

	All firms		Labor cost in output			
			top %25		bottom %25	
	Mean	SD	Mean	SD	Mean	SD
Wage (million KRW)	6.8	2.6	6.0	2.2	7.9	3.2
Labor cost (million KRW)	7.8	3.2	6.7	2.6	9.1	4.0
Employment (number of workers)	121.7	463.5	59.7	170.6	197.3	654.1
Non-wage share in labor cost (%)	3.5	1.9	2.8	1.4	4.3	2.3
Labor cost share in output (%)	26.2	18.8	52.3	17.5	8.6	3.0
Depreciation share in output (%)	2.7	10.9	2.8	20.5	2.6	3.9
Export share in output (%)	14.3	30.7	6.8	23.2	22.3	35.7
Value-added share in output (%)	40.7	34.3	74.0	32.3	16.3	26.0
Fixed asset share in output (%)	37.0	68.0	61.3	115.7	19.6	23.0
Affected by minimum wage	0.033	0.179	0.045	0.206	0.025	0.155
No. of firms	12,649		3,162		3,162	

Note: All attributes are for the year 1987, one year prior to the minimum wage introduction. The last four columns are for the firms with top 25% and bottom 25% of the labor cost share in output, respectively. Affected by minimum wage is the indicator of firms strongly affected by the minimum wage.

Figure 2. Change in Average Labor Costs Before and After NMW Introduction

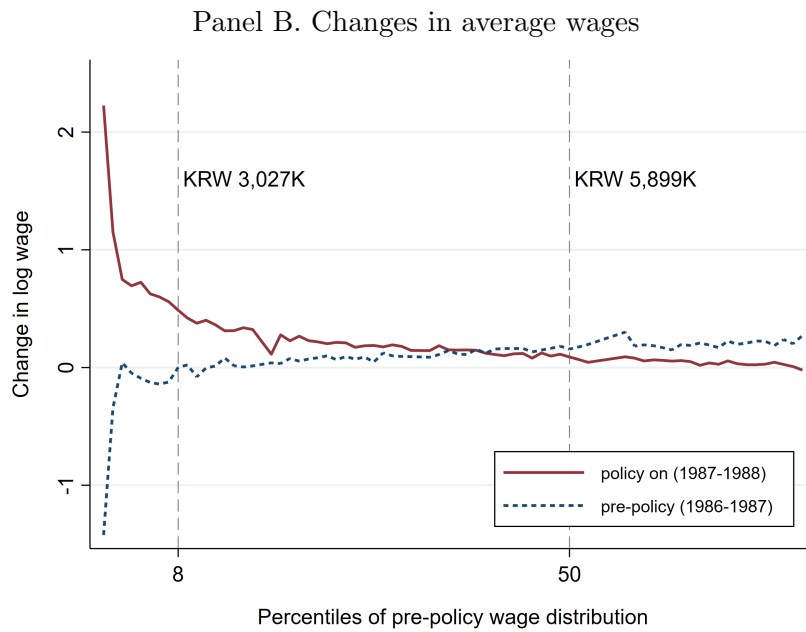
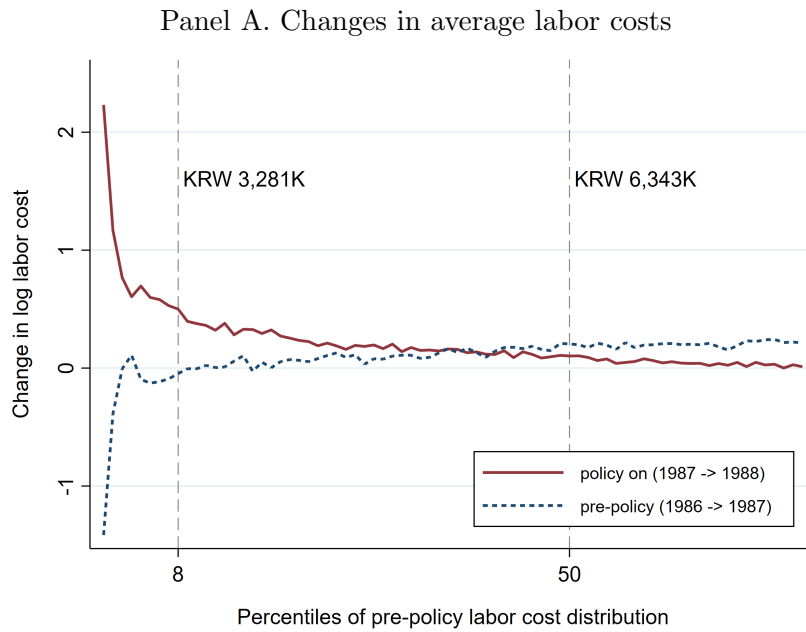


Table 3. Firm-level Productivity and Wages

Panel A: Mean growth rate of total factor productivity by wage quartile

Year	Average TFP				Avg. wage
	0–25th	25–50th	50–75th	75–100th	
1984	7.62 (0.043)	10.97 (0.178)	13.71 (0.271)	26.20 (0.367)	5.36 (0.181)
1986	8.73 (0.030)	12.10 (0.143)	15.43 (0.210)	30.07 (0.292)	5.92 (0.142)
1988	12.26 (0.262)	17.12 (0.385)	21.85 (0.450)	37.84 (0.469)	7.06 (0.250)
1990	14.92 (0.0003)	19.97 (0.135)	24.93 (0.203)	42.45 (0.257)	8.95 (0.302)

Panel B: Mean growth rate of labor productivity by wage quartile

Year	Average labor productivity				Avg. wage
	0–25th	25–50th	50–75th	75–100th	
1984	5.10 (0.025)	7.17 (0.186)	8.79 (0.279)	15.16 (0.384)	5.36 (0.181)
1986	5.61 (0.017)	7.77 (0.140)	9.69 (0.217)	18.18 (0.312)	5.92 (0.142)
1988	8.13 (0.298)	11.65 (0.424)	14.56 (0.499)	23.45 (0.517)	7.06 (0.250)
1990	10.48 (0.071)	14.76 (0.219)	17.87 (0.302)	28.24 (0.362)	8.95 (0.302)

Note: The first four columns are the average firm-level productivity by wage quartiles and the last column is the average wage. Biennial growth rates are in parenthesis.

Table 4. Employment Effects of Minimum Wage Introduction

	Changes b/w 1987–1988	Changes b/w 1987–1989	Changes b/w 1987–1990	Changes b/w 1986–1987
<i>Panel A. Baseline model</i>				
<i>MWbite</i>	-0.041** (0.021)	-0.088*** (0.029)	-0.065 (0.040)	0.028 (0.021)
Observations			87,419	
Adj. R^2			0.105	
<i>Panel B. Without industry fixed effects (SUTVA)</i>				
<i>MWbite</i>	-0.047** (0.020)	-0.084*** (0.028)	-0.056 (0.039)	0.027 (0.020)
Observations			87,419	
Adj. R^2			0.092	

Notes: *MWbite* is the indicator of firms strongly affected by the minimum wage. Regressions include industry fixed effects and other covariates. The sign of the coefficient for the change between 1986–1987 is flipped because the dependent variable is defined as the change relative to 1987. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

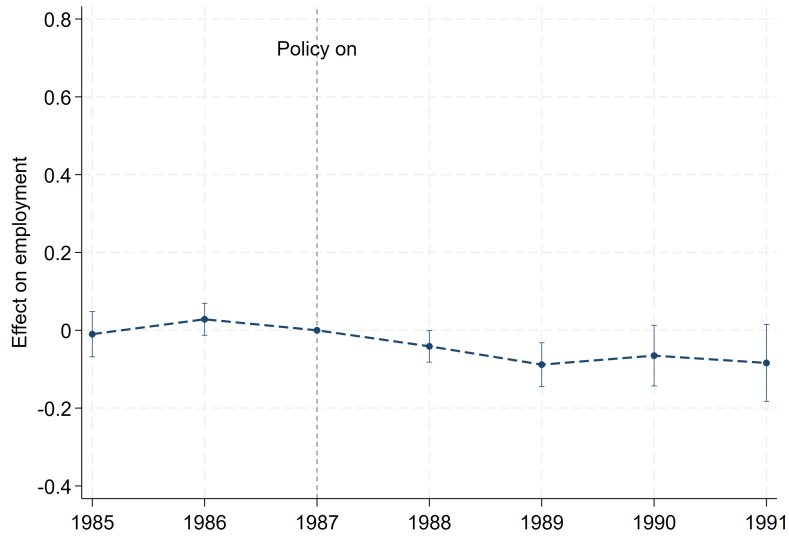
Table 5. Wage Effects of Minimum Wage Introduction

	Change b/w 1987–1988	Change b/w 1987–1989	Change b/w 1987–1990	Change b/w 1986–1987
<i>Panel A. Change in average wage</i>				
MW bite	0.314*** (0.022)	0.470*** (0.028)	0.583*** (0.037)	-0.095*** (0.022)
Employment elasticity with respect to wage	-0.131* (0.069)	-0.188*** (0.066)	-0.112 (0.072)	- -
<i>Panel B. Change in average cost of labor</i>				
MW bite	0.281*** (0.023)	0.467*** (0.028)	0.539*** (0.037)	-0.095*** (0.022)
Employment elasticity with respect to labor cost	-0.147** (0.073)	-0.189*** (0.065)	-0.121 (0.078)	- -

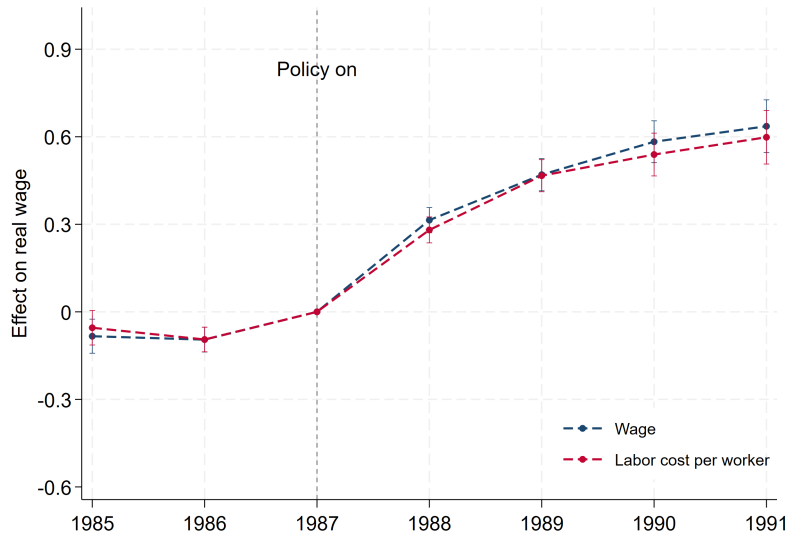
Notes: Labor costs include both wage and non-wage expenses. The specification of regressions is the same as Table 4. The sign of the coefficient for the change between 1986-1987 is flipped because the dependent variable is defined as the change relative to 1987. Elasticities are computed based on the estimates of employment effects from Table 4. Standard errors for elasticities are obtained by bootstrapping with 1,000 samples. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 3. Effect on Employment and Wages

Panel A. Change in employment

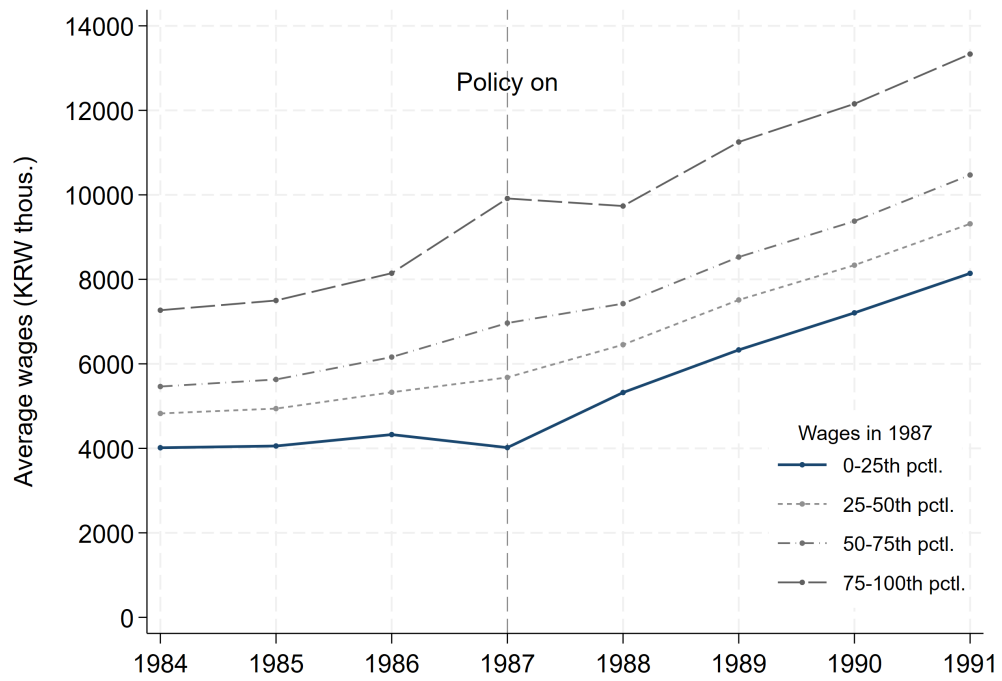


Panel B. Change in wages and labor cost



Notes: Each dot shows the estimated effects on employment (Panel A) and wages (Panel B) of Table 4 and 5, and vertical lines indicate 95 percent confidence intervals for the estimates. The sign of the coefficient for the change between the post-policy period and 1987 is flipped because the dependent variable is defined as the change relative to 1987.

Figure 4. Evolution of Wage by Quartile of the 1987 Wage



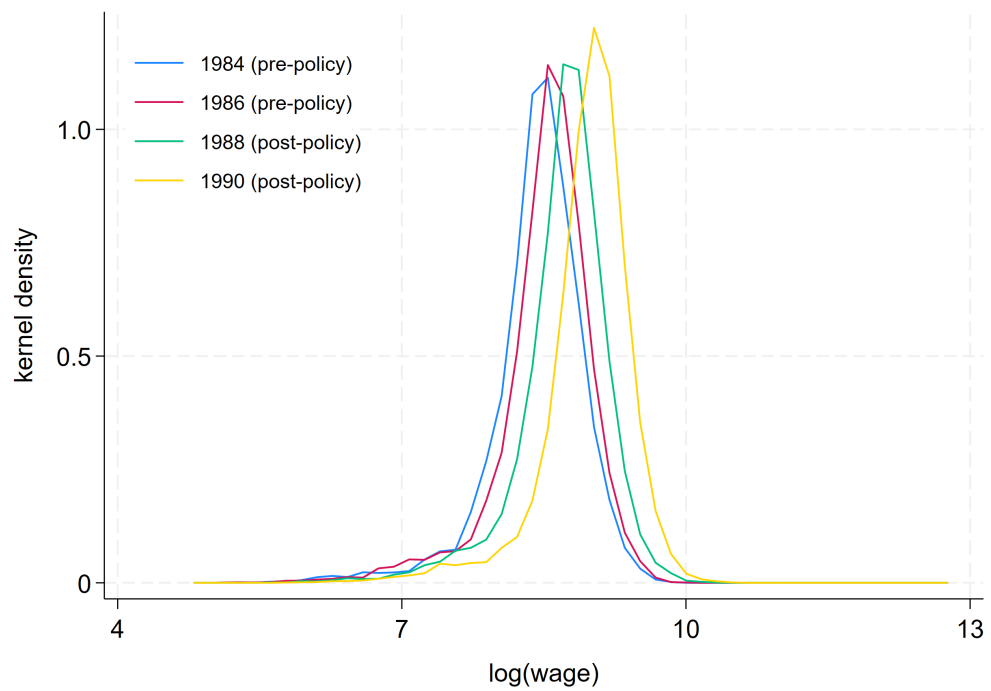
Notes: Each dot shows the average real wages of each quartile in the distribution of firm's average yearly wage in 1987. The first quartile includes the treatment group of firms for which the minimum wage policy has bitten hard.

Table 6. Robustness Checks: Employment Effects

	Changes b/w 1987–1988	Changes b/w 1987–1989	Changes b/w 1987–1990
<i>Panel A. Lower bound for extensive margins</i>			
MW bite	-0.069*** (0.019)	-0.118*** (0.024)	-0.096*** (0.032)
Employment elasticity with respect to wage	-0.195*** (0.052)	-0.229*** (0.049)	-0.152*** (0.051)
<i>Panel B. Tight lower bound for extensive margins</i>			
MW bite	-0.071*** (0.020)	-0.129*** (0.026)	-0.108*** (0.033)
Employment elasticity with respect to wage	-0.202*** (0.058)	-0.250*** (0.052)	-0.170*** (0.053)
<i>Panel C. Upper bound for extensive margins</i>			
MW bite	-0.075*** (0.021)	-0.133*** (0.026)	-0.116*** (0.034)
Employment elasticity with respect to wage	-0.211*** (0.061)	-0.258*** (0.053)	-0.183*** (0.053)
<i>Panel D. Varying treatment cutoff (Elasticities)</i>			
Lower cutoff: 7.5th pctl.	-0.123 (0.087)	-0.173** (0.084)	-0.047 (0.092)
Higher cutoff: 8.5th pctl.	-0.132** (0.064)	-0.179*** (0.061)	-0.112 (0.070)

Notes: The first row of Panel A-C reports the estimate for *MW bite* as in Table 4. Extensive margin of the employment change is bounded both above and below by setting the employment of firms, which dropped out of the sample during the post-policy period, to zero (Panel A), four (Panel B), or the mixture of both allowing for closure probability (Panel C). Cutoff of labor costs for the treatment indicator is varied in Panel D. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 5. Wage Distribution and Minimum Wage Introduction



Notes: Firms with the highest and lowest 1 percent growth rate of output through 1984 and 1991 are dropped from the MMS data. The Gaussian kernel function is used in the estimation of kernel density, and the optimal bandwidth is found by minimizing mean integrated squared errors.

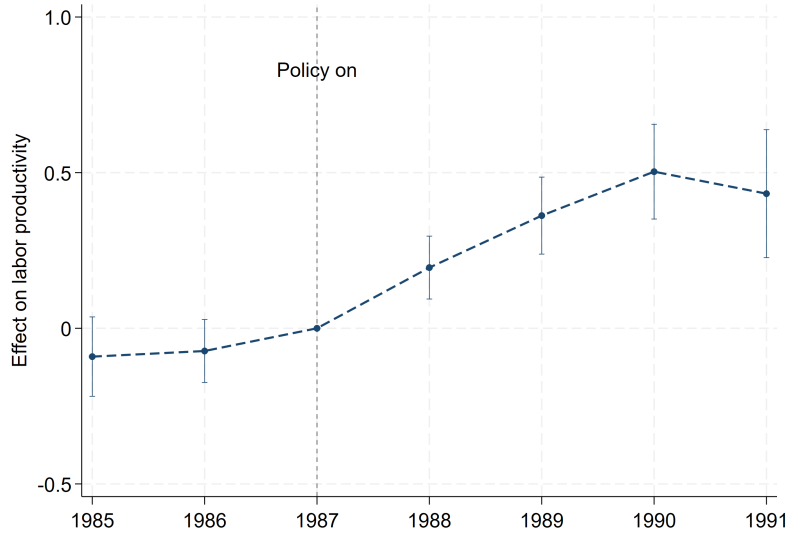
Table 7. Effects on Firm-Level Productivity

	Changes b/w 1987–1988	Changes b/w 1987–1989	Changes b/w 1987–1990	Changes b/w 1986–1987
<i>Panel A. Effect on labor productivity</i>				
MW bite	0.195*** (0.052)	0.362*** (0.063)	0.503*** (0.078)	-0.073 (0.052)
Elasticity of labor productivity with respect to wage	0.620*** (0.144)	0.770*** (0.125)	0.863*** (0.119)	- -
<i>Panel B. Effect on total factor productivity</i>				
MW bite	0.174*** (0.051)	0.330*** (0.062)	0.462*** (0.074)	-0.046 (0.050)
Elasticity of TFP with respect to wage	0.553*** (0.148)	0.702*** (0.124)	0.792*** (0.118)	- -

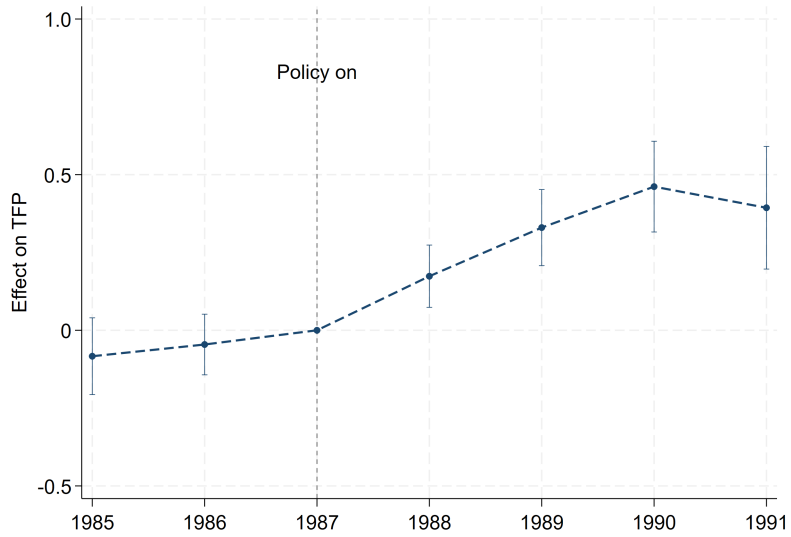
Notes: The specification of regressions is the same as Table 4. The sign of the coefficient for the change between 1986-1987 is flipped because the dependent variable is defined as the change relative to 1987. Elasticity are computed based on the change between 1987 and the post-policy year. Standard errors for elasticities are obtained by bootstrapping with 1,000 samples. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 6. Change in Firm-Level Productivity

Panel A. Effect on labor productivity



Panel B. Effect on total factor productivity



Notes: Each dot shows the estimated effects on firm-level productivity of Table 7, and vertical lines indicate 95 percent confidence intervals for the estimates. The sign of the coefficient for the change between the post-policy period and 1987 is flipped because the dependent variable is defined as the change relative to 1987.

Table 8. Robustness Checks: Effects on Firm-Level Productivity

	Changes b/w 1987–1988	Changes b/w 1987–1989	Changes b/w 1987–1990	Changes b/w 1986–1987
<i>Panel A. Effect on labor productivity with a tighter comparison group</i>				
MW bite	0.157*** (0.055)	0.311*** (0.067)	0.424*** (0.084)	-0.056 (0.055)
Elasticity of labor productivity with respect to wage	0.771*** (0.236)	0.984*** (0.209)	1.128*** (0.205)	- -
<i>Panel B. Effect on TFP with a tighter comparison group</i>				
MW bite	0.159*** (0.054)	0.317*** (0.066)	0.440*** (0.080)	-0.025 (0.053)
Elasticity of labor productivity with respect to wage	0.782*** (0.230)	1.000*** (0.210)	1.172*** (0.203)	- -
<i>Panel C. Effect on TFP: Estimation with a structural break</i>				
MW bite	0.219*** (0.050)	0.377*** (0.062)	0.512*** (0.075)	-0.052 (0.050)
Elasticity of TFP with respect to wage	0.698*** (0.148)	0.803*** (0.129)	0.879*** (0.122)	- -

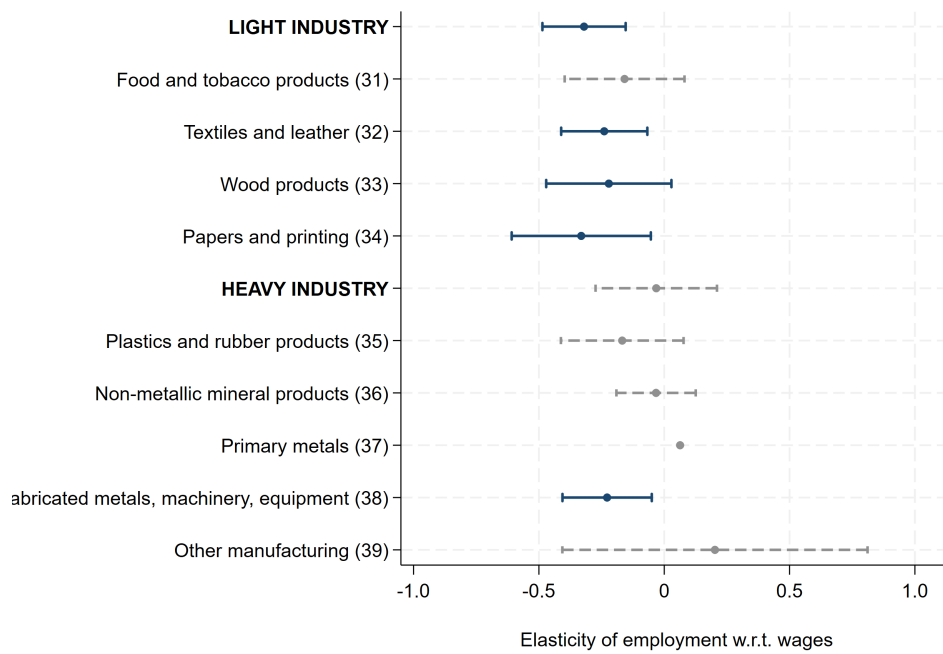
Notes: The specification of regressions is the same as Table 4. The sign of the coefficient for the change between 1986–1987 is flipped because the dependent variable is defined as the change relative to 1987. Elasticities are computed based on the change between 1987 and the post-policy years. The tighter comparison group includes firms with less than the median average labor cost. Panel C uses TFP measures from estimating production functions with a structural break of the minimum wage introduction. Standard errors for elasticities are obtained by bootstrapping with 1,000 samples. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9. Minimum Wage Effects: Light and Heavy Industries

	Change b/w 1987–1988	Change b/w 1987–1989	Change b/w 1987–1990
<i>Panel A. Light Industries</i>			
<u>Elasticity with respect to wage</u>			
Employment	-0.204** (0.094)	-0.320*** (0.086)	-0.246*** (0.089)
Labor productivity	0.388 (0.249)	0.632*** (0.193)	0.792*** (0.203)
Total factor productivity	0.339 (0.240)	0.569*** (0.188)	0.739*** (0.196)
<i>Panel B. Heavy Industries</i>			
<u>Elasticity with respect to wage</u>			
Employment	-0.097 (0.138)	-0.032 (0.123)	-0.031 (0.139)
Labor productivity	0.565** (0.285)	0.587** (0.246)	0.806*** (0.155)
Total factor productivity	0.529* (0.313)	0.555** (0.245)	0.752*** (0.169)

Notes: The specification of regressions is the same as Table 4. Elasticities are computed based on the change between 1987 and the post-policy years. Standard errors for elasticities are obtained by bootstrapping with 1,000 samples. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

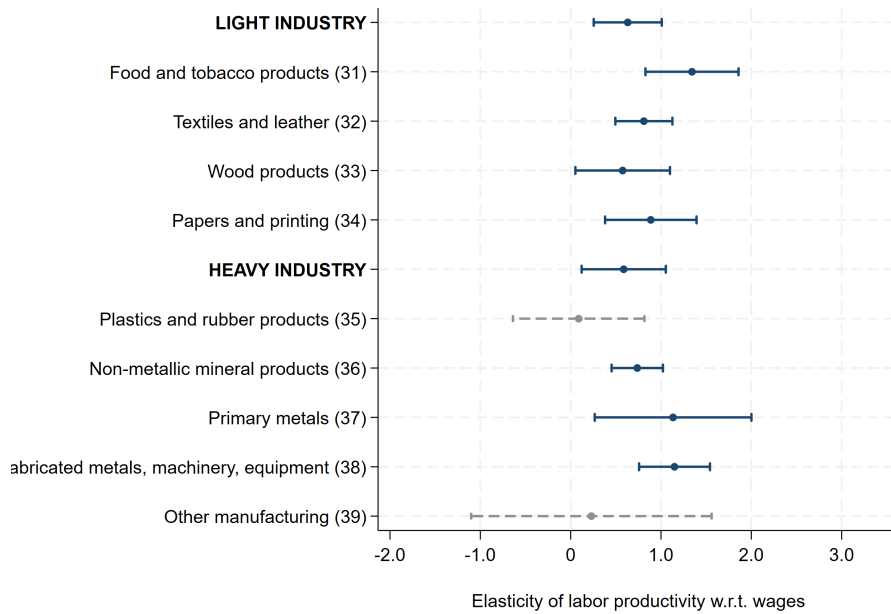
Figure 7. Responses in Employment to Minimum Wage by Industry



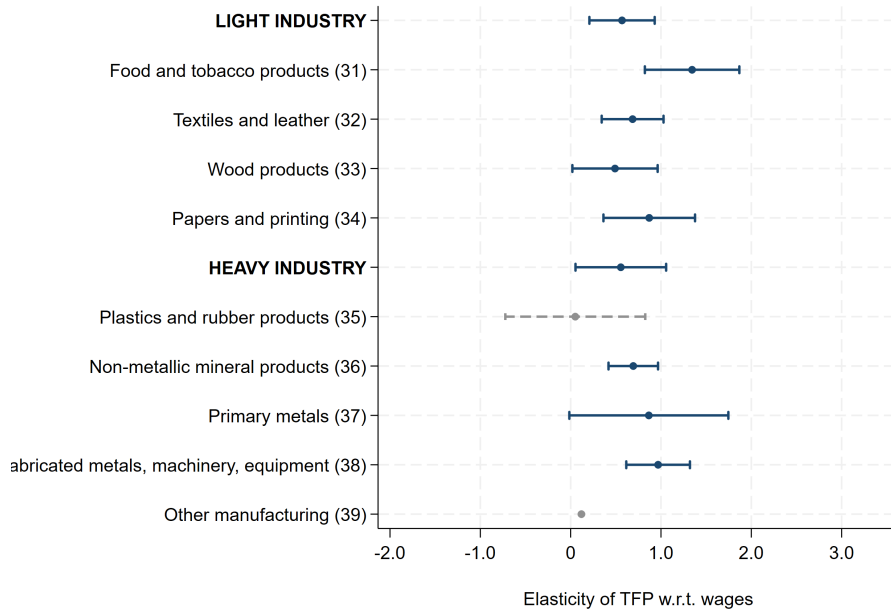
Notes: Each dot represents the point estimate for elasticity of employment with respect to wages with a 95 percent confidence interval. Blue dots and solid lines are for the elasticity estimates with p -value lower than 0.1, and gray dots with dotted lines of confidence intervals are for the elasticity estimates with p -value greater than or equal to 0.1. Confidence intervals are omitted if they lie outside the given range.

Figure 8. Responses in Productivity to Minimum Wage by Industry

Panel A. Elasticity of labor productivity w.r.t. wages



Panel B. Elasticity of TFP w.r.t. wages



Notes: Each dot represents the point estimate for elasticity of productivity with respect to wages with a 95 percent confidence interval. Blue dots and solid lines are for the elasticity estimates with p -value lower than 0.1, and gray dots with dotted lines of confidence intervals are for the elasticity estimates with p -value greater than or equal to 0.1. Confidence intervals are omitted if they lie outside the given range.