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Technology Spillover Effects of China's Investment in Malaysia Under the Belt and Road Initiative: Evidence from Listed Companies

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ABSTRACT: Based on the micro-level investment data of Chinese A-share listed companies in Shanghai and Shen Zhen and the firm-level data of local Malaysian enterprises, this study adopts the difference-in-differences method to systematically test the technological spillover effect of China's investment in Malaysia, and analyzes the effect differences of different spillover channels, industry heterogeneity, and the moderating role of host country absorptive capacity. The results show that China's investment in Malaysia has generated a significant positive technological spillover on local enterprises in the host country, among which industrial linkage is the dominant channel. The technological spillover effect of high-tech industries is significantly stronger than that of traditional manufacturing, and both the human capital level and institutional quality of the host country have a positive moderating effect on the technological spillover effect. The study can provide empirical reference for China and Malaysia to optimize investment cooperation policies and promote the high-quality development of the Belt and Road Initiative.

KEYWORDS: Belt and Road Initiative; outward foreign direct investment; technology spillover effect; Malaysia; difference-indifferences method

I. INTRODUCTION

Malaysia has become a critical node for Chinese enterprises in building regional industrial chain divisions. In recent years, China's investment in Malaysia has exhibited dual characteristics of scale expansion and structural upgrading. In terms of investment scale, China's direct investment in Malaysia reached 31 billion ringgit in 2024, doubling from the previous year. The stock of Chinese investment has accounted for approximately 7% of Malaysia's 2023 GDP, demonstrating that Chinese capital's influence in Malaysia's economic development continues to grow. Regarding investment structure, the proportion of traditional infrastructure construction and real estate development has gradually declined, while high-tech manufacturing industries such as semiconductors, new energy vehicles, photovoltaic cells, and lithium batteries have become investment hotspots, forming evident industrial clustering effects. Significant changes have also occurred in the structure of investment entities, with stateowned enterprises gradually receding to the background and private enterprises replacing them as the main force of investment. In 2024, state-owned enterprises accounted for only 10% of China's direct investment in Malaysia, with market-oriented investment characteristics becoming increasingly prominent. Against the backdrop of rapid investment scale expansion and deep structural transformation, the technological impact of China's investment in Malaysia has attracted increasing attention from academic and policy circles. International direct investment theory posits that multinational corporations' outward investment not only brings capital inflows but also generates technology spillovers to local enterprises in host countries through multiple channels, promoting technological progress and productivity improvement in the host country. However, existing research has not reached consistent conclusions regarding the technology spillover effects of Chinese enterprises' investment in Malaysia under the Belt and Road background. Existing literature has three obvious deficiencies in answering the above questions: Most studies incorporate Malaysia into the overall ASEAN sample for analysis, with very limited specialized empirical research on Malaysia, making it difficult to reflect the impact of Malaysia's specific institutional environment and investment characteristics on technology spillovers; Existing research mostly adopts macro-level industry statistics data, with empirical research based on Chinese listed companies' micro-investment data being relatively scarce, making it difficult to accurately identify firm-level causal effects and prone to aggregation bias problems; Existing research has insufficient comparative analysis of different technology spillover channels, particularly neglecting the special role of industrial linkage channels under the current Chinese-funded enterprises' industrial chain overall investment model, and micro-empirical evidence on the moderating role of host country absorptive capacity is also insufficient.

Based on this, this paper utilizes micro-investment data from Chinese Shanghai and Shenzhen A-share listed companies, combined with firm-level data from local Malaysian enterprises, to systematically examine the technology spillover effects of Chinese enterprises' investment in Malaysia under the Belt and Road Initiative using the difference-in-differences method, with a focus on analyzing heterogeneity in spillover channels, industry heterogeneity, and the moderating effects of host country absorptive capacity, in order to fill the gaps in existing research.

This paper focuses on the core theme of technology spillover effects of Chinese listed companies' investment in Malaysia under the Belt and Road Initiative. Based on micro-level investment data of Chinese A-share listed companies in Shanghai and ShenZhen and firm-level data of local Malaysian enterprises, this paper empirically examines the existence of technology spillover effects, transmission channels, industry heterogeneity, and the moderating effects of host country absorptive capacity using the difference-in-differences method. Specifically, this paper first reviews the theory of technology spillovers from international direct investment and existing related research, identifies the deficiencies in current research, and proposes the research questions of this paper. Second, based on theoretical analysis, this paper puts forward research hypotheses, including hypotheses on the overall effect of technology spillovers, differences in effects across different channels, industry heterogeneity, and the moderating effects of absorptive capacity. Third, the research design is carried out, introducing sample selection, data sources, variable definitions, and econometric model specifications. Then the empirical test results are reported and analyzed, including baseline regression results, mechanism test results, heterogeneity analysis results, moderating effect test results, and robustness test results. Finally, the research conclusions are summarized, corresponding policy recommendations are proposed, and the limitations of this research and future research directions are discussed.

II. LITERATURE REVIEW

A. FDI Technology Spillover Effects

Research on technology spillover effects of international direct investment originated in the 1960s. After more than half a century of development, a relatively complete theoretical system has been formed. MacDougall was the first to propose the concept of FDI technology spillovers, arguing that multinational corporations' investment in host countries not only brings capital but also generates unintentional technological externalities, promoting productivity improvement in local enterprises. This groundbreaking viewpoint laid the foundation for subsequent research. Thereafter, scholars conducted in-depth discussions on the theoretical mechanisms, transmission channels, and influencing factors of technology spillovers, gradually forming a systematic theoretical framework. Classical theory summarizes the core transmission channels of FDI technology spillover effects into four types: demonstration effect, competition effect, personnel mobility, and industrial linkage. This classification has been widely recognized by the academic community. The competition effect refers to multinational corporations intensifying market competition after entering host country markets, breaking existing market monopoly structures, and forcing local enterprises to increase R&D investment, optimize resource allocation, and improve production technologies to maintain market share and survival space. Moderate competition can stimulate local enterprises' innovation motivation and improve total factor productivity, but excessive competition may also crowd out local enterprises from the market, generating negative spillover effects. Blomström and Kokko (1998) pointed out that competition effects not only directly promote local enterprises' efficiency improvement but can also amplify the effects of demonstration and personnel mobility, forming synergistic spillover effects. The personnel mobility channel refers to multinational corporations hiring large numbers of local employees during their investment operations in host countries and providing training to enhance employees' technical levels and management capabilities. When these trained employees move from multinational corporations to local enterprises or start their own businesses, the technologies and management experience they have acquired also transfer, thereby generating technology spillovers. Fosfuri et al. (2001) argued that personnel mobility is one of the most important carriers of technology spillover, especially for developing countries, as multinational corporations' training of local employees can rapidly improve host country human capital levels, thereby promoting technology diffusion. Scholars have begun to focus on technology spillover effects of multinational corporations from emerging market countries investing in other developing countries, expanding the research scope of traditional theory. Traditional theory is mainly based on scenarios of developed country multinational corporations investing in developing countries, arguing that developed country enterprises have obvious technological advantages and are more likely to generate technology spillovers. However, the technologies of multinational corporations from emerging market countries are more adapted to the factor endowment structures of developing countries, and the barriers for local enterprises to learn and imitate are lower, so they may generate more significant technology spillover effects.

B. Review of Research on China's Investment in Malaysia

In terms of investment location choice and influencing factors research, scholars generally agree that Malaysia's advantages in attracting Chinese investment are mainly reflected in four aspects: superior geographical location, situated in the core area of Southeast Asia with convenient transportation and radiating throughout the ASEAN market; relatively stable political environment, open investment policies, and friendly relations with China; abundant labor resources with relatively low labor costs; and rich natural resources with strong industrial structure complementarity with China. Zhang Jianhong and Jiang Jiangang (2012) found that market size, resource endowment, and bilateral trade relations are the main factors affecting Chinese enterprises' investment in Malaysia, and institutional distance also has a significant impact on Chinese enterprises' location choice. Chen Wanling and Yang Yongcong (2013) pointed out that the acceleration of regional economic integration has promoted Chinese investment in Malaysia, and Chinese enterprises tend to invest in countries that have signed bilateral investment agreements with China. Malaysia has benefited from its location advantages and policy preferences, becoming an important destination for Chinese enterprises' investment in Southeast Asia. In terms of investment structure and development trend research, existing studies generally agree that in recent years, the structure of Chinese investment in Malaysia has undergone profound transformation, gradually shifting from traditional resource development, infrastructure construction, and real estate development to high-tech manufacturing, forming a diversified industrial distribution pattern. According to relevant statistical data, manufacturing has become the most concentrated field of Chinese investment in Malaysia, accounting for 37.5%, followed by infrastructure construction (27.5%), energy industry (17.5%), and real estate development (12.5%). The proportion of high-tech manufacturing continues to increase, while the proportion of traditional industries gradually declines[3]. The structure of investment entities has also changed, with private enterprises gradually replacing state-owned enterprises as the main force of investment. The investment model has shifted from individual enterprise investment to entire industrial chain investment, with large numbers of upstream and downstream enterprises expanding overseas together, forming industrial agglomeration effects [8]. For example, leading Chinese photovoltaic enterprises such as Trina Solar, JinkoSolar, JA Solar, and LONGi have invested and established factories in Malaysia, driving the development of supporting industries such as photovoltaic auxiliary materials and equipment manufacturing, forming a complete photovoltaic industrial chain and promoting the overall development of Malaysia's photovoltaic industry[7]. Chinese new energy vehicle enterprises such as Great Wall and BYD have also entered Malaysia successively, promoting the construction of Malaysia's electric vehicle ecosystem and driving the development of related industries such as batteries and components.

In terms of economic impact research, most scholars believe that Chinese investment in Malaysia has promoted Malaysia's economic growth, increased employment opportunities, and improved infrastructure conditions. Tham (2024) systematically reviewed and comprehensively analyzed the evidence of Chinese investment in Malaysia ten years after the Belt and Road Initiative was proposed, finding that Chinese investment has made positive contributions to Malaysia's economic growth, employment creation, and infrastructure improvement. However, the long-term impact of technology transfer remains unclear. Existing research generally ignores the technology spillover effects of Chinese investment on local Malaysian enterprises, which is an important gap in this field of research[1]. The few existing studies involving technology spillovers are mostly qualitative analyses, lacking micro-level empirical testing, with significant disagreements in conclusions. Some studies believe that after the upgrade of Chinese investment structure, the increase in high-tech manufacturing investment will inevitably bring more technology spillovers and promote Malaysia's technological progress. However, other studies point out that Chinese enterprises' high-tech investment mainly utilizes Malaysia's location advantages and preferential policies, with core technologies still retained in China. Local enterprises find it difficult to obtain substantial technology spillovers. Whether technology spillover effects are significant still requires empirical testing[6]. Overall, existing research on Chinese investment in Malaysia has adequately analyzed investment location choice, influencing factors, structural changes, and macroeconomic impacts. Microlevel empirical research on technology spillover effects is very scarce, making it difficult to answer the important question of whether Chinese investment in Malaysia generates significant technology spillovers. This inability to provide solid empirical support for policy formulation highlights the necessity and practical significance of this research [12].

III. DATA SOURSE AND VARIABLE MEASUREMENTS

A. Overall Effect

The core viewpoint of international direct investment technology spillover theory holds that during the investment and operation process of multinational corporations in host countries, unconscious technological externalities are generated, promoting technological progress and productivity improvement in local enterprises. This basic theoretical framework lays the foundation for analyzing the technology spillover effects of Chinese investment in Malaysia. Since the proposal of the Belt and Road Initiative, Chinese investment in Malaysia has undergone profound changes in both scale and structure, creating more

favorable conditions for technology spillovers. Unlike early investments concentrated in infrastructure construction and resource development, Chinese investment in Malaysia has shown a clear trend toward high-tech industries in recent years, with rapid growth in investments in semiconductors, new energy vehicles, photovoltaics, and lithium batteries. These investments have brought not only capital but also advanced technologies, equipment, processes, and management experience. Compared with multinational corporations from developed countries, Chinese enterprises possess higher technological maturity that better matches Malaysia's factor endowment structure and development stage, with relatively lower barriers for local enterprises to learn and imitate, making significant positive technology spillover effects more likely.

From the perspective of investment entities, private enterprises have replaced state-owned enterprises as the main force of Chinese investment in Malaysia. Private enterprises focus more on market efficiency and long-term development, with higher degrees of localization and deeper cooperation with local enterprises, which is also conducive to technology spillovers. Stateowned enterprise investments are mostly concentrated in capital-intensive fields such as infrastructure, where these projects have relatively low degrees of industrial chain localization and limited opportunities for technology spillovers. Private enterprise investments are more concentrated in manufacturing, especially high-tech manufacturing, requiring substantial local supporting services, employing large numbers of local employees, and having more frequent interactions with local enterprises, providing more channels for technology spillovers. Under the Belt and Road Initiative framework, China and Malaysia have signed a series of bilateral investment agreements and economic and trade cooperation agreements, providing a more stable institutional environment for Chinese enterprise investment and creating better conditions for technology exchange and cooperation.

Although some existing studies suggest that Chinese enterprises do not have obvious technological advantages, have low degrees of local embeddedness, and find it difficult to generate significant technology spillovers, these studies are mostly based on early data of Chinese investment in Malaysia, when Chinese investment was indeed mainly concentrated in traditional fields with limited technology spillovers. In recent years, the structure of Chinese investment in Malaysia has undergone fundamental changes, with the proportion of high-tech manufacturing investment continuously increasing, and the investment model has shifted from individual enterprise investment to entire industrial chain investment. These changes have significantly enhanced the potential for technology spillovers. Based on the above theoretical analysis, this paper proposes the first research hypothesis: **H1: Controlling for other factors, the investment of Chinese listed companies in Malaysia under the Belt and Road Initiative has generated significant positive technology spillovers, promote productivity improvement in enterprises of the host country.**

B. Mechanism of Action and Differential Effects

The industrial linkage channel refers to multinational corporations establishing industrial chain connections with local upstream and downstream enterprises, transferring technology and management experience to forward and backward linked enterprises. Under the entire industrial chain investment model, Chinese-funded enterprises are highly dependent on local enterprises to provide raw materials, components, and supporting services. To ensure that the final product quality meets international standards, Chinese-funded enterprises have strong incentives to help local suppliers improve their technical levels and production efficiency. They typically provide technical support, equipment assistance, personnel training, and management guidance to local suppliers, a process that naturally promotes the transfer and diffusion of technology to local enterprises (ID: 30). For backward linkages, Chinese-funded enterprises as downstream customers will actively help upstream local suppliers improve production processes and product quality to meet their own production needs. For forward linkages, Chinese-funded enterprises as upstream suppliers provide downstream local enterprises with intermediate products and after-sales services with higher technological content, also driving the technological upgrading of downstream local enterprises.

The personnel mobility channel is another important carrier of technology spillovers. Multinational corporations hire local employees and train them. When these employees flow to local enterprises or start their own businesses, the technology and management experience they have mastered also transfer accordingly. Chinese enterprises' investment in Malaysia, whether in manufacturing or services, requires hiring large numbers of local employees. To adapt to the technical standards and management requirements of Chinese enterprises, Chinese-funded enterprises usually provide systematic training to local employees to improve their skill levels. In recent years, with the increase of Chinese high-tech industry investment, the demand for local technical workers and management personnel has been growing, and training efforts have been continuously strengthened. Once these trained employees flow to local enterprises, they will bring the diffusion of technology and management experience. Compared with the industrial linkage channel, the spillover effect of the personnel mobility channel may be slightly weaker, but it still plays an important role. On the one hand, Chinese-funded enterprises may restrict core technical personnel to maintain technological advantages and reduce technology spillovers. On the other hand, Malaysia's labor market generally has good mobility, and personnel mobility can still produce considerable spillover effects.

The demonstration effect channel refers to local enterprises improving their own production efficiency by imitating and learning the advanced technology and management experience of Chinese-funded enterprises. Theoretically, the technology of Chinese enterprises is more suitable for local Malaysian enterprises to imitate and learn, so the demonstration effect should be relatively obvious. However, in practice, the play of demonstration effects is constrained by the absorptive capacity of local enterprises and technological complexity. The competition effect channel refers to the entry of Chinese-funded enterprises intensifying market competition in Malaysia, forcing local enterprises to increase R&D investment, optimize resource allocation, and improve production efficiency. Moderate competition can indeed promote efficiency improvement of local enterprises, but excessive competition may also crowd out local enterprises, producing negative spillover effects. Malaysian local enterprises generally have lower technological levels than Chinese enterprises. After Chinese-funded enterprises enter, they may seize large market shares by virtue of technological and cost advantages, leading to decreased market shares, reduced profits, or even being crowded out of the market for local enterprises. In this case, competition effects may produce negative spillovers. In addition, the play of competition effects requires local enterprises to have certain innovation capabilities to cope with competitive pressure and increase R&D investment. However, Malaysian local enterprises generally have low R&D investment and insufficient innovation capabilities, making it difficult to achieve technological upgrading under competitive pressure. Therefore, the spillover effect of competition effects may also be relatively limited. Based on this paper proposes the second research hypothesis: **H2: Among the four technology spillover channels, the spillover effect of the industrial linkage channel is the most significant, followed by the personnel mobility channel, while the contributions of demonstration effects and competition effects are relatively smaller.**

C. Technology Spillover Effect

Chinese investment in Malaysia covers multiple industries ranging from traditional resource development and infrastructure construction to modern high-tech manufacturing. Different industries exhibit significant differences in technological intensity, technological complexity, degree of industrial chain linkage, and investment models. These differences affect the intensity and effectiveness of technology spillovers, leading to industry heterogeneity in technology spillover effects. From the perspective of technological characteristics, high-tech industries such as semiconductors, new energy vehicles, photovoltaics, and lithium batteries inherently possess high technological content and rapid technological progress. After the entry of Chinese-funded enterprises, they can bring more advanced technologies and management experience, resulting in greater potential for technology spillovers. Traditional industries such as resource development, infrastructure construction, and traditional manufacturing have relatively lower technological content and slower technological progress, naturally resulting in relatively smaller potential for technology spillovers. From the perspective of industrial chain linkage, high-tech manufacturing typically features longer industrial chains requiring more local supporting industries, maintaining closer ties with local enterprises. This creates better conditions for technology spillovers through industrial linkage channels. Chinese high-tech enterprises investing in Malaysia often adopt an entire industrial chain investment model, driving large numbers of upstream and downstream enterprises to invest together. To ensure product quality, photovoltaic enterprises must provide technical guidance and personnel training to local supporting enterprises, thereby promoting the transfer and diffusion of technology to local enterprises. Traditional resource development projects and infrastructure construction projects have relatively shorter industrial chains with fewer localization supporting requirements, resulting in fewer opportunities for technology spillovers.

From the perspective of personnel training, high-tech industries have higher requirements for employee skill levels. Chinesefunded enterprises must increase training efforts for local employees to enhance their skill levels to meet production requirements, making the technology spillover effects through personnel mobility channels more significant. High-tech industries require not only production workers but also large numbers of technical personnel and management staff. Chinesefunded enterprises typically dispatch Chinese technical experts to provide hands-on guidance to local employees, and even send local employees to Chinese headquarters for training. These trainings enhance the technical levels of local employees, and when these employees flow to local enterprises, they bring significant technology spillovers. In contrast, traditional industries have relatively lower skill requirements for employees and smaller training efforts, resulting in naturally weaker spillover effects through personnel mobility channels. From the perspective of demonstration effects, high-tech industries feature rapid technological progress and frequent product updates. Chinese-funded enterprises continuously introduce new technologies and products, providing local enterprises with more opportunities for learning and imitation, making demonstration effects more pronounced. Local enterprises can observe new products, new processes, and new management models from Chinese-funded enterprises, continuously improving their own products and production processes to achieve technological upgrading. In contrast, traditional industries have mature technologies with slow changes, resulting in relatively fewer opportunities for demonstration effects. Additionally, high-tech industries typically have stronger competition effects that can promote local enterprises to accelerate

innovation and improve production efficiency. Although competition effects have limited overall contribution, their positive effects remain stronger in high-tech industries than in traditional industries.

It should be pointed out that in recent years, the structural transformation of Chinese investment in Malaysia has mainly manifested as a rapid increase in the proportion of high-tech industry investment, with the proportion of traditional industries gradually declining. This structural transformation itself means that overall technology spillover effects will gradually strengthen. If high-tech industries indeed have stronger technology spillover effects, then this structural transformation will be beneficial for Malaysia to obtain more technology benefits from Chinese investment, promoting local industrial upgrading. Based on the above analysis, this paper proposes the third research hypothesis: **H3: The technology spillover effects of Chinese investment in Malaysia under the Belt and Road Initiative exhibit significant industry heterogeneity, with technology spillover effects in high-tech industries being significantly stronger than in traditional manufacturing.**

D. Moderating Effect of Host Country Absorptive Capacity

Host country absorptive capacity mainly includes two core dimensions: human capital level and institutional quality. Human capital level reflects the ability of host country employees to learn and master new technologies. The higher the human capital level, the easier it is for local enterprise employees to understand, absorb, and apply the advanced technologies brought by Chinese-funded enterprises, and the more significant the technology spillover effects [5]. Specifically, the higher the human capital level, the easier it is for local enterprise engineers and technical personnel to master the advanced technologies of Chinese-funded enterprises through learning and imitation, and the easier it is for management personnel to absorb the advanced management experience of Chinese-funded enterprises. When employees flow from Chinese-funded enterprises to local enterprises, employees with high human capital levels can better apply what they have learned to local enterprises, producing greater spillover effects. In the process of industrial linkages, the higher the human capital level of local suppliers, the easier it is to meet the technical requirements of Chinese-funded enterprises, and the easier it is to absorb the technical guidance of Chinese-funded enterprises to achieve technological upgrading. Therefore, human capital level should have a significant positive moderating effect on technology spillover effects. In regions with higher human capital levels, the technology spillover effects produced by Chinese investment are more significant.

Institutional quality is another core dimension of host country absorptive capacity. Institutional quality mainly includes property rights protection level, rule of law level, government efficiency, and market openness. A good institutional environment can provide favorable conditions for technology spillovers. First, sound property rights protection can motivate local enterprises to increase R&D investment and absorb and utilize external technologies, because enterprises can obtain reasonable returns from innovation. Second, good institutional quality can promote rational labor mobility, enabling employees trained by Chinese-funded enterprises to freely flow to local enterprises, promoting technology diffusion. Third, better institutional quality can promote in-depth cooperation between Chinese-funded enterprises and local enterprises, strengthening industrial chain linkages, thereby promoting technology spillovers. Fourth, the better the institutional quality, the more sufficient the market competition, and the more the positive role of competition effects can be played, forcing local enterprises to improve technology and efficiency. Conversely, in regions with poor institutional quality, weak property rights protection, low government efficiency, and serious market segmentation, these factors are not conducive to the occurrence and diffusion of technology spillovers [5]. Therefore, institutional quality should also have a positive moderating effect on technology spillover effects. In regions with better institutional quality, the technology spillover effects of Chinese investment are more significant.

As a diversified emerging economy, Malaysia has unbalanced development between different regions. The west coast regions including the capital Kuala Lumpur, Penang, and Johor have higher economic development levels, richer human capital, better institutional environments, and stronger absorptive capacity. In contrast, east Malaysian regions such as Sabah and Sarawak have relatively backward economic development, lower human capital levels, relatively poorer institutional quality, and weaker absorptive capacity. These regional-level differences in absorptive capacity provide an excellent opportunity for this paper to test the moderating effects of host country absorptive capacity. Based on the above theoretical analysis, this paper proposes the fourth research hypothesis: **H4: The human capital level and institutional quality of different regions in Malaysia significantly and positively moderate the technology spillover effects of Chinese investment in Malaysia. In regions with stronger absorptive capacity, the technology spillover effects are more significant.**

IV. RESULT ANALYSIS

A. Descriptive Statistics and Correlation Analysis

This section reports the empirical results. The sample consists of local Malaysian firms observed from 2013 to 2024, matched with the Malaysian investment records of Chinese A-share listed companies. After excluding financial firms, firms with missing key variables, and firms observed for fewer than three consecutive years, an unbalanced panel of 5,186 firm-year observations covering 468 local firms is obtained. Local firms operating in the same industry and state as a Chinese-funded listed company, or having supply-chain transactions with it, form the treatment group (187 firms), and the other 281 firms form the control group. The explained variable is firm-level total factor productivity (TFP), estimated by the Levinsohn-Petrin method and taken in logarithms. The core explanatory variable is the DID term (Treat × Post), which equals one for treated firms in and after the year of the first Chinese-funded project's entry. The controls are firm size (Size), age (Age), leverage (Lev), return on assets (ROA), R&D intensity (RD), and export intensity (Export); the channel variables and the moderators are defined in the corresponding subsections. Table 1 presents the descriptive statistics.

Table 1. Descriptive Statistics of Main Variables

Variable Name	Obs	Mean	Std. Dev.	Min	Max
TFP	5186	2.316	0.742	0.384	4.927
DID	5186	0.287	0.452	0.000	1.000
Size	5186	18.426	1.538	14.652	23.417
Lev	5186	0.412	0.196	0.038	0.862
ROA	5186	0.048	0.062	-0.176	0.231
RD (%)	5186	1.480	1.120	0.000	6.350
LINK	5186	0.186	0.134	0.000	0.742
MOB	5186	0.092	0.081	0.000	0.436
DEMO	5186	0.148	0.112	0.000	0.615
COMP	5186	0.205	0.158	0.000	0.823
HC	5186	0.312	0.094	0.148	0.536
INST	5186	0.567	0.118	0.318	0.812

Local firms differ considerably in productivity: TFP has a mean of 2.316 and ranges from 0.384 to 4.927, indicating ample room for technological catching-up. The mean of DID is 0.287, so about 29% of firm-year observations are exposed to Chinese-funded investment. HC and INST vary widely, reflecting the gap between the developed west coast and East Malaysia. DID is positively correlated with TFP ($r = 0.164$, $p < 0.01$), and the largest variance inflation factor is 2.31, so multicollinearity is not a concern.

B. Baseline Regression Results

To test H1, this paper estimates the following two-way fixed effects DID model:

$$TFP_{it} = \alpha + \beta \cdot DID_{it} + \gamma \cdot Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where i and t denote firm and year, TFP_{it} is firm productivity, DID_{it} is the treatment-by-post interaction, and $Controls_{it}$ is the vector of control variables. μ_i and λ_t are firm and year fixed effects, which absorb time-invariant firm characteristics and common shocks, and ε_{it} is the error term. H1 is supported if β is significantly positive. Table 2 reports the results.

Table 2. Baseline Regression Results

Variable	(1) TFP	(2) TFP	(3) TFP
DID	0.078***	0.064***	0.057***
	(0.021)	(0.019)	(0.020)
Size	-	0.118***	0.109***
		(0.016)	(0.017)
ROA	-	0.305***	0.281***
		(0.071)	(0.074)
Firm and Year FE	Yes	Yes	Yes

Industry × Year FE	No	No	Yes
Obs	5186	5186	5186
Adj. R^2	0.538	0.561	0.597

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Column (1) controls only for firm and year fixed effects, and the DID coefficient is 0.078 ($p < 0.01$). After adding controls in column (2), it falls to 0.064 but remains significant at the 1% level. Column (3) further includes industry-by-year fixed effects, and the coefficient is 0.057 ($p < 0.01$): after the entry of Chinese-funded investment, the productivity of exposed local firms rises by about 5.9% relative to the control group, equivalent to 7.7% of one standard deviation of TFP. Larger and more profitable firms are more productive, as expected. These results support H1.

C. Mechanism Test of Technology Spillover Channels

Channel variables are constructed. LINK is the weighted sum of the backward and forward shares of Chinese-funded output in the industry-state cell, using Malaysian input-output weights. MOB is the share of local employees of Chinese-funded firms in the cell's employment. DEMO is the output share of Chinese-funded firms weighted by technological proximity to local firms, and COMP is their market share in the cell. Each variable is included separately and then jointly in the baseline model (Table 3).

Table 3. Test of Technology Spillover Channels

Variable	**(1) LINK**	**(2) MOB**	**(3) DEMO**	**(4) COMP**	**(5) All**
LINK	0.094*** (0.024)	-	-	-	0.073*** (0.022)
MOB	-	0.058*** (0.020)	-	-	0.041** (0.018)
DEMO	-	-	0.031* (0.017)	-	0.019 (0.016)
COMP	-	-	-	0.014 (0.015)	0.006 (0.014)
Controls & FE	Yes	Yes	Yes	Yes	Yes
Obs	5186	5186	5186	5186	5186
Adj. R^2	0.549	0.543	0.538	0.535	0.558

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors clustered at the firm level are reported in parentheses. Controls & FE: control variables and firm and year fixed effects are included.

The coefficient of LINK is 0.094 ($p < 0.01$), about 1.6 times that of MOB (0.058, $p < 0.01$), while DEMO is only weakly significant (0.031, $p < 0.10$) and COMP is insignificant (0.014). When all four channels enter together in column (5), the ranking is unchanged: LINK (0.073) and MOB (0.041) remain significant, while DEMO (0.019) and COMP (0.006) are indistinguishable from zero. The differences between LINK and MOB ($p = 0.043$) and between MOB and DEMO ($p = 0.087$) are significant. Measured by coefficient times sample mean, industrial linkage accounts for 63.5% of the combined channel contribution, followed by personnel mobility (17.6%), demonstration (13.1%), and competition (5.8%). Backward linkage (0.081, $p < 0.01$) matters more than forward linkage (0.037, $p < 0.05$), consistent with Chinese-funded firms, as downstream customers, having strong incentives to upgrade local suppliers, while the weak competition effect reflects the low R&D investment of local firms.

D. Industry Heterogeneity Test

The manufacturing sample is divided into high-tech industries (semiconductors and electronics, photovoltaics, lithium batteries, and new energy vehicle components; 1,938 observations) and traditional manufacturing (food processing, textiles, rubber products, and wood and furniture; 2,341 observations), and DID × HighTech is added to the pooled sample (Table 4).

Table 4. Industry Heterogeneity Test

Variable	(1) High-tech	(2) Traditional	(3) Pooled
DID	0.103*** (0.029)	0.036* (0.020)	0.034* (0.020)
DID × HighTech	-	-	0.067** (0.031)
Controls & FE	Yes	Yes	Yes
Obs	1938	2341	4279
Adj. R^2	0.584	0.536	0.561

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors clustered at the firm level are reported in parentheses. Controls & FE: control variables and firm and year fixed effects are included.

The DID coefficient is 0.103 ($p < 0.01$) in high-tech industries but only 0.036 ($p < 0.10$) in traditional manufacturing. A Fisher permutation test with 1,000 replications confirms that the difference is significant ($p = 0.012$), and the interaction term in column (3) is 0.067 ($p < 0.05$). Channel regressions by industry show that the LINK coefficient is 0.121 in high-tech industries versus 0.052 in traditional manufacturing, so the stronger spillovers come from longer industrial chains and more intensive technical training. H3 is supported, implying that the shift of Chinese investment toward high-tech manufacturing will help Malaysia obtain more technology benefits.

E. Moderating Effect of Host Country Absorptive Capacity

To test H4, human capital (HC, the share of workers with tertiary education in each state) and institutional quality (INST, a state-level index of property rights protection, government efficiency, and market openness built by the entropy method) are standardized and interacted with DID, so each interaction coefficient is the change in spillover per one-standard-deviation increase in the moderator. Columns (4) and (5) re-estimate the baseline model for West and East Malaysia (Table 5).

Table 5. Moderating Effect of Absorptive Capacity

Variable	(1) HC	(2) INST	(3) Both	(4) West	(5) East
DID	0.061*** (0.019)	0.060*** (0.019)	0.059*** (0.019)	0.071*** (0.021)	0.018 (0.037)
HC	0.043** (0.020)	-	0.038* (0.020)	-	-
DID × HC	0.034*** (0.012)	-	0.027** (0.013)	-	-
INST	-	0.036* (0.019)	0.029 (0.019)	-	-
DID × INST	-	0.028** (0.012)	0.019* (0.011)	-	-
Controls & FE	Yes	Yes	Yes	Yes	Yes
Obs	5186	5186	5186	4388	798
Adj. R^2	0.563	0.559	0.567	0.571	0.488

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors clustered at the firm level are reported in parentheses. Controls & FE: control variables and firm and year fixed effects are included.

DID × HC (0.034, $p < 0.01$) and DID × INST (0.028, $p < 0.05$) are both significantly positive. A one-standard-deviation increase in human capital raises the spillover by about 56% of its baseline level (0.034/0.061), and the figure for institutional quality is about 47% (0.028/0.060). With both moderators in column (3), DID × HC (0.027, $p < 0.05$) and DID × INST (0.019, $p < 0.10$) remain positive, suggesting complementary roles. The regional split agrees: the DID coefficient is 0.071 ($p < 0.01$) in West Malaysia but only 0.018 and insignificant in East Malaysia, and the difference is significant ($p = 0.046$). Without sufficient human capital and institutional support, local firms in Sabah and Sarawak cannot convert exposure to Chinese-funded firms into productivity gains. H4 is supported. Several robustness tests support the baseline results. First, combining propensity score matching (1:3 nearest neighbor, caliper 0.05) with DID, to mitigate selection bias from investors' preference for productive locations, gives a coefficient of 0.059 ($p < 0.01$). Second, re-estimating TFP by the Olley-Pakes method gives 0.061 ($p < 0.01$). Third, excluding the pandemic years 2020 and 2021 gives 0.060 ($p < 0.01$). Fourth, the heterogeneity-robust estimator of Callaway and Sant'Anna, which accounts for staggered entry, yields an average treatment effect of 0.049 ($p < 0.01$). Finally, in 500 placebo tests with randomly assigned treatment, coefficients center at 0.001 and the actual estimate of 0.057 lies beyond the 99th percentile, and moving the entry year three years earlier gives an insignificant coefficient of 0.009 (standard error 0.017).

CONCLUSIONS

Using micro-level investment data of Chinese A-share listed companies and firm-level data of local Malaysian enterprises from 2013 to 2024, this paper applies the difference-in-differences method to examine the technology spillover effects of China's investment in Malaysia under the Belt and Road Initiative. The main findings are as follows. First, Chinese investment generates significant positive technology spillovers, raising the TFP of exposed local firms by about 5.7% to 7.8%, and the result survives parallel trend, PSM-DID, alternative TFP, sample exclusion, heterogeneity-robust, and placebo tests. Second, industrial linkage is the dominant channel (about 63.5% of the combined channel effect), followed by personnel mobility, while demonstration and competition effects are limited. Third, spillovers are significantly stronger in high-tech industries than in traditional manufacturing. Fourth, human capital and institutional quality positively moderate the spillover effect, and firms in West Malaysia benefit much more than those in East Malaysia. Malaysia should encourage Chinese-funded enterprises to embed deeply in local supply chains through supplier development programs and local-content incentives, strengthen vocational training to promote the diffusion of skilled workers, improve intellectual property protection and government efficiency, and extend infrastructure and preferential policies to Sabah and Sarawak. Chinese enterprises should pursue whole-industry-chain investment, localized R&D and training, and technical cooperation with local firms. Both countries can use Belt and Road cooperation mechanisms, such as industrial parks and mutual recognition of technical standards, to guide capital toward hightech sectors. The channel variables are proxies built from industry-level and state-level data, and the sample is limited to firms that can be matched with Chinese investment records. Future research could use customs transaction records, patent citations, and employer-employee matched data to identify the channels more precisely and extend the analysis to other ASEAN countries.

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