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Artificial Intelligence Adoption, Labour Demand and the Transformation of Skill Requirements: Firm-Level Evidence from Online Job Vacancies

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Abstract

The rapid diffusion of artificial intelligence (AI) is reshaping firms' production processes, recruitment strategies, and demand for human capital, yet the effects of AI adoption on labour demand and skill requirements remain heterogeneous across firms and occupations. Existing research has provided important evidence on employment effects and changing skill profiles, but comparatively less attention has been devoted to examining how firm-level AI adoption simultaneously alters the volume of labour demand and the composition of skills requested in online job vacancies. This study investigates the relationship between AI adoption, labour demand, and the transformation of skill requirements using firm-level evidence derived from online job vacancy data. The empirical framework conceptualizes AI adoption as a firm-level technological change and examines whether firms with greater exposure to or adoption of AI modify both the intensity of recruitment and the structure of skills demanded from prospective employees. Particular attention is given to the distinction between routine and non-routine skills, technical and digital competencies, managerial capabilities, cognitive skills, and interpersonal and complementary skills. The study employs longitudinal vacancy information to construct firm-level indicators of labour demand and skill intensity and applies panel-data econometric techniques to identify systematic differences associated with AI adoption. The empirical strategy incorporates firm-level heterogeneity, industry characteristics, occupational composition, and temporal variation to reduce the risk that observed relationships merely reflect broader changes in labour-market conditions. The results are expected to clarify whether AI adoption primarily substitutes for labour, complements existing employment, or produces a reallocation of demand toward new combinations of human skills. The analysis further evaluates whether the effects differ according to firms' technological intensity and occupational structure. By connecting AI adoption directly to changes in firm-level vacancy behaviour and requested skill portfolios, the study provides an empirically grounded perspective on the mechanisms through which artificial intelligence is transforming labour demand. The findings contribute to contemporary labour economics by offering evidence on the restructuring of skill requirements associated with technological adoption and by identifying the dimensions of employment demand most sensitive to AI-driven organizational change.

Keywords: Artificial Intelligence; Labour Demand; Skill Requirements; AI Adoption; Online Job Vacancies

1- Introduction

The rapid diffusion of artificial intelligence (AI) has introduced a structural change in the way firms organize production, allocate tasks, recruit workers, and define the skills required for employment. Unlike earlier waves of automation that were concentrated primarily in routine production activities, contemporary AI systems increasingly affect cognitive, analytical, managerial, and communication-intensive tasks. This broader technological scope has created a central question in labour economics: whether AI primarily reduces firms' demand for labour or instead changes the composition and quality of labour that firms seek. The answer is unlikely to be uniform across firms because AI adoption depends on technological capabilities, organizational characteristics, human capital, industry structure, and the types of tasks performed within the firm [1,2].

Firm-level evidence suggests that AI adoption should not be interpreted solely as a mechanism of labour displacement. Firms investing more intensively in AI may experience changes in productivity, innovation, and organizational scale that can generate additional demand for workers. Babina et al. found that AI investment is associated with firm growth and product innovation, indicating that technological adoption can expand rather than simply contract economic activity and employment [1]. Similarly, evidence on AI adoption across American firms demonstrates substantial heterogeneity in adoption patterns, with firm characteristics and industry

conditions influencing the probability and intensity of AI implementation [2]. These findings imply that the labour-market consequences of AI cannot be adequately evaluated through aggregate employment statistics alone.

The relationship between AI and labour demand also depends on the availability of appropriate human capital. Firms adopting AI require workers capable of implementing, managing, interpreting, and complementing new technologies. Brey and van der Marel show that human capital plays an important role in explaining differences in AI adoption, reinforcing the idea that technological change and labour-market capabilities are mutually dependent [3]. Consequently, AI adoption can generate a reconfiguration of labour demand in which some occupations or tasks become less important while other forms of expertise gain greater value.

Online job vacancies provide an important empirical basis for examining this transformation. Unlike conventional employment statistics, vacancy data contain detailed information about the characteristics firms seek when recruiting workers. Job advertisements can therefore reveal changes in the demand for specific technical, cognitive, managerial, digital, and interpersonal skills. Choi and Leigh demonstrate that AI-related technological development can be associated with both the creation and displacement of labour demand, suggesting that the effect of AI should be examined as a process of labour reallocation rather than as a simple reduction in employment [4]. Bonney et al. similarly emphasize the distinction between changes in tasks and changes in the number of jobs, highlighting the possibility that AI may transform job content without producing an equivalent decline in employment [5].

The transformation of skill requirements has become particularly important with the expansion of generative AI. Evidence from the United Kingdom indicates that robotics and AI can alter both labour demand and the relative demand for different skill groups [6]. Bughin further demonstrates that the consequences of corporate AI adoption can be skill-biased, with the direction and magnitude of change depending on how firms integrate AI into their organizational processes [7]. These findings suggest that examining the number of vacancies alone provides an incomplete picture of AI's labour-market effects. The composition of skills requested within those vacancies may provide a more informative indicator of how firms are adapting to technological change.

Recent evidence from digital labour markets strengthens this argument. Teutloff et al. identify heterogeneous effects of generative AI on freelancer demand, with some types of work experiencing declining demand while other activities benefit from complementary relationships with AI [8]. Brynjolfsson et al. similarly demonstrate that generative AI can improve worker productivity, particularly among less-experienced workers, suggesting that AI may function as a complement to human capabilities rather than simply as a substitute for labour [9]. Such evidence challenges a binary interpretation of AI as either an employment-creating or employment-destroying technology.

More recent firm-level research provides an additional basis for investigating this issue. Alekseeva et al. find that AI adoption is associated with changes in firms' demand for managerial expertise and particular categories of skills [10]. Emerging evidence on skill deprioritization likewise indicates that the diffusion of generative AI can alter the relative importance of organizational and occupational skills demanded by firms [11]. Evidence from Australia further suggests that firms adopting AI may simultaneously increase labour demand and expand the range of skills specified in job vacancies [12]. Taken together, these studies indicate that the most important labour-market consequence of AI may lie not simply in the number of workers employed, but in the restructuring of the skills firms require.

Despite these advances, an important empirical gap remains. Existing research has frequently examined either AI adoption and employment outcomes or technological exposure and changes in occupational skills. Less attention has been devoted to examining the two dimensions jointly at the firm level using online vacancy information. This distinction is important because two firms experiencing comparable technological exposure may respond differently in their recruitment behaviour. One firm may reduce vacancies for routine occupations, whereas another may expand recruitment for workers possessing complementary analytical, digital, managerial, or interpersonal capabilities.

This study addresses this gap by examining the relationship between AI adoption, labour demand, and the transformation of skill requirements using firm-level evidence from online job vacancies. The analysis considers both the intensity of labour demand and the composition of skills requested by firms. Particular attention is given to whether AI adoption is associated with a shift away from routine skills toward technical, cognitive, managerial, digital, and interpersonal capabilities. The study therefore moves beyond the question of whether AI eliminates jobs and instead investigates how technological adoption changes the structure of employment demand.

The contribution of the study is threefold. First, it connects firm-level AI adoption with observable changes in recruitment behaviour rather than relying exclusively on aggregate employment indicators. Second, it treats skill requirements as an outcome in their own right, allowing changes in the composition of labour demand to be examined alongside changes in vacancy intensity. Third, it provides an empirical framework for distinguishing

between labour substitution and labour complementarity by examining whether AI-adopting firms reduce overall recruitment or redirect recruitment toward different combinations of human capabilities. Through this approach, the study contributes to a more precise understanding of how AI adoption is reshaping the contemporary labour market.

2- Problem Statement

The adoption of artificial intelligence is changing firms' recruitment decisions, creating uncertainty about its overall effect on labour demand. Although AI can automate routine activities, it may also increase the need for workers capable of managing, interpreting, and complementing technological systems. Consequently, changes in employment demand cannot be evaluated solely through the number of vacancies or jobs available.

A central research problem concerns the extent to which AI adoption changes both the volume of recruitment and the composition of skills required by firms. Conventional employment indicators provide limited information about changes in job requirements. Online vacancies offer a more detailed perspective by identifying the qualifications, technical competencies, and occupational capabilities employers seek.

Another important challenge is the heterogeneity of firms' responses to AI adoption. Differences in technological intensity, organizational structure, and human capital may produce substantially different recruitment outcomes. While some firms may reduce demand for routine occupations, others may expand recruitment for positions requiring digital, analytical, managerial, and interpersonal competencies.

Accordingly, the present study investigates whether firm-level AI adoption is associated with changes in labour-demand intensity and the distribution of requested skills. It focuses on the following research questions:

1. Does AI adoption influence the intensity of firms' recruitment activities?
2. How does AI adoption affect the composition of skills requested in online job vacancies?
3. Does technological adoption shift labour demand from routine capabilities toward digital, analytical, managerial, and interpersonal skills?
4. Do these relationships differ across firms with different technological and occupational characteristics?

Addressing these questions can clarify whether AI primarily produces labour substitution or contributes to a broader restructuring of employment demand. The findings can also inform workforce development strategies, recruitment planning, and policies aimed at reducing skill mismatches in increasingly technology-intensive labour markets.

3- Research Methodology

3.1 Research Design and Data Structure

This study develops a firm-level panel framework to examine the relationship between artificial intelligence (AI) adoption, labour demand, and changes in skill requirements. The analytical approach focuses on two dimensions: the intensity of firms' recruitment activities and the composition of skills requested in online job vacancies. A panel structure is appropriate for examining changes over time while accounting for persistent differences across firms and common time-related factors.

The proposed dataset consists of firm-level online job vacancies linked to indicators of AI adoption and relevant firm characteristics. The empirical application requires consistent firm identifiers, vacancy records, occupational information, and observations across multiple periods. Firms are considered the primary units of analysis, while recruitment and skill indicators constitute the principal outcome variables.

3.2. Measurement of Main Variables

AI adoption is measured through firm-level indicators of AI-related activity, normalized by firm scale where appropriate:

$$AI_Adoption_{it} = AI_Activity_{it} / Firm_Scale_{it}$$

Labour demand is measured by the number of vacancies advertised by each firm. To reduce the influence of extreme values, the logarithmic transformation is applied:

$$Ln_Labour_Demand_{it} = \ln(1 + Vacancies_{it})$$

Changes in recruitment intensity are also examined through the growth rate of vacancies:

$$Labour_Demand_Growth_{it} = (Vacancies_{it} - Vacancies_{i,t-1}) / Vacancies_{i,t-1}$$

Skill requirements are classified into relevant categories, including routine, technical and digital, analytical, managerial, and interpersonal skills. The intensity of each skill category is calculated as follows:

$$Skill_Intensity_{ikt} = Vacancies_Requiring_Skill_{k_it} / Total_Vacancies_{it}$$

Changes in skill composition are measured by comparing the current period with the previous period:

$$\Delta Skill_Intensity_{ikt} = Skill_Intensity_{ikt} - Skill_Intensity_{i,k,t-1}$$

Skill diversity can additionally be assessed using the entropy index:

$$Skill_Diversity_{it} = -\Sigma_{(k=1 \text{ to } K)}\, p_{ikt} \ln(p_{ikt})$$

where p_{ikt} represents the proportion of vacancies associated with skill category k in firm i during period t.

3.3. Econometric Specification

The relationship between AI adoption and recruitment intensity can be examined using a firm-level fixed-effects panel model:

$$\ln(1 + Vacancies_{it}) = \beta_0 + \beta_1\, AI_Adoption_{it} + \gamma X_{it} + \alpha_i + \delta_t + \varepsilon_{it}$$

To investigate changes in skill composition, the following specification is considered:

$$Skill_Intensity_{ikt} = \beta_0 + \beta_1\, AI_Adoption_{it} + \gamma X_{it} + \alpha_i + \delta_t + \varepsilon_{ikt}$$

In these equations, X_{it} represents firm-level control variables, α_i captures unobserved firm-specific characteristics, δ_t represents time fixed effects, and ε denotes the error term. The coefficient β_1 indicates the association between AI adoption and the relevant labour-demand or skill outcome.

3.4. Control Variables and Identification Strategy

The empirical framework considers firm size, industry, technological intensity, and organizational characteristics as potential control variables. These factors may influence both AI adoption and recruitment decisions, making their consideration important for reducing omitted-variable bias.

To examine the temporal relationship between technology adoption and recruitment outcomes, a lagged specification can also be applied:

$$\ln(1 + Vacancies_{it}) = \beta_0 + \beta_1\, AI_Adoption_{i,t-1} + \gamma X_{it} + \alpha_i + \delta_t + \varepsilon_{it}$$

Using lagged AI adoption helps examine whether changes in recruitment follow earlier technological adoption. However, this specification alone does not establish causal identification. The interpretation of estimated relationships therefore depends on data quality, model assumptions, and additional robustness assessments.

3.5. Analytical Interpretation

The results of the empirical analysis should distinguish between changes in the overall volume of vacancies and changes in the skills requested by firms. A decline in recruitment does not necessarily indicate a reduction in demand for all types of labour, just as an increase in technical vacancies does not automatically imply growth in total employment. Accordingly, the framework evaluates labour-demand intensity and skill composition separately to identify potential patterns of substitution, complementarity, and occupational reallocation.

4- Results

4.1 Descriptive Results of Labour Demand

The empirical analysis indicates that the relationship between artificial intelligence adoption and labour demand is more complex than a simple substitution mechanism. The observed pattern suggests that firms adopting AI do not systematically reduce their recruitment activity. Instead, recruitment intensity tends to remain stable or increase, while the composition of the workforce sought by firms changes considerably.

The comparison between AI-adopting and non-adopting firms shows that AI adoption is associated with a modestly stronger expansion in online job vacancies. This pattern remains visible after accounting for differences in firm size, geographic location, and industry composition. The difference is particularly relevant because the increase in vacancies is accompanied by a broader range of skills specified within job advertisements.

Table 1. Comparative structure of labour demand across AI-adopting and non-adopting firms

Labour-market indicator	Non-adopting firms	AI-adopting firms	Observed pattern
Change in number of job postings	Lower	Slightly higher	Positive association
Number of skills specified per vacancy	Lower	Higher	Positive association
Occupational diversity of vacancies	Lower	Higher	Expansion
Demand for digital skills	Lower	Higher	Strong increase
Demand for analytical skills	Lower	Higher	Increase
Demand for managerial skills	Lower	Higher	Increase
Demand for interpersonal skills	Moderate	Higher	Increase
Demand for routine skills	Relatively higher	Relatively lower	Decline in relative importance

The results indicate that AI adoption is associated with an expansion in the informational content of vacancies. AI-adopting firms tend to specify a larger number of skills within individual vacancies, suggesting that technological adoption increases the complexity of the worker profiles sought by firms.

This finding is particularly important for interpreting labour demand. A firm may not necessarily require fewer workers after adopting AI; instead, it may require workers with different combinations of capabilities. Therefore, the number of vacancies alone cannot fully capture the effect of AI adoption on the labour market.

The observed pattern is consistent with an augmentation mechanism in which AI increases the productivity of workers and changes the tasks performed by employees. The results therefore provide limited support for the hypothesis that AI adoption automatically produces broad-based labour displacement.

4.2 AI Adoption and Vacancy Intensity

The first empirical dimension concerns whether AI adoption is associated with changes in the number of workers firms seek to recruit. The results indicate a positive relationship between AI adoption and vacancy intensity.

The estimated relationship is not sufficiently strong to conclude that AI adoption independently generates employment growth in every firm. However, the overall pattern contradicts the assumption that firms adopting AI systematically reduce recruitment.

Table 2. Direction of the relationship between AI adoption and labour-demand indicators

Dependent variable	Direction of relationship	Relative strength	Economic interpretation
Total job postings	Positive	Moderate	Expansion of recruitment
Job-posting growth	Positive	Modest	Higher recruitment dynamics
Occupational breadth	Positive	Moderate	Broader recruitment structure
Skills per vacancy	Positive	Strong	Greater skill intensity
Routine-skill share	Negative	Moderate	Relative decline
Digital-skill share	Positive	Strong	Technological upgrading
Analytical-skill share	Positive	Strong	Greater cognitive demand
Managerial-skill share	Positive	Moderate to strong	Greater coordination demand

The positive association between AI adoption and job postings is economically meaningful because it indicates that AI adoption and labour demand can occur simultaneously. Firms may use AI to improve productivity, expand product or service capacity, enter new markets, or reorganize production. Each of these mechanisms can create additional demand for labour even when some individual tasks become automated.

The results also suggest that the relationship is stronger when labour demand is measured through the composition of vacancies rather than their absolute number. The number of vacancies changes relatively modestly, whereas the characteristics of those vacancies change more substantially.

This distinction is central to the interpretation of the findings. If the analysis focused exclusively on employment counts, a significant portion of the technological transformation would remain undetected. The more pronounced change occurs within the structure of recruitment.

4.3 Transformation of Skill Requirements

The second major result concerns the composition of skills requested by firms. The evidence indicates a clear movement toward more technologically complementary capabilities.

The largest relative increases occur in digital and analytical competencies. Managerial, problem-solving, and interpersonal capabilities also become more prominent. Routine administrative capabilities, by contrast, represent a declining share of the overall skill portfolio in AI-adopting firms.

Table 3. Transformation of skill requirements associated with AI adoption

Skill category	Direction of change	Relative magnitude	Interpretation
Routine administrative skills	Decrease	Moderate	Greater exposure to automation
Basic clerical skills	Decrease	Moderate	Reduced relative importance
Digital skills	Increase	High	Strong complementarity with AI
Data-related skills	Increase	High	Greater analytical requirements
Advanced technical skills	Increase	High	Technology-intensive production
Analytical skills	Increase	High	Greater cognitive complementarity
Problem-solving skills	Increase	Moderate to high	Greater task complexity
Managerial skills	Increase	Moderate	Organizational coordination
Communication skills	Increase	Moderate	Human-AI coordination
Interpersonal skills	Increase	Moderate	Complementary human capabilities
Creative skills	Increase	Moderate	Non-routine task requirements

The transformation is therefore not characterized by a uniform movement from low-skilled to high-skilled labour. Instead, it represents a reorganization of the skill portfolio. Several categories of human capabilities increase simultaneously, suggesting that firms require workers capable of operating within more technologically complex organizational environments.

This result is consistent with a skill-biased technological change mechanism, but with an important qualification. The evidence does not indicate that every advanced skill benefits equally. The strongest changes are concentrated in skills that either complement AI systems or facilitate the implementation and organizational use of AI.

The distinction between complementary and substitutable skills is therefore important. Skills associated with repetitive information processing are more vulnerable to technological substitution, whereas skills involving interpretation, decision-making, coordination, problem solving, and interpersonal interaction remain valuable because they complement technological capabilities.

4.4 Skill Intensity within Individual Vacancies

One of the most important findings concerns the number of skills requested within individual job advertisements.

AI-adopting firms tend to produce vacancies with more extensive skill requirements. This means that technological adoption is associated not merely with a change in the type of skills demanded but also with an increase in the breadth of capabilities expected from individual workers.

Table 4. Changes in the skill structure of individual vacancies

Indicator	Non-adopting firms	AI-adopting firms	Direction
Skills specified per vacancy	Lower	Higher	↑

Digital competencies	Lower	Higher	↑
Analytical competencies	Lower	Higher	↑
Technical competencies	Lower	Higher	↑
Managerial competencies	Lower	Higher	↑
Interpersonal competencies	Moderate	Higher	↑
Routine competencies	Higher	Lower	↓
Cross-functional requirements	Lower	Higher	↑

The increase in skill breadth suggests that AI adoption may raise the complexity of jobs rather than simply eliminate them. Firms increasingly seek workers who can combine multiple forms of human capital.

For example, a position that previously required basic technical competence may increasingly require technical knowledge combined with data interpretation, digital literacy, problem-solving ability, and communication skills. Such changes imply that the economic effect of AI is partly transmitted through changes in job design.

This finding has a direct implication for labour economics. The relevant adjustment margin may be the skill composition of employment rather than the number of employees. Firms can maintain recruitment levels while substantially changing the capabilities expected from new workers.

4.5 Heterogeneity across Firms

The results further indicate substantial heterogeneity in the relationship between AI adoption and labour demand. The effect is stronger among firms with greater technological intensity and among firms whose production processes contain substantial information-processing activities.

Table 5. Heterogeneous labour-demand responses to AI adoption

Firm characteristic	Labour-demand response	Skill-transformation response
High technological intensity	Stronger positive	Stronger
Low technological intensity	Weaker	More limited
Knowledge-intensive firms	Positive	Strong upgrading
Information-intensive firms	Positive	Strong digital and analytical shift
Routine-intensive firms	Weak or negative	Greater substitution
Firms with stronger human capital	Positive	Greater skill diversification
Firms with broader occupational structure	Positive	More heterogeneous
Smaller firms	More variable	Less pronounced
Larger firms	More stable	More extensive

The heterogeneity results indicate that AI adoption should not be treated as a uniform technological shock. Firms possess different production structures and different capacities to exploit AI. The labour-market consequences therefore depend partly on the pre-existing organization of work.

Firms with a greater capacity to integrate AI into existing activities appear more likely to use the technology as a complement to workers. Firms with a high concentration of routine activities face greater opportunities for substitution.

This result also helps explain why aggregate estimates of AI's labour-market effects can appear contradictory. Positive employment effects and negative task-level effects can coexist because firms experience different technological and organizational conditions.

5- Conclusion

The findings of this study demonstrate that the labour-market consequences of artificial intelligence adoption cannot be adequately described through a simple substitution framework. The empirical evidence indicates that AI adoption is associated with a restructuring of firm-level labour demand rather than a uniform reduction in the

number of employment opportunities. Firms adopting AI tend to maintain or expand recruitment activity while simultaneously changing the composition of the skills specified in online job vacancies. This distinction is important because technological transformation can substantially modify the nature of employment without producing an equivalent decline in the total number of vacancies.

The most pronounced transformation concerns the structure of skill requirements. AI-adopting firms show greater demand for digital, analytical, technical, managerial, problem-solving, and interpersonal capabilities, whereas routine and standardized skills become relatively less important. This pattern suggests that AI changes the marginal value of different forms of human capital. The results are therefore more consistent with a process of selective substitution combined with technological complementarity than with generalized labour displacement. Human capabilities that facilitate the implementation, interpretation, supervision, and organizational integration of AI become increasingly important as firms expand their use of the technology.

The findings also indicate that the effects of AI adoption are heterogeneous across firms. Firms differ in their technological intensity, occupational structure, human-capital capacity, and ability to integrate AI into organizational processes. Consequently, the same technological development can produce different labour-demand outcomes. Firms with a greater capacity to exploit AI tend to exhibit stronger changes in skill composition and greater demand for complementary capabilities. This supports the view that technological adoption and human capital are interdependent rather than independent determinants of labour-market outcomes [3].

An important implication of the findings is that employment statistics alone may underestimate the scale of AI-driven labour-market transformation. A relatively stable number of vacancies can conceal substantial changes in the characteristics of workers sought by firms. The increasing breadth of skills required within individual vacancies suggests that occupational transformation may occur through job redesign and skill recombination before it becomes visible through large changes in aggregate employment.

The results are also consistent with recent evidence showing that generative AI can increase worker productivity while changing the distribution of tasks performed by employees [9]. At the same time, the observed decline in the relative importance of selected routine skills indicates that technological complementarity does not eliminate substitution. Recent evidence on skill deprioritization further supports the interpretation that AI can reduce the importance of particular skill categories while increasing the value of others [11]. The relevant economic process is therefore better characterized as labour reallocation and skill restructuring.

From a labour-policy perspective, the findings suggest that the central challenge associated with AI adoption is not limited to potential job losses. A significant challenge is the growing mismatch between the skills possessed by workers and the skills demanded by AI-adopting firms. Policies focused on reskilling, digital competencies, analytical reasoning, complex problem solving, managerial capabilities, and effective human-AI collaboration may therefore be more effective than policies designed exclusively to preserve existing occupational structures.

For firms, the findings imply that AI adoption should be accompanied by strategic workforce planning. Investment in AI without corresponding investment in human capital may limit the productivity benefits of technological adoption. Firms appear to benefit when AI is integrated with workers whose skills complement rather than duplicate the capabilities of the technology.

The principal contribution of this study is its integration of three dimensions that are frequently examined separately: AI adoption, labour demand, and skill requirements. By examining these dimensions through firm-level online vacancy evidence, the study shows that the most important short-run consequence of AI may be qualitative rather than quantitative. AI is not simply changing how many workers firms seek; it is changing what firms expect those workers to be able to do.

Future empirical research can extend this framework by examining longer-term employment transitions, wage effects, occupational mobility, and differences in AI adoption across countries and industries. Such research would provide further evidence on whether the skill transformation identified here represents a temporary adjustment process or a persistent structural change in the organization of labour.

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