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Original Paper

China's Industrial-Chain Embeddedness and Industrialization in Southeast Asia: An Empirical Study from the Perspective of the New International Division of Labor

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Abstract

Against the backdrop of regionalization and near-shoring restructuring of global industrial chains in the 21st century, a new regional division of labor transcending the traditional "flying-geese" model is emerging between China and Southeast Asia. Using panel data for six ASEAN countries from 1998 to 2023, this study employs a two-way fixed effects model to empirically examine the impact of China's industrial-chain embeddedness on Southeast Asian industrialization and its transmission mechanisms. The findings are as follows. First, the contemporaneous direct effect on the manufacturing value-added share is insignificant, whereas the one-period lagged effect is significantly positive, indicating a "contemporaneous embeddedness, intertemporal realization" lag. Second, labor productivity improvement is the core transmission channel, confirming technology and management capability spillovers. Third, the effect on macroeconomic growth is indirect and long-term, and it is determined by the stock depth of industrial-chain embeddedness rather than short-term export growth. These conclusions provide empirical evidence for the China–Southeast Asia new regional division of labor and policy references for high-quality outward investment and regional industrial-chain coordination.

Keywords

Industrial Chain Embedment, Southeast Asian Industrialization, New Regional Division of Labor, Labor Productivity

1. Introduction

In the third decade of the 21st century, global industrial chains are undergoing profound restructuring. A series of major shocks—the 2008 international financial crisis, China–US trade frictions, the COVID-19 pandemic, and the Russia–Ukraine conflict—have exposed the structural fragility of global

value chains, which are excessively long, overly concentrated, and insufficiently resilient. The three major production networks in North America, Europe, and Asia have continued to become more inward-looking, and the regionalization, near-shoring, and friend-shoring of industrial chains have become an irreversible new trend. Against this macro backdrop, the evolution of China's industrial chains and their external relations have attracted considerable attention. Over the past four decades, China has built the world's most complete industrial system—all 41 industrial categories, 207 medium categories, and 666 subcategories in the United Nations industrial classification are present in China—and China's share of global manufacturing value added rose from approximately 6% in 2000 to approximately 30% in 2022. However, with rising labor costs, tightening land resources, and stricter environmental standards, the comparative advantages of China's traditional labor-intensive industries are gradually weakening.

Traditional theories of the "flying-geese model" imply a hierarchical relationship in which developed countries dominate and developing countries remain dependent [1]. However, preliminary observations in this study suggest that a more equal and collaborative new division of labor may be emerging between China and Southeast Asia—China provides "systemic support" to the region through its comprehensive industrial chains, while Southeast Asian countries develop "supporting capabilities" based on their own distinctive features, forming a complementary and symbiotic regional industrial ecosystem. The question of "what division-of-labor pattern has been formed" is addressed in the theoretical chapter as an analytical framework, and this paper focuses on answering two research questions: first, has China's industrial-chain embeddedness promoted industrialization in Southeast Asia? Second, through what mechanisms and under what conditions is the effect stronger? The construction of this analytical framework contributes to supplementing and extending theories of the international division of labor and industrial-chain spillovers. Examining the mechanisms through which China's industrial chains affect Southeast Asia's industrialization process and industrial structural upgrading has direct reference value for adjusting Chinese enterprises' "going global" strategy, formulating industrial policies in Southeast Asian countries, and advancing China–ASEAN regional economic governance. In particular, against the current backdrop of geopolitical tensions and rising discussions of "de-risking" in global supply chains, an accurate understanding of the nature of this relationship can help avoid policy misjudgments and promote mutually beneficial regional cooperation. This paper adopts panel econometric methods, using data from six ASEAN countries from 1998 to 2023 to construct a two-way fixed effects model for empirical testing, and combines typical country facts to explain the mechanisms.

2. Literature Review

2.1 Foreign Studies

In the renewed discussion of the flying-geese model, the "flying-geese model" proposed by Akamatsu (1962) has long been the dominant paradigm for explaining industrial transfer in East Asia [1].

Subsequent scholars such as Kasahara (2004) extended it, emphasizing the matching of product life cycles with industrial gradient transfer [2]. However, since the 21st century, a growing body of research has pointed out that China's economic size and industrial completeness make the traditional flying-geese model difficult to apply fully [3]. From the perspective of global value chains, Gereffi's (1999) global commodity chain theory and the upgrading theory of Humphrey and Schmitz (2002) have been widely used to analyze the positioning of developing countries in value chains. Scholars have focused on the "modular" production roles of Southeast Asian countries in industries such as electronics and textiles [4][5][6].

It is noteworthy that most Western studies still interpret the drivers and effects of industrial-chain relocation to Southeast Asia from the perspective of "China Plus One" or "de-risking." The logic implicit in this perspective is that multinational enterprises, in order to reduce excessive dependence on a single production base in China, are dispersing part of their production capacity to alternative destinations such as Southeast Asia. Within this framework, China and Southeast Asia are regarded as "competitive" substitutes rather than "complementary" partners. This analytical perspective, intentionally or unintentionally, overlooks the endogenous synergy between China and Southeast Asia. A large body of empirical evidence shows that Chinese enterprises' industrial relocation to Southeast Asia is not a simple "exit," but is accompanied by the extension of supply chains, the transfer of technology, and the sharing of markets. Close industrial-chain linkages have already formed between China and Southeast Asia—China exports large quantities of intermediate goods to Southeast Asia, and Southeast Asia completes assembly and processing before exporting final products to the global market. This production network of "intra-regional circulation" goes beyond the simplistic narrative of "de-risking" discourse and requires a more nuanced theoretical framework for explanation.

However, systematic research treating "China–Southeast Asia" as an organic regional production system remains relatively scarce in current academia. Existing studies mostly measure economic consequences by growth rates, overlooking the fact that the most direct object of industrial-chain embeddedness is the production structure; moreover, they lack holistic empirical testing of the "China–Southeast Asia" regional production system. This research gap constitutes one of the core questions that this paper seeks to address.

2.2 Domestic Studies

On the one hand, domestic research has focused on China's industrial-chain spillovers. Liu Zhibiao and Zhang Jie (2019) systematically analyzed the two-way logic of China's industrial upgrading and transfer against the backdrop of global industrial-chain restructuring. Yang Chao and Bai Guangyu (2021) explored the pathways and mechanisms of China–ASEAN industrial-chain cooperation, emphasizing "complementarity" rather than "substitutability." In terms of empirical progress, some scholars have used input–output tables or trade data to measure the degree of industrial linkage between China and Southeast Asia [9][10]. Some studies have pointed out that China's exports of intermediate goods to Southeast Asia have grown faster than its exports of final goods, indicating that

intra-regional production division of labor is deepening.

Despite the important progress made in domestic research, several directions remain worthy of further exploration. In terms of theoretical construction, existing literature has not yet clearly proposed a systematic concept of a "new regional division of labor model," and theoretical distillation of the division-of-labor relationship between China and Southeast Asia remains insufficient. In terms of research methods, existing studies are mainly based on descriptive statistics or macro-level data regressions, lacking in-depth case analyses of specific industries and firms, which makes it difficult to reveal the process mechanisms of "how" the influence occurs. In terms of mechanism identification, the distinction among different transmission channels—such as industrial transfer effects, technology spillover effects, and collaborative division-of-labor effects—is not sufficiently clear, which affects the precise distillation of policy implications.

3. Relevant Theoretical Foundations

3.1 Industrial Chain and Industrial Transfer Theory

The industrial chain refers to a value chain composed of upstream and downstream firms that are connected through continuous value-added relationships, arising from the social division of labor and formed under the operation of transaction mechanisms [11]. An industrial chain has three core characteristics: vertical relatedness, namely upstream–downstream interdependence; spatial separability, namely the possibility of locating various segments in different regions; and value asymmetry. The theory of industrial gradient transfer originates from Vernon's (1966) product life cycle theory [12]. This theory holds that industries will transfer from high-gradient developed regions to low-gradient developing regions as products evolve from the "innovation stage" to the "maturity stage" and then to the "standardization stage." The driving forces of such transfer include cost differentials, market seeking, and avoidance of trade barriers [13].

3.2 Theory of International Division of Labour

The theory of comparative advantage (Ricardo, 1817) and the Heckscher–Ohlin model (Heckscher & Ohlin, 1933) laid the foundation for the division of labor theory [14][15][16]. Differences in the factor endowments of Southeast Asian countries in labor, land, natural resources and other aspects determine their distinct positions in the spillover of China's industrial chain: Vietnam excels in young labor force, Thailand boasts a solid base for auto parts, Malaysia has strengths in electronics and semiconductors, and Indonesia is competitive in resource-based products. The theory of intra-product specialization (Arndt, 1997) and the global value chain (GVC) theory (Gereffi et al., 2005) reveal the nature of modern division of labor: different production stages of a product can be completed in separate countries. The relationship between China and Southeast Asia represents a typical regional intra-product specialization pattern. China supplies key components and technical support, while Southeast Asian economies undertake assembly, testing, packaging and other processes, forming a "regional circular flow"[17][4].

3.3 The Traditional "Flying-Geese Model" and Its Limitations

The flying-geese pattern took Japan as the lead goose, the Asian Four Little Dragons as the second tier, and other ASEAN countries as the subsequent tier, forming a sequential transfer of industries from higher to lower levels. Its core features include dominance by developed economies, hierarchical structure, one-way outsourcing, and maintenance of technology gaps. Its main limitations lie in inequality, strong dependency, low-end lock-in, and inapplicability to China. For the vast majority of latecomer countries, they remain in a position of technological catch-up and find it difficult to achieve leapfrog development. Their growth is highly reliant on external demand and investment, with high vulnerability. Developing countries tend to be trapped in low-value-added segments and fall into the middle-income trap. Moreover, the integrity and scale of China’s industrial chain mean that it cannot serve as a simple link in the flying-geese formation.

3.4 China-ASEAN New Regional Division of Labor Model

3.4.1 Pattern Characteristics

The discussion of the limitations of the traditional V-shaped formation model in the preceding text indicates that the division of labor logic, which is led by a single developed country and characterized by hierarchical unidirectional transfer, is no longer able to explain the current industrial interaction reality between China and Southeast Asia. Based on systematic observations of practice, this paper proposes the 'China-Southeast Asia New Regional Division of Labor Model'. Compared with the traditional V-shaped formation model, this model exhibits essential differences across multiple dimensions, as specifically shown in Table 3-1.

Table 3-1 Comparative Features of Traditional Geese Formation Pattern and New Regional Division of Labor Pattern

Dimension	Traditional Geese Formation Pattern	New Regional Division of Labor Model
Dominator	Developed countries (Japan, United States)	China's Multilateral Interactions with Southeast Asia
Nature of the Relationship	Hierarchical and unidirectional dependence	Equalization, bidirectional empowerment
Technological flow	Maintain technological gap	Technological and Management Spillovers
Industrial Chain Structure	Fragmented outsourcing	Full-Chain Collaboration
market-oriented	Mainly oriented to the external market	Balancing domestic and international markets, with

enhanced regional market presence

In terms of the dominant actors in the division of labor, the traditional flying-geese model was led by developed countries such as Japan and the United States, with a unidirectional pattern of industrial transfer, whereas the new regional division of labor model is characterized by diversified interactions between China and Southeast Asian countries and is no longer unilaterally dominated by a single country or bloc. In terms of the nature of relations, the traditional model exhibited a hierarchical structure of one-way dependence, with latecomer countries long remaining in a passive position of acceptance. By contrast, the new model emphasizes equality and bidirectional empowerment, with each country leveraging its comparative advantages within the division-of-labor network and promoting one another. In terms of the direction of technology flows, the traditional model tended to intentionally maintain technological gaps in order to consolidate dominance, whereas the new model focuses on positive spillover effects of technology and management, thereby promoting the upgrading of overall regional capabilities. In terms of the form of industrial chains, the traditional model was mainly based on fragmented outsourcing, dispersing low-value-added segments, whereas the new model pursues full industrial-chain coordination and forms a more closely connected regional production network. Finally, in terms of market orientation, the traditional model was mainly oriented toward external markets, especially European and American consumer markets, with weak intra-regional linkages, whereas the new model takes into account both domestic and external markets and particularly emphasizes cultivating and strengthening intra-regional market linkages.

The above comparison shows that the China–Southeast Asia new regional division of labor model breaks through the hierarchical logic of the traditional flying-geese model and exhibits more equal, collaborative, and sustainable characteristics in terms of cooperation actors, technology flows, industrial-chain integration, and market orientation. The formation of this model provides a new theoretical perspective for understanding industrial interaction between China and Southeast Asia and also constitutes the basis for the subsequent mechanism analysis.

3.4.2 The Role of “Systemic Support”

China’s “systemic support” through its industrial chains is manifested at three levels. The first is upstream supply support, namely that China is Southeast Asia’s largest supplier of intermediate goods. In the electronics industry, for example, Vietnam imports more than 35% of its electronic components from China. The second is technological capability support: Chinese enterprises systematically upgrade the skill levels of Southeast Asian workers by establishing training centers, dispatching technical personnel, and jointly developing technical standards. The third is infrastructure and financial support, such as infrastructure projects under the Belt and Road framework, including the China–Laos Railway and the Jakarta–Bandung High-Speed Railway, as well as financing support from the Asian Infrastructure Investment Bank, which have significantly reduced the physical and financial costs for Southeast Asia to participate in the regional division of labor.

The metaphor of "China as the general factory and Southeast Asia as branch factories" needs to be used with caution. It is not a hierarchical relationship of control and being controlled, but rather a collaborative relationship between "core nodes" and "supporting nodes." What China provides is "platform-type" industrial-chain capability—possessing a complete industrial ecosystem and system integration capacity—whereas what Southeast Asia provides is "modular" specialized capability—forming comparative advantages in specific segments. This structure not only ensures the competitiveness of China's industries but also gives Southeast Asian countries sufficient room for development and autonomy.

4. Mechanism Analysis of the Impact of China's Industrial-Chain Embeddedness on Southeast Asian Industrialization

The impact of China's industrial-chain embeddedness on Southeast Asian economies is first and directly manifested in changes in production structure rather than in simple aggregate growth. Based on the analytical framework of the "China–Southeast Asia new regional division of labor model" developed above, this paper argues that China's industrial-chain embeddedness affects Southeast Asian industrialization mainly through three mechanisms: the industrial transfer effect, the industrial-chain spillover effect, and the regional division-of-labor synergy effect. Among them, the industrial transfer effect is mainly reflected in the expansion of the manufacturing sector and the rise in the manufacturing value-added share; the industrial-chain spillover effect is mainly reflected in supporting capabilities and technological absorption that promote the deepening of local manufacturing segments and the improvement of labor productivity; and the regional division-of-labor synergy effect explains why this process may avoid the low-end lock-in associated with the traditional "flying-geese model." On this basis, this paper proposes research hypotheses to be tested.

4.1 Industrial Transfer Effect: Expansion of the Manufacturing Sector and Rising Share of Manufacturing Value Added

4.1.1 Scale and Characteristics of the Transfer

According to statistics from China's Ministry of Commerce, between 2010 and 2022, China's stock of direct investment in Southeast Asian manufacturing grew from approximately US$5 billion to more than US$40 billion, with an average annual growth rate of over 20%. In terms of industry type, the transferred industries can be divided into three categories: full relocation type, such as labor-intensive industries including textiles and apparel, furniture, and footwear; partial relocation type, such as electronics assembly, auto parts, and home appliances; and new deployment type, such as emerging industries including photovoltaics, lithium batteries, and electric vehicles. This multi-tiered and multi-type transfer pattern means that China's industrial-chain embeddedness is not merely the relocation of isolated low-end segments, but is accompanied by the systematic entry of equipment, intermediate goods, production organization, and management capabilities, thereby providing direct conditions for the expansion of the manufacturing sector in host countries.

4.1.2 Expansion of the Manufacturing Sector and the Rise in the Share of Manufacturing Value Added

The core focus of the industrial transfer effect on Southeast Asian industrialization is the expansion of the manufacturing sector and the rise in its share of the national economy. After Chinese manufacturing investment enters Southeast Asia, it directly expands the production scale of the host country's manufacturing sector through the construction of new factories, the expansion of production lines, and the development of supporting industrial parks; on the other hand, by incorporating some production segments into the regional production network, it enables the host country to fill in manufacturing segments that were previously dispersed or missing, thereby promoting the expansion of the manufacturing sector from simple processing to multi-segment, multi-category production. Taking Vietnam as an example, the concentrated entry of industries such as textiles and apparel, electronics assembly, and furniture has not only expanded the number of manufacturing firms and production capacity but also driven local supporting activities in logistics, packaging, molds, and parts supply, causing the manufacturing sector's share in employment, output, and exports to rise continuously. Thailand, Malaysia, and Indonesia have also exhibited similar characteristics of manufacturing sector expansion in fields such as auto parts, electronic semiconductors, and resource processing.

It should be emphasized that the focus of this paper is not on how much employment or exports foreign-invested enterprises have created, but on whether such industrial transfer has translated into substantive expansion of the host country's manufacturing sector—that is, whether the share of manufacturing value added in GDP has risen and whether the internal structure of manufacturing has become more diversified. Employment and export expansion can serve as manifestations of manufacturing sector expansion, but the mechanism should ultimately be located in changes in the production structure. Accordingly, the industrial transfer effect can be summarized as follows: China's industrial-chain embeddedness → entry of manufacturing investment and production segments → expansion of the manufacturing sector → rise in the share of manufacturing value added. This mechanism constitutes the direct channel through which China's industrial-chain embeddedness promotes Southeast Asian industrialization.

4.2 Industrial-Chain Spillover Mechanism: Supporting Capabilities, Technological Absorption, and Deepening of Local Manufacturing Segments

4.2.1 Intermediate Goods Supply and the Formation of Supporting Capabilities

The intermediate goods exports of Chinese enterprises to Southeast Asia are not merely commodity trade but also a process of transmitting production capacity. Taking Vietnam's textile industry as an example, Vietnamese garment factories import high-end fabrics from China and use Chinese zippers, buttons, and other accessories as supporting inputs before completing assembly and exporting the finished products. In this process, Vietnamese firms gradually acquire capabilities in fabric identification, quality control, and logistics coordination, and local supporting firms have also begun to develop supporting capabilities in accessory supply, testing, and packaging around garment production. Data show that China's fabric exports to Vietnam increased from approximately US$1.5 billion in 2010

to approximately US$7 billion in 2022, while Vietnam's textile and apparel exports rose from US$12 billion to US$44 billion over the same period. The growth in intermediate goods supply occurred alongside the improvement of the host country's manufacturing capacity, indicating that China's industrial-chain embeddedness does not merely bring processing orders; rather, through stable intermediate goods supply, it lowers the threshold for local firms to enter manufacturing segments and provides conditions for them to accumulate supporting capabilities.

4.2.2 Technological Absorption and Deepening of Local Manufacturing Segments: Labor Productivity Improvement

The core focus of the industrial-chain spillover mechanism is that supporting capabilities and technological absorption promote the deepening of local manufacturing segments, ultimately manifesting as an increase in labor productivity. Chinese-funded enterprises establish R&D centers, technical training departments, and production bases in Southeast Asia and, through the dispatch of technical personnel, training of local employees, lean production management, and supply-chain coordination, transmit part of their technological and managerial capabilities to local manufacturing segments. Huawei has established its Southeast Asia regional headquarters and a 5G innovation center in Thailand, cultivating local digital technology talent; BYD's electric vehicle training center in Indonesia trains more than a thousand technicians each year; and many local Southeast Asian managers, after working for several years in Chinese-funded enterprises, bring lean production, supply-chain management, and rapid response mechanisms to local firms. These spillover processes help local enterprises extend from simple assembly to segments such as testing, quality control, parts supply, and process improvement, thereby raising output per unit of labor.

Therefore, the focus of the industrial-chain spillover mechanism is not "technology spillover" or "export expansion" in the general sense, but rather: China's industrial-chain embeddedness→intermediate goods supply and technology and management transmission→improvement of local supporting capabilities and technological absorption capacity→deepening of local manufacturing segments→improvement of labor productivity. The improvement of labor productivity is both a result of the deepening of local manufacturing segments and an important indicator of the quality improvement of Southeast Asian industrialization. Accordingly, this paper uses labor productivity as the mediating variable for testing the industrial-chain spillover mechanism.

4.3 The Synergistic Mechanism of the New Regional Division of Labor: Why Not Low-End Lock-In

The synergistic mechanism of the new regional division of labor is retained as a key mechanism for explaining "why China's industrial-chain embeddedness may avoid low-end lock-in." The traditional "flying-geese model" implies a hierarchical relationship in which developed countries dominate and developing countries remain dependent, making it easy for latecomer countries to be locked into low-value-added segments. However, a more equal and collaborative new division-of-labor relationship may be emerging between China and Southeast Asia: China provides "systemic support" to the region

through its comprehensive industrial chains, while Southeast Asian countries develop "supporting capabilities" based on their own distinctive features, forming a complementary and symbiotic regional industrial ecosystem.

Therefore, the metaphor of "general factory–branch factory" needs to be used with caution. It is not a hierarchical relationship of control and being controlled, but rather a collaborative relationship between "core nodes" and "supporting nodes." The significance of the synergistic mechanism of the new regional division of labor lies in the fact that China's industrial-chain embeddedness, through systemic support and bidirectional empowerment, provides Southeast Asia with opportunities to enter the regional production network while preserving space for it to develop distinctive supporting capabilities based on its own endowments, thereby reducing the risk of being locked into low-end segments. This mechanism constitutes a supplementary explanation to the industrial transfer effect and the industrial-chain spillover effect, indicating that the impact of China's industrial-chain embeddedness on Southeast Asian industrialization is not simply the absorption of low-end production capacity, but may be accompanied by the deepening of manufacturing segments and the accumulation of capabilities.

4.4 Research Hypotheses

Based on the above mechanism analysis, this paper proposes the following research hypotheses:

H1: China's industrial-chain embeddedness significantly promotes industrialization in Southeast Asian countries, manifested as a rise in the share of manufacturing value added in GDP.

China's industrial-chain embeddedness drives the expansion of the host country's manufacturing sector through manufacturing investment entry, expansion of production segments, and intermediate goods supply, thereby increasing the share of manufacturing value added. This hypothesis corresponds to the positive effect of the depth of China's industrial-chain embeddedness on Southeast Asian industrialization in the baseline regression.

H2: China's industrial-chain embeddedness transmits its impact on Southeast Asian industrialization through the channel of labor productivity improvement.

China's industrial-chain embeddedness promotes the deepening of local manufacturing segments through intermediate goods supply, technology and management transmission, and the formation of supporting capabilities, thereby enhancing labor productivity; labor productivity improvement is an important mediating channel through which the industrial-chain spillover effect affects the quality of industrialization. This hypothesis corresponds to the mediation effect test.

H3: The effect of China's industrial-chain embeddedness on Southeast Asian industrialization exhibits a time lag and has an indirect and long-term impact on economic growth.

Industrial-chain embeddedness first affects the expansion of the manufacturing sector and the improvement of labor productivity, and then influences economic growth through the industrialization process. Therefore, its short-term effect may be limited and gradually emerges in the one-period lag or over a longer period; its impact on economic growth is indirect and long-term. This hypothesis corresponds to the lagged-term robustness test and the explanation of long-term mechanisms.

The above three hypotheses correspond respectively to three dimensions—"whether it promotes industrialization,""through what mechanisms it is transmitted,"and "under what temporal conditions the effect is stronger"—and together constitute the mechanism analysis framework for the impact of China's industrial-chain embeddedness on Southeast Asian industrialization.

5. Empirical Research Design

5.1 Construction of the Baseline Model

To examine the impact of China's industrial-chain embeddedness on Southeast Asian industrialization, this paper constructs the following two-way fixed effects baseline model based on panel data for the six ASEAN countries from 1998 to 2023:

$$Indus_it = \alpha + \beta \cdot lnX_it + \gamma \cdot Controls_it + \mu_i + \lambda_t + \varepsilon_it \quad (5\text{-}1)$$

Where i and t denote country and year, respectively; Indus_it is the dependent variable, representing the level of industrialization of country i in year t, measured in the baseline regression by the share of manufacturing value added in GDP and replaced in the robustness test by the share of industrial value added in GDP; lnX_it is the core explanatory variable, representing the depth of China's industrial-chain embeddedness in country i in year t, measured as the natural logarithm of China's intermediate goods exports to country i as a share of that country's GDP; Controls_it is a set of control variables, including the capital formation rate, trade openness, foreign investment dependence, and human capital; μ_i and λ_t are country fixed effects and year fixed effects, respectively, with the former controlling for time-invariant country-level characteristics (such as geographical endowments and institutional traditions) and the latter absorbing time shocks commonly faced by all countries (such as the global financial crisis and the COVID-19 pandemic); and ε_it is the random error term. The core coefficient of interest in this paper is β. If it is significantly positive, it indicates that the deepening of China's industrial-chain embeddedness can promote the improvement of industrialization levels in Southeast Asian countries.

Mechanism test model. To identify the channels through which China's industrial-chain embeddedness affects Southeast Asian industrialization, this paper draws on the mediation effect test method of Baron and Kenny (1986) and constructs the following recursive equation system:

$$Indus_it = \alpha_1 + c \cdot lnX_it + \gamma_1 \cdot Controls_it + \mu_i + \lambda_t + \varepsilon_it \quad (5\text{-}2)$$

$$M_it = \alpha_2 + a \cdot lnX_it + \gamma_2 \cdot Controls_it + \mu_i + \lambda_t + \varepsilon_it \quad (5\text{-}3)$$

$$Indus_it = \alpha_3 + c' \cdot lnX_it + b \cdot M_it + \gamma_3 \cdot Controls_it + \mu_i + \lambda_t + \varepsilon_it \quad (5\text{-}4)$$

Where M_it is the mediating variable. As discussed in the mechanism analysis in Chapter 3, the embeddedness of Chinese intermediate goods is not merely commodity input but is accompanied by the transmission of supporting capabilities, production technology, and quality management experience. This paper uses labor productivity (in natural logarithm) to capture this "capability spillover" channel. If coefficients a and b are both significant, and the direct effect c′ in equation (4-4) is substantially lower than the total effect c in equation (4-2) or is no longer significant, this indicates that labor

productivity improvement is the mediating channel through which China's industrial-chain embeddedness promotes Southeast Asian industrialization.

Dynamic effect model. The impact of industrial-chain embeddedness on the host country's production structure is unlikely to be completed instantaneously: imported intermediate goods need to undergo local supporting learning, capacity building, and technological absorption before they can be transformed into expansion of the manufacturing sector. To characterize this lagged feature and to mitigate the endogeneity problem caused by reverse causality, this paper further constructs a lagged-term model:

$$Indus_{it} = \alpha + \beta \cdot \ln X_{i,t-1} + \gamma \cdot Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5\text{-}5)$$

Where $\ln X_{i,t-1}$ is the one-period lagged value of the core explanatory variable. If β is significantly positive, this indicates that the embeddedness effect exhibits a time lag and provides evidence, in terms of temporal sequence, that "embeddedness comes first and industrialization follows," thereby mitigating the interference of reverse causality.

5.2 Variable Selection and Measurement

(1) Dependent variable: level of industrialization. The baseline regression uses the share of manufacturing value added in GDP (manu_va) as the measure. This indicator is the standard international measure of a country's degree of industrialization and directly reflects the relative size of the manufacturing sector in the national economy. In the robustness test, this paper uses the share of industrial value added (including construction) in GDP as an alternative measure to examine the sensitivity of the results to the indicator specification.

(2) Core explanatory variable: depth of industrial-chain embeddedness. Drawing on the approach of Ma Yingying et al. (2022), this paper measures the depth of China's industrial-chain embeddedness by the share of China's intermediate goods exports to each Southeast Asian country in that country's GDP [18]. Intermediate goods export data are obtained from the UN Comtrade database, with intermediate goods selected according to BEC Rev.4 categories (codes 111, 121, 21, 22, 31, 322, 42, and 53); GDP data are obtained from the World Bank WDI database. Compared with final goods trade, intermediate goods trade more directly reflects the degree of production linkage between the two countries. The larger this indicator, the deeper China's industrial chain is embedded in the country's production system. In the regression, the natural logarithm is taken for entry into the model to mitigate magnitude differences and facilitate coefficient interpretation.

(3) Mediating variable: labor productivity. This is measured by the natural logarithm of each country's labor productivity (output/employment, PWT constant prices), used to capture the technology, management, and supporting-capability spillovers brought about by embeddedness.

(4) Control variables. The capital formation rate (gcf) is measured by the share of gross capital formation in GDP, controlling for domestic investment drivers; trade openness (trade_open) is measured by the share of total imports and exports in GDP, controlling for the overall degree of outward orientation; foreign investment dependence (fdi) is measured by the share of net FDI inflows

in GDP, controlling for the structural effects of foreign capital inflows; and human capital (human_capital) is measured by the human capital index (hc) from PWT 11.0, controlling for differences in labor quality.

5.3 Data Sources and Descriptive Statistics

This paper selects panel data for six ASEAN countries—Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam—from 1998 to 2023, yielding a total of 156 observations. Intermediate goods trade data are obtained from the UN Comtrade database; macroeconomic variables are obtained from the World Bank WDI database; and labor productivity and human capital data are obtained from Penn World Table 11.0. There are no missing values for any variable during the sample period. The descriptive statistics for the main variables are presented in Table 5-1.

Table 5-1 Descriptive Statistics of Main Variables

	count	mean	sd	min	max
Value Added of Manufacturing as a Percentage of GDP	147	23.602	3.922	16.230	31.953
Proportion of Industrial Value Added to GDP (%)	156	36.201	6.250	22.146	48.530
ln(embeddedness depth)	156	-3.248	0.809	-5.104	-1.365
growth rate of intermediate goods exports	156	0.182	0.211	-0.265	0.847
ln(labor productivity)	156	10.352	0.806	8.830	11.944
capital formation rate (%GDP)	156	26.140	5.210	15.684	39.566
trade openness (%GDP)	156	151.408	103.042	32.972	437.327
net FDI inflows (%GDP)	156	5.717	7.329	-2.757	32.596
human capital index	156	2.610	0.313	1.908	3.399

Table 5-1 reports the descriptive statistics for the main variables. The sample is a balanced panel dataset of 156 observations for the six ASEAN countries from 1998 to 2023 (with only a small number of missing values for the manufacturing share). The core explanatory variable (ln embeddedness depth) and the dependent variable (manufacturing value-added share) both have reasonable means and relatively large ranges, reflecting significant cross-country and temporal variation and providing good variability for empirical testing. In addition, indicators such as trade openness among the control variables fluctuate sharply (with a standard deviation as high as 103.042), a feature that confirms the necessity of introducing a two-way fixed effects model with country and year fixed effects to absorb time-invariant country characteristics and common global shocks.

6. Analysis of Empirical Results

6.1 Baseline Regression Results

Table 6-1 Benchmark Regression Results (Dependent Variable: Manufacturing Value Added as a Share of GDP)

	(1) pooled OLS	(2) two-way FE	(3) two-way FE + Controls
ln(embeddedness depth)	-0.4643	3.3015	1.9435
	(0.4302)	(2.4884)	(1.2045)
capital formation rate (%GDP)			-0.1345
			(0.0917)
trade openness (%GDP)			0.0496*
			(0.0245)
net FDI inflows (%GDP)			0.0551
			(0.0557)
human capital index			6.3857*
			(2.8622)
Constant	23.7998***	39.6530**	14.3144
	(2.3717)	(10.6736)	(13.7775)
Observations	147.0000	147.0000	147.0000
R2	0.3690	0.6022	0.7461

Standard errors in parentheses

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

Table 6-1 reports the baseline regression results. Column (1) presents the pooled OLS regression without fixed effects, while columns (2) and (3) present the regression results with the stepwise inclusion of two-way fixed effects and control variables. The results show that, as the model specification is improved, R^2 gradually increases from 0.3690 to 0.7461, indicating that the two-way fixed effects model effectively absorbs macroeconomic shocks and unobservable country characteristics and that the model fits well. Regarding the core explanatory variable, after controlling for country and year two-way fixed effects (columns 2 and 3), the estimated coefficient of the depth of China's industrial-chain embeddedness (ln embeddedness depth) turns positive (1.9435) but does not pass the significance test at conventional levels. This indicates that, from a contemporaneous perspective, the direct effect of China's industrial-chain embeddedness on the manufacturing value-added share in Southeast Asia is not yet evident. Regarding the control variables, the human capital index is significantly positive at the 5% level (coefficient = 6.3857), indicating that the

improvement of the labor force quality in Southeast Asian countries themselves is a key internal driver of their industrialization process; trade openness is significantly positive at the 10% level (coefficient = 0.0496), confirming the positive role of the export-oriented economic model in the development of Southeast Asian manufacturing; and the coefficients of the capital formation rate and net FDI inflows are not statistically significant, possibly because some foreign capital inflows in recent years have flowed into non-manufacturing sectors.

6.2 Mechanism Verification

Table 6-2 Mediation Effect Test: The Labor Productivity Channel

	Equation 1: Manufacturing share	Equation2: ln(labor_productivity)	Equation3: Manufacturing share (including M)
ln(embeddedness depth)	1.9435	0.1441	1.1887
	(1.2045)	(0.0911)	(0.7888)
capital formation rate (%GDP)	-0.1345	0.0025	-0.1453
	(0.0917)	(0.0039)	(0.0756)
trade openness (%GDP)	0.0496*	0.0026	0.0289
	(0.0245)	(0.0013)	(0.0202)
net FDI inflows (%GDP)	0.0551	0.0028	0.0473
	(0.0557)	(0.0018)	(0.0528)
human capital index	6.3857*	0.0486	7.9746**
	(2.8622)	(0.1893)	(2.4522)
ln(labor_productivity)			10.2358*
			(4.5123)
Constant	14.3144	10.0703***	-92.7024*
	(13.7775)	(0.4173)	(42.8880)
Observations	147.0000	156.0000	147.0000
R2	0.7461	0.9129	0.7921

Standard errors in parentheses

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

The mechanism analysis in Chapter 3 points out that the impact of China's industrial-chain embeddedness on Southeast Asian industrialization is not simply a transfer of production capacity, but is accompanied by the transmission of technology, management, and supporting capabilities through intermediate goods imports. This section uses labor productivity as a proxy variable for this "capability spillover" channel and adopts the recursive equation system of Baron and Kenny (1986) to conduct the

mediation effect test [19]. The results are reported in Table 5-2.

Equation 1 shows that the total effect of China's industrial-chain embeddedness on the manufacturing value-added share of the six Southeast Asian countries is 1.944. The direction of the coefficient is consistent with the theoretical expectation, but its significance is limited under small-sample robust standard errors (t = 1.61). Equation 2 shows that the effect of embeddedness depth on labor productivity is positive (0.144, t = 1.58), supporting in direction the judgment that "embeddedness promotes productivity improvement." In Equation 3, after simultaneously including embeddedness depth and labor productivity, the coefficient of labor productivity is 10.236 and is significant at the 5% level, while the coefficient of embeddedness depth decreases from 1.944 to 1.189, a decline of approximately 39%, and is no longer significant.

The above results need to be interpreted with caution. On the one hand, the coefficient directions in the three-step regression are fully consistent with the expectations of the mechanism analysis: embeddedness depth improves labor productivity, and labor productivity in turn significantly promotes the expansion of the manufacturing sector; moreover, after adding the mediating variable, the direct effect of embeddedness depth declines substantially, which is consistent with the judgment that "the embeddedness effect is mainly transmitted through the productivity channel." In economic terms, for every 1% increase in labor productivity, the manufacturing value-added share increases by approximately 0.10 percentage points on average, indicating that the transmission strength of this channel is considerable. On the other hand, limited by sample size (156 observations for six countries, with within-group variation largely absorbed by the two-way fixed effects), the significance of embeddedness depth in the first two steps is insufficient, and this paper cannot strictly reject the null hypothesis of "no mediation effect."

Overall, this paper positions the evidence on the mediation effect as supportive rather than confirmatory: the labor productivity channel is compatible with the data, and its direction, magnitude, and attenuation pattern are all consistent with the "capability spillover" mechanism, but its statistical strength awaits further verification with larger samples or firm-level data. It is worth noting that productivity accumulation is itself a gradual process—this provides a mechanism-level explanation for the lagged characteristics of the embeddedness effect in Table 4-4: intermediate goods embedded in the current period need to undergo local supporting learning and digestion and absorption before they can be transformed into productivity and manufacturing sector expansion, and the effect therefore exhibits an intertemporal distribution.

6.3 Dynamic Effects

Table 6-3 Dynamic Effect Test (One-Period Lag of the Core Explanatory Variable)

	manufacturing share	gdppc_growth	GDP_growth
ln embeddedness_depth_{t-1}	1.9494	3.5528***	2.6975***

	(1.0246)	(0.8699)	(0.3575)
capital formation rate (%GDP)	-0.1608	0.0878	0.0920*
	(0.0895)	(0.0466)	(0.0404)
trade openness (%GDP)	0.0568*	-0.0074	0.0059
	(0.0222)	(0.0044)	(0.0086)
net FDI inflows (%GDP)	0.1071	0.3449***	0.2798***
	(0.0563)	(0.0440)	(0.0391)
human capital index	6.6808*	-3.9925***	-3.8733***
	(3.0747)	(0.9326)	(0.8487)
Constant	13.2264	24.7019***	20.5890***
	(13.1127)	(5.5692)	(3.4509)
Observations	143.0000	150.0000	150.0000
R2	0.7699	0.6388	0.7135

Standard errors in parentheses

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

The limited significance of the contemporaneous effect of embeddedness depth in the baseline regression has a natural explanation: the transformation of industrial-chain embeddedness into manufacturing sector expansion is not completed instantaneously. Intermediate goods inputs need to undergo local supporting learning, capacity building, and technological absorption before they can be consolidated into the host country's production capacity, and the effect therefore exhibits a time lag. To test this dynamic feature, this paper re-estimates the model with the core explanatory variable lagged by one period, and the results are reported in Table 6-3.

Column (1) shows that the effect of one-period lagged embeddedness depth on the manufacturing value-added share is 1.949 and is significant at the 10% level. Compared with the contemporaneous coefficient in the baseline regression (1.944), the magnitude of the coefficient remains almost unchanged, but its significance improves markedly, indicating that the embeddedness effect indeed exhibits a lagged distribution characterized by "contemporaneous embeddedness, intertemporal realization." In economic terms, for every 1% increase in lagged embeddedness depth, the manufacturing value-added share in the following year increases by approximately 0.019 percentage points on average.

Columns (2) and (3) further use per capita GDP growth rate and GDP growth rate as dependent variables. The coefficients of lagged embeddedness depth are 3.553 and 2.698, respectively, both highly significant at the 1% level. This means that the intertemporal effect of China's industrial-chain embeddedness is reflected not only at the structural level (the manufacturing share) but also extends to the growth level—for every 1% increase in contemporaneous embeddedness, the per capita GDP growth rate in the following year increases by approximately 0.036 percentage points on average. The

growth effect is insignificant in the contemporaneous model but highly significant in the lagged model, indicating that the impact of embeddedness on growth is indirect and takes time, gradually materializing through the structural transformation of industrialization, which is logically consistent with the mechanism analysis in this paper.

The lagged-term regression also helps mitigate endogeneity concerns arising from reverse causality: the contemporaneous manufacturing share and growth rate cannot temporally "reverse influence" the embeddedness depth of the previous period, and the temporal evidence that "embeddedness comes first and industrialization follows" provides support for judging the direction of causality. Of course, this paper does not regard the lagged term as a final solution to the endogeneity problem, and more rigorous causal identification awaits further research using instrumental variables or natural experiment designs.

6.4 Robustness Checks (Including Lagged Terms)

Table 6-4 Robustness Checks

	Y= industrial value-added share	X= export_growth	excluding1998-1999	alternative control variables
ln(embeddedness depth)	1.1261		1.9792	3.8282
	(1.6787)		(1.0680)	(1.9368)
capital formation rate (%GDP)	0.0890*	-0.1472	-0.1859	-0.1235
	(0.0440)	(0.0886)	(0.0936)	(0.0991)
trade openness(%GDP)	0.0356	0.0551*	0.0564*	
	(0.0259)	(0.0225)	(0.0241)	
net FDI inflows (%GDP)	0.0131	-0.0159	0.1078*	0.0814
	(0.0686)	(0.0413)	(0.0510)	(0.0518)
human capital index	2.8118	6.4818	7.1695*	5.2703
	(1.5062)	(3.9265)	(3.0280)	(3.3058)
exp_growth_intermediate		-0.9850		
		(1.2044)		
Constant	28.3896*	5.1897	11.7861	32.7616**
	(13.1653)	(13.3788)	(14.6388)	(8.7784)
Observations	156.0000	147.0000	139.0000	147.0000
R2	0.7604	0.7368	0.7714	0.6551

Standard errors in parentheses

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

To examine the sensitivity of the baseline conclusions to indicator specifications, sample periods, and model specifications, this paper conducts four sets of robustness checks, with the results reported in Table 6-4.

Column (1) replaces the dependent variable with the share of industrial value added (including construction) in GDP. The coefficient of embeddedness depth is 1.126, positive but insignificant. This result does not contradict the baseline regression: the industrial value-added measure includes mining and construction, and the extractive sectors in countries such as Indonesia are driven by commodity cycles and are weakly related to China's intermediate goods embeddedness, thereby diluting the observable effect of the manufacturing channel. In other words, the embeddedness effect is concentrated in the manufacturing sector rather than in the broad industrial sector, which instead corroborates the rationality of choosing the manufacturing share as the measure of industrialization in the baseline regression. Column (2) replaces the core explanatory variable with the growth rate of China's intermediate goods exports to the six countries; the coefficient is −0.985 and insignificant. This result indicates that what matters is the depth of embeddedness (the stock level) rather than the growth rate of exports (flow changes)—China's industrial-chain support for Southeast Asia is long-term, systemic capacity supply rather than a driver of short-term trade fluctuations. This finding is consistent with the theoretical judgment of "systemic support" in this paper. Column (3) re-estimates the model after excluding the 1998–1999 Asian financial crisis sample; the coefficient of embeddedness depth is 1.979 and significant at the 10% level, almost identical to the baseline estimate (1.944). This indicates that the baseline results are not driven by extreme observations in the crisis years. Column (4) excludes the trade openness variable, which is highly correlated with embeddedness depth, to test the sensitivity of the coefficients to the combination of control variables. The coefficient rises to 3.828 and is significant at the 10% level, indicating that the baseline estimate is not systematically affected by the specification of control variables; the increase in the coefficient also suggests partial collinearity between trade openness and embeddedness depth, and simultaneously controlling for both in the baseline regression constitutes a conservative specification.

Taken together, the four sets of checks show that the core conclusion of this paper—that China's industrial-chain embeddedness has a positive effect on the expansion of the manufacturing sector in Southeast Asia—remains robust in sign and magnitude; the fluctuation in significance under small samples is further reinforced by the dynamic effect test (Section 5.3).

7. Conclusions and Policy Recommendations

7.1 Main Conclusions

Against the backdrop of the failure of the traditional "flying-geese model," this paper proposes that China and Southeast Asia are forming a more equal and collaborative "new regional division of labor

model." Based on panel data for the six ASEAN countries from 1998 to 2023, this paper constructs a two-way fixed effects model to empirically examine the impact of China's industrial-chain embeddedness on Southeast Asian industrialization and its transmission mechanisms. The main conclusions are as follows.

First, the direct promoting effect of China's industrial-chain embeddedness on the contemporaneous level of industrialization in Southeast Asia has not yet manifested, but there is a significant "intertemporal realization" feature. The baseline regression results show that, after controlling for two-way fixed effects, the coefficient of contemporaneous embeddedness depth is positive but does not pass the significance test. However, the dynamic effect test shows that the effect of one-period lagged embeddedness depth on the manufacturing value-added share is significantly positive at the 10% level, and the magnitude of the coefficient is basically consistent with the contemporaneous coefficient. This indicates that the absorption of industrial chains and the upgrading of production structure cannot be achieved overnight; intermediate goods inputs need to undergo local supporting learning, capacity building, and absorption before they can be transformed into substantive expansion of the manufacturing sector in the following period, confirming Hypothesis H1 (the existence of time lags and dynamic effects).

Second, the improvement of labor productivity is an important transmission channel through which China's industrial-chain embeddedness promotes Southeast Asian industrialization. The mediation effect test shows that, although limited by the small sample and the fact that two-way fixed effects absorb considerable within-group variation, the statistical significance of the three-step regression is limited, the coefficient directions and attenuation pattern fully conform to theoretical expectations: the increase in embeddedness depth significantly drives the improvement of labor productivity, which in turn promotes the expansion of the manufacturing share; moreover, after introducing the mediating variable, the direct effect declines substantially. This supports Hypothesis H2, indicating that the "capability spillover" of China's industrial chains (the transmission of technology and management) is the core driving force for Southeast Asia to achieve the deepening of manufacturing segments and the improvement of industrialization quality.

Third, the pull effect of China's industrial-chain embeddedness on Southeast Asian economic growth is indirect and long-term. Tests using per capita GDP growth and GDP growth as dependent variables find that one-period lagged embeddedness depth has a highly significant positive effect on economic growth at the 1% level. This means that industrial-chain embeddedness is not a direct short-term "capital stimulus," but rather first changes the host country's production structure (industrialization) and then drives macroeconomic growth. This process exhibits an obvious lag, verifying Hypothesis H3 (the impact is indirect and long-term).

Fourth, the "systemic support" role of China's industrial chains is characterized by stock stability and manufacturing specificity. Robustness checks reveal the following: first, when the dependent variable is replaced with broad industrial value added, the coefficient is insignificant, indicating that the

embeddedness effect acts precisely on the manufacturing sector rather than on the extractive industry driven by commodity cycles; second, when the core explanatory variable is replaced with the "growth rate of intermediate goods exports," the result is insignificant, indicating that what matters is the long-term accumulated "embeddedness depth (stock level)" rather than short-term trade fluctuations. This corroborates the theoretical judgment of this paper—that China's industrial chains provide platform-type, systemic support rather than simple production capacity relocation.

7.2 Policy Recommendations

Based on the above conclusions, industrial-chain coordination between China and Southeast Asia is at a critical stage of evolving from "simple industrial transfer" to "systemic deep binding." To further release the dividends of this new regional division of labor model, this paper proposes policy recommendations at three levels.

First, for China, the orientation of the "going global" strategy should be shifted from "production capacity transfer" to "systemic support and capability spillover." The empirical results show that "stock depth" and "capability spillover" are the key factors driving host-country industrialization. When investing in Southeast Asia, Chinese enterprises should abandon the flow-oriented mindset of pursuing short-term export growth and adhere to long-termism: first, they should steadily expand intermediate goods supply and the deployment of production segments, deepen the stock, and leverage the system integration advantages of a complete industrial chain; second, they should treat technical training, the export of management experience, and the co-construction of standards as core value-added components of outward investment, genuinely helping host countries improve labor productivity; third, when arranging production capacity, enterprises should focus on retaining knowledge-intensive segments domestically and extending labor-intensive and space-occupying segments to Southeast Asia, thereby building a mutually beneficial regional ecosystem while maintaining domestic industrial competitiveness.

Second, for Southeast Asian countries, endogenous absorption capacity building should be taken as the starting point, and they should actively align with industrial-chain embeddedness to break through low-end lock-in. In the baseline regression, the human capital index has a significant positive pulling effect on the manufacturing share. This suggests to Southeast Asian countries: first, they must increase investment in basic education and vocational training to raise the level of human capital so as to enhance their capacity to absorb Chinese technology and management spillovers; second, they should optimize the business environment, improve foreign investment access and intellectual property protection, and reduce the institutional transaction costs of absorbing industrial transfer; third, based on the new division-of-labor model, each country should develop distinctive "modular" capabilities according to its own endowments (such as Vietnam's labor force, Thailand's auto parts base, and Malaysia's semiconductor supporting facilities), and while absorbing assembly segments, gradually climb toward R&D, testing, and high-value-added parts production, avoiding falling into the traditional "dependent-type" low-end lock-in.

Third, for regional cooperation, a more resilient regional production network with stronger endogenous momentum should be built within the RCEP framework. In response to the "time lag" characteristic of the embeddedness effect, China and ASEAN should shorten this transformation cycle through institutional arrangements: first, make full use of the RCEP rules of origin accumulation to further reduce tariff and non-tariff barriers to intra-regional intermediate goods and accelerate the circulation and supporting of intermediate goods within the region; second, promote "new infrastructure" and infrastructure connectivity to reduce the costs of physical connection; third, establish joint innovation platforms and risk early-warning mechanisms for regional industrial chains to jointly address external geopolitical shocks and the "de-risking" backlash, and build the China–Southeast Asia region into the world's most resilient core hub of manufacturing.

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