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Article

Impact of high-speed rail opening on the efficiency of enterprise human capital investment: Evidence from China

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Abstract: In the current context of China's vigorous development of its high-speed rail (HSR) network to accelerate the realization of connectivity, which is the aim of the "Belt and Road" initiative, it is crucial to study how the specific opening of HSR enhances enterprise human capital investment efficiency. Using a multiple-time-point difference-in-differences (DID) regression model, we empirically study data from listed Chinese companies. An HSR opening can promote the efficiency of an enterprise's human capital investment. We further explore the relationship between HSR and a company's human capital investment, by considering the moderating effects of firm property rights and foreign shareholding. Our findings indicate that these factors can enhance the impact of HSR on the efficiency of firms' investments in human capital. Finally, to ensure the reliability of our experimental findings, we employed a combination of propensity score matching and the DID methodology. The findings of this study offer empirical evidence that can inform enterprise management strategies and provide valuable insights for policymakers seeking to promote economic growth.

Keywords: high-speed rail opening; human capital investment efficiency; firm property rights; foreign shareholding

1. Introduction

China has recently made remarkable progress in the construction of high-speed railways (HSR), leading to the continuous development of this transportation mode. The opening of high-speed rail (HSR) networks has had a profound impact, significantly reducing transportation time and costs between regions, expediting the flow of information, labor, and capital, and lowering transaction costs associated with interregional trade. Moreover, it has enhanced the ability of firms to make decisions regarding human capital investment (Duffhues, 2014).

As an essential element in promoting social development, human resources must be matched with appropriate positions to achieve optimal resource allocation, which is the core essence of human capital investment efficiency (Bertrand, 2003). Over-investment can lead to a waste of human resources, while underinvestment can result in the inadequate utilization of financial resources.

Improving human capital investment efficiency is crucial for achieving rational allocation of human and other resources, helping enterprises save labor costs, and reducing the wastage of other resources. Therefore, adopting appropriate measures to enhance human capital investment efficiency is a key factor in resolving some of the current economic development problems and challenges (Marginson, 2019). This study explored the relationship between HSR openings and human capital investment efficiency from an enterprise perspective in the context of the new era.

Previous studies have focused on the quality of financial reporting, management earnings forecasts, disclosure of internal control deficiencies, and the influence of top management teams and financial analysts on corporate investment decisions (Malmendier and Tate, 2005; Biddle, 2006; Richardson, 2006; et al.). However, these studies do not consider human capital, and ordinary employees, as important stakeholders, may also contribute to a firm's daily profit activities. Hence, exploring the efficiency of firms' investments in human capital is of immense significance. There is limited research on the relationship between external business environments and corporate human capital investments. Ben-Nasr and Alshwer (2016) suggest that relaxation of stock price constraints can alleviate insufficient corporate labor investment. Factors such as local government officials' promotions (Mourao, 2018), labor mobility under environmental uncertainty (Chu and Fang, 2021), and labor mobility under government institutional reforms that expand labor market size (Wei and Chen, 2020) can also influence corporate labor investment efficiency. According to the new economic geography theory, geographic distance plays a significant role in trade production, transportation transactions, and information dissemination (Forward, 1958). Transportation infrastructure development can stimulate local economies, reduce transaction costs, and promote employment within businesses (Shi et al., 2020). Therefore, considering China's unique transportation infrastructure landscape, in this study, HSR network development is selected as the focal point within the framework of the new economic geography theory to further explore the relationship between HSR opening and corporate human capital investment efficiency.

In this study, we deduce the impact mechanisms of HSR opening on corporate human capital investment efficiency based on theoretical foundations and previous research as follows: First, increased labor mobility resulting from the opening of HSR reduces information constraints for businesses (Shi et al., 2020). It accelerates the movement of personnel, facilitating quicker labor mobility between regions through the discovery of transportation infrastructure (Xu et al., 2022). This decrease in search and communication costs between jobseekers and recruiting companies enables both parties to find suitable matches more swiftly. Furthermore, it reduces labor costs for businesses, thereby enhancing the efficiency of corporate human capital investments (Xu et al., 2022). Second, opening of HSR also reduces external monitoring costs and enhances the transparency of information for publicly listed companies (Wu et al., 2022). This contributes to alleviating agency problems, improving corporate managers' ethical behavior, and reducing opportunistic behavior (Guo et al., 2020). This heightened transparency also facilitates the collection of information by external monitoring agencies and board directors, thereby enhancing the effectiveness of corporate oversight. As corporate human capital investment efficiency is influenced by information asymmetry and agency theory (Khedmat and Yawson, 2020), HSR opening mitigates these issues, leading to an enhancement in corporate human capital investment efficiency. Finally, the opening of HSR broadens the labor market and enables the mobility of senior management personnel, fostering external competition and reducing agency problems (Xu et al., 2022). This benefits corporate human resource management decisions and increases human capital investment efficiency (Jung et al., 2014).

Simultaneously, senior management becomes more competitive, further reducing agency problems (Guo et al., 2020).

This study examines the correlation between HSR opening and the efficiency of firms' human capital investment by analyzing data from 2612 publicly listed companies spanning 2011 to 2019, excluding those in the financial industry and Special treatment (ST) companies. The main analysis was conducted using a multiperiod difference-in-differences (DID) model. The primary empirical findings of this research demonstrate that HSR opening can enhance the efficiency of firms' investment in human capital. Moreover, we explore the moderating effects of factors such as enterprise property rights and overseas shareholding on the relationship between HSR opening and enterprise human capital investment efficiency. The empirical results indicate that the efficiency of firm investment in human capital can be enhanced by the opening of HSR, particularly for state-owned enterprises (SOEs) and enterprises with overseas shareholdings. Finally, to avoid potential sample selection bias caused by endogeneity, we used propensity score matching (PSM) combined with the DID method (PSM-DID) to reanalyze the model, which can eliminate the heterogeneity between the experimental and control groups and make the results more robust.

This study makes several contributions to the literature. First, it introduces a novel approach for investigating the efficiency variables of human capital investment in enterprises. Building on prior research findings (Jung et al., 2014), we enhance the measurement of labor investment efficiency variables by incorporating factors such as employee education level and workforce size, thereby making it more comprehensive and precise. This study integrates external environmental factors with internal corporate governance to supplement existing research outcomes. This finding enriches the study of HSR opening and the efficiency of corporate human capital investments.

Second, it extends the theoretical research framework by investigating human capital investment efficiency within the context of HSR opening. This study not only explores the internal mechanisms of enterprises from the perspectives of information asymmetry and agency theory but also enriches the relevant theoretical research on enterprise human capital investment efficiency by incorporating the new economic geography theory and transaction cost theory as theoretical foundations.

Third, this study contributes to the research on corporate management and governance by empirically examining the relationship between HSR opening and human capital investment efficiency in listed companies using real-world data. This study provides empirical evidence and theoretical support for companies responding to national policies and the subsequent personnel recruitment and management appointments.

2. Literature review and proposed hypotheses

2.1. Literature review

2.1.1. High-speed rail opening

The opening of HSR has had extensive impacts on economy, labor mobility,

and corporate management (Shi et al., 2020). First, HSR opening is typically closely associated with economic growth and regional development (Li et al., 2020). Research has indicated that the construction and operation of HSR stimulates economic activities in the corresponding regions, promotes investments, creates employment opportunities, and enhances connectivity between cities (Li et al., 2020). These effects play a positive role in narrowing development disparities among regions. Concurrently, HSR also contributes to improving economic efficiency within regions, expediting the urbanization process (Chen and Haynes, 2017).

The opening of HSR has resulted in increased labor mobility and reduced information constraints for enterprises (Shi et al., 2020; Xu et al., 2022). This has accelerated the movement of talent between regions, decreased the search and communication costs for jobseekers and recruiting companies, and improved the efficiency of talent matching. Simultaneously, businesses have benefited from reduced labor costs, which has consequently enhanced employment levels (Shi et al., 2020).

Second, the opening of HSR facilitates the enhancement of information transparency for enterprises and effectively reduces the costs of external oversight, thus contributing to the alleviation of agency problems (Wu et al., 2022). This has facilitated improvements in the ethical behavior of corporate managers, lowered the risks of opportunistic behavior, and bolstered the capacity of external oversight bodies and board directors, thereby enhancing the effectiveness of corporate supervision (Guo et al., 2020). This influence enables businesses to better address agency issues and further enhances corporate managers' decision-making regarding investments in human capital.

2.1.2. Enterprise human capital investment efficiency

The management team may, for various reasons such as the pursuit of higher compensation, prestige, excessive self-interest, and overconfidence, make adjustments to their hiring decisions, which may involve either excessive hiring or staff reduction, to serve their personal objectives. This can impact human capital investment efficiency and harm a company's interests (Ghaly et al., 2019). The phenomenon of increased labor mobility resulting from the opening of HSR plays a significant role in influencing enterprises hiring practices. From the perspective of corporate human capital investment efficiency, human capital is a crucial factor that holds research value for both the macroeconomic landscape of a country and daily operational management of enterprises (Jung et al., 2014). Thus, investigating the factors affecting corporate human capital investments is of practical significance. In this study, we primarily conduct a literature review of these influencing factors from both internal and external environment perspectives.

Financing constraints and managerial decisions involving agency problems are pivotal concerns (Jung et al., 2014). Information asymmetry makes financing challenging and costly, potentially hindering viable projects from obtaining financial support (Chu and Fang, 2021). Researchers have explored factors, such as policy frameworks, economic conditions, cash dividends, and executive backgrounds, to investigate their impact on human capital investment efficiency in the context of information asymmetry and agency problems (Ben-Nasr and Alshwer, 2016).

Managerial decisions driven by self-interest and overconfidence, including excessive hiring or staff layoffs, can detrimentally affect human capital investment efficiency and company interests (Gomes and Novaes 2005). High-quality accounting information can help mitigate agency problems and adverse effects (Jung et al., 2014). Additionally, factors such as employee welfare, analysts, stock prices, and internal controls have been examined from an agency problem perspective to elucidate their relationship with human capital investment efficiency (Cao and Rees, 2020; Ben-Nasr and Alshwer, 2016; Lee and Mo, 2020; et al.).

An enterprise's external environment encompasses factors such as politics, markets, resource availability, and transportation, all of which exert a significant influence on daily operations and personnel management (Wei and Chen, 2020; Shi et al., 2020). Political factors include policymaking related to macroeconomic planning by the state, such as the impact of the hukou system on labor mobility (Bosker et al., 2012). Market factors influence human capital investment efficiency within enterprises owing to disparities in industrial development across different regions, leading to significant variations in labor market returns. Human resource availability directly affects a company's human capital investment efficiency, with ample supply lowering recruitment and increasing costs (Cao and Rees, 2020). Transportation factors, in line with the new economic geography theory, influence transportation costs, information flow, and production efficiency. The opening of HSR in China has provided an efficient and convenient mode of transportation that positively affects human capital investment efficiency in enterprises (Wei and Chen, 2020)

2.1.3. High-speed rail opening and enterprise human capital investment efficiency

Consequently, this study investigates the link between HSR and the efficiency of enterprises' human capital investments. Based on the new economic geography theory, geographic distance is an important factor that influences trade production, transportation transactions, and information flow. Progress in transportation infrastructure mitigates the negative impacts of geographic distance and serves as a catalyst for diminishing regional economic disparities. For enterprises, HSR opening facilitates labor mobility, which is closely related to enterprise development. First, labor is the source of enterprise production efficiency and market supply. Second, labor tends to gravitate toward regions that offer higher wages, thereby stimulating local enterprise growth. This study examines the macro-level association between the introduction of HSR and the efficiency of human capital investment by selecting possible factors at the macro level that contribute to labor mobility. The related variables promote labor mobility to some extent, breaking the spatial constraints between cities, reducing transaction costs caused by information, improving the effective allocation of factor resources, and increasing human capital investment efficiency, while promoting urban economic development.

Owing to differences in the equity structure of listed companies between the Chinese and Western capital markets, where a significant portion of Chinese companies are SOEs with unique characteristics and objectives, ownership is an important representative variable in the study of listed companies (Alon and Zhang,

2014). Research has shown that companies with state ownership tend to face financing constraints, and the higher the proportion of state ownership, the more severe these constraints become (Wang and Alhaleh, 2021). China's listed companies also have non-state-owned equity holdings and studies indicate that large non-state-owned shareholders can have a constraining effect on corporate overinvestment (Xie, 2015). Regarding the relationship between environmental uncertainty and corporate human capital investment efficiency, Chu and Fang (2021) found that over-investment exists in SOEs, while under-investment is mainly observed in private enterprises.

External supervision is an important means of addressing internal information asymmetry and agency problems within enterprises (Cao and Rees, 2020). Regarding the impact of foreign ownership on firm performance, most scholars believe that foreign ownership can reduce agency problems and enhance corporate transparency and governance (Tran, 2020). Using empirical research on listed companies, Hungarian scholars have demonstrated that a higher proportion of foreign ownership has a more positive impact on company performance (Campbello, 2002). Domestic scholars have found a positive correlation between foreign ownership and firm performance; however, if foreign ownership consists of ownership by financial institutions, it may lead to a decline in a company's operational performance (Dollar and Wei, 2007).

2.2. Proposed hypotheses

Based on the literature review, the following three hypotheses are proposed in this study: First, the relationship between HSR openings and efficiency of corporate human capital investment is examined. Second, given that corporate human investment efficiency is influenced by information asymmetry and agency theory (Oh and Park, 2022), in this study, we use property rights variables as moderating factors based on the unique equity nature of publicly listed Chinese companies (Wang and Alhaleh, 2021). Finally, external supervision is an essential means of addressing internal information asymmetry and agency issues (Cao et al., 2020), with foreign ownership as a moderating variable (Tran, 2020).

The opening of HSR significantly reduced business transaction costs, improved employee recruitment, and facilitated the adjustment of management personnel, thereby promoting more efficient resource allocation and enhancing the efficiency of human capital investment in enterprises (Guo et al., 2020). This has led to the breakdown of urban barriers and reduced information search and communication costs between employees and businesses. Moreover, this attracts job seekers to choose out-of-town companies with higher salaries, increasing options for employers and reducing transaction costs, ultimately improving the matching efficiency between individuals and businesses and reducing labor shortages caused by inconvenient regional transportation (Khedmat and Yawson, 2020). Additionally, HSR has lowered the adjustment costs for business management personnel, allowing managers to make personnel adjustments at lower costs, further enhancing human capital investment efficiency. Furthermore, the opening of HSR alleviates information constraints (Xu et al., 2022). On the one hand, it improves the external

information environment, facilitates face-to-face communication between the labor force and businesses, reduces information asymmetry, and enhances resource allocation efficiency (Shi et al., 2020). On the other hand, it expands the supply of labor to the job market, reduces labor costs for businesses, and improves the efficiency of human capital investment (Jung et al., 2014). Management leverages information resources to reduce decision-making errors using reasonable wage incentives to mitigate mistakes resulting from information asymmetry, ultimately enhancing the efficiency of human capital investment in enterprises (Xu et al., 2022). Moreover, HSR opening can increase external competition and reduce agency problems (Jung et al., 2014). Human capital investment decisions are typically based on market sales budgets, and managements must estimate these decisions based on market sales budget-related information (Shi et al., 2020). HSR opens the door to greater competition, motivating managements to make more equitable human capital investment decisions, enhance decision-making skills, and avoid excessive or insufficient human capital investment due to self-interest (Oh and Park, 2022). HSR improves information asymmetry by introducing external competition (Wu et al., 2022). This strengthens competitive constraints on management and encourages more equitable human capital investment decisions, ultimately reducing labor investment inefficiencies.

H1: HSR openings enhance the efficiency of firms' investments in human capital.

The opening of HSR enhances labor mobility and reduces external supervision costs (Shi et al., 2020). The different property rights of enterprises may affect labor investment efficiency (Alon and Zhang, 2014). Private enterprises are typically more flexible and market-oriented, whereas SOEs may be constrained by bureaucratic procedures and hierarchies, which limit their flexibility (Wang and Alhaleh, 2021). Private enterprises are more likely to attract external investors and increase their financing flexibility (Xie, 2015). HSR opening has lowered information-acquisition costs, especially for non-SOEs, making external supervision more convenient (Jung et al., 2014). Non-SOEs often have external shareholders or financing, and HSR opening reduces third-party information acquisition costs, promotes external supervision, and reduces opportunistic managerial behavior, thereby enhancing labor investment efficiency (Tran, 2020). The opening of the HSR increases labor mobility and reduces agency problems. SOEs may exhibit opportunism and ethical risks owing to a lack of shareholder supervision (Song et al., 2011). HSR opening affects labor market competition and flexibility, creating more employment opportunities and potentially increasing competition (Chu and Fang, 2021). Non-SOEs face fewer agency problems, and market competition encourages them to focus more on labor training and investment, thereby enhancing labor investment efficiency. This leads to the following hypothesis:

H2: The involvement of state-owned controlling shareholders in Chinese listed companies diminishes the positive impact of HSR openings on the efficiency of human capital investment in these enterprises. Conversely, in the case of non-state-owned controlling shareholders in listed companies, the positive effect of HSR openings are amplified on the efficiency of human capital investment.

As ongoing reforms increasingly transform SOEs and foreign capital in Chinese listed companies, affecting their strategies, management, and governance, foreign shareholders can mitigate agency problems (Alon and Zhang, 2014). They tend to engage professional consultants, enhance decision-making rigor, and reduce conflicts of interest between management and shareholders, thereby contributing to improved economic efficiency (Wang et al., 2021). Foreign shareholders enhance external oversight and increase corporate transparency (Tran, 2020). They subject listed companies not only to Chinese government supervision but also to foreign investors' constraints on management behavior. From an agency perspective, this reduction in agency problems among actual decision makers influences firms' staffing decisions, allowing for the effective allocation of human resources and optimization of labor capital investment efficiency. Foreign shareholder ownership can also act as a check for dominant shareholders (Dollar and Wei, 2007). Examining equity balances prevents dominant shareholders from pursuing excessive self-interest and safeguards the interests of minority shareholders. In terms of human capital investment, HSR openings have increased labor mobility, expanded the labor market, and facilitated the development of appropriate personnel management and recruitment policies, thereby enhancing the efficiency of enterprise human capital investment (Wu et al., 2022).

H3: Foreign shareholders can amplify the positive impact of HSR openings on enterprises' human capital investment efficiency.

3. Research design

In accordance with the literature, HSR opening is considered an exogenous shock in macroeconomic terms because it is an infrastructure project typically led and implemented by the government or railway-operating companies. Its initiation is usually driven by strategic government initiatives and policies rather than market or internal corporate decisions (Du and Peng, 2017; Fan, 2020; Wu et al., 2022). HSR opening is considered an exogenous variable implemented at the macroeconomic level and is suitable for the application of a multi-period DID model (Wu et al., 2022). In this study, we employ the DID model for three main reasons. First, it enables a dynamic, multi-period analysis of adjustments in firms' human capital investment efficiency before and after the opening of the HSR. Second, as the independent variable in this study is a dummy variable, it divides the sample into an experimental group (companies located in cities with HSR opening) and a control group (companies located in cities without HSR opening) to examine the efficiency of human capital investment in enterprises. Utilizing coefficients representing the interaction between the independent variables and time ($\mathrm{Emp\_labor_{it}} \times \mathrm{Post_{it}}$) provides a more intuitive observation of changes in enterprise human capital investment efficiency before and after the implementation of HSR opening in different listed companies' locations, confirming Hypothesis 1 (as shown in Equation (2)) (Roberts and Whited, 2013). The dependent variable is represented by the residuals from Equation (1); refer to Equations (1) and (2).

This approach mitigates potential issues related to other variables that affect the relationship between HSR opening and enterprises' human capital investment

efficiency. Consequently, in this study, we designed quasi-natural experiments with staggered timing based on exogenous variables in different cities and employed a multi-time-period DID regression model for the main analysis.

Moreover, after obtaining the main regression results and verifying the relationship between HSR opening and enterprise labor investment efficiency, additional robustness checks were performed. These include balancing trends and placebo tests to examine the applicability of the DID model and to assess whether the experimental results are influenced by unobserved omitted variables or other policies. This reaffirms the conclusions of Hypothesis 1.

Furthermore, this study investigates the moderating effects of property rights (Soe_{it}) and foreign ownership (For_{it}) on the relationship between HSR opening and enterprises' labor capital investment efficiency. A regression analysis with different coefficients for the two grouping variables was conducted to test Hypotheses 2 and 3.

Finally, we employed a virtual variable, substituting an HSR opening with an airline route opening, to demonstrate the robustness of the experiments. Additionally, because the DID regression model in this study divides the experimental sample into experimental and control groups, factors other than the independent variable under investigation were omitted. This could potentially interfere with the main regression results and introduce endogeneity into the empirical results owing to differences arising from these omitted factors, data biases, and confounding variables. To address these issues, we employed a combination of PSM and DID to ensure the robustness of the results for Hypotheses 1, 2, 3, and 4.

3.1. Samples selection and data

In this study, data from Chinese listed companies for the period between 2000 to 2021 were used as the sample. For HSR opening, data before 2015 were obtained from the latest HSR data disclosed by China Railway, and data after 2015 were collected from various local government websites, China Railway 12306, and local news websites. This data was cross-checked, reviewed, and manually collected. For the empirical analysis, we utilized other relevant data, such as financial data sourced from the China stock market & accounting research (CSMAR)database. The sample data were processed as follows: Missing sample data, sample data with negative net assets, and sample data from the financial industry were deleted and 1% trimming was conducted of all sample data belonging to continuous variables.

3.2. Measure of human capital investment efficiency

Concerning the measurement of variables related to human capital investment efficiency, in this study, we draw on the research findings of Pinnuck and Lillis (2007). The net employment level of a company is represented by the percentage change in the number of employees. Furthermore, a regression analysis is conducted on various financial indicators that could potentially impact a company's human capital investment level to estimate the baseline level of human capital investment.

As the above model does not consider the educational level of employees, the previous net employment level estimation model is improved upon in this study by

incorporating employee education levels, as the number and quality of employees represent a company's investment level in human resources (Ghaly et al., 2020). Building on previous research, the employee education level was added to the model.

Additionally, employing the approach outlined in Jung et al. (2014), we conduct a regression analysis in which multiple financial indicators with potential effects on the level of human capital investment are regressed against net employment levels to estimate the expected level of human capital investment. The residuals of the regression model reflect the proportion of inefficient human capital investments.

$$\begin{aligned} NET\_HIRE_{it} = {} & \beta_0 + \beta_1 SALES\_GROWTH_{it-1} + \beta_2 SALES\_GROWTH_{it} \\ & + \beta_3 \Delta ROA_{it} + \beta_4 \Delta ROA_{it-1} + \beta_5 ROA_{it} + \beta_6 RETURN_{it} \\ & + \beta_7 INSIZE_{it-1} + \beta_8 QUICK_{it-1} + \beta_9 \Delta QUICK_{it-1} \\ & + \beta_{10} \Delta QUICK_{it} + \beta_{11} LEV_{it-1} + \beta_{12} LOSSBIN1_{it-1} \\ & + \beta_{13} LOSSBIN2_{it-1} + \beta_{14} LOSSBIN3_{it-1} + \beta_{15} LOSSBIN4_{it-1} \\ & + \beta_{15} LOSSBIN5_{it-1} + \beta_{16} AVG\_EDU_{it} + INDFIX + \varepsilon_{it} \end{aligned} \quad (1)$$

The variable, Net_hire_{it}, represents the percentage change in employee count. $Salesgrowth_{i,t}$ and $Salesgrowth_{i,t-1}$ denote the operating income growth rates in the current and previous periods, respectively. $Roa_{i,t}$ and $\Delta Roa_{i,t}$ denote the return on total assets and its first difference, while $Return_{i,t}$ represents the firm return of stock. $Insize_{i,t-1}$ denotes the percentage ranking of an enterprise's total market value for a given year. $Quick_{i,t-1}$ and $\Delta Quick_{i,t-1}$ are the quick ratio and its first difference, respectively. $Lev_{i,t-1}$ is the ratio of long-term liabilities to total assets. $Lossbin1\text{-}Lossbin5_{i,t-1}$ is a set of dummy variables that divides the average, $Roa_{i,t}$, of the previous year into five intervals ranging from −0.25 to 0. If $Roa_{i,t}$ is in the mth interval, then the value of Lossbin is one; otherwise, it is zero. $Avg\_edu_{i,t}$ is the ratio of employees with undergraduate degrees or higher to the total number of employees (Gomes and Novaes, 2005). The model incorporates fixed effects for industry, company, and year into the regression analysis. The absolute value of the residual obtained from the regression serves as the primary dependent variable, denoted as the human investment efficiency indicator (Abs_nethire). Residuals larger than zero indicate over human capital investment, whereas residuals less than zero represent under human capital investment.

3.3. Measure of high-speed rail opening

The independent variable in this study is the opening of HSR (Du et al., 2017; Wu et al., 2022), represented as a binary variable. Specifically, if the prefecture-level city where a listed company is situated opens an HSR in the current year, the value is 1; otherwise, it is 0.

3.4. Control variables

The selection of control variables was based on previous research findings, as described in the explanation of the main regression model in the following section (Jung et al., 2014).

3.5. Model setting

Drawing upon existing research on human capital investment efficiency (Jung

et al., 2014; Khedmati et al., 2020; Bu et al., 2020; et al.), in this study, the following Model 2 is formulated as the primary regression equation to examine the association between employee welfare level and labor investment efficiency.

The dependent variable in the regression is inefficient human capital investment (Abs_nethire), and the independent variables are divided into the opening of the HSR (Emp_labor).

$$\begin{aligned} ABS\_NETHIRE_{it} &= \beta_0 + \beta_1 Emp\_labor_{it} \times Post_{it} + \beta_2 LNSIZE_{it-1}\, \beta_3 QUICK_{it-1} \\ &+ \beta_4 LEV_{it-1} + \beta_5 AB\_INVEST_{it} + \beta_6 DIVD_{it-1} + \beta_7 SD\_CHA_{it-1} \\ &+ \beta_8 SD\_CFO_{it-1} + \beta_9 SD\_SALES_{it-1} + \beta_{10} PPE_{it-1} \\ &+ \beta_{11} LOSS_{it-1} + \beta_{12} LABOR\_INTENSITY_{it-1} + INDFIX + \varepsilon_{it} \end{aligned} \quad (2)$$

The dependent variable $Abs\_nethire_{i,t}$ represents the absolute value of the residuals in Model 1 during for the current year. The independent variable $Emp\_labor_{i,t}$ assumes a value of 1 if the HSR is accessible at the location where the listed company is situated during the current year and 0 otherwise. $Post_{i,t}$ is the control indicator and equals 1 for the post-treatment periods. The coefficient on $Emp\_labor_{it} \times Post_{it}$ captures the change in human capital investment efficiency for different publicly listed companies before and after the opening of the HSR. $Insize_{i,t-1}$ represents the size of the company and $Quick_{i,t-1}$ denotes the quick ratio of the enterprise. $Lev_{i,t-1}$ represents the ratio of assets to liabilities in the previous period. $Abs\_Invest_{i,t-1}$ denotes the absolute value of inefficient capital investment. $Divd_{i,t-1}$ is the dividend payout. $Sd\_Cha_{i,t-1}$ represents employment volatility. $Sd\_Cfo_{i,t-1}$ denotes the volatility of operating working capital. $Sd\_sales_{i,t-1}$ represents sales revenue volatility. $Ppe_{i,t-1}$ denotes the ratio of fixed assets to total assets. $Labor\_intensity_{i,t-1}$ represents the degree of labor intensity. In the above formula, i represents the selected listed company, and t represents the annual financial reporting period of each year. Indfix refers to the removal of the fixed effects of year, industry, and company, as shown in **Table 1**.

Table 1. Variable definition.

Variables	Variable names	Variable definition
Model (1) variables		
Net_hire	Net employment	The percentage change in employee count
Salesgrowth	Revenue Growth Rate	Revenue Growth Rate = (Increase in Revenue/Total Revenue in the Previous Year) × 100%
Roa	Return on total assets	ROA = (Net Profit/Total Assets) × 100%
ΔRoa	Percentage change in the Roa	ROA's first difference
Return	Return of stock	Return = (Stock Investment Return/Stock Investment Principal) × 100%
InSize	Firm size	The natural logarithm of the total market capitalization of listed companies
Quick	Quick ratio	Ratio of quick assets (current assets-inventories-prepaid expenses)/current liabilities
ΔQuick	Percentage change in the quick ratio	Quick's first difference
Lev	Asset-liability ratio	Ratio of long-term liabilities to total assets
Lossbin	Report loss	A set of dummy variables that divide the average $Roa_{i,t}$ of the previous year into five intervals ranging from −0.25 to 0.

Table 1. (*Continued*).

Variables	Variable names	Variable definition
Model (1) variables		
Avg_edu	Edication quality	The ratio of employees with undergraduate and above degrees to the total number of employees
Model (2) variables		
Abs_nethire	Inefficient human capital investment	Pinnuck et al. (2007) Absolute value of model regression residuals
Emp_labor	High-speed rail opening	The dummy variable takes a value of 1 if the prefecture-level city where the listed company is located opened high-speed rail in the current year; otherwise, it is 0.
InSize	Firm Size	The natural logarithm of the total market capitalization of listed companies
Quick	Quick ratio	Ratio of quick assets (current assets-inventories-prepaid expenses)/current liabilities
Lev	Assets and liabilities	Ratio of total liabilities/total assets of listed companies
Abs_Inv	Inefficient capital investment	Absolute value of regression residuals from Richardson (2006) model
Divd	Dividend distribution	Dummy variable, take 1 for dividend distribution of listed companies, otherwise take 0
Sd_Cha	Employment fluctuations	Within a span of 5 years, the standard deviation of the number of employees employed by listed companies
Sd_Cfo	Working capital volatility	Over a period of 5 years, the standard deviation of working capital for listed companies
Sd_sales	Fluctuation in sales revenue	Within a timeframe of 5 years, the standard deviation of sales revenue for listed companies
Ppe	Proportion of fixed assets	Ratio of net fixed assets to total assets of companies
Loss	Loss measure	The dummy variable takes a value of 1 if the net profit of a listed company is negative, and 0 otherwise.
Labor_intensity	Labor intensity	The employee-to-total-assets ratio of a listed company

4. Baseline results

4.1. Descriptive statistics

As shown in **Table 2**, the sample size for each variable was 12738. The dependent variable (Abs_nethireit) has mean, minimum, and maximum values of 0.157, 0, and 2.961, respectively. This indicates that, on average, the difference between the actual number of employees per unit size and the expected number of employees hired was 157, with a variance of 0.187. This variance suggests variations in labor investment efficiency among different publicly listed companies. The mean value of the independent variable (Emp_laborit) is 0.847, signifying the widespread adoption of HSR in most cities. The remaining variables are consistent with prior research findings (Jung et al., 2014). The variance for these variables is 0.360, indicating significant differences depending on whether publicly listed companies were located in regions with HSR connectivity. Eleven control variables were included in this study. As shown in the descriptive statistics in **Table 2**, the differences in these variables were not significantly different from those found in other studies (Guo et al., 2021).

Table 2. Sample descriptive statistics.

Variable	N	mean	sd	min	max
$Abs\_nethire_{it}$	12738	0.157	0.187	0	2.961
Em_labor_{it}	12738	0.847	0.360	0	1
$InSize_{it-1}$	12738	22.96	1.074	20.38	26.13
$Quick_{it-1}$	12738	1.785	2	0.161	13.57
Lev_{it-1}	12738	0.436	0.207	0.0560	0.975
Ab_Invest_{it}	12738	0.0400	0.0460	0.00100	0.291
$Divd_{it-1}$	12738	0.767	0.423	0	1
Sd_Cha_{it-1}	12738	0.269	0.337	0.0140	1.454
Sd_Cfo_{it-1}	12738	0.0990	0.0660	0.0130	0.352
Sd_sales_{it-1}	12738	0.430	1.114	0.0350	10.08
Ppe_{it-1}	12738	0.166	0.155	0	0.695
$Loss_{it-1}$	12738	0.102	0.303	0	1
$Labor\_intensity_{it-1}$	12738	0.00900	0.00800	0	0.0630

This study is based on the factual situation of HSR development in China. **Table 3** and **Figure 1** and **Figure 2** illustrate the recent growth of HSR stations and the increase in HSR carrying capacity. It is evident that the country is currently vigorously developing HSR, which has led to increased labor mobility. Specific data were compiled from the China Railway Network.

Table 3. High-speed rail development trends.

Year	Number of high-speed rail stations	High-speed rail passenger traffic
2010	65	133,230,000
2011	68	285,520,000
2012	95	388,150,000
2013	111	529,620,000
2014	156	703,780,000
2015	174	961,390,000
2016	182	1,221,280,000
2017	189	1,752,160,000
2018	205	2,054,300,000
2019	230	2,358,330,000

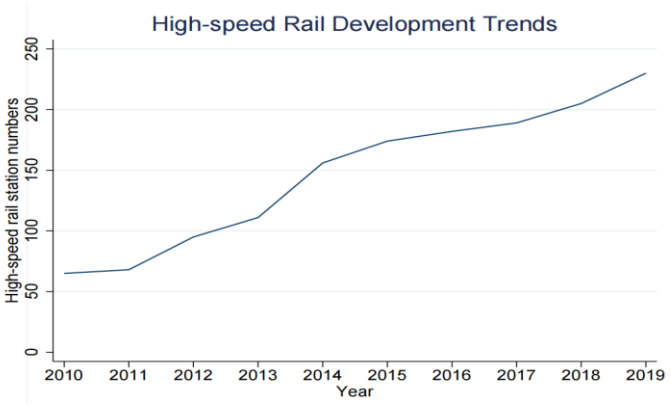

Figure 1. High-speed rail development trends.

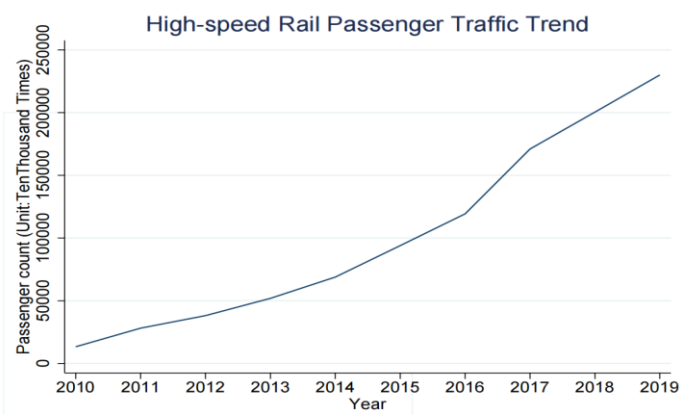

Figure 2. High-speed rail passenger Traffic trend.

4.2. Correlation analysis

In **Tables 4** and **5**, the correlation analysis exhibits the Spearman correlation coefficient values above the main diagonal and Pearson correlation coefficient values below the main diagonal; the correlation coefficient shows a significant negative correlation at the 1% level. However, additional verification is necessary to establish the causal relationship between these two factors.

Table 4. Correlation analysis.

	Sd_Cha$_{it-1}$	**Sd_Cfo$_{it-1}$**	**Sd_sales$_{it-1}$**	**Ppe$_{it-1}$**	**Loss$_{it-1}$**	**Labor_intensity$_{it-1}$**
Abs_nethire$_{it-1}$	0.280***	0.133***	0.198***	−0.075***	−0.018**	−0.045***
Em_labor$_{it}$	0.018**	−0.052***	−0.060***	−0.118***	0.002	−0.074***
lnSize$_{it-1}$	−0.001	−0.121***	0.001	−0.130***	−0.062***	−0.230***
Quick$_{it-1}$	0.017*	0.070***	−0.075***	−0.068***	−0.040***	0.091***
Lev$_{it-1}$	0.029***	−0.101***	0.104***	−0.100***	0.060***	−0.115***
Ab_Invest$_{it}$	0.100***	0.173***	0.057***	0.090***	0.002	0.034***
Divd$_{it-1}$	−0.103***	−0.141***	−0.162***	−0.007	−0.386***	−0.012
Sd_Cha$_{it-1}$	1	0.230***	0.405***	−0.185***	0.035***	−0.021**
Sd_Cfo$_{it-1}$	0.191***	1	0.247***	−0.034***	0.018**	−0.046***
Sd_sales$_{it-1}$	0.441***	0.209***	1	−0.180***	0.050***	−0.231***

Table 4. (*Continued*).

	Sd_Cha$_{it-1}$	**Sd_Cfo$_{it-1}$**	**Sd_sales$_{it-1}$**	**Ppe$_{it-1}$**	**Loss$_{it-1}$**	**Labor_intensity$_{it-1}$**
Ppe$_{it-1}$	−0.121***	−0.047***	−0.092***	1	0.009	0.232***
Loss$_{it-1}$	0.012	0.004	−0.005	0.008	1	−0.025***
Labor_intensity$_{it-1}$	0.069***	−0.034***	0.006	0.070***	−0.016*	1

Table 5. Correlation analysis.

	Abs_nethire$_{it-1}$	**Em_labor$_{it-1}$**	**lnSize$_{it-1}$**	**Quick$_{it-1}$**	**Lev$_{it-1}$**	**Ab_Invest$_{it}$**	**Divd$_{it-1}$**
Abs_nethire$_{it-1}$	1	−0.064***	−0.006	−0.036***	0.039***	0.112***	−0.062***
Em_labor$_{it}$	−0.091***	1	0.074***	0.049***	0.002	−0.056***	0.033***
lnSize$_{it-1}$	−0.066***	0.079***	1	−0.236***	0.338***	−0.072***	0.230***
Quick$_{it-1}$	−0.020**	0.038***	−0.197***	1	−0.765***	0.098***	0.115***
Lev$_{it-1}$	0.034***	−0.002	0.342***	−0.630***	1	−0.137***	−0.116***
Ab_Invest$_{it}$	0.177***	−0.041***	−0.018**	0.026***	−0.065***	1	−0.038***
Divd$_{it-1}$	−0.081***	0.033***	0.225***	0.058***	−0.124***	−0.027***	1
Sd_Cha$_{it-1}$	0.244***	0.003	0.048***	−0.039***	0.063***	0.086***	−0.063***
Sd_Cfo$_{it-1}$	0.160***	−0.037***	−0.139***	0.068***	−0.103***	0.202***	−0.167***
Sd_sales$_{it-1}$	0.176***	−0.042***	0.038***	−0.030***	0.096***	0.080***	−0.087***
Ppe$_{it-1}$	−0.060***	−0.104***	−0.050***	−0.090***	−0.037***	0.040***	−0.021**
Loss$_{it-1}$	−0.021**	0.002	−0.061***	−0.036***	0.059***	−0.015*	−0.386***
Labor_intensity$_{it-1}$	0.051***	−0.067***	−0.183***	−0.048***	−0.037***	0.044***	−0.028***

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.3. Baseline regression results

Table 6 presents the regression results, accounting for year and industry fixed effects. The dependent variable is Abs_nethire$_{it}$, while the coefficients of the independent variables $Emp\_labor_{it} \times Post_{it}$ and Abs_nethire$_{it}$ are −0.026 (t = −4.162) and are significant at the 1% level in the negative direction. This finding suggests that HSR can promote human capital investment efficiency. As the dependent variable represents residuals, smaller values indicate less-inefficient human capital investment. The results presented in **Table 6** support Hypothesis 1. Prior research on HSR opening has primarily focused on macroeconomic aspects, such as its impact on economic growth and employment (Fan, 2020; Shi et al., 2020). There is limited literature on HSR opening from a business perspective. Existing studies have examined the relationship between financial information quality and enterprise human capital investment efficiency (Jung et al., 2017). Ben-Nasr and Alshwer (2016) suggest that stock price constraints can alleviate firms' underinvestment in human capital. Factors such as the promotion of local government officials (Mourao, 2018) and labor mobility under economic policies can also influence enterprises' human capital investment efficiency (Chu and Fang, 2021). Labor mobility under government institutional reforms, which expand labor markets, can impact enterprise labor investment efficiency (Wei and Chen, 2020). Transportation infrastructure

development can stimulate local economies, reduce transaction costs, and improve enterprises' human capital investment efficiency (Shi et al., 2020). Combining the study of HSR openings with enterprise human capital investment efficiency has practical significance for national policies and research on human capital investment in businesses.

Table 6. Relationship between high-speed rail and human capital investment efficiency.

Variables	Coeff	t
$Em\_labor_{it} \times Post_{it}$	−0.026***	−4.162
$lnSize_{it-1}$	−0.008***	−4.145
$Quick_{it-1}$	−0.000	−0.251
Lev_{it-1}	0.004	0.283
Ab_Invest_{it}	0.564***	8.223
$Divd_{it-1}$	−0.022***	−4.622
Sd_Cha_{it-1}	0.094***	10.607
Sd_Cfo_{it-1}	0.199***	5.278
Sd_sales_{it-1}	0.008***	2.616
Ppe_{it-1}	−0.051***	−4.762
$Loss_{it-1}$	−0.030***	−4.297
$Labor\_intensity_{it-1}$	0.199	0.521
Intercept	0.380***	8.512
Year and industry fixed effects	YES	
Firm fixed effects	YES	
F	21.99	
adj. R^2	0.137	
N	12738	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.4. Parallel trend assumption

To design a DID model, it is crucial to consider its applicability conditions of the DID model. We employ a parallel trend assumption to test whether the DID model is applicable. Therefore, we used a time analysis method to examine parallel trends. This approach allowed us to consider factors such as the implementation of relevant policies and the number of pilot programs in an intuitive manner. Specifically, we conducted a regression analysis using data from four years before policy implementation and two years later. The results are shown in **Figure 3**.

In **Figure 3**, we examine the parallel trend test of the impact of HSR opening on human capital investment efficiency. It can be observed that before the HSR opening, the trend exhibits a balancing pattern, with the confidence interval on the X-axis indicating significant positive effects. However, after the HSR opening, the regression coefficient increases and exhibits a significant negative trend. This finding satisfies the conditions for DID regression.

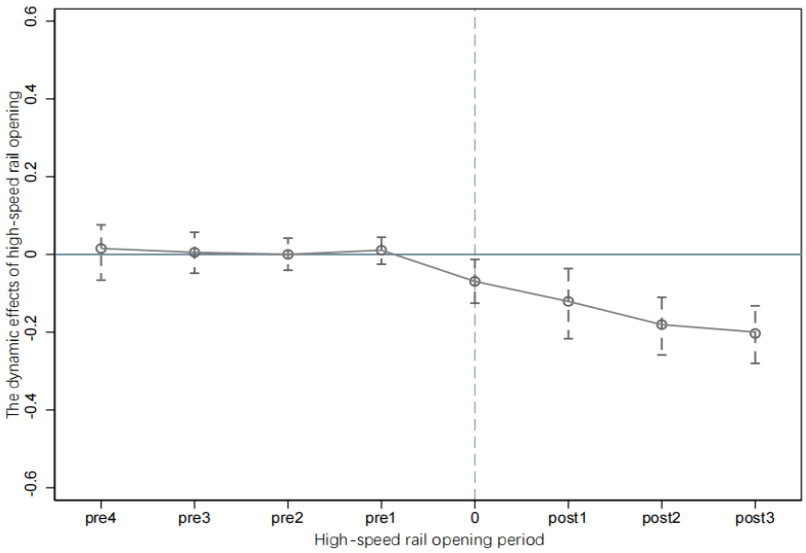

Figure 3. Balanced trend test char.

4.5. Placebo test

Additionally, for this study, we drew inspiration from prior research on urban placebo testing (Song and Chen, 2023). In the original sample of cities, 177 had HSR openings. To create a placebo control group, 177 cities were randomly selected from the same original sample as a placebo control group, with the remaining cities designated as the treatment group. Subsequently, the estimated coefficients for the impact of HSR opening on enterprise labor investment efficiency were obtained using the urban placebo test, repeated in 500 regressions. The resulting estimated kernel density plots and p-values are shown in **Figure 4**.

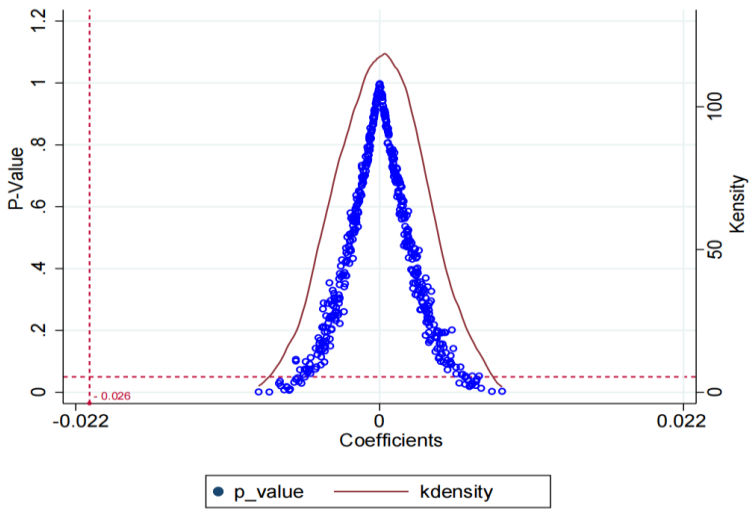

Figure 4. Placebo test.

According to the graph, the regression coefficients clustered around zero, indicating a normal distribution pattern. Furthermore, most *P*-values were greater than 0.1, indicating no statistical significance. The true coefficient of the DID model in this study was −0.026. The coefficient estimated from this method lies to the right

of the true value, confirming the robustness of the original main regression findings. In conclusion, labor mobility can enhance enterprise labor investment efficiency.

4.6. Moderating effect of property rights

In this study, property rights (Soe) are used as a moderating variable to explore their moderating effect on the relationship between HSR openings and enterprises' human capital investment efficiency. Property rights are categorized into two groups, SOEs (Soe = 1) and non-SOEs (Soe = 0), with a regression analysis conducted, as presented in **Table 7**.

Table 7. The adjustment effect of property rights on high-speed rail opening and enterprise human capital investment efficiency.

Variables	**(2)** **Soe = 1**	**(1)** **Soe = 0**
$Em\_labor_{it} \times Post_{it}$	−0.032	−0.053**
	(−1.118)	(−2.348)
$InSize_{it-1}$	−0.007	−0.002
	(−1.017)	(−0.214)
$Quick_{it-1}$	0.000	−0.003
	(0.081)	(−0.991)
Lev_{it-1}	−0.048	0.011
	(−1.371)	(0.263)
Ab_Invest_{it}	0.363***	0.638***
	(4.821)	(6.338)
$Divd_{it-1}$	−0.007	−0.010
	(−0.915)	(−0.816)
Sd_Cha_{it-1}	0.042***	0.092***
	(3.496)	(4.083)
Sd_Cfo_{it-1}	0.100	0.184**
	(1.552)	(2.163)
Sd_sales_{it-1}	0.009	−0.002
	(1.709)	(−0.465)
Ppe_{it-1}	0.012	0.003
	(0.530)	(0.102)
$Loss_{it-1}$	−0.015	−0.033**
	(−1.411)	(−2.180)
$Labor\_intensity_{it-1}$	1.323	3.956***
	(1.539)	(3.218)
Intercept	0.345	−0.093
	(1.575)	(−0.461)
Year and industry fixed effects	YES	YES
Firm fixed effects	YES	YES
adj. R^2	0.135	0.161
N	6964	5774

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

In Column (1) of **Table 7**, the regression coefficient of HSR opening ($Em\_labor_{it} \times Post_{it}$) on the dependent variable ($Abs\_nethire_{it}$) is significantly negative (5%) for non-SOEs, while it is not statistically significant for SOEs (Column 1). This

finding suggests that non-SOEs can leverage the impact of HSR openings to enhance human capital investment efficiency. Thus, Hypothesis 2 is verified.

4.7. Moderating effect of property rights

This study uses the proportion of shares held by foreign shareholders (for) as a moderating variable to investigate its effect on the relationship between the HSR opening and human capital investment efficiency. The sample is divided into two groups: firms with foreign shareholders (For = 1) and firms without foreign shareholders (For = 0), as shown in **Table 8**.

In Column (1) of **Table 8**, the regression coefficient of the variable, $Em\_labor_{it} \times Post_{it}$, on the dependent variable, $Abs\_nethire_{it}$, which represents inefficient human capital investment, is significantly negative by 1% for firms with overseas shareholders, while it is not significant for firms without overseas shareholders (Column 2). This indicates that overseas shareholding can facilitate the effectiveness of HSR openings in promoting human capital investment efficiency. Thus, Hypothesis 3 is supported.

Table 8. The moderating effect of foreign shareholders holding on the relationship between high-speed rail opening and the efficiency of human capital investment in enterprises.

Variables	**(1)** **For=1**	**(2)** **For=0**
$Em\_labor_{it} \times Post_{it}$	−0.027***	−0.007
	(−3.262)	(−1.117)
$InSize_{it-1}$	0.011***	−0.015***
	(6.154)	(−4.633)
$Quick_{it-1}$	−0.001	−0.000
	(−1.075)	(−0.037)
Lev_{it-1}	−0.032**	0.017
	(−2.076)	(0.927)
Ab_Invest_{it}	0.326***	0.654***
	(4.095)	(7.770)
$Divd_{it-1}$	−0.018***	−0.018***
	(−2.665)	(−2.889)
Sd_Cha_{it-1}	0.055***	0.110***
	(5.562)	(9.399)
Sd_Cfo_{it-1}	0.025	0.248***
	(0.530)	(5.229)
Sd_sales_{it-1}	0.001	0.009**
	(0.293)	(2.248)
Ppe_{it-1}	−0.011	−0.063***
	(−0.948)	(−4.025)
$Loss_{it-1}$	−0.016	−0.036***
	(−1.415)	(−4.428)
$Labor\_intensity_{it-1}$	0.304	0.263
	(0.934)	(0.467)
Intercept	0.011***	0.489***

Table 8. (*Continued*).

Variables	(1) For=1	(2) For=0
	(6.154)	(6.577)
Year and industry fixed effects	YES	YES
Firm fixed effects	YES	YES
adj. R^2	0.116	0.125
N	5349	7389

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5. Robustness tests

In this study, we employed PSM to match the experimental and control groups, thereby reducing the impact of sample selection bias and further examining the research hypotheses. In this study, a nearest-neighbor one-to-one matching approach was utilized, meaning that for each experimental sample, the closest control sample was selected for matching. Detailed results related to the average treatment effect on the treated (ATT) are presented in **Table 9**. The *T*-value of −4.73 for ATT was highly significant at the 1% level.

The results of the balance tests conducted after PSM matching are presented in **Table 10**. The standardized differences in the variables between the two groups were significantly reduced to within 10%, and there were no significant differences in the matched variables. This indicates the effectiveness of PSM. Finally, as shown in **Table 11** (Column 1), the regression coefficient of the independent variable HSR opening ($Em\_labor_{it} \times Post_{it}$) on the dependent variable net hiring ($Abs\_nethire_{it}$) is −0.026 (t = −3.393), which is significant at the 1% level in the negative direction. This confirms Hypothesis 1 that opening an HSR can improve the efficiency of enterprise human capital investment. In addition, it resolved the heterogeneity between the experimental and control groups, making the regression results robust.

As shown in **Table 11** (Columns 2 and 3), property rights are categorized into two groups: SOEs (Soe = 1) and non-SOEs (Soe = 0), and the regression coefficient of HSR opening ($Em\_labor_{it} \times Post_{it}$) on the dependent variable ($Abs\_nethire_{it}$) is significant by 1% in non-SOEs, while it is not statistically significant for SOEs (Column 2). This finding suggests that non-SOEs can leverage the impact of HSR openings to enhance human capital investment efficiency. Thus, Hypothesis 2 was supported.

As shown in **Table 11** (Columns 4 and 5), the sample is divided into two groups: firms with foreign shareholders (For = 1) and firms without foreign shareholders (For = 0); the regression coefficient of the variable of $Em\_labor_{it} \times Post_{it}$ on the dependent variable of $Abs\_nethire_{it}$, which represents non-efficient human capital investment, is significantly negative by 1% for firms with overseas shareholders, while it is not significant for firms without overseas shareholders. This result indicates that overseas shareholdings can facilitate effectiveness in promoting human capital investment efficiency. Thus, Hypothesis 3 was supported.

Table 9. The PSM matching table.

Variable Sample	Treated	Controls	Difference	S.E.	T-stat
Abs_nethire Unmatched	0.144	0.190	−0.046	0.004	−11.17
ATT	0.143	0.180	−0.037	0.008	−4.73

Table 10. Propensity score matching with matching balance test.

	Unmatched	Mean		%reduct		*t*-test	
Variable	Matched	Treated	Control	%bias	|bias|	*t*	*p*>|*t*|
lnSize	U	23.192	23.009	17.3		7.44	0.000
	M	23.191	23.217	−2.5	85.8	−1.62	0.102
Quick	U	1.586	1.383	12.5		5.25	0.000
	M	1.585	1.569	1.0	91.7	0.73	0.468
Lev	U	0.454	0.465	−5.4		−2.35	0.019
	M	0.455	0.443	5.5	−26.1	1.63	0.108
Ab_Invest	U	0.036	0.041	−10.5		−4.72	0.000
	M	0.036	0.037	−0.9	91.0	−0.76	0.450
Divd	U	0.744	0.688	12.5		5.57	0.000
	M	0.744	0.733	2.4	80.7	1.63	0.112
Sd_Cha	U	0.264	0.265	−0.6		−0.25	0.801
	M	0.263	0.266	−0.8	−47.7	−0.63	0.529
Sd_Cfo	U	0.085	0.091	−11.1		−4.90	0.000
	M	0.084	0.085	−1.8	83.8	−1.39	0.164
Sd_sales	U	0.429	0.574	−11.4		−5.38	0.000
	M	0.428	0.441	−0.9	92.3	−0.78	0.436
Ppe	U	0.159	0.207	−29.6		−13.15	0.000
	M	0.148	0.162	−1.6	94.7	−1.24	0.216
Loss	U	0.049	0.054	−1.7		−0.75	0.452
	M	0.050	0.049	0.7	61.1	0.50	0.617
Labor_intensity	U	0.0082	0.009	−14.1		−6.42	0.000
	M	0.0083	0.008	2.6	81.6	1.55	0.136

Table 11. PSM-DID results.

Variables	(1)	(2) Soe = 1	(3) Soe = 0	(4) For = 1	(5) For = 0
$Em\_labor_{itit} \times Post_{it}$	−0.026***	0.006	−0.091***	−0.029***	−0.019
	(−3.393)	(0.249)	(−2.641)	(−3.333)	(−0.900)
$InSize_{it-1}$	−0.000	0.027	−0.012	0.011***	0.032*
	(−0.074)	(1.290)	(−0.772)	(2.687)	(1.882)
$Quick_{it-1}$	0.002	0.006	−0.000	0.000	−0.007
	(0.957)	(0.486)	(−0.059)	(0.124)	(−0.962)
Lev_{it-1}	0.051*	−0.008	−0.023	−0.030	−0.086

Table 11. (*Continued*).

Variables	(1)	(2) Soe = 1	(3) Soe = 0	(4) For = 1	(5) For = 0
	(1.643)	(−0.089)	(−0.270)	(−0.963)	(−0.752)
Ab_Invest_{it}	0.780***	0.304*	1.310***	0.399***	1.163***
	(5.423)	(1.931)	(8.541)	(3.959)	(3.961)
$Divd_{it-1}$	−0.019*	−0.028	−0.013	−0.032***	−0.010
	(−1.762)	(−1.401)	(−0.599)	(−2.842)	(−0.594)
Sd_Cha_{it-1}	0.153***	0.060**	0.114***	0.106***	0.041
	(6.428)	(2.286)	(3.427)	(6.541)	(1.732)
Sd_Cfo_{it-1}	0.081	0.086	0.025	−0.052	0.277
	(0.988)	(0.533)	(0.164)	(−0.632)	(1.256)
Sd_sales_{it-1}	0.005	0.029***	−0.014*	0.006	0.019
	(0.795)	(3.578)	(−1.805)	(1.126)	(1.637)
Ppe_{it-1}	−0.029	0.029	0.008	−0.019	0.011
	(−1.479)	(0.565)	(0.125)	(−0.739)	(0.222)
$Loss_{it-1}$	−0.035**	−0.044	−0.041	−0.025	−0.057**
	(−2.562)	(−1.460)	(−1.032)	(−1.205)	(−2.638)
$Labor\_intensity_{it-1}$	1.077	6.137***	3.582**	0.680	6.880***
	(1.317)	(4.550)	(2.572)	(1.323)	(4.066)
Intercept	0.152	−0.495	0.391	−0.032	−0.684
	(1.514)	(−1.039)	(1.125)	(−0.342)	(−1.736)
Year and industry fixed effects	YES	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES	YES
adj. R^2	0.165	0.042	0.069	0.152	0.112
N	3925	1971	1954	1416	2553

6. Conclusion

In this study, we investigated the association between HSR openings and the efficiency of enterprises' human capital investment. The findings reveal that HSR opening facilitates the enhancement of enterprise human capital investment efficiency, leading to a 5% increase in its efficiency.

Based on this conclusion, in this study, we further investigate the moderating effects of property rights and the shareholding of overseas shareholders and conclude that both can promote the efficiency of enterprise human capital investment through HSR opening.

Specifically, this study provides important theoretical support for enterprises to respond to national policies and promote their development through the construction of transportation infrastructure. Empirical research has been conducted on employee recruitment, employee relations, and corporate governance. Corporate governance can be improved through internal control and external supervision by increasing

overseas shareholdings, which can effectively reduce human manipulation, optimize internal management, and enhance enterprise value.

Finally, in China's unique institutional context, the government's macroeconomic policies are key factors influencing regional economic development. Infrastructure development, including transportation, provides opportunities and spatial feasibility for resource redistribution. Local governments should seize this opportunity to create an attractive environment for investment, technology, and talent, and inject new vitality into urban economic development. This not only enhances local economies (Li et al., 2020) but also improves enterprise labor investment efficiency, fosters labor development at both the enterprise and national levels, and advances the nation's technology sector.

HSR city enterprises must seize opportunities by swiftly managing information flow and talent acquisition to boost innovation and efficiency (Benmelech et al., 2011). They must strengthen external market communication, prepare for high-skilled talent acquisition, and leverage market expansion. Prioritizing management talent to better understand market dynamics is essential. Accurately navigating technological advancements and identifying innovation project risks enhance production efficiency (Fan, 2020). Skilled professionals, particularly in technology and management, are vital for labor investment, attracting resources, and elevating core competitiveness (Du and Peng, 2020). Attracting high-caliber talent not only enhances labor investment efficiency, but also fosters growth capacity and market value (Wu et al., 2012).

Conflict of interest: The author declares no conflict of interest.

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