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Research paper

The Nexus Between Labor Rights Protection and Manufacturing Production Efficiency: A Case Study of China's Minimum Wage System

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Abstract

This study investigates whether the implementation of minimum wage regulations in China has effectively enhanced the productivity of the manufacturing sector while adequately protecting the rights of the labor force. We find that policy implementation will improve firms' compliance, narrow the labor price distortion gap between firms, and improve static allocation. It will also dredge the market exit channel, improve the dynamic allocation of resources, and create a productivity-forcing mechanism. We conduct empirical testing using data for industrial enterprises and minimum wage data for prefecture-level cities. We confirm that minimum wage regulations favorably affect manufacturing industry productivity and help achieve the goals of "ensuring safety" and "increasing efficiency." Therefore, the government should further improve the minimum wage supervision system, enhance the supervision of small, low-productivity enterprises and give full play to its incentivizing effects on market mechanisms and production efficiency.

Keywords*: Minimum Wage Regulation; Industry Productivity; Resource Allocation*

1. Introduction

With the reform of China's labor system and the establishment of market-oriented labor relations, labor's vulnerability in relation to capital has become increasingly apparent, as employees with previously secure positions have become precarious wage workers who potentially face job insecurity. At the same time, there has been a profound transformation in China's labor market supply and demand structure. The shift from an abundant supply to a shortage of labor (Cai, 2008) has empowered workers by increasing their bargaining power and raising their demands for better working conditions and benefits.

In response, China's government has formulated various policies and regulations intended to safeguard workers' rights and interests. One example is the implementation of minimum wage legislation designed to protect the right to fair remuneration. However, opinions about this system are divided. Supporters argue that it distributes wealth more fairly, while skeptics suggest that government intervention can potentially hinder market development through price regulation's effects on the factors of production.

Central to this debate is the question of whether the minimum wage system can effectively ensure both job security and production efficiency. Undoubtedly, one triggering factor for such governmental intervention is the general increase in labor costs (Ma et al., 2012; Liu & Kou, 2017). Facing cost pressures, enterprises must adjust their decision-making regarding the use of labor, capital, and other production factors, thereby disrupting intrafirm allocation patterns. Do such changes in a firm's factor allocation facilitate the flow of factors between firms? Do they move enterprises toward self-reliance and promote advancements in enterprise productivity? This study aims to address these questions by examining the effect of minimum wage regulations on manufacturing industry productivity.

2. Literature review

According to Melitz & Polanec (2015), changes in industry productivity arise from alterations in enterprise productivity itself as well as the efficiency of resource allocation among enterprises. When a government intervenes in the factor market through minimum wage policies, it can not only reshape the factor structure within firms by controlling factor prices but also create opportunities for resource repositioning among firms by reversing the flow of factors, thus altering the pattern of economic efficiency represented by industrial productivity.

Studies have extensively investigated the former aspect, mainly focusing on employee effort, technological innovation, human capital investment, inventory management, management practices and capital factors' substitution effect aiming to confirm the positive effect of minimum wage policies on enterprise productivity (Sun et al., 2013; Mayneris et al., 2018; Hau et al., 2020; Wang & Li, 2023). However, there is limited research on the latter aspect. Existing studies of the relationship between minimum wage policies and labor flow among enterprises and resource allocation mainly analyze search-and-matching friction (Acemoglu, 2001), workers' noncapital preferences (Berger et al., 2019), and product-market friction (Dustmann et al., 2020). In China, minimum wage policy's effects on interfirm resource-allocation efficiency have been studied from various perspectives, including firm productivity differences (Liu et al., 2017), marginal output and cost differences (Xu et al., 2019), spatial spillover effects (Liang & Wang, 2019), enterprises' entry and exit (Zhu et al., 2023), labor market power (Li et al., 2024). There is a lack of analysis, however, of factor price distortion. Although Huang (2021) addressed this issue by examining how minimum wage policy corrects labor price distortion and improves resource-allocation efficiency under conditions of excessive labor input, insufficient labor input remains unexplored. Furthermore, studies fail to consider changes in industry productivity resulting from policy influence or the contribution of resource allocation to firm productivity. We therefore investigate the influence of policy on industrial productivity and its decomposition effect under ordinary labor input scenarios. The aim is to explore the role of government in market-oriented factor allocation and production incentives while providing a theoretical basis for achieving both "security" and "efficiency" in China's labor rights protection system.

This study's marginal contributions are as follows: (1) Existing studies rarely address the resource-allocation effect of minimum wage policy in terms of labor price distortion. Only one study has discussed the corrective effect of minimum wage policy on distortion and the enhancement effect on resource allocation in cases of excessive labor input (Huang,2021). It is important, however, to consider that there might also be instances of insufficient labor input amid the general situation of excessive labor input in Chinese enterprises. We extend the analysis to include scenarios involving ordinary levels of labor input to examine the effect of minimum wage policy on resource allocation. (2) Few studies have explored this topic in the context of industrial productivity. Therefore, this study presents novel evidence for evaluating China's minimum wage policy efficiency.

3. Theoretical analysis

3.1 The impact of minimum wage regulation on the efficiency of static resource allocation in industrial productivity

In a regulatory environment that prioritizes larger enterprises over smaller ones, small-scale businesses are more likely to evade supervision by pushing wages below the minimum threshold and attempting to gain cost advantages through illegal employment practices. This exacerbates labor prices falling below market equilibrium levels, resulting in increased labor price distortion. On the other hand, larger enterprises face stricter regulations, which lead to standardized procedures and management practices for hiring employees. As a result, their labor markets resemble competitive markets more closely, with closer alignment between labor prices and market equilibrium levels, leading to relatively lower degrees of distortion. Consequently, differences in policy compliance contribute to variations in labor price distortions among firms. According to the theory of resource mismatch, the severity of differentiation positively correlates with the variance of inter-firm revenue productivity and the extent of deviation from optimal resource allocation (Hsieh & Klenow, 2009). As resources flow from large enterprises with high marginal cost and productivity to small enterprises with low marginal cost and productivity, there is an increase in efficiency loss.

The introduction of Minimum Wage Regulations explicitly prohibits violations disguised as overtime pay, piecework wages, or commission wages. It also clarifies the supervision responsibility of labor and security administration while increasing penalties for violations, thereby raising the cost for non-compliant enterprises. This will negatively impact labor costs for small-scale businesses by elevating their labor price and reducing labor price distortion compared to market equilibrium prices. On the other hand, although Minimum Wage regulations also affect labor costs for large enterprises through spillover effects (Autor et al., 2016), this impact is relatively minor compared to that on small enterprises. Consequently, it reduces the degree of differentiation in labor price distortion between large and small firms, promotes income productivity equality among businesses, and minimizes deviations from optimal resource allocation. These findings indicate a flow of resources from low-productivity small firms to high-productivity large firms while enhancing static allocation efficiency among surviving entities.

Theoretical hypothesis 1 is thus proposed: The implementation of the Minimum Wage Regulations is expected to mitigate labor price differentiation among enterprises and enhance the static allocation efficiency of resources.

3.2 The impact of minimum wage regulation on the efficiency of dynamic resource allocation in industrial productivity

According to recent studies (Sun Churen et al., 2013), the critical level of entering the market is influenced by factors such as industry-wide material productivity, enterprise compliance levels, and average wage levels within the industry. Specifically, a higher average wage paid to workers in an industry corresponds to a higher threshold for firms entering into production. After the implementation of Minimum Wage Regulations, enterprises face strict constraints in implementing minimum wage standards. This not only increases the wages of low-skilled workers but also generates a spillover effect on high-skilled workers, leading to an overall increase in wages. However, this rise will further elevate the market threshold and hinder new entrants from joining the market. As a result, enterprises with high productivity that do not exceed the critical level fail to enter, while those with low productivity continue to occupy resources, resulting in a decline in resource allocation efficiency between surviving enterprises and potential entrants.

Therefore, theoretical hypothesis 2 is proposed: minimum wage regulations promote wage growth, raise the critical productivity level for entering markets, impede potential entrants from joining markets, and ultimately reduce resource allocation efficiency between surviving enterprises and potential entrants.

In addition, from the perspective of market exit, small enterprises with wages lower than the minimum wage standard will bear the brunt of the impact, as they face an increased cost burden in terms of wages and salaries. These enterprises often lack sufficient capital, technology, and operational capacity to internalize labor costs, exacerbating their business difficulties and leading to their withdrawal from the market. While large businesses are also affected by spillover effects of the minimum wage policy, they are relatively less impacted by labor costs compared to small businesses. Moreover, due to fewer borrowing or capital constraints, large enterprises possess a stronger ability to withstand shocks and sustain their presence in the market. Consequently, heterogeneous labor costs generate a selection effect among enterprises. As a result of this effect, low-productivity small enterprises are eliminated while high-productivity large enterprises remain in the market. This process releases resources previously occupied by low-productivity small enterprises and enhances dynamic allocative efficiency between surviving and exiting firms.

Theoretical hypothesis 3 is therefore proposed: minimum wage regulations facilitate the market exit of low-productivity enterprises, thereby enhancing resource allocation efficiency between surviving and exiting firms.

3.3 The effect of minimum wage regulations on the productivity of enterprises

The implementation of minimum wage regulations may lead to changes in enterprises' production factor decisions due to the increase in labor prices. Faced with costly labor resources, enterprises are likely to opt for machinery and equipment as a rational choice to replace low-skilled workers, thereby increasing the input of material capital in the production process. According to the theory of capital-skill complementarity, advanced machinery and equipment require a highly skilled workforce. In response to this demand, enterprises may enhance employee training programs aiming at improving human capital levels, resulting in alterations in both labor employment structure and production factor composition.

Moreover, minimum wage regulations can not only trigger factor substitution effects within enterprise production but also induce management promotion effects. Influenced by labor costs, managers will pay more attention to performance gaps among peers and strive towards enhancing enterprise profitability. Alternatively, they may improve management practices by implementing measures such as inventory reduction to cope with shocks. The backward forcing mechanism involving factor substitution and management promotion effects contributes positively towards enhancing enterprise productivity.

Therefore, theoretical hypothesis 4 is proposed: Following the implementation of minimum wage regulations, enterprises will be compelled to engage in factor replacement and managerial improvement processes that ultimately drive their own productivity enhancement.

On the assumptions, the implementation of minimum wage regulations has the potential to stimulate enterprise productivity growth (hypothesis 4) and enhance both static resource allocation efficiency among surviving enterprises (hypothesis 1) and dynamic resource allocation efficiency between surviving and exiting enterprises (hypothesis 3). Therefore, we propose competitive hypothesis 5: Minimum wage regulations may facilitate industry productivity improvement.

However, this policy may also result in market blockage, thereby reducing dynamic resource allocation efficiency between surviving and entering enterprises (hypothesis 2). Consequently, Competitive thesis 6 suggests that Minimum wage regulations may hinder industry productivity progress.

4. Model configuration, variable selection, and data description

4.1 Model development and variable identification

We construct the following Difference-in-Differences model (Eq.1) to evaluate the influence of minimum wage regulation on manufacturing industry productivity. The Difference-in-Differences (DID) model is a widely used causal inference method in observational studies, particularly in policy evaluation and program effect analysis. Its core logic lies in comparing the changes in outcomes over time between two groups: a "treatment group" (subject to a specific policy) and a "control group" (not subject to the policy). Specifically, it calculates two layers of differences: first, the difference in outcomes within the treatment group before and after the policy implementation; second, the difference in outcomes within the control group over the same period. The "double difference" (i.e., the difference between these two within-group differences) is then used to isolate the net effect of the policy or intervention.

$$\Delta TFP_{cit} = \chi + \beta Exposed_{ci03} \times Change_t + CV_{cit} + \mu_{ci} + \nu_t + \varepsilon_{cit} \tag{1}$$

where $Exposed_{ci03}$ represents the susceptibility of industry i in city c to policy influence before its implementation, while $Change_t$ indicates whether the policy has been implemented. ΔTFP_{cit} denotes the change in productivity for industry i in city c from year t−1 to t, and CV_{cit} represents a control variable at the city–industry level. The model incorporates controls for city–industry fixed effects μ_{ci} and time fixed effects ν_t. ε_{cit} is the stochastic error term. If the interaction coefficient $\beta > 0$It indicates that the implementation of minimum wage has effectively stimulated productivity progress in the manufacturing industry.

We use Melitz & Polanec's (2015) method, , to compute the variation value of industry productivity. The calculation formula is

$$\Delta TFP_{cit} = \underbrace{\Delta \overline{tfp_{cit}^S}}_{Intra-group} + \underbrace{\Delta\, cov(p_{et}^S, tfp_{et}^S)}_{Inter-group} + \underbrace{\textstyle\sum_{e\in N} p_{et}(TFP_{cit}^N - TFP_{cit}^S)}_{Entry} - \underbrace{\textstyle\sum_{e\in X} p_{e(t-1)}(TFP_{cit}^X - TFP_{cit}^S)}_{Exit} \tag{2}$$

where $\Delta \overline{tfp_{cit}^S}$represents the change in average productivity of the surviving firm (measured arithmetically) from year t−1 to year t, reflecting the inherent changes in productivity within the firm itself. The covariance term $\Delta\, cov(p_{et}^S, tfp_{et}^S)$ indicates that alterations in the matching degree between market share P_{et}^S and productivity tfp_{et}^S of the surviving firm from year t−1 to year t reflects resource-allocation efficiency within the firm. $\sum_{e\in N} P_{et}(TFP_{cit}^N - TFP_{cit}^S)$ and $\sum_{e\in X} P_{e(t-1)}(TFP_{cit}^X - TFP_{cit}^S)$ denote the effects of newly established and existing firms, respectively, on overall industry productivity. p_{et} represents the market share of enterprise e in year t, which is measured by its employment volume. $p_{Dt} = \sum_{e\in D} p_{et}$ represents the aggregate proportion of class D enterprises, where $D = S, N, X$S denotes surviving enterprises, N denotes new enterprises, and X denotes exiting enterprises. $TFP_{cit}^D = \sum_{e\in D} \frac{p_{et}}{P_{Dt}} tfp_{et}$, where TFP_{cit}^D is the aggregate productivity of Class D enterprises in industry i within city c, while tfp_{et} denotes the individual productivity of firm e during year t. In the concrete regression, we use Levinsohn & Petrin's (2003) algorithm to compute firm e's productivity in year t. The labor share serves as a weight for calculating the corresponding change value of industry-wide total productivity, while ΔLP_{cit} represents ΔTFP_{cit}. Significance is verified by using the algorithms of Olley & Pakes (1996) and Ackerberg et al. (2006) to compute enterprise productivity, followed by the calculation of the corresponding industry productivity change values ΔOP_{cit} and ΔACF_{cit}.

Calculating a firm's productivity requires output and factor data. Following Yin et al. (2015), we select sales revenue as the indicator of total enterprise output. Additionally, intermediate input is defined as the value of product sales costs minus wages, benefits, and depreciation, while labor input is determined by the total number of employees in the enterprise. Following Yin et al. (2015), real capital is estimated, and total output and intermediate inputs are adjusted to their real values based on 1998.

If the proportion of enterprises in 2003 in industry i in city c, whose monthly average wage is below the local minimum wage standard, exceeds the national median level, it means this industry is susceptible to the effect of minimum wage regulations $Exposed_{ci03} = 1$; otherwise, $Exposed_{ci03} = 0$. Since the minimum wage regulations came into force in 2004, 2004 and later years are taken as the years in which the policy occurred, in which case $Change_t = 1$; otherwise, $Change_t = 0$. To assess the sensitivity of grouping variables, we use the average ratio of the monthly average wage to the minimum wage in industry i in city c in year t as an indicator to measure wage density. Industries with this indicator below the national median level in 2003 are categorized as those susceptible to policy effect, while those above are classified as industries not susceptible to policy effect.

The control variables at the city–industry level include net assets $networth_{cit}$, which represent the logarithm of the mean value of enterprises' net assets (total assets minus total liabilities) within the city–industry range. Export ratio exp_{cit} is calculated as the average export output ratio of enterprises operating in the city–industry scope. State capital soe_{cit} is measured by determining the average proportion of state and collective capital in enterprises' paid-in capital within the city–industry range. The number of employed persons lab_{cit} represents the logarithm of total employment across all enterprises within the city–industry scope. Per capita real capital cap_lab_{cit} is determined by dividing the actual total capital of enterprises within the city–industry range by their respective number of employees. The degree of monopoly hhi_{cit} is assessed using the Herfindahl index at the city–industry scale.

To mitigate the effect of the policy "Regulations on Labor Security Supervision" on model identification, we also incorporate the proportion of labor dispute case settlements in each province $dispute_{pt}$ as a control variable to account for regional variations in labor security supervision capacity. Additionally, considering that minimum wage standards are determined by government departments based on local economic development status, and industrial productivity is influenced by the local economic environment, there are macroenvironmental factors that affect both the independent and dependent variables. Therefore, we further include control variables such as GDP, population, average wage, and number of employees (all are logarithmic). Table 1 presents the descriptive statistical findings for the main variables.

4.2 Data sources and processing

Our enterprise data mainly comes from the database of all state-owned and non-state-owned industrial enterprises above a designated size, provided by China's National Bureau of Statistics. Since we focus on manufacturing enterprises, we only retain samples from this category. The remaining data consist of minimum wage standards across different regions. For empirical analysis, we select data from prefecture-level cities. In this paper, the minimum wage standards for prefectural-level cities were systematically collected by integrating data from the Peking University database and local government websites. Ultimately, we collect data on minimum wage standards for 303 prefecture-level cities for analysis, representing 90.7% coverage of the national total of 334 prefecture-level cities. Compared with previous studies, we cover a wide scope of prefecture-level cities, thus providing a representative overview of urban areas nationwide. Additionally, we compile information from the China Labor Statistics Yearbook and China City Statistics.

This study constructs panel data for industrial enterprises from 1998 to 2013 following the method of Yin et al. (2015). We also incorporate minimum wage data and corresponding yearbook data. Subsequently, following the standard cleaning procedure for industrial enterprise databases (Nie et al., 2012), samples with missing or nonpositive values for sales income, capital, intermediate material input, total wages, and welfare are excluded. Additionally, we exclude samples with fewer than eight employees as well as those with single or multiple factor input costs exceeding total output and export value surpassing total output. Furthermore, samples with obviously incorrect years of establishment and those with a survival time of less than or equal to one year are eliminated. We further refine the sample by excluding urban industry-level variables that have fewer than five enterprises and extreme values falling outside the range of ±5% for sales income, capital, labor, and intermediate input variables. Owing to insufficient data availability in Tibet, it is not included in the sample analysis. Moreover, we address industry code inconsistencies around 2002 based on methods used by Ma et al. (2013) and Gao et al. (2017), leading to a standardized definition of enterprise status.

Table 1: Descriptive Statistics of Key Variables

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value	Sample Size
ΔOP_{cit}	0.0320	0.0600	−0.0770	0.160	36000
ΔLP_{cit}	0.0350	0.0620	−0.0760	0.167	36000
ΔACF_{cit}	0.0310	0.0630	−0.0880	0.161	36000
$networth_{cit}$	8.587	0.750	3.555	13.69	36000
exp_{cit}	0.113	0.173	0	1.071	36000
soe_{cit}	0.255	0.241	0	1	36000
lab_{cit}	8.188	1.275	2.890	13.83	36000
cap_lab_{cit}	3.999	0.768	−0.113	8.495	36000
hhi_{cit}	0.220	0.173	0.003	1	36000

5. Findings and analysis based on empirical results

5.1 Analysis of benchmark results

Column (1) in Table 2 presents the regression results based on using Eq. (1) as the benchmark model and clustering the parameters to the city level based on standard errors. The coefficient of the secondary interaction term shows a significant positive effect at the 1% significance level. This initially confirms competitive hypothesis 5 by showing a substantial increase in the productivity growth rate for low-wage industries after the implementation of minimum wage regulations. Column (2) shows the estimated outcomes after further controlling for variables at both the city and industry levels. Notably, even with this additional control, the coefficient of the interaction term remains significantly positive at the 1% significance level. This indicates that regardless of city–industry characteristics, there is no change in how minimum wage regulations positively affect productivity in low-wage industries.

To mitigate the confounding effects of concurrent policies, we use the proportion of resolved labor dispute cases in each province $dispute_{pt}$ as an indicator of the effect of labor security supervision regulations. Column (3) in Table 2 presents the findings after controlling for this variable. Although there is a slight reduction in the significance of the coefficient for the interaction term, it remains positively significant at the 5% level. This suggests that, while the implementation of labor security supervision regulations has somewhat amplified the promotional effect of minimum wage regulations on industrial productivity, even after accounting for other policies, minimum wage regulations still significantly contribute to increased growth in industrial productivity. Considering the effect of urban economic development on minimum wage levels, as well as its influence on enterprises and industry productivity through various channels, we control the variables in column (4) at this level. The significant interaction coefficient at the 5% level suggests that city-level economic development does not significantly alter the industry's promotion effect on minimum wage regulation, thus further confirming competitive hypothesis 5.

Table 2: Baseline Regression

	(1)	(2)	(3)	(4)
	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}
$Exposed_{ci03} \times Change_t$	0.0053***	0.0061***	0.0053**	0.0051**
	(3.38)	(3.86)	(2.58)	(2.47)
$networth_{cit}$		0.0021*	0.0032	0.0034*
		(1.70)	(1.65)	(1.72)
exp_{cit}		−0.0109*	−0.0216**	−0.0219**
		(−1.73)	(−2.32)	(−2.32)
soe_{cit}		0.0071*	0.0009	0.0031
		(1.86)	(0.17)	(0.58)
lab_{cit}		0.0143***	0.0172***	0.0177***
		(12.89)	(10.11)	(10.20)
cap_lab_{cit}		0.0015	0.0002	−0.0004
		(1.20)	(0.11)	(−0.19)
hhi_{cit}		0.0260***	0.0360***	0.0363***
		(5.73)	(5.02)	(4.88)
$dispute_{pt}$			0.0084	0.0091
			(0.57)	(0.62)
gdp_{ct}				0.0036
				(0.71)
$popu_{ct}$				−0.0026
				(−0.50)
$avewage_{ct}$				0.0008
				(0.11)
emp_{ct}				−0.0048
				(−1.50)
Year	Yes	Yes	Yes	Yes
City–industry	Yes	Yes	Yes	Yes
N	32545	32544	28849	28257
r2_a	0.0755	0.0863	0.0806	0.0795

5.2 Parallel trend test and dynamic trend analysis

The application of a differential model assumes there is no significant disparity in productivity between high- and low-wage industries before the implementation of minimum wage regulations. Otherwise, the estimated results might be biased. The following model is commonly adopted by the academic community to test this hypothesis. This study likewise adheres to this methodology to conduct parallel trend tests on the two industry groups.

$$\Delta TFP_{cit} = \chi + \sum_{n=-4}^{3} \beta_n Exposed_{ci03} \times Dum_t^n + CV_{cit} + \mu_{ci} + \nu_t + \varepsilon_{cit} \quad (3)$$

Here, Dum_t^n is a policy dummy variable, where $Dum_t^n = 1$ if the period of the sample is n years away from 2004, and $Dum_t^n = 0$ otherwise. When $n < 0$, the estimated coefficient β_n reflects the difference in productivity growth between high-wage and low-wage industries before the implementation of the Minimum Wage Regulations. If β_n is insignificant, it indicates that there was no significant difference in productivity growth between the two types of industries before the policy implementation, which is consistent with the parallel trend assumption; otherwise, the parallel trend assumption is violated. When $n \geq 0$, β_n reflects the dynamic changes in annual industry productivity growth after the policy implementation.

Following the criteria for assessing enterprise status, we observe that most enterprises in 1998 were newly established ones. Consequently, the change in industry productivity was mainly influenced by these new enterprises, which significantly differed from other years. Therefore, when examining dynamic trends, we exclude data for that year. Furthermore, consistent with the literature, we choose the first year as the base period for analysis; thus, we examine dynamic trends from 2000 onward. The results of estimation using Equation (3) are presented in Figure 1. From Figure 1, it is evident that before the implementation of minimum wage regulations, there was no substantial disparity in productivity growth between high- and low-wage industries, thus indicating adherence to the parallel trend assumption necessary to satisfy the Difference-in-Differences (DID) model. Following the enactment of the minimum wage regulation in 2004, a noteworthy divergence emerged as low-wage industries exhibited a significantly higher rate of productivity growth than their high-wage counterparts. This persisted until 2007 without showing any signs of expansion. These findings suggest that during the initial phase of policy implementation, minimum wage regulations had a profound effect on industry productivity that gradually diminished over time.

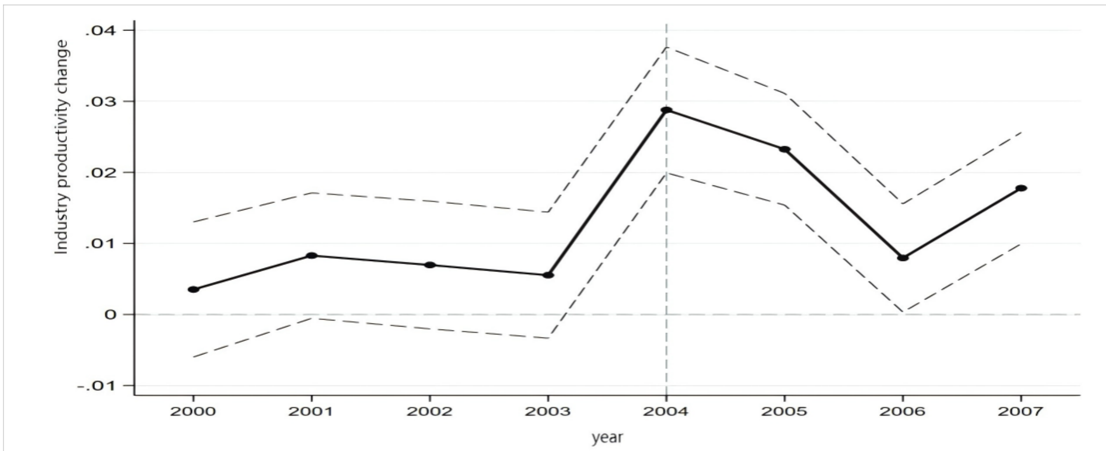

Fig. 1: Dynamic trend

5.3 Robustness test

To redefine the policy grouping criteria, industries with a proportion of low-wage enterprises exceeding the 70th percentile nationwide are affected by the policies, whereas those below the 30th percentile are considered unaffected. Column (1) in Table 3 shows the regression results. An alternative approach involves extending the time horizon for policy grouping and calculating the average city-sector share from 1998 to 2003 based on its relationship with the national median level. If this share surpasses the median level, we infer that such industries will be influenced by the policy; otherwise, they remain unaffected. Column (2) in Table 3 shows the outcomes. Additionally, we compute the average wage density mentioned above for this specific time frame. If it surpasses the national median, it is deemed to be influenced by the policy; conversely, if it falls below the median, it is considered unaffected. Column (3) in Table 3 shows the results. We can see that even after substituting different methods for the policy grouping variables, the coefficient of the interaction term remains significantly positive. This indicates that altering these variables does not substantially affect the significance of the baseline regression results and lends support to hypothesis 5 regarding competitiveness.

Table 3: Robustness Estimation Results I

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}	ΔOP_{cit}	ΔACF_{cit}	ΔLP_{cit}
	70th pctl / 30th pctl	98–03	Wage Dens	OP	ACF	Drop 1998
$Exposed_{ci03} \times Change_t$	0.0065***	0.0031**	0.0055***	0.0049***	0.0051***	0.0055***
	(3.37)	(1.98)	(2.78)	(3.38)	(3.26)	(3.39)
CV	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
City–industry	Yes	Yes	Yes	Yes	Yes	Yes
N	24710	34112	34035	32544	32544	29925
r2_a	0.0788	0.0842	0.0592	0.1003	0.0877	0.0707

To ensure the robustness of the regression results, we recalculate the change values of enterprise productivity and industry productivity using the methods of Olley & Pakes (1996) and Ackerberg et al. (2006). We then retest the benchmark regression. Columns (4) and (5) in Table 3 show the revised results. Replacing the method for calculating productivity does not fundamentally alter the interaction coefficient or its significance, indicating a certain level of robustness in our baseline regression. As noted above, most enterprises in 1998 were classified as new establishments. To mitigate the effect of this abnormal year, we use sample data from 1999 to 2003 and recompute the regression using Eq. (1), yielding column (6) in Table 3. Even after accounting for sample variations, the interaction coefficient remains statistically significant at the 1% level. This reinforces competitive hypothesis 5.

Although we control for observable factors that might affect industry wage levels and productivity, there is still the issue of missing variables, which introduces bias into the estimation results. A common concern is that enterprises might proactively adjust their wage expenditures based on unobservable factors before policy implementation to mitigate the effects of minimum wage regulations. As a result, the selection of grouping variables becomes nonrandom, leading to the self-selection problem.

To mitigate estimation bias caused by self-selection, we use propensity score matching (PSM) to match specific control group samples with processing group samples. Propensity Score Matching (PSM) is a statistical method employed to tackle bias issues in observational studies. This method works by calculating the probability of everyone receiving a specific treatment (e.g., participating in a program, undergoing a certain therapy, etc.) and then matching individuals in the treatment group with those in the control group based on this probability, thereby ensuring that the two groups are comparable in terms of key variables. The objective of PSM is to simulate the effect of random assignment, to reduce selection bias caused by non-random assignment, and render causal inference more accurate.

This ensures that the two groups of samples have similar characteristics in all aspects as much as possible; we then use a differential model for estimation. Given the relatively poor comparability of matching samples across different years, we use a year-by-year matching approach. The procedure is as follows: Using the 1:2 nearest-neighbor matching method, we identify control group samples from each year's pool based on covariates (net assets $networth_{cit}$, export proportion exp_{cit}, state-owned capital soe_{cit}, employment number lab_{cit}, real capital per capita $caplab_{cit}$, monopoly degree hhi_{cit}). Then, we conduct a balance test. Finally, we apply Eq. (1) to all matched samples. This is PSM-DID, short for Propensity Score Matching combined with Difference-in-Differences. It is a combined causal inference method widely used in observational studies, particularly in policy evaluation and program effect analysis. By combining these two methods, PSM-DID effectively mitigates both selection bias (from non-random assignment to treatment) and confounding from unobservable factors, thereby enhancing the validity and reliability of causal inference regarding the effect of a treatment, policy, or intervention.

The result in column (1) in Table 4 is based on whether the proportion of low-wage enterprises in 2003 exceeds the national median. In column (2), industries with a ratio higher than 60 points nationwide are considered the treatment group, while those with a ratio equal to or lower than 60 points are regarded as the control group. Column (3) reflects the effect of the policy by considering the average proportion of low-wage enterprises from 1998 to 2003 for each industry. If this value surpasses the national median level, the industry is included in the treatment group; otherwise, it falls into the control group. Furthermore, column (4) presents results obtained through nearest-neighbor matching at a ratio of 1:3 based on column (1). Notably, after employing PSM-DID, we observe significantly positive coefficients for cross terms, suggesting that baseline regression results in Table 2 have a certain reliability, further supporting competitive hypothesis 5.

Table 4: Robustness Estimation Results II

	(1)	(2)	(3)	(4)
	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}
	50^{th} pctl (2003)	60^{th} pctl (2003)	50^{th} pctl (98–03)	1:3
$Exposed_{ci03} \times Change_t$	0.0045**	0.0039**	0.0035**	0.0054***
	(2.58)	(2.12)	(1.97)	(3.25)
CV	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
City–industry	Yes	Yes	Yes	Yes
N	24148	24288	24143	27745
r2_a	0.0921	0.0852	0.0894	0.0903

5.4 Heterogeneity analysis

The business objectives of state-owned enterprises (SOEs) largely revolve around social and political goals (Lin et al., 2004). Thus, they tend to be more compliant with minimum wage policies than non-SOEs. Non-SOEs are more focused on their economic interests and have more incentive to reduce labor costs and violate minimum wage policies. Therefore, minimum wage regulations will have a stronger corrective effect on low-wage employment in non-SOEs and address labor price distortions. Based on this expectation, we consider an enterprise as predominantly state-owned if the proportion of state and collective capital in its paid-in capital is more than half. Columns (1) and (2) in Table 5 show the results of the subsample analysis. We can see that when only non-SOEs exist in an industry, minimum wage regulations can significantly enhance productivity growth levels in those industries. However, no significant effect is found for the sample comprising solely SOEs.

Table 5: Heterogeneity Estimation Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}	ΔLP_{cit}
	SOE	NON-SOE	EAST	MID	WEST	Legal	PoorLegal
$Exposed_{ci03} \times Change_t$	0.0029	0.0029*	0.0040**	0.0056*	0.0095**	0.0021	0.0043*
	(1.06)	(1.88)	(2.04)	(1.76)	(2.01)	(1.14)	(1.77)
CV	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City–industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	26081	32108	17768	10088	4688	16087	15584
r2_a	0.0062	0.0777	0.1297	0.0717	0.0478	0.1314	0.0666

The more developed the factor market becomes, the less distorted factor prices are and the narrower the room for correction. Consequently, minimum wage regulations have limited potential to enhance industry productivity by rectifying labor price distortions. We anticipate, therefore, that the productivity enhancement resulting from minimum wage provisions might be weaker in China's eastern region than in other regions. Columns (3)–(5) in Table 5 present the subsample regression results. In the sample of the eastern region, although the coefficient of the interaction term is slightly more significant than that for the central and western regions, its value is noticeably smaller. Comparing these two regions, it is evident that in the central region, the coefficient value is smaller than that observed in the western region, further confirming our conclusion that economic development level inversely correlates with policy effectiveness.

In regions characterized by a robust rule of law, there is enhanced oversight by law enforcement agencies, greater adherence to corporate compliance standards, and a reduced prevalence of sub-minimum wage hiring practices. The effect of minimum wage regulations on firms in such areas is comparatively limited, resulting in a constrained productivity boost. To gauge the regional legal environment, we use the market intermediary organization development scores and legal system environment scores calculated by Fan et al. (2011). Provinces scoring above the median are categorized as having a superior legal environment, while those below the median are classified as having an inferior legal environment. The results in columns (6) and (7) in Table 5 confirm our expectation: minimum wage policies significantly enhance industry productivity in regions with poor legal environments but do not have similar effects in regions with better legal environments.

5.5 Mechanism test

In empirical research, the covariance between firm productivity and its market share (Olley & Pakes, 1996) is commonly used as an indicator of static resource-allocation efficiency. A higher value signifies a more effective distribution of resources among firms. To calculate enterprise productivity and its covariance at the year–city–industry level, we use the Olley & Pakes' method, Levinsohn & Petrin's method, and Ackerberg's method. We then consider the annual variation of this covariance as the dependent variable in Eq. (1). Columns (1)–(3) in Table 6 show the regression results. The coefficient of the interaction term is significantly positive at the 10% level. This indicates that minimum wage regulations have considerably enhanced static resource-allocation efficiency in the industry, thus validating theoretical hypothesis 1 regarding static resource allocation.

From the theoretical analysis, we can see that narrowing disparities in labor price distortion among enterprises is instrumental in enhancing static resource allocation. We adopt Hsieh & Klenow's (2009) approach for labor price distortion derivation, which is widely used in previous studies (e.g., Huang, 2021). Assume a firm's labor price distortion can be represented as

$$\tau_{L_{si}} = \frac{\sigma-1}{\sigma}\beta_s \frac{P_{si}Y_{si}}{wL_{si}} - 1 = Dist_{ft}, \tag{4}$$

where β_s denotes the proportion of the firm's labor input within its respective two-digit industry and city, $P_{si}Y_{si}$ is the firm's actual sales revenue, wL_{si} signifies the total actual wages payable by the enterprise during the year, and $\sigma = 3$ (Hsieh & Klenow, 2009). We calculate the standard deviation of labor price distortion at the year–city–industry level, as well as the proportions of the difference between the 75th and 25th percentiles and between the 90th and 10th percentiles relative to the median. These values represent the explained variables in Eq. (1), capturing their annual changes. The regression results in columns (4)–(6) in Table 6 reveal that all interaction coefficients are negative at the 10% significance level. This indicates that since the implementation of minimum wage regulations, the expansion of labor price distortion within industries has been suppressed, thus confirming theoretical hypothesis 1.

Table 6: Mechanism Test: Statistical Resource Allocation

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta Op\,cov\_LP$	$\Delta Op\,cov\_OP$	$\Delta Op\,cov\_ACF$	ΔSD_Dist	$\Delta Qt75\_Dist$	$\Delta Qt90\_Dist$
	LP	OP	ACF	SD	75th/25th pctl	90th/10th pctl
$Exposed_{ci03} \times Change_t$	0.0027***	0.0023**	0.0017*	−0.0118*	−0.0600*	−0.0484*
	(2.71)	(2.44)	(1.84)	(−1.65)	(−1.87)	(−1.66)
CV	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
City–industry	Yes	Yes	Yes	Yes	Yes	Yes
N	28140	28140	28140	27998	27170	27496
r2_a	−0.0788	−0.0918	−0.0953	−0.0062	0.0071	0.0201

According to the theoretical analysis, minimum wage regulation induces low-productivity enterprises to exit the market, thus enhancing resource-allocation efficiency between surviving and exiting enterprises. This also raises the market entry threshold, impeding high-productivity enterprises from entering the market and reducing resource-allocation efficiency between new and surviving enterprises. In this regard, we use Eq. (1) to perform regression using the proportion of exiting enterprises with productivity lower than that of incumbent enterprises as the dependent variable; columns (1)–(3) in Table 7 show the results. We can see that, regardless of changes in productivity calculation methods, minimum wage regulation significantly promotes the exit of low-productivity enterprises from the market, confirming theoretical hypothesis 3. Columns (4)–(6) show the regression results using the proportion of entering firms with productivity higher than that of incumbent firms as explanatory variables. From this perspective, minimum wage regulation does not significantly hinder high-productivity firms' entry into the market, thus invalidating theoretical hypothesis 2. This could be attributable to a potential reduction in labor price distortion for businesses following the introduction of minimum wage regulations, which offsets any threshold-raising effect caused by rising industrial wages.

Table 7: Mechanism Test: Dynamic Resource Allocation

	(1)	(2)	(3)	(4)	(5)	(6)
	$Exit\_lp$	$Exit\_op$	$Exit\_acf$	$Entry\_lp$	$Entry\_op$	$Entry\_acf$
$Exposed_{ci03} \times Change_t$	0.0431**	0.0371*	0.0401*	−0.0077	−0.0041	−0.0022
	(2.06)	(1.68)	(1.89)	(−0.38)	(−0.24)	(−0.12)
CV	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
City–Industry	Yes	Yes	Yes	Yes	Yes	Yes
N	4853	4698	4859	7535	7884	7972
r2_a	0.2462	0.2382	0.2087	0.2817	0.2707	0.2484

Drawing on Mayneris et al. (2018), we classify enterprises as "affected" ($Exposed_{ft} = 1$) if their average monthly wage in the previous year falls below the local minimum wage standard for the current year, while those whose wages meet or exceed this standard are considered "unaffected" ($Exposed_{ft} = 0$). By incorporating this policy variable, along with firm-level control variables and a set of fixed effects, we construct a DID model, as shown in Eq. (5):

$$\Delta TFP_{ft} = \chi + \alpha Exposed_{ft} + \beta Exposed_{ft} \times Change_t + CV_{ft} + \mu_{ci} + \nu_{it} + \kappa_f + \varepsilon_{ft} \quad (5)$$

where ΔTFP_{ft} represents the change in the productivity of the surviving enterprise f during the period T−1 to t. $Change_t$ is defined according to Eq. (1); it consists of a series of control variables at the enterprise level, including logarithmic employment $labor_{ft}$, logarithmic capital per capita $cap\_int\,e\,nse_{ft}$, asset–liability ratio lev_{ft}, state holding soe_hold_{ft}, export proportion exp_{ft}, and the foreign capital proportion $foreign_{ft}$. μ_{ci}, ν_{it}, and κ_f represent fixed effects at the city–industry level, industry–year level, and individual enterprise level, respectively. ε_{ft} is the random error term. Columns (1)–(3) in Table 8 show the regression results. We can see that, in line with expectation, there is a positive relationship between the policy's effect and firm productivity growth, thus confirming theoretical hypothesis 4.

Following Mayneris et al. (2018), we use the ratio of finished goods inventory to sales revenue as an indicator of enterprise inventory status. The capital input of enterprises is reflected by the per capita fixed assets used in production and operations. Additionally, following Shen & Hao (2021), we estimate the educational attainment of employees from 2001 to 2007 using the proportion of employees holding a college degree or higher as a measure of enterprise human capital level. Following Li et al. (2020), we take the logarithmic value of total patent applications as a proxy for enterprise innovation behavior. Substituting these variables into Eq. (5) yields the results shown in columns (4)–(7) of Table 8.

According to the regression results, and in line with expectation, minimum wage regulations have led to a reduction in enterprises' inventory levels. Additionally, they have facilitated capital substitution for labor, enhanced firms' human capital, and promoted productivity growth, further validating theoretical hypothesis 4. However, increased labor costs resulting from regulations have constrained innovation expenditure and reduced the number of patent applications.

Table 8: Mechanism Test: Enterprise Productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ΔLP_{ft}	ΔOP_{ft}	ΔACF_{ft}	$Inven_{ft}$	$Fact_{ft}$	Edu_{ft}	$Paten_{ft}$
$Exposed_{ft} \times Change_t$	0.0092***	0.0043**	0.0043**	−0.003***	1.9002***	0.0073***	−0.0043**
	(3.30)	(2.09)	(2.10)	(−3.50)	(3.37)	(4.56)	(−2.17)
CV	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City–Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	818330	818330	818330	818330	818330	502824	605968
r2_a	−0.0465	0.0218	0.0088	0.6107	0.7372	0.9742	0.4223

6. Conclusions

Based on the dynamic OP method and HK method, we investigate the effect of minimum wage regulation on industry productivity in terms of resource allocation and enterprise productivity. The findings indicate the following: (1) Minimum wage regulation not only safeguards workers' compensation rights but also generates policy benefits for manufacturing industry productivity, achieving the objectives of "ensuring safety" and "enhancing efficiency." These policy benefits arise not only from improved configuration but also from production incentives. (2) The enhancement of static allocation reveals that after the implementation of minimum wage regulations, labor price distortions caused by increased corporate policy compliance are mitigated, leading to the equalized marginal benefits of factors. (3) Market competition mechanisms compel enterprises to adopt measures such as factor substitution, employment structure alteration, and management level enhancement to increase their productivity while providing incentives for workers and enterprises alike. Additionally, the triggered market competition creates an exit channel for inefficient enterprises, freeing up resources and improving allocation efficiency. (4) Heterogeneity analysis indicates that the policy benefits of minimum wage regulations for industrial productivity are more pronounced for non-SOEs, in the western regions, and in regions with weak legal environments.

Our findings have the following implications for policy: (1) Expedite the enhancement of the labor rights protection system, taking the minimum wage system as exemplary, and emphasize its incentivizing effect on market mechanisms and production efficiency. Traditionally, safeguarding workers' rights has been seen as benefiting employees at the expense of economic efficacy. Our findings indicate, however, that the cost shock induced by the minimum wage system has disrupted market competition mechanisms and stimulated production efficiency. (2) Particular attention should be paid to enhancing the regulatory framework for minimum wage to promote corporate compliance with policies, mitigate market distortions caused by violations, generate factor restructuring effects, and create opportunities for new economic growth potential. (3) In supervising minimum wage, it is crucial to enhance oversight over small, low-productivity enterprises. Our research reveals that the minimum wage system significantly affects market "blocking" and "thinning." Therefore, more regulations targeting small low-productivity enterprises should be implemented to encourage their exit from the market while facilitating smooth exit channels to release occupied resources, reshape resource flows, and enhance dynamic allocation efficiency.

The conclusions of this paper also have implications for emerging economies such as Indonesia, Thailand, India, Mexico, and Brazil. Particularly in the context of rising labor prices, the precariousness of labor cost advantages, and the declining demographic dividend, governments of emerging economies also face the challenge of balancing worker protection and production efficiency. The policy implication proposed in this paper—"strengthening supervision of low-productivity small enterprises, leveraging cost mechanisms, and optimizing resource allocation"—is equally applicable to emerging economies with minimum wage systems. Furthermore, whether the research conclusions of this paper are also applicable to service sector enterprises requires further empirical evidence, and this will constitute an important direction for our subsequent research.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Sharing Agreement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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