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Raising the Floor Without Compressing Inequality: Minimum Wage Thresholds and Female Labor Participation in U.S. States

Ziyun Wang[1], Zhe Li[2]*

1. School of Accounting, Hainan Vocational University of Science and Technology, Haikou 571126, China
2. Faculty of Finance, City University of Macau, Macau 999078, China

Corresponding author: Zhe Li, F25092100152@cityu.edu.mo

Abstract: This study examines the impact of high minimum wage policies on labor markets and inequality, using the first instance a U.S. state reached a $10/hour minimum wage as a discrete shock. Analyzing 2010–2024 state-level data (excluding 2020) with two-way fixed effects and various DID estimators, it finds that while the policy had no significant average effect on state-level inequality or poverty, it significantly improved labor outcomes for prime-age women (20–64). Specifically, their labor force participation rose by 2.10 percentage points, the employment-to-population ratio increased by 2.73 points, and unemployment fell by 1.86 points. However, these effects were sensitive to specification, attenuating with population weighting and state trend controls, and event studies revealed potential pre-trends for female participation, suggesting these results may be influenced by existing structural trends or policy anticipation.

Keywords: Minimum Wage; Social Inequality; Labor Force Participation; Event Study; Labor Markets
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1. Introduction

The minimum wage policy is one of the most controversial and highly visible tools within the institutional framework of the labor market. The core debate is not only whether it affects employment, but also whether it can improve income distribution, reduce poverty, and enhance the position of vulnerable groups without significantly damaging employment. Consequently, with the long-term stagnation of the federal minimum wage in the United States (maintained at $7.25 per hour since 2009), minimum wage policies have gradually shown significant interstate institutional differentiation. This has created a natural quasi-experimental setting for examining the relationship between the minimum wage and social inequality.

From the perspective of labor economics, the impact of the minimum wage is not unidimensional / not linear. On the one hand, raising the minimum wage may directly increase the wages of low-income workers and compress the lower end of the wage distribution, thus reducing wage inequality and family income inequality. On the other hand, if enterprises respond by reducing working hours, cutting jobs, cutting benefits, or limiting advancement opportunities, then the income improvement at the family level may not be significant. At the same time, from the perspective of socioeconomics, the effect of the minimum wage is also related to many factors, such as family structure, regional industrial structure, the response of labor supply to wage changes, the policy expectations of enterprises and workers, the intensity of law enforcement, and

its interaction with other social policies (such as EITC, childcare subsidies, and medical security). Therefore, whether the minimum wage can bring about a "visible reduction in inequality" needs to be assessed using multiple indicators, dynamic changes, and appropriate identification methods.

The goal of this paper is to systematically evaluate the impact of a "state minimum wage entering a higher level" on labor market and social inequality indicators, and to cross-validate the findings using various DID methods. Different from research that only focuses on a single employment outcome, this paper examines three sets of outcome variables simultaneously: first, social inequality and poverty (Gini coefficient, poverty rate, and median household income); second, overall labor market conditions (unemployment rate, labor force participation rate, and employment-to-population ratio); and third, gender-related labor market outcomes (female prime-age labor force participation rate, employment-to-population ratio, unemployment rate, and gender income gap). This design allows us to address questions more central to policy evaluation: whether the minimum wage has an observable impact on a broader range of social welfare indicators, and for which indicators the evidence is more robust.

In this paper, the identification strategy takes the state minimum wage reaching $10/hour (nominal value) for the first time as a treatment event, constructs a state × year panel DID model, and includes state and year fixed effects to absorb time-invariant state characteristics and national common shocks. Given the staggered adoption of the minimum wage policy, this paper further employs an event study model to depict the dynamic treatment effect and test parallel trends. At the same time, a CS-style aggregation based on "untreated/not-yet-treated" states as the control group is constructed as a supplement. Then, the "pseudo-policy effect" is tested using placebo tests (randomly reassigning the treatment timing) and fake lead placebos. In addition, this paper also uses robustness tests such as population weighting, state-specific linear trends, continuous treatment intensity (log of actual minimum wage), and an alternative threshold ($11) to avoid misjudgment caused by a single specification.

The main findings of this paper can be summarized as three points. First, under the benchmark TWFE specification, the high minimum wage regime is associated with a significant increase in the female prime-age labor force participation rate and employment-to-population ratio, and a significant decrease in their unemployment rate. This finding is consistent in the continuous treatment intensity model and when using alternative thresholds. Secondly, the average effect on state-level income inequality (Gini) and poverty rate is not significant in most specifications, suggesting that the redistributive effect of the minimum wage may be diluted by heterogeneity, time lags, and other policy changes when aggregated at the state level. Thirdly, identification diagnostics show that the reliability of estimates varies across outcome variables: the pre-trend and placebo tests for the Gini coefficient are generally stable, while the female labor force participation rate exhibits evidence of pre-existing trends and anticipation effects. Therefore, this part of the results should be interpreted as "strong correlations and quasi-causal clues" rather than definitive causal conclusions.

The main contributions of this paper are as follows. First, regarding the research topic, it integrates the labor economics literature on minimum wage with the socioeconomic integrative framework of "inequality-participation-family income," thereby helping to move beyond the long-standing debate on a single employment elasticity. Secondly, in terms of methodology, it emphasizes a logic of "evidence stratification" within the DID family: the credibility of identification is evaluated through TWFE, dynamic effects, alternative control group logics, placebo tests, and specification sensitivity checks, rather than relying on any single significant coefficient. Thirdly, regarding data and reproducibility, the entire process utilizes publicly available APIs, enabling transparent replication and convenient annual incremental updates.

2. Literature Review and Research Positioning

2.1 The Main Trajectory of Minimum Wage Research: From "Does Employment Decline?" to "Do Welfare and Distribution Improve?"

The minimum wage is one of the most typical and controversial institutional tools in labor economics. The traditional perfect competition model usually predicts that a minimum wage increase will reduce low-skilled employment. However, a large number of empirical studies based on natural experiments and quasi-experiments over the past 30 years show that the total employment effect is unstable across different scenarios, and the conclusions are highly dependent on identification design,

control group selection, and the magnitude of the policy change. The classic research, based on the natural experiment in the New Jersey-Pennsylvania fast food industry, found that a minimum wage increase may not bring about an observable decline in employment, thus initiating a research paradigm of "identifying policy shocks with more credible controls"[1]. As research has accumulated, the focus of inquiry has shifted. Early studies centered on the question of whether employment would drop significantly. Later, the literature expanded to address broader welfare-related questions: how firms would adjust, how the wage distribution would change, whether poverty and inequality would improve, and who would benefit most. For example, the border identification method compares contiguous areas on either side of a state boundary and emphasizes controlling for common trends. A consistent finding from many studies is that the negative employment effects are very small, often indistinguishable from zero [2]. From the perspective of wage distribution, some studies have pointed to a structural change at the bottom of the wage distribution following a minimum wage increase: the number of jobs paying below the new minimum wage decreases, while the number of jobs paying just above it increases. This change resembles "a shift of jobs from just below to just above the new threshold"; consequently, net employment may change little, but the wage and job structure in the low-wage range is noticeably altered [3]. Meanwhile, meta-analyses and literature reviews also indicate that the conclusions regarding employment effects are not entirely consistent. Researchers continue to hold differing views on how to define the identification window, whether the findings can be generalized to different contexts, and the magnitude of the response among low-skilled or young workers. Neumark & Shirley systematically reviewed recent minimum wage research and argue that, under stricter identification strategies, some studies still detect a decline in employment or working hours [4]. Neumark extended the analysis to health, crime, and welfare outcomes, emphasizing that conclusions are sensitive to research design and the institutional environment [5]. Consequently, a more nuanced consensus has emerged: the minimum wage may improve income distribution by raising wages at the bottom, but these benefits may be partially offset by firms' behavioral responses, such as reducing working hours, altering job structures, raising prices, or substituting labor with automation. The resulting net effect varies considerably across regions, industries, demographic groups, and policy intensities.

2.2 Minimum Wage and Inequality: Do Improvements in the Wage Distribution Translate into Household Income and State-Level Gini?

There are usually two logical chains for the influence of minimum wage on distribution:

1. Wage distribution channels: the minimum wage directly raises the lowest wage and has an overflow or compression effect on wage levels slightly above the minimum wage, thus reducing wage inequality;

2. Household income and transfer payment channels: Wage changes work together through employment/working hours, labor supply of multiple household members, tax credits and welfare qualifications, and ultimately affect household income distribution, poverty and macro inequality indicators.

But "the improvement of wage distribution" is not necessarily equivalent to "the decline of household income inequality". The reason is that income at the household level consists of multiple sources (labor, capital, and transfers), and fluctuations at the high-income end, population mobility, and changes in living costs may obscure the reflection of improvements in bottom wages in macro-inequality indicators. Therefore, many studies have found that the average effect of the minimum wage on state poverty rates and overall inequality is not always significant, or it exhibits a time lag and heterogeneity. Newer research pays more attention to poverty indices, the cost of living, and welfare substitution effects. For example, Lehner used the stacked DID method and the Supplementary Poverty Measure (SPM) to analyze the impact of the minimum wage on poverty and food difficulties. At the same time, he regards 'the rising cost of living will offset some income' as one of the key mechanisms [6]. In terms of 'inter-group inequality, Blau et al. used long-term microdata to study the impact of the minimum wage on gender, racial, and ethnic disparities [7]. The research suggests that the minimum wage may alter the wage gap between groups and the distribution of opportunities because it more strongly affects low-paid groups. These studies show that even if the minimum wage significantly affects the low decile wage or the employment of some groups, the state-level Gini coefficient or poverty rate may not change significantly in the short term. There may be three reasons for this: these indicators are more macro in nature; the policy's effects are dispersed across many channels; and at the same time, other institutional changes occur concurrently, making the situation more complicated.

2.3 Minimum Wage and Labor Force Participation: Why the "Female Prime Age" Deserves Attention as a Core Outcome Variable

In the early days, research on the minimum wage focused more on employment levels, but in recent years, an increasing number of studies have focused on the "extensive margin" of labor supply and the quality of work. The intuition is that a minimum wage increase may not be primarily reflected in 'job losses,' but rather by changing the attractiveness, stability, and reward structure of jobs. This, in turn, affects whether marginal workers enter the labor market and whether they can transition from unemployment or non-participation to employment. In terms of gender, women (especially 'prime-age' women aged 25-54) are often considered to be more affected by minimum wage policy. The reason is straightforward: women account for a higher proportion of workers in low-paid industries, and many women have caregiving responsibilities for children or family members. Therefore, their decision to work outside the home often places greater emphasis on wage returns. It is often mentioned in policy discussions that raising the minimum wage may be beneficial for women's income and family welfare. However, at the same time, the female labor force participation rate is also susceptible to external factors, such as economic conditions, childcare costs, telecommuting arrangements, and the family policy mix at the state level. These factors have changed considerably over time, so the female labor force participation rate also fluctuates significantly.

2.4 Identification and Methodological Advances

Different states raised the minimum wage above $10 for the first time in different years. In recent years, econometric research has pointed out that if the policy effect is heterogeneous across states and the timing of implementation varies, then the traditional TWFE DID estimator may be equivalent to a weighted average of many 2×2 DID estimators. In this weighting, some weights may even be negative, so the sign of the estimated coefficient may not correspond to the true ATT [8][9]. In the study of dynamic events, Sun & Abraham also pointed out that the lead/lag coefficients in TWFE may be contaminated by policy effects from other cohorts and other periods, thus biasing the results [10]. More seriously, even in the absence of a pre-trend, it is possible to produce a plot that appears to show a 'pre-trend.' In this context, newer DID methods provide a more robust estimation and aggregation framework. For example, Callaway & Sant'Anna proposed using group-time average treatment effects ATT(g,t) for identification, estimation, and aggregation, allowing for 'not-yet-treated' or 'never-treated' units as control groups. This setup is more suited to the policy evaluation problem [11].

2.5 Summary: Positioning and Marginal Contribution of This Paper within the Literature

To sum up, the primary focus of minimum wage research has expanded from a singular debate on whether employment is declining to a multi-outcome evaluation of wage distribution, labor force participation, household income, poverty, and inequality. In terms of methodology, DID estimation and event study interpretations under staggered implementation have also entered the 'post-TWFE era,' requiring researchers to provide more systematic diagnostics and robust evidence. Taking 'the state minimum wage reaches $10/hour for the first time' as the institutional threshold shock, this paper examines outcomes related to inequality, poverty rates, and the labor market (especially prime-age female labor force participation) simultaneously on an interstate annual panel. It forms an evidence matrix using the family of DID methods: on the one hand, it helps to explain why state-level Gini/poverty rates may be "insignificant on average"; on the other hand, it can also provide a more cautious quasi-causal inference boundary for highly sensitive outcome variables such as female labor force participation. This research orientation not only responds to the practical policy debate surrounding the minimum wage but also aligns with the recent methodological initiatives in DID for transparent diagnostics and evidence stratification.

3. Institutional Background, Theoretical Mechanisms, and Research Hypotheses

3.1 Institutional Background: Federal Inaction and Interstate Divergence

The federal minimum wage in the United States has been maintained at $7.25 per hour since 2009, and state governments have the authority to set their own minimum wage higher than the federal standard. This institutional arrangement has led to the primary dynamics of minimum wage policy occurring at the state level. Since the 2010s, some coastal states, more urbanized states, and states with stronger political support for pro-labor policies have quickly entered the $10 or even $15 or more range. Meanwhile, other states have long maintained the federal floor or remained near it. The sample in this paper shows that during the 2010–2024 period (excluding 2020), 30 state-level units reached the $10 per hour threshold for the first

time within the sample period, while 21 state-level units never reached it. The treatment timing is distributed between 2015 and 2024, exhibiting the typical characteristics of staggered implementation.

3.2 Mechanism Framework

This paper proposes three main mechanism channels through which the minimum wage affects social inequality and the labor market:

Mechanism 1: Raising the bottom wage and reducing low-end dispersion.

After the minimum wage is increased, if implementation is effective and most firms and employers comply, the wages of low-income individuals are directly raised. At the same time, wages for positions slightly above the minimum wage may also be affected, but the overall wage gap narrows, resulting in a 'compression effect' toward the middle. This mechanism generally reduces wage inequality and may also affect the Gini coefficient and poverty rate by influencing household labor supply and total income.

Mechanism 2: Improving work returns and boosting participation.

For individuals who are on the margin between labor force participation and non-participation, a higher minimum wage makes work more financially rewarding, thereby increasing their likelihood of entering the labor force. This, in turn, raises the labor force participation rate and the employment-to-population ratio. This mechanism may be more pronounced among prime-age women, as they are often constrained by caregiving responsibilities and are more sensitive to wage returns.

Mechanism 3: Firm adjustments offsetting some effects.

Firms may respond to a minimum wage increase in several ways, such as raising prices, reducing working hours, adjusting job composition, or substituting labor with automation. These adjustments may offset some of the distributional gains resulting from wage increases. If such adjustments occur primarily in low-profit industries or among low-productivity firms, the net changes in household income and poverty rates at the state level may not be significant.

3.3 Research Hypotheses

Based on the above mechanisms, this paper proposes the following empirical hypotheses:

Hypothesis 1 (Labor Force Participation): After the state minimum wage reaches a higher level, the prime-age female labor force participation rate will increase, the employment-to-population ratio will rise, and the unemployment rate will decline.

Hypothesis 2 (Inequality): After the state minimum wage reaches a higher level, state-level income inequality (as measured by the Gini coefficient) will decrease. However, the average effect may not be substantial, and there may be considerable heterogeneity across different states.

Hypothesis 3 (Poverty and Household Income): After the state minimum wage reaches a higher level, how will the poverty rate and median household income change? The direction of the effect remains theoretically ambiguous. The outcome may depend on the policy's strength, its effective duration, and regional economic structures.

Hypothesis 4 (Heterogeneity): In states with higher baseline inequality, the distributional improvements brought about by the minimum wage will be more pronounced.

4. Research Design and Identification Strategy (The DID Family)

4.1 Baseline Two-Way Fixed Effects DID Model

The baseline model of this paper is a state-year two-way fixed effects DID specification:

$$Y_{st} = \beta \cdot HighMW_{st} + \mu_s + \lambda_t + \varepsilon_{st}$$

Where Y_{st} is the outcome variable for state s in year t; $HighMW_{st}$ is the treatment variable. It equals 1 if the state's effective minimum wage (the higher of the state and federal minimum wages) reaches or exceeds \$10/hour, and 0 otherwise; μ_s represents state fixed effects; λ_t represents year fixed effects. Standard errors are clustered at the state level.

The model absorbs time-invariant differences between states and common nationwide shocks, but still relies on the key identifying assumption: in the absence of the policy reaching the high threshold, the trends in outcome variables for treated and control states would have been parallel.

4.2 Event Study Model (Dynamic DID)

In order to test for parallel trends and depict the dynamic effects, this paper estimates the following event study specification:

$$Y_{st} = \sum_{k \neq -1} \beta_k \cdot 1EventTime_{st} = k + \mu_s + \lambda_t + \varepsilon_{st}$$

The event time is defined as the year when a state first enters the high minimum wage regime; the year prior to the event (k = -1) is omitted as the baseline category. In this paper, the event window is truncated to [-4, 6] to reduce instability caused by sparsity in the tails. The pre-trend test primarily examines whether the coefficients for periods prior to the event (k < 0) are statistically insignificant.

4.3 CS-Style Aggregated Event Study (Not-Yet-Treated / Never-Treated Controls)

Considering that TWFE event studies may be biased due to the weighting of heterogeneous treatment effects in staggered adoption settings, this paper further constructs an aggregated event study based on group-time average treatment effects: for each treatment cohort (g) and year (t), the control group consists of states that are either not-yet-treated or never-treated in year t. The estimator computes the difference relative to the pre-treatment year (g-1), which is then aggregated into an event-time ATT path using the population weights of treated states. This approach is conceptually close to the Callaway & Sant'Anna framework. Uncertainty estimates are obtained using bootstrap or subsampling methods; therefore, this approach is primarily used for robust comparisons of dynamic patterns and directions, rather than serving as the sole basis for statistical inference.

4.4 Robustness Checks and Extensions

In order to test whether the results depend on specific modeling choices, this paper adopts the following extended specifications:

1. Population-weighted TWFE: Weighted by state population to assess whether the results are driven by states with small populations;

2. State-specific linear trend TWFE: Controlling for state-specific linear time trends to account for differential long-term structural evolution across states;

3. Continuous treatment intensity DID: Replacing the discrete treatment indicator with the logarithm of the real minimum wage (adjusted to 2024 dollars using the CPI);

4. Alternative threshold test: Changing the high minimum wage threshold to $11/hour;

5. Heterogeneity analysis: Estimating interactive models by stratifying states based on their baseline Gini coefficient in 2010, as well as by Southern vs. non-Southern states.

4.5 Placebo Tests

In this paper, two types of placebo tests are implemented:

Permutation Placebo: Randomly reassign the treatment years across states, while keeping the 'distribution of treatment years' and the 'number of never-treated states' unchanged. The TWFE coefficient is repeatedly estimated, and the position of the true coefficient in the resulting placebo distribution is examined.

False Lead Placebo: The treatment year is artificially advanced by three years. If a significant 'policy effect' still emerges, it would suggest that the results may reflect pre-existing trends or common shocks, rather than the policy shock itself.

5. Data Sources, Variable Definitions, and Sample Construction

5.1 Data Sources and Replicability

The data in this paper are all obtained through public APIs, and are automatically cleaned, merged, and estimated using Python scripts. The data sources are as follows:

1. FRED minimum wage and price data [12-14]:

Annual series of state-level minimum wages [14];

Federal minimum wage [12];

CPI [13].

2. U.S. Census Bureau ACS 1-year API [15][16]:

Median household income, Gini coefficient, and detailed population estimates;

Poverty rate, labor force participation rate, employment-to-population ratio, and unemployment rate by demographic group,

as well as prime-age labor market indicators by sex;

Median earnings for all workers and median earnings for full-time workers by sex (used to construct the gender earnings gap).

Because the 2020 ACS 1-year estimates were significantly affected by pandemic-related survey implementation issues and exhibit a structural break in their usability, this paper excludes 2020 following common practice.

5.2 Sample Scope and Treatment Group Construction

The sample includes 51 state-level units: the 50 states and Washington, D.C. The time period is 2010–2024, which, after excluding 2020, yields 14 years. This results in a total of 714 state-year observations.

The treatment variable, high_mw, is defined as follows: it equals 1 if a state's effective minimum wage reaches $10 per hour or above, and 0 otherwise. The 'effective minimum wage' here refers to the higher of the state minimum wage and the federal minimum wage.

In the sample, 30 states entered the high minimum wage regime for the first time during the sample period, while 21 states never entered. The distribution of first-entry years is as follows: 1 state in 2015, 2 states in 2016, 5 states in 2017, 6 states in 2018, 1 state in 2019, 7 states in 2021, 2 states in 2022, 4 states in 2023, and 2 states in 2024. The variation in entry timing across states provides the identifying variation for DID-related methods.

For states (Alabama, Louisiana, Mississippi, South Carolina, and Tennessee) that lack available FRED series[14] for state-level minimum wages, this paper adopts the federal minimum wage as the effective minimum wage, consistent with the institutional fact that these states have either long had no independent state minimum wage or have not set one above the federal standard.

5.3 Main Variable Definitions

1. Core Explanatory Variables

effective_mw_nominal: State effective minimum wage (nominal value);

effective_mw_real_2024: Adjusted to 2024 dollars using the annual CPI;

high_mw: Indicator for whether the state has entered a high minimum wage regime ($10 threshold);

log_mw_real_2024: Logarithm of the real minimum wage (continuous treatment intensity).

2. Social Inequality and Income Outcome Variables

gini: State-level Gini coefficient for income;

poverty_rate: State-level poverty rate (%);

log_hh_income_real_2024: Logarithm of median state household income (in 2024 dollars);

gender_earn_gap_log: Logarithmic difference between median earnings of full-time full-year male and female workers.

3. Labor Market Outcome Variables

lfpr_16p, epop_16p, unemp_16p: Overall labor force participation rate, employment-to-population ratio, and unemployment rate for individuals aged 16 and over;

female_prime_lfpr, female_prime_epop, female_prime_unemp: Labor force participation rate, employment-to-population ratio, and unemployment rate for prime-age women (aged 20–64);

Corresponding prime-age male indicators are included as supplementary descriptions.

5.4 Ensuring Consistency in Variable Definitions

While collecting the data for this paper, we found that some variable codes in the ACS profile tables change across years, primarily due to changes in labels or definitions. This issue is more common in tables DP02 and DP05. Directly pooling different years using fixed codes can easily lead to inconsistent measurement. To ensure comparability across years, this paper retains only those profile variables (mainly indicators related to workers' income) whose definitions remain unchanged upon year-by-year inspection over the sample period. For variables that may be subject to potential inconsistencies, this paper does not include them in the main analysis. While this approach reduces the number of control variables, it ensures greater consistency in definitions and enhances the reliability of the results.

5.5 Descriptive Statistics

Table 1. presents descriptive statistics for the main variables. Over the sample period, the average nominal effective minimum wage across states was $8.61 per hour, with a median of $7.45 and a maximum of $17.50. In 2024 dollars, the average was $10.62. The average state-level Gini coefficient was approximately 0.464, and the average poverty rate was 13.61%. The average labor force participation rate for prime-age women was 66.93%, the average employment-to-population ratio for prime-age women was 59.32%, and the average unemployment rate for prime-age women was 13.00% (this indicator exhibited substantial fluctuations during the pandemic and recovery period).

Table 1. Descriptive Statistics for Main Variables (State-Year Panel)

Variable	Mean	Std. Dev.	Minimum	Median	Maximum
Effective minimum wage (nominal, USD/hour)	8.609	2.066	7.250	7.450	17.500
Effective minimum wage (2024 dollars)	10.624	1.930	7.250	10.321	17.597
Gini coefficient	0.464	0.021	0.408	0.464	0.542
Poverty rate (%)	13.606	3.176	7.200	13.100	24.200
Labor force participation rate, prime-age women (%)	66.927	11.158	39.000	71.150	84.700
Employment-to-population ratio, prime-age women (%)	59.324	16.703	23.700	67.400	80.400
Unemployment rate, prime-age women (%)	13.001	12.346	1.200	5.200	49.200
Overall unemployment rate (16+, %)	6.137	2.448	1.900	5.500	15.100
Median household income (log, 2024 dollars)	11.224	0.170	10.833	11.217	11.637
Gender earnings gap (log difference)	0.227	0.060	0.072	0.223	0.450

Note: The sample covers the 50 U.S. states and Washington, D.C., comprising 714 state-year observations from 2010 to 2024 (excluding 2020).

6. Baseline Results: The Relationship Between High Minimum Wage Regimes, Labor Markets, and Inequality

6.1 Baseline TWFE Estimation Results

Table 2. reports the baseline TWFE results. The results show that the high minimum wage regime is not significantly associated with the state-level Gini coefficient (coefficient: -0.0010) or poverty rate (coefficient: 0.0108). There is also no statistically significant relationship with the overall unemployment rate, median household income, or the gender earnings gap. In contrast, the labor market outcomes for prime-age women exhibit consistent and statistically significant changes: the labor force participation rate increased by 2.103 percentage points ($p = 0.0045$), the employment-to-population ratio increased by 2.730 percentage points ($p = 0.0018$), and the unemployment rate decreased by 1.859 percentage points ($p = 0.0190$).

This set of results is consistent with the mechanism hypothesis that the minimum wage has a more pronounced effect on the marginal labor supply of women. It also suggests that the initial observable impacts of minimum wage policy are more likely to manifest as improvements in labor force participation and employment matching, rather than being quickly reflected in state-level aggregate inequality indices.

Table 2. Baseline TWFE Results (State Fixed Effects + Year Fixed Effects, State-Clustered Robust Standard Errors)

Outcome Variable	Coefficient (High MW)	Standard Error	P-value	Interpretation
Gini coefficient	-0.0010	0.0013	0.4439	Not significant
Poverty rate (%)	0.0108	0.2729	0.9686	Not significant
Labor force participation rate, prime-age women (%)	2.1027	0.7385	0.0045	Significant increase
Employment-to-population ratio, prime-age women (%)	2.7296	0.8686	0.0018	Significant increase
Unemployment rate, prime-age women (%)	-1.8591	0.7904	0.0190	Significant decrease
Overall unemployment rate (16+, %)	-0.0426	0.2075	0.8376	Not significant
Median household income (log)	0.0134	0.0107	0.2119	Not significant
Gender earnings gap (log difference)	0.0013	0.0055	0.8189	Not significant

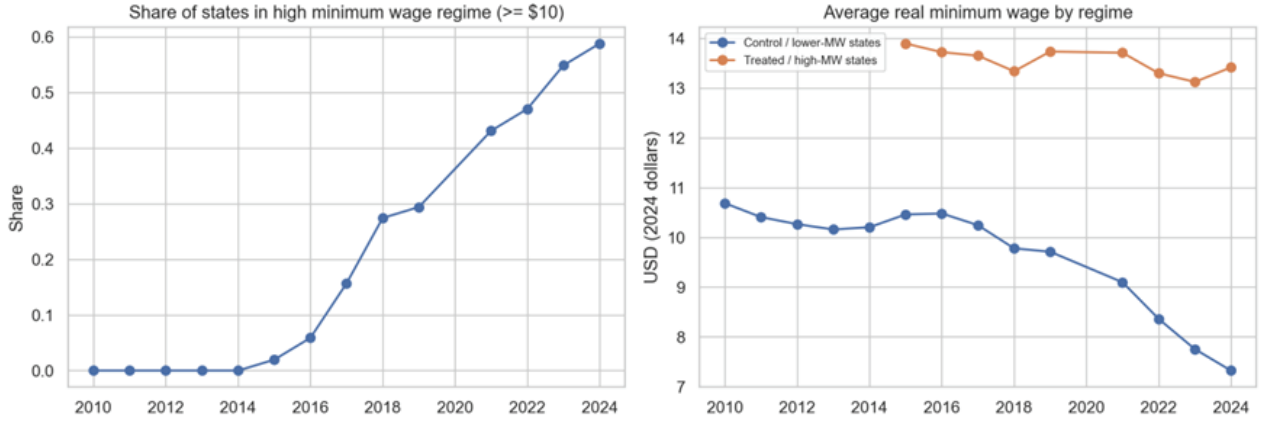
Note: Regressions include state fixed effects and year fixed effects, with standard errors clustered at the state level. The treatment variable is an indicator for the high minimum wage regime (equal to 1 if the state's effective minimum wage reaches or exceeds $10/hour).

In terms of magnitude, an increase of more than 2 percentage points in the female labor force participation rate is substantial for state-level annual data. If a causal interpretation is warranted, this implies that the policy has significant implications for improving social employment participation. However, given the non-negligible magnitude, it is necessary to further validate the identifying assumptions using dynamic and placebo tests in subsequent analyses.

6.2 Intuitive Trend Chart

Figure 1. shows the changes in the proportion of high minimum wages and low minimum wages during the sample period, and the actual minimum wages in different system groups. It can be seen that the proportion of states reaching the $10 threshold has increased significantly since 2015, and the gap between the actual minimum wage levels of the high minimum wage group and the low minimum wage group has gradually widened, providing a foundation of institutional strength for identification.

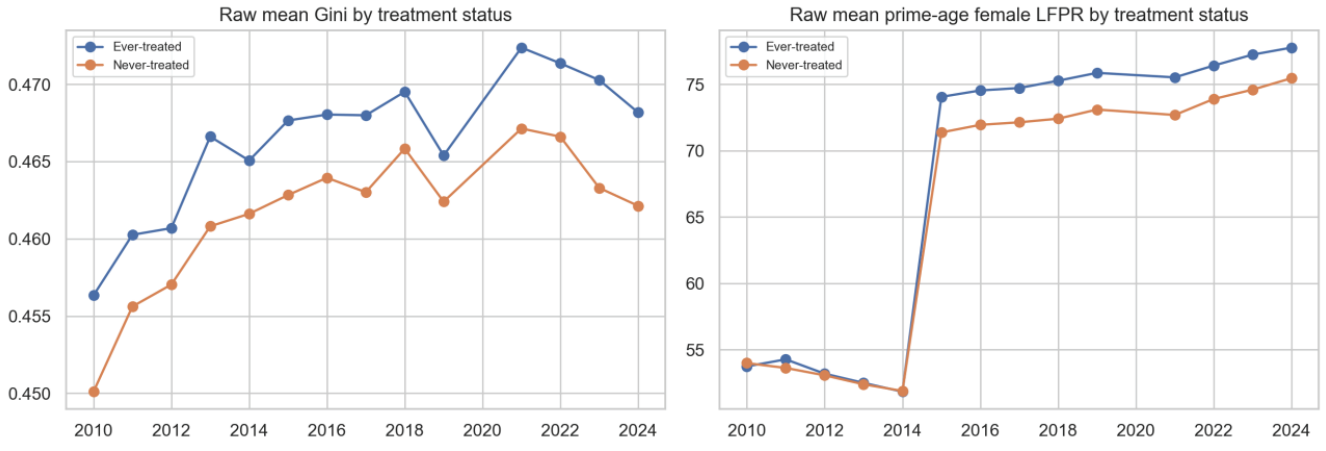
Figure 1.



Note: The author calculated and plotted using the state minimum wage series from FRED [14], the federal minimum wage [12], and CPI data [13]. The high minimum wage system is defined as the state effective minimum wage reaching or exceeding $10/hour (nominal value).

Figure 2. shows the raw mean trends of the Gini coefficient and the female prime-age labor force participation rate for groups that will eventually enter the treatment group and those that will never enter the treatment group. The raw trends provide only descriptive information and do not constitute causal evidence, but they are helpful for assessing whether there are significant differences in parallel trends. Figure 2. shows that there are obvious differences in the level and trend of female labor force participation between the two groups, suggesting that we must rely on fixed effects and event study designs for further diagnosis.

Figure 2.

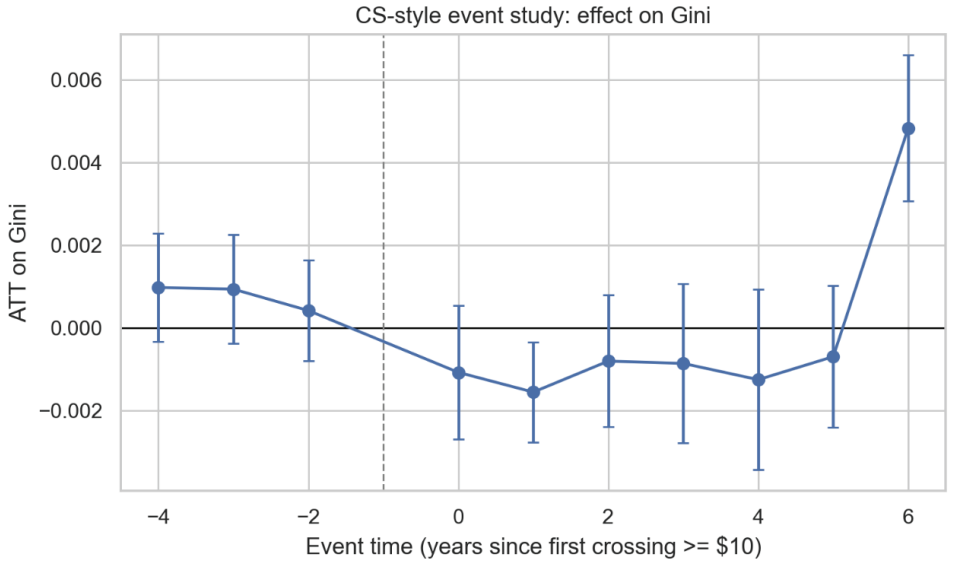


7. Dynamic Effects, Parallel Trends, and Placebo Tests

7.1 Gini: Weak Dynamic Effects, Relatively Robust Identification Diagnosis

For the Gini coefficient, the pre-treatment coefficients in the TWFE event study are close to zero overall. The p-value of the pre-trend joint test is 0.476, indicating that the parallel trend assumption is not rejected. The CS-style aggregated event study estimates also show that the magnitude of the coefficients from periods -4 to -2 before treatment is very small, and the confidence intervals contain zero. After treatment, there is a slight negative effect in the short term (especially at t+1). For example, the CS-style coefficient is about -0.00156 in the first year after the event, and its 95% confidence interval does not contain zero. However, the medium-term effect is unstable, and an outlier with a positive jump (+0.00483) appears in the sixth year post-treatment, which should be regarded as boundary sample noise rather than a stable policy effect. This means that the average effect of the high minimum wage system on the Gini coefficient is very small at the state level, and the dynamic path does not show a continuous monotonic decline pattern. If there is an improvement in distribution, it is more likely to be concentrated in specific states, specific stages, or more disaggregated groups, rather than forming a stable and large change in the overall Gini coefficient at the state level.

Figure 3.



Note: The author draws the figure based on the research results of the CS-style aggregated event study; the error bars represent the 95% confidence interval; event time -1 is the base period.

7.2 Female Prime-Age Labor Force Participation: Positive Post-Treatment Effects but Non-Negligible Pre-Trend Risks

The female prime-age labor force participation rate is the most "significant" result dimension in this paper, and it is also the dimension that requires careful explanation in terms of identification. The TWFE event study shows that the coefficients become generally positive after treatment, and the later period point estimates are mostly positive. The CS-style aggregated event study also shows a generally positive dynamic path from period 0 to 4 after treatment, with notably positive estimates in the current year (t=0) and years two to four.

However, the pre-trend diagnosis also provides warning signals:

1. The joint test p-value for the pre-treatment coefficients in the TWFE event study is 0.0377, indicating that the parallel trend assumption is rejected;

2. In the TWFE event study, the pre-event coefficient is approximately -1.69 percentage points, and its 95% confidence interval does not contain zero;

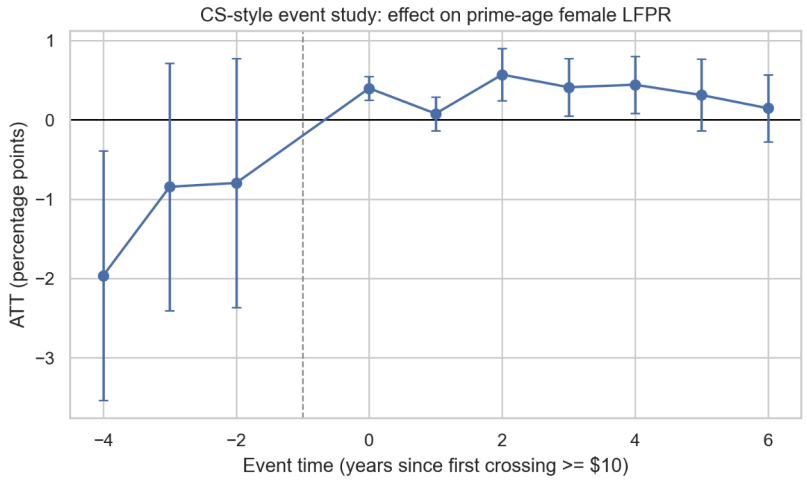
3. In the CS-style aggregated event study, the coefficient in the four years before the event is approximately -1.97 percentage points, which is also significantly negative;

4. The placebo test that artificially advances the treatment year by three years remains significant (coefficient = 1.588, p =

0.0176).

Together, this evidence suggests that the "policy effect" on women's labor force participation may be confounded by pre-policy trends, policy expectation effects, or state-level policy packages—such as childcare, labor protection, tax credits, and differences in employment recovery paths—that are promoted concurrently with the minimum wage increase. Therefore, the interpretation of this finding should be limited to: there is a robust correlation and quasi-causal evidence between the high minimum wage system and the improvement in women's labor force participation, but the parallel trend assumption is not fully satisfied. A strong causal explanation requires more detailed identification strategies—such as micro data from border areas, disentangling policy packages, instrumental variables, or synthetic control methods.

Figure 4.

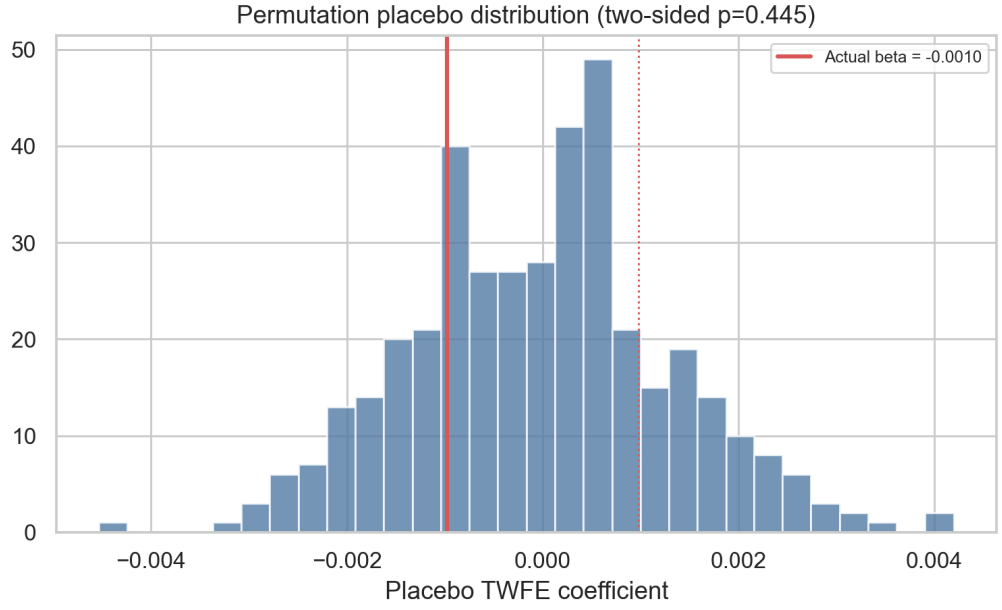


Note: The author draws the figure based on the research results of the CS-style aggregated event study; the error bars represent approximately the 95% confidence interval; event time -1 is the base period.

7.3 Placebo Tests with Artificially Advanced Treatment: A Direct Test for "Spurious Identification"

Figure 5. reports the permutation placebo test with Gini as the outcome variable. The distribution of TWFE coefficients obtained by randomly rearranging the treatment assignments is roughly centered around zero, and the true estimated coefficient (about -0.0010) lies in the middle of the permutation distribution, with a two-sided p-value of approximately 0.445. The results show that the Gini benchmark coefficient does not deviate from the random permutation distribution, which further supports the judgment that the average effect on Gini is not significant.

Figure 5.



Note: The author draws the figure based on the results of the permutation placebo test. The histogram shows the distribution of TWFE coefficients obtained after randomly rearranging the treatment assignments, and the solid line represents the estimated coefficient from the actual sample.

The placebo test with artificially advanced treatment further shows that the pre-treatment coefficient for Gini is not significant (coefficient = 0.00042, p = 0.731), but the pre-treatment coefficient for the female prime-age labor force participation rate is significantly positive (coefficient = 1.588, p = 0.018). This is consistent with the conclusion of the pre-trend tests from the event study, which reminds us again that the results for female labor force participation require stricter identification.

8. Robustness Checks

8.1 Population Weighting: Testing for Small-State Driven Issues

When weighted by state population, the significance of the results for female labor market outcomes is substantially weakened: the coefficient for the female prime-age labor force participation rate drops to 0.973 (p = 0.260), the coefficient for the employment-population ratio drops to 1.300 (p = 0.232), and the coefficient for the female unemployment rate is -0.955 (p = 0.286)—all of which are no longer significant. The results suggest that the benchmark estimates may be driven to some extent by smaller states, or that larger states experienced more complex concurrent policy changes and economic structural shifts, which makes it more difficult to identify the net effect in state-level average measures. From a policy perspective, this does not mean that the minimum wage has no effect on female labor supply, but rather suggests that the "national population-weighted average effect" and the "state average effect" may differ, and that it is necessary to distinguish between the geographic distribution and population weighting of policy impacts.

8.2 State-Specific Linear Trends: Controlling for Long-Term Structural Changes

After including state-specific linear trends, the results for female labor market outcomes are further attenuated and become insignificant: the coefficient for the female prime-age labor force participation rate drops to 0.853 (p = 0.192), the coefficient for the employment-population ratio drops to 0.670 (p = 0.396), and the coefficient for the unemployment rate drops to -0.223 (p = 0.734). This suggests that part of the benchmark results may stem from differences in long-term structural paths between the treatment and control states, rather than simply from crossing the minimum wage threshold. It is worth noting that under this specification, the poverty rate coefficient becomes -0.295 (p = 0.085), which is marginally significant at the 10% level. Although this result is not robust, it suggests that there may be a slow adjustment process of the poverty rate that is confounded with state-specific long-term trends, and it warrants further testing using longer panels and more granular data.

8.3 Continuous Treatment Intensity DID: Not Relying on Discrete Threshold Definitions

After replacing the discrete variable with the logarithm of the actual minimum wage (in 2024 prices), the three female labor market indicators still exhibit the same sign and remain significant: the coefficient for the female prime-age labor force participation rate is 7.379 (p < 0.001), the coefficient for the employment-population ratio is 9.200 (p < 0.001), and the coefficient for the unemployment rate is -5.576 (p = 0.0299). Although the magnitude of the continuous treatment coefficient cannot be directly compared with that of the discrete threshold DID, the consistency in sign suggests that the results are not entirely driven by the specific "$10 threshold". However, continuous treatment specifications cannot eliminate concerns about policy endogeneity and common trends; they only indicate the existence of a pattern of "higher intensity, better results," rather than automatically strengthening causal identification.

8.4 Alternative Threshold ($11): Robustness Check of the Policy Definition

After raising the high minimum wage threshold to $11, the results for female labor market outcomes remain stable: the coefficient for the female prime-age labor force participation rate is 2.060 (p = 0.0063), the coefficient for the employment-population ratio is 2.532 (p = 0.0053), and the coefficient for the unemployment rate is -1.667 (p = 0.0328). In addition, the coefficient on the logarithm of median household income is 0.0231 (p = 0.0401), indicating a positive association of about 2.3% for state-level median household income when a higher threshold is applied. This result suggests that if the minimum wage policy is to generate a more noticeable income improvement in state-level aggregate indicators, it may need to reach a higher threshold, or that stronger policy intensity and higher compliance may work in tandem.

9. Heterogeneity Analysis and Mechanism Discussion

9.1 Heterogeneity in Baseline Inequality: More Pronounced Distributional Effects in High-Inequality States

Based on the median Gini coefficient in 2010, this paper divides states into high- and low-baseline inequality groups and estimates the interaction between the high minimum wage indicator and the group dummy variables. The results show that in the Gini regression, the coefficient on the interaction term is -0.00623 ($p = 0.0016$), which is significantly negative. This indicates that, compared to states with low baseline inequality, those with high baseline inequality are more likely to experience a reduction in the Gini coefficient after adopting the high minimum wage policy. This finding aligns with theoretical expectations: when the bottom and lower-middle deciles of a state's income distribution are more constrained by the minimum wage, the marginal effect of a minimum wage increase on inequality compression is more likely to be reflected in macro-level inequality indicators. In other words, "the average is not significant" does not mean "invalid for all states"; rather, there may be significant heterogeneity masked by the average. It should be noted that this paper does not further estimate the within-group net effects and their joint standard errors for the high- and low-inequality groups. Therefore, the interpretation of heterogeneous results should still focus on the "direction and significance of the difference" rather than on overly precise magnitude comparisons.

9.2 Regional Heterogeneity: Differences Between Southern and Non-Southern States

Based on the interaction analysis between southern and non-southern states, the regional differences in the effects on the Gini coefficient and poverty rate are not significant. The coefficient for the female prime-age labor force participation rate is positive but not significant in southern states (coefficient = 2.157, $p = 0.339$). In contrast, the coefficient for the gender income gap (in log differences) is significantly positive in southern states (coefficient = 0.0309, $p = 0.0326$), suggesting that the relationship between the high minimum wage system and the gender income gap in southern states may differ from that in other regions. This result may reflect multiple factors, such as differences in industry structure, union coverage, the gender composition of employment sectors, compliance with the minimum wage, urban-rural structure, and other concurrent changes in labor systems. Because this paper uses state-level aggregate data, it is not possible to isolate the relative contributions of these mechanisms. Therefore, this analysis is only intended as a clue for subsequent micro-level research, rather than a definitive conclusion.

9.3 Mechanism Discussion: Why Can Improvements in the Female Labor Market Coexist with Insignificant Overall Inequality?

A key finding of this paper is that labor market indicators for prime-age women improved significantly (at least in the baseline and some robustness specifications), while the average effects on the state-level Gini coefficient and poverty rate are not significant. This combination is not contradictory and may be driven by the following mechanisms:

1. Labor force participation of marginal workers may materialize prior to observable changes in distributional outcomes: an increase in the minimum wage may first draw some marginal workers into the labor market, while improvements in income distribution may take longer to be reflected in the annual state-level Gini coefficient;

2. The distributional effect at the household level is diluted in the aggregate measure: the state-level Gini is influenced by factors such as capital income, fluctuations in high-income earnings, and population mobility, while wage improvements for low-wage groups account for a limited share of the overall distribution index;

3. Offsetting effects from hours adjustments and price pass-through: part of the wage increase may be offset by reductions in working hours or price increases, resulting in no significant net change in the poverty rate or Gini coefficient;

4. Concurrent policy and economic changes: Treatment states often implement other social policies simultaneously or undergo distinct industrial restructuring, making it difficult for the minimum wage effect to be isolated as a distinct effect in state-level aggregate indicators.

Therefore, from a policy evaluation perspective, the effectiveness of the minimum wage policy should not be judged solely by whether the state-level Gini coefficient has dropped significantly. Instead, attention should be paid to its comprehensive effects on labor force participation, employment quality, intra-group distribution, and long-term human capital accumulation.

10. Heterogeneity Analysis and Mechanism Discussion

Based on the evidence in this paper, the following policy recommendations can be proposed.

1. The Minimum Wage as a Tool to Incentivize Labor Force Participation, but Not a Panacea for Poverty Alleviation.

This paper finds that the high minimum wage system has a strong correlation with prime-age women's labor force participation and employment, suggesting that the minimum wage policy has potential value in enhancing the attractiveness of the labor market and boosting marginal labor force participation. However, its average effects on state-level poverty rates and overall inequality are not significant, indicating that the minimum wage alone is insufficient to achieve all the goals of poverty reduction and reducing social inequality. Policymakers should avoid over-reliance on a single policy tool.

2. Forming a Policy Package with Childcare, Tax Credits, and Labor Law Enforcement

If the goal is to improve women's labor supply and family welfare, the minimum wage should be promoted in coordination with complementary policies—such as childcare accessibility, childcare subsidies, the Earned Income Tax Credit (EITC), stable shift scheduling, and commuting support. Particularly in light of the identified pre-trend risks in female labor force participation, this suggests that real-world policy effects are likely driven by a "policy package" rather than by a single policy alone.

3. Gradual Implementation and Regional Assessment: Potential Distributional Gains in High-Inequality Areas

The heterogeneity results suggest that the reduction in the Gini coefficient is more pronounced in states with high baseline inequality, indicating that the minimum wage may yield greater distributional gains in areas with a worse initial distribution structure. In policy design, phased implementation, dynamic evaluation, and region-specific approaches should be considered, rather than applying the same implementation path and evaluation criteria uniformly nationwide.

4. Shifting the Evaluation Framework from "Single Indicator Significance" to an "Evidence Matrix"

A key methodological implication of this paper is that the identification credibility of the same policy can vary greatly across different outcome variables. Policy evaluation should not draw an overarching conclusion based solely on the significance of a single outcome, but should instead establish an "evidence matrix" that includes: average effects, dynamic paths, pre-trends, placebo tests, alternative specifications, heterogeneity analyses, and implementation contexts. This approach not only enhances academic rigor, but also improves the transparency and credibility of policy communication.

11. Conclusions

Using public state-level panel data from the United States, this paper systematically evaluates the impact of adopting a high minimum wage on the labor market and social inequality through a suite of DID methods. Benchmark TWFE results show that the high minimum wage system is significantly associated with increases in the prime-age female labor force participation rate and employment-to-population ratio, and a decrease in their unemployment rate. However, its average effects on the state-level Gini coefficient, poverty rate, overall unemployment rate, median household income, and gender income gap are not significant. Continuous treatment intensity and alternative threshold tests support the directional findings for the female labor market. However, population weighting and state-specific trend controls attenuate their significance, while event studies and placebo tests with artificially advanced treatment reveal pre-trend risks, suggesting that strong causal interpretations should be made with caution. In contrast, the pre-trend diagnostics for the Gini coefficient are relatively robust to placebo tests, but its overall average effect remains close to zero. From a policy perspective, the minimum wage is better understood as a tool to promote labor force participation—particularly among women—rather than as a standalone solution to poverty and inequality. Future research, leveraging individual-level micro data, border area identification strategies, and more comprehensive information on policy packages, holds greater promise for isolating the impact of the minimum wage from that of concurrent reforms.

Appendix A: Methodological Boundaries and Interpretation

1. State-level aggregate data are suitable for macro policy evaluation, but it is difficult to identify quantile effects at the individual level and heterogeneity in policy compliance.

2. The results for the female labor force participation rate exhibit signals of pre-trends/anticipation effects, and thus causality

needs to be re-confirmed under a stronger identification design.

Appendix B: Potential Directions for Future Research

1. Introduce micro-data from border counties or commuting zones: Strengthen identification using county-level or individual data within and across state borders;

2. Control for policy packages: Incorporate state-level policy variables such as EITC, paid sick leave, childcare subsidies, and union density;

3. Test industry structure mechanisms: Examine the share of service sector employment, adjustments in retail and food service jobs, and price pass-through indicators;

4. Analyze distributional effects: Investigate wage percentiles, household income percentiles, and inequality decomposition (within-state/between-state);

5. Address the pandemic discontinuity: Model structural breaks more precisely for the 2020 gap and the 2021–2022 recovery period;

6. Employ alternative identification methods: Utilize synthetic control, stacked DID, Sun-Abraham estimators, and DRDID, among others.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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