AUTOMATION ADOPTION AND WORKPLACE INEQUALITY IN JAPANESE MANUFACTURING

Firm-Level Evidence on Wages, Employment, and Job Quality

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Abstract

This paper develops a firm-level research design for examining how automation exposure is associated with workplace inequality in Japanese manufacturing. It focuses on three connected outcomes: wages and pay dispersion, employment levels and composition, and non-monetary dimensions of job quality, including working hours, overtime, and employment status. The central argument is that automation should not be treated as a uniform shock: its consequences may depend on firms' organisational responses, workforce composition, training opportunities, and the extent to which technological change substitutes for or complements particular tasks. The empirical plan combines enterprise-level information from Japan's Basic Survey of Japanese Business Structure and Activities with industry-level measures of industrial-robot exposure. Where access and identifiers permit, worker- and establishment-level information from the Basic Survey on Wage Structure will be used to examine earnings and working conditions by age, sex, education, occupation, tenure, and employment type. A critical distinction will be maintained between directly observed firm adoption and industry-level exposure; the latter will not be described as firm-specific adoption. The analysis will begin with data-feasibility and linkage checks, proceed to descriptive panel analysis and fixed-effects specifications, and use event-study or instrumental-variable strategies only if a defensible source of identifying variation can be established. The paper contributes a sociological perspective to research on automation by examining not only aggregate employment and wage effects but also the distribution of benefits and risks across firms and worker groups. No empirical findings are reported at this stage; the proposed hypotheses will be evaluated after the data have been secured, harmonised, and analysed.

JEL Classification: J23; J31; O33; L60; Z13

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1. Introduction

Automation is often presented as a response to labour scarcity and a source of productivity growth. Yet the distributional consequences of new technologies are not determined by technology alone. They also depend on how firms reorganise production, allocate tasks, train workers, structure employment contracts, and share productivity gains. In manufacturing, industrial robots and AI-enabled systems may replace some routine tasks, complement others, and generate new activities in maintenance, programming, quality control, logistics, and process coordination. These changes can raise output while producing uneven consequences for wages, job stability, working time, and occupational mobility.

Japan provides a consequential setting in which to study these questions. Its manufacturing sector has a long history of industrial automation, while demographic ageing and persistent labour-market adjustment pressures have intensified interest in technological solutions. However, a simple account in which automation either destroys jobs or improves productivity cannot capture the simultaneous processes of job displacement, job creation, task redesign, and unequal access to the gains from innovation. Research on Japan has already documented important effects of robotics on employment and adjustment within firms (Ni & Obashi, 2021; Adachi, Kawaguchi, & Saito, 2024), while more

recent work has examined ICT capital and automation risk in relation to Japanese wages and working hours (Fukao et al., 2025). The present study builds on this evidence rather than assuming that the relationship between automation and labour-market outcomes remains unexamined.

The proposed contribution is to place workplace inequality and job quality at the centre of the analysis. From an economic-sociological perspective, firms are not merely production functions; they are organisational settings in which resources, authority, security, and opportunities are distributed. The same technological investment may therefore have different implications for employees according to their skills, gender, age, employment status, and position within the firm, as well as according to firms' size and organisational capacity. An increase in average productivity or wages, for example, may coexist with stagnant pay among some worker groups, a shift toward non-standard contracts, or increased pressure on working time.

The paper addresses three questions:

1. How is firms' exposure to automation associated with average pay, wage dispersion, and the distribution of earnings across worker groups in Japanese manufacturing?
2. How does automation exposure relate to employment levels and composition, including differences by skill, age, sex, and standard versus non-standard employment status?
3. Under what organisational and workforce conditions is automation associated with improved or deteriorating job-quality indicators, such as overtime, working hours, employment security, and access to training?

The analysis is designed to distinguish descriptive association from causal inference. The title's reference to firm-level evidence refers to firm-level outcomes; unless restricted microdata or direct firm adoption measures can be accessed and linked, automation will be measured using industry-level exposure. That distinction is central to the credibility of the study. The paper therefore begins with a data audit and makes the strength of any causal claim conditional on the empirical variation available.

2. Conceptual Framework and Related Literature

2.1 Task change, substitution, and complementarity

Task-based approaches distinguish between technologies that substitute for labour in particular activities and technologies that complement workers by raising productivity or expanding the scale of production (Acemoglu & Autor, 2011; Autor, 2015). The relevant unit is often the task rather than the occupation as a whole: a job may combine automatable routine tasks with tasks requiring judgement, communication, troubleshooting, or contextual knowledge. This implies that the labour-market consequences of automation depend on the mix of tasks within firms and occupations, and on whether firms reorganise work in ways that allow employees to move into complementary activities.

The empirical implication is that average employment or wage effects can conceal substantial reallocation. A firm may reduce one category of production work while expanding engineering, maintenance, or quality-assurance roles. Aggregate headcount may change little even as the distribution of work, pay, and security changes materially. Accordingly, the proposed study separates

employment quantity from employment composition and treats wage levels, wage dispersion, and job quality as related but distinct outcomes.

2.2 Workplace inequality and employment segmentation

Economic sociology emphasises that workplace outcomes are shaped by institutional and organisational relations as well as by individual productivity. Access to training, promotion, secure contracts, and wage bargaining may vary systematically across worker groups. The literature on precarious work further shows why employment security and contract status should be treated as substantive dimensions of inequality rather than as secondary outcomes (Kalleberg, 2009). In this study, automation is therefore examined as a possible mechanism of labour-market segmentation: some workers may gain access to new technical roles and training, while others may face reduced task demand, less predictable hours, or fewer routes into secure employment.

The framework also recognises that these mechanisms may operate between firms. Large firms may have more capacity to finance automation, internal training, and redeployment; smaller firms may adopt technologies more selectively or depend on external suppliers and contractors. These are empirical propositions, not assumptions about all Japanese firms. The analysis will test for heterogeneity by firm size and subsector where the data permit.

2.3 Evidence from Japan and the proposed contribution

Existing Japan-focused studies establish that employment effects need not move in a single direction. Ni and Obashi (2021) examine within-firm employment adjustment and report that robot exposure is associated with both job creation and job destruction, with the balance depending on the activities under consideration. Adachi et al. (2024) use a distinctive dataset and identification strategy to study robot prices and employment in Japan over 1978–2017, finding that declining robot prices increased robot use and employment through productivity and scale channels. Fukao et al. (2025) examine ICT capital, automation risk, wages, and working hours using Japanese industry-level panel data. Together, these studies caution against assuming that automation necessarily reduces total employment or has uniform wage effects.

The proposed study's added value is narrower and explicitly distributional: it seeks to combine enterprise-level outcomes with worker-level or establishment-level evidence on wage structure and job quality, subject to data access and linkage feasibility. Rather than claim that prior studies have ignored inequality, it will investigate whether the available Japanese microdata allow a more integrated account of employment composition, earnings distribution, and working conditions. If direct linkage is infeasible, the design will be revised to avoid presenting separate data sources as if they formed a single linked panel.

3. Research Questions and Hypotheses

The hypotheses below are preregisterable expectations for empirical testing, not findings. They should be refined after a detailed audit of measurement and data access.

H1. Heterogeneous wage associations. Automation exposure will be associated with different wage trajectories across occupational and skill groups; workers in tasks complementary to automation may experience more favourable wage outcomes than workers in more substitutable tasks.

H2. Reallocation rather than uniform displacement. Automation exposure will be associated with changes in employment composition as well as total employment, with job creation and job destruction potentially occurring simultaneously within firms or sectors.

H3. Unequal job-quality effects. Associations between automation and working hours, overtime, and employment status will differ across worker groups and will depend on firms' organisational responses and training opportunities.

H4. Firm heterogeneity. The relationships between automation exposure and labour outcomes will vary by firm size and manufacturing subsector, reflecting differences in resources, production technologies, and opportunities for internal redeployment.

H5. Distribution of gains. Positive changes in productivity or average pay will not necessarily translate into more equal wage distributions; the distribution of gains will be assessed directly where worker-level wage observations are available.

4. Data and Measurement Strategy

4.1 Enterprise-level data

The proposed enterprise panel will begin with Japan's Basic Survey of Japanese Business Structure and Activities, administered by the Ministry of Economy, Trade and Industry (METI). The survey provides enterprise-level information on business activities and includes firms meeting coverage thresholds; the current published description identifies enterprises with at least 50 employees and capital or investment funds of at least JPY 30 million within covered industries. This makes it potentially useful for tracking larger manufacturing firms, but it does not represent all firms, especially the smallest enterprises (METI, 2026). The exact years, identifiers, employment measures, labour-cost items, capital investment variables, and rules for access will be verified before estimation.

The principal outcomes will be chosen only after this variable audit. Candidate firm-level outcomes include employment levels, changes in workforce size, labour-cost or personnel-expense measures where consistently recorded, sales and productivity proxies, and capital expenditure. Personnel expenses divided by headcount can be used only as an approximate average labour-cost measure; it should not be described as a wage distribution or a measure of within-firm wage inequality.

4.2 Wages and working conditions

The Ministry of Health, Labour and Welfare's Basic Survey on Wage Structure provides information on earnings and worker characteristics, including sex, age, education, tenure, employment type, occupational or job classification, working days and hours, overtime, contractual earnings, and annual special cash earnings (MHLW, n.d.). These measures are directly relevant to pay and job

quality. However, access conditions, sample design, establishment identifiers, and the feasibility of longitudinal linkage with METI enterprise data must be established. Unless linkage is explicitly authorised and technically valid, the wage survey will be analysed as a separate worker/establishment-level dataset and its estimates will not be represented as linked firm-level outcomes.

For wider context and robustness, the Labour Force Survey and the Employment Status Survey published by Japan's Statistics Bureau can supply aggregate or person-level information on employment status, industry, hours, and regular versus non-regular work. These sources may help assess whether patterns observed in the enterprise data are consistent with broader labour-market developments, but they do not automatically identify the effect of automation at the firm level (Statistics Bureau of Japan, 2026).

4.3 Measuring automation

Industrial-robot exposure will be measured using robot stocks, installations, or robot density by manufacturing industry and year, subject to the availability and licensing conditions of the International Federation of Robotics' World Robotics data. The measure will be mapped to compatible Japanese industry classifications. This is an industry-level exposure measure, not direct evidence that each observed firm adopted a robot. Where a usable firm-level technology-adoption variable is available in an authorised survey, it will be retained as a distinct measure and compared with the industry-exposure measure.

AI adoption and industrial robotics should not be treated as interchangeable. Robotics data capture a relatively specific class of industrial automation and cannot, by themselves, measure the adoption of generative AI, machine-learning decision systems, or software automation. The baseline paper will therefore focus on industrial-robot exposure unless a separate and validated AI-adoption measure can be obtained. This scope discipline is necessary to avoid using a broad AI label for a narrower robotics design.

4.4 Outcomes and operational definitions

- Employment: total employees, employment growth, and available breakdowns by worker type or occupational category.
- Pay: contractual cash earnings, overtime compensation, annual special cash earnings, and hourly-equivalent pay where working-hour denominators are available and appropriate.
- Wage inequality: within-group or within-establishment dispersion measures only if worker-level wage observations and adequate sample sizes are available; otherwise, the study will use between-group gaps and will not claim to measure within-firm dispersion.
- Job quality: scheduled and actual working hours, overtime hours, employment type, and indicators of security or training only where directly observed. Job security and training will not be inferred from wages alone.
- Firm context: size, manufacturing subsector, capital intensity, productivity proxies, export orientation, and other consistent covariates available from authorised enterprise data.

5. Empirical Strategy

5.1 Descriptive and panel analysis

The first stage will describe the distribution of automation exposure across manufacturing subsectors and document trends in employment, pay, and available job-quality outcomes. The panel design will then estimate fixed-effects associations between automation exposure and firm outcomes, controlling for time-invariant firm characteristics and common year shocks. A baseline specification is:

$$Y_{it} = \beta\ \text{AutomationExposure}_{jt} + X_{it}'\gamma + \alpha_i + \lambda_t + \varepsilon_{it}$$

where Y_{it} is a firm-level outcome for firm i in year t; $\text{AutomationExposure}_{jt}$ is robot exposure in the firm's manufacturing subsector j and year t; X_{it} is a vector of observed firm-level covariates; α_i represents firm fixed effects; and λ_t represents year fixed effects. Standard errors will be clustered at the level at which the exposure varies, subject to the number of clusters and the final design. If exposure varies at a more aggregated level, conventional firm-level clustering would be inappropriate.

Because the baseline exposure measure may vary by industry and year rather than directly by firm, β should initially be interpreted as an association between industry-level automation exposure and firm-level outcomes. The results will not be labelled causal merely because fixed effects are included.

5.2 Worker-level analysis

If the wage-structure microdata provide suitable coverage and identifiers, complementary models will examine wages and job-quality outcomes at the worker or establishment level. These models will include observed worker characteristics and fixed effects appropriate to the sampling structure. Heterogeneity by sex, age, education, tenure, occupation, and employment type will be tested using pre-specified interaction terms. Survey weights and design features will be incorporated where required by the official data documentation.

5.3 Identification and robustness

The primary threat to interpretation is endogeneity: industries may automate in response to expected changes in demand, wages, skill supply, or productivity. The empirical strategy will therefore be staged. First, the study will report descriptive and fixed-effects associations. Second, event-study or difference-in-differences designs will be considered only if adoption timing and comparison groups can be defined credibly, with pre-trend diagnostics and attention to anticipation. Third, an instrumental-variable approach based on changes in robot prices interacted with pre-existing industry suitability may be explored if the necessary data are available and the exclusion restriction can be defended. This is a candidate design rather than an established identification strategy.

Robustness checks will include alternative automation-exposure measures, different lags, alternative outcome definitions, exclusion of influential subsectors, and sensitivity to the treatment of firm entry and exit. Results will be reported separately for direct firm adoption and industry-level exposure,

where both are available. Missing data, survey attrition, sample coverage, and the consequences of restricting the enterprise sample to larger firms will be documented explicitly.

6. Expected Contribution and Policy Relevance

The study's contribution is to connect technological change to the social organisation of work. It asks not only whether employment and pay rise or fall on average, but also how labour-market gains and risks are distributed across worker groups and firms. In doing so, it brings a workplace-inequality perspective to Japan-focused research on robotics and automation, while building on existing empirical studies of employment adjustment, robot prices, and wage outcomes.

The policy implications will depend on the estimates and will not be pre-judged. If the analysis identifies unequal access to wage gains or training, the findings may inform targeted reskilling and internal redeployment policies. If overtime or employment insecurity worsens for particular groups, they may support closer monitoring of job quality alongside productivity indicators. If automation complements rather than displaces workers in some contexts, policy attention should also focus on the conditions under which such complementarity is achieved. In all cases, recommendations will be tied to measured outcomes rather than to a presumption that automation is inherently harmful or beneficial.

7. Limitations and Research Integrity

Three limitations are foreseeable. First, the enterprise survey's coverage thresholds limit representativeness for small firms. Second, industry-level robot exposure is a proxy for firms' technology environments and cannot identify firm-specific adoption without additional information. Third, a valid integrated analysis of wages, employment, and job quality depends on access to compatible microdata and authorised linkage. If the required linkage is not possible, the paper will present transparently separated analyses and narrow its claims accordingly.

A further scope limitation concerns artificial intelligence. Unless a distinct adoption measure is obtained, the study will make claims about industrial robots and automation exposure rather than AI adoption broadly. The final paper will document data sources, variable definitions, sample restrictions, code where permissions allow, and all robustness checks. No empirical result, causal claim, or policy conclusion will be presented as established before the corresponding analysis has been completed.

8. Conclusion

Automation can alter not only the number of jobs but also the distribution of tasks, wages, security, and opportunities within manufacturing organisations. A sociological account of these changes requires attention to the institutions and organisational practices through which the gains and risks of technological change are allocated. This research design proposes to examine those processes in Japanese manufacturing by combining enterprise-level outcomes with worker- and establishment-level evidence where access permits. Its credibility will depend on disciplined measurement, explicit

separation of firm adoption from industry exposure, and an identification strategy proportionate to the available data. The resulting analysis can contribute to a more differentiated understanding of when automation accompanies more productive work, when it deepens workplace inequality, and which organisational conditions may shape those outcomes.

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Appendix A. Submission Readiness Checklist

The following checks should be completed before this research-design draft is submitted as an extended abstract or developed into a full paper:

- Confirm data access, years covered, and exact enterprise-level variables in the Basic Survey of Japanese Business Structure and Activities.
- Verify whether worker-level wage data can be lawfully linked to establishment or enterprise identifiers; do not assume linkage is available.
- Secure a documented industrial-robot exposure series and map its industry classification to the Japanese Standard Industrial Classification.
- Decide whether the paper studies robotics specifically or can support a broader AI-and-automation claim with a separate AI adoption measure.
- Produce descriptive tables, sample-flow information, and preliminary estimates before describing any results as findings.
- Review the official NBER call: submit a PDF by 11:59 p.m. Eastern Time on 1 December 2026. NBER indicates that outlines and extended abstracts are acceptable, but completed papers receive priority.
- Keep the authorship and affiliation block factual. Do not add an NBER affiliation or describe the work as NBER-sponsored research; the meeting is the target conference, not the author's institutional affiliation.