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RESEARCH ARTICLE

Unified National Market, Regional Technological Diversification, and Enterprise Technological Complexity*

BIAN Yuanchao[a], BAI Junhong[a]

Abstract

Fostering a diverse regional technology environment within a unified national market is one of the key approaches to encouraging enterprises to enhance technological complexity. From the perspective of regional technological diversification, this paper investigates the mechanisms and effects of building unified national commodity and factor markets on enterprise technological complexity. The construction of unified national commodity, labor, and capital markets helps enhance enterprise technological complexity. The development of a unified national market cultivates diversified market demand and factor supply, thereby promoting regional technological diversification and advancing enterprise technological complexity. Both related and unrelated regional technological diversification have played a significant positive role in enhancing enterprise technological complexity during the construction of a unified national market. Further research reveals that a unified national market facilitated by transportation infrastructure development significantly enhances enterprise technological complexity, whereas a unified national market promoted by local government policies does not yield notable effects. Moreover, owing to the spatial correlation of unified national market construction, the level of such markets in adjacent regions positively influences the technological complexity of local enterprises. Finally, the development of a unified national market primarily increases the technological complexity of non-state-owned and high-tech enterprises, while its impact on state-owned and non-high-tech enterprises is not statistically significant. The conclusions of this study provide insights for fully recognizing the benefits of building a unified national market and for accelerating enterprises' scientific and technological self-reliance.

Keywords unified national market; regional technological diversification; technological complexity; knowledge breadth

1 Introduction

Amid profound adjustments in the global economic landscape and a complex interplay of various uncertainties and instabilities, how to more effectively establish a new development paradigm with domestic circulation as the mainstay, foster a diversified technology

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[a] School of Business, Nanjing Normal University, Nanjing 210023, China

environment within the vast domestic market, and thereby incentivize enterprises to strengthen complex technology research and development (R&D) and enhance technological complexity, have become a critical issue that demands urgent attention in China's pursuit of scientific and technological self-reliance and high-quality economic development.

In fact, for an emerging economic powerhouse like China, the diverse resource endowments across its regions offer opportunities to cultivate a rich and varied regional technology environment. In recent years, China has intensified the reform of its socialist market economy, promoted coordinated regional development, eliminated various forms of local protectionism and market segmentation, and worked to build a unified national market. In March 2022, the Central Committee of the Communist Party of China and the State Council issued the *Guideline on Accelerating the Establishment of a Unified Domestic Market*[1] (hereinafter referred to as the "Guideline"), which calls for accelerating the establishment of unified national market institutions and rules, eliminating local protectionism and market segmentation, removing impediments restricting economic circulation, and facilitating the smooth and broad flow of goods and factors of production. From an economic perspective, a unified national market is defined as a market system in which various commodities and factors flow freely across regions, and the market operates in an integrated fashion nationwide. This is achieved through robust competition among market entities, underpinned by unified policies, consistent rules, and coordinated implementation (Liu, 2023). Therefore, the foundation of a unified national market is institutional consistency, with robust market competition as the key driving force and the free flow of goods and factors as its core feature. Its main aspects include the unification of commodity markets and the unification of factor markets (such as labor and capital markets). A unified national market not only facilitates interregional commodity trade, expands the market reach for local enterprises, and increases the diversity of market preferences, but also optimizes the allocation of factors across regions, broadens both the scale and types of factors available, and diversifies the structure of factor supply. This, in turn, provides both demand-side and supply-side support for the advancement of regional technological diversification.

More importantly, a regionally diverse technology environment not only breaks down technological isolation, enabling the recombination of a wider range of differentiated knowledge on a larger scale (Miller, 2006) and expanding the breadth of enterprises' technology knowledge base, but also fosters competition and substitution between different technical fields, as well as between new and existing technologies, thereby motivating enterprises to conduct R&D of complex technologies. Compared with simple and low-end technologies, complex technologies feature a more diversified knowledge base, higher R&D difficulty, and greater technological barriers, making them less susceptible to imitation. Such technologies can more effectively establish technological monopolies and market monopoly returns (Zhang & Zheng, 2018), enabling enterprises to rapidly escape from

[1] The corresponding Chinese title is 中共中央 国务院关于加快建设全国统一大市场的意见.

market competition (Bian & Bai, 2022). However, the R&D of complex technologies not only requires substantial and diversified innovation resources, but also demands sufficient technological competition pressure, both of which place higher demands on the creation of a diverse regional technology environment. Therefore, different from the historical experience of developed countries, regions characterized by diverse technological components and a variety of technologies are often more effective in overcoming technology path dependence (Kim & Tang, 2020; Savino et al., 2017), fostering complex technological knowledge systems, and cultivating non-replicable developmental advantages (Balland & Rigby, 2017).

With the deepening implementation of China's coordinated regional development strategy, recent years have seen scholars examine how domestic market segmentation or regional integration during China's economic transformation has affected enterprise technological innovation (Li et al., 2022; Qing & Huang, 2021). They have also highlighted, from various perspectives, the positive significance of eliminating market segmentation and building a unified national market (Chen et al., 2021; Chen & Zhao, 2023; Liu, 2022). Unfortunately, previous research has not systematically examined, from the perspective of regional technological diversification, how the construction of a unified national market promotes the development of technological diversity in different regions and thereby influences enterprise technological complexity. This oversight may hinder a comprehensive understanding of the intrinsic relationship between the establishment of a unified national market and the enhancement of enterprise technological complexity, and is also not conducive to the in-depth exploration of strategies for achieving breakthroughs in core technologies in key fields and fostering scientific and technological self-reliance in the new era.

Amidst profound changes not seen in a century, China, as an emerging major country, must overcome institutional and systemic obstacles that restrict the market-oriented allocation of production factors and the circulation of goods and services in order to build a new development paradigm with domestic circulation as the mainstay (Fan & Zhou, 2022). By doing so, a unified national market can foster the development of regional technological diversification and drive the advancement of enterprise technological complexity. Therefore, from the perspective of regional technological diversification, this study investigates the impact mechanism through which the construction of a unified national market (including commodity and factor markets) promotes the increase in enterprise technological complexity. Utilizing micro-level data from Chinese industrial enterprises, an empirical analysis was conducted to assess these effects. This study finds that the establishment of unified national commodity and factor (labor and capital) markets helps enhance enterprise technological complexity. The primary operational mechanism is that building a unified national market raises the level of regional technological diversification. Moreover, both related and unrelated regional technological diversification have played a significant positive role in enhancing enterprise technological complexity during the construction of a unified national market. This study may offer the following two marginal contributions:

Firstly, compared with previous research, this study examines the impact of building

a unified national market on enterprise technological complexity from the perspective of regional technological diversification. It clarifies the underlying mechanism through which the construction of unified national commodity and factor markets influences the development of regional technological diversification and, in turn, affects enterprise technological complexity. This helps to further expand the research framework regarding the relationship between domestic market segmentation and enterprise technological innovation, and also provides valuable insights for more comprehensively identifying the factors that contribute to the enhancement of technological complexity among Chinese enterprises. Secondly, compared with previous research, this study closely examines the main path of building a unified national market in China. Specifically, it investigates the driving mechanisms of this unified national market from two perspectives: policy promotion by local governments and the development of transportation infrastructure. Furthermore, it explores how both a unified national market promoted by local government policies and that facilitated by transportation infrastructure affect the enhancement of technological complexity among enterprises. This study helps us better understand the pathways through which the construction of a unified national market affects enterprise technological complexity, and also provides a reference for China to further accelerate the formulation of policies for a unified national market.

2 Literature Review

A unified national market embodies the integrated state of markets across different regions within the country. According to the explanation of the Law of One Price, a truly unified national market refers to a situation where, provided trade occurs or can occur freely, the price of a given commodity or factor, after deducting transaction costs, is equal in different regional markets when measured in the same currency (Góes & Matheson, 2017). If the prices of a commodity or factor differ between two regions, it may be due to various forms of trade barriers or obstacles to market accessibility arising from factors such as geographical distance or transportation. Therefore, scholars have examined the factors influencing the construction of a unified national market from two perspectives: institution-related factors and transportation infrastructure factors.

Most studies hold that incentive distortions among local governments during China's economic transformation and the resultant local protectionism are major drivers of "unnatural market segmentation" and the primary obstacles to building a unified national market (Bian & Bai, 2021; Chen & Yan, 2024). Young (2000) argues that China's reform of the economic system has been accompanied by significant incentive distortions and resource misallocation. Decentralization has fostered a group of vested interests, and in order to protect these interests, local governments tend to engage in further resource distortions, suppress market competition, and create a "fragmented and segmented domestic market." Mok and Wu (2013) also contend that fiscal decentralization is a key factor contributing to the localization of

social welfare and the rise of local protectionism. Therefore, facilitating domestic circulation and achieving domestic market integration require fundamentally reshaping the fiscal incentives of local governments (Fan & Zhou, 2022), and eliminating regional barriers and protectionist practices that impede the flow of production factors, goods, and services across regions (Chen et al., 2021). However, some studies believe that a complex geographical environment can result in "market segmentation in the natural sense." Underdeveloped infrastructure raises trade costs and hinders regional integration into a unified market (Donaldson, 2018). Therefore, advancements in transportation can reduce transaction costs between regions, accelerate the flow of production factors (Mao et al., 2022), and alter the dynamic equilibrium between centripetal and centrifugal forces in the spatial distribution of industries (Nawaz & Mangla, 2021), thereby promoting integrated regional development (Ma & Huang, 2023; Sun et al., 2019; Wang & Hou, 2022).

In recent years, as China has advanced coordinated regional development, scholars have increasingly focused on issues of technological innovation in the context of building a unified national market. Some empirical studies use regional market segmentation as an entry point to examine its inhibitory effect on technological innovation. Qing and Huang (2021) argue that enterprise technological innovation is driven by dual incentives from domestic and international markets, but domestic market segmentation leads to shrinking domestic sales, weakening these incentives and ultimately hindering enterprise technological innovation. Shen and Wang (2015) also find that market segmentation reduces R&D investment by innovation entities, thereby hindering technological innovation. However, the study by Li et al. (2020) reveals an inverted U-shaped relationship between market segmentation and enterprise technological innovation; specifically, a lower level of market segmentation facilitates technological innovation within enterprises, while excessive market segmentation is detrimental to such innovation. Meanwhile, some scholars have focused their studies on how to reverse regional market segmentation and promote technological innovation activities through regional integration (Lei & Lang, 2020). Among these, most studies examine the impact of government-driven regional market integration and market consolidation on technological innovation. Based on a framework of regional integration under policy guidance, Li and Chen (2021) find that local government initiatives to advance regional integration policies help stimulate technological innovation. Li et al. (2022) have investigated the influence of the Yangtze River Delta Urban Economic Coordination Committee, an interregional market integration mechanism led by local governments, on enterprises' selection of partners for cooperative innovation. Their findings indicate that collaboration with cities participating in the Economic Coordination Committee yields more pronounced results in terms of innovation. Kong et al. (2022) have also assessed the impact of integration enlargement policies in the Yangtze River Delta on regional innovation. They find that integration enlargement policies are conducive to enhancing regional innovation capabilities.

Previous research literature has provided valuable reference for this study in examining the relationship between the construction of a unified national market and enterprise

technological complexity. However, extant studies have not considered the role of regional technological diversification—that is, they have overlooked how such diversification, prompted by the establishment of a unified national market, affects the advancement of technological complexity within enterprises. In the era of open innovation, technological diversification is characterized by the extension of innovation entities' technical capabilities into different fields (Chen et al., 2012; Li & Zhao, 2020). In essence, this refers to the efforts of innovation entities to maintain and strengthen their core competitiveness by expanding their R&D and technological knowledge base into new areas, thereby acquiring new technical capabilities or enhancing existing ones (Lin & Chen, 2014). This strategy of breaking through existing technological boundaries and adopting a diversified R&D approach not only allows for the acquisition of heterogeneous resources from various fields, broadens innovation experience, and facilitates the sharing of information and knowledge, but also contributes to achieving economies of scope in technological R&D activities, reducing R&D costs and risks (Garcia-Vega, 2006), and thus enhancing technological innovation capabilities (Lopez-Vega et al., 2016). At the regional level, technological diversification primarily manifests as a process in which different innovation entities within a region reshape technological networks, thereby expanding the region's technological domains and enabling the dynamic evolution of its technological comparative advantages. Zheng and Ran (2021) argue that regional technological diversification refers to the process by which enterprises within a region continuously innovate and adopt new technologies. This results in the expansion of the region's technological domains, leading to changes in the portfolio and structure of regional technologies. In a diverse regional technology environment, not only does it drive technological competition both among enterprises and between new and old technologies (Yang et al., 2022), but it also accelerates knowledge integration and spillovers, thereby contributing to the enhancement of enterprise technological complexity.

The greater the degree of uniformity between the local market and other regional markets, the more it facilitates the trade of local goods across regions and the flow of production factors between them. This not only expands the scale of market demand for local products and enriches the diversity of market preferences, providing demand-side incentives for the development of regional technological diversification, but also increases the supply of production factors in the region and enhances their variety. In turn, this supports regional technological diversification from the supply side. Therefore, building a unified national market (commodity market and factor market) fosters a diversified regional technology environment, which in turn promotes the advancement of enterprise technological complexity. From this perspective, overlooking the role of regional technological diversification may hinder a comprehensive understanding of the internal mechanisms by which the construction of a unified national market affects enterprise technological complexity. It may also impede us from identifying, more deeply, the key factors affecting the quality of technological innovation and the R&D of complex technologies within Chinese enterprises. This paper investigates the impact of building unified national commodity and factor (labor and capital)

markets on the enhancement of enterprise technological complexity. Furthermore, it analyzes the impact mechanism from the standpoint of regional technological diversification, aiming to more thoroughly elucidate the pathways through which a unified national market incentivizes enterprises to advance their technological complexity.

3 Research Hypotheses

3.1 Impact Mechanism of Unified National Market Construction on Enterprise Technological Complexity: From the Perspective of Regional Technological Diversification

A more diversified technology base is a crucial factor for regions seeking to enhance their capacity for technological innovation and achieve sustainable long-term economic growth. The realization of regional technological diversification requires not only a more differentiated supply of factors, but also demand-driven incentives shaped by diverse preferences. Theoretically, different regions within a large economy possess distinct resource endowments and varying demand preferences, which creates the conditions necessary for a diversified regional technology environment. In recent years, China has steadily accelerated coordinated regional development and the construction of a unified domestic market, actively eliminating regional blockades and local protectionism, strengthening transportation infrastructure, and enhancing connectivity among regions to facilitate the flow of goods and production factors. These efforts not only increase the disparity in preference among regional product markets but also promote the exchange and integration of production factors across regions, thereby providing diversified market demand incentives and factor supply support for the development of regional technological diversification.

Specifically, the development of a unified national market facilitates the formation of diversified market demands across regions, enhancing the disparity in demand preferences for local products. This, in turn, promotes the advancement of regional technological diversification. Within a unified national market, institutional barriers among local governments are gradually being eliminated, and regional interconnectivity is rapidly increasing. As a result, the domestic market space available to local enterprises expands, and interregional trade becomes more convenient, contributing to the growth in market demand for enterprise products (Li et al., 2019). Furthermore, as transportation infrastructure, such as high-speed railways and expressways, continues to develop, trade channels for various goods between regions become smoother, transportation costs decrease, and efficiency improves. These factors further enhance the market accessibility of enterprise products and broaden market opportunities. More importantly, according to the principle of technological comparative advantage, the structure of regional market demand determines the technological structure, and a region's product comparative advantage determines its technological comparative advantage. Under regional market segmentation, enterprises' product market demand is largely confined to the local region. The market demand preference structure for products within the region tends to be relatively simple, resulting in R&D and innovation

activities aimed at meeting market demand being predominantly focused on the region's areas of technological comparative advantage. Therefore, as a unified national market is established, the scope of product market demand for local enterprises expands, exposing them to a more diverse range of market demand preferences. This fosters R&D activities that move beyond the region's established areas of technological comparative advantage in order to respond to more varied market demand preferences, thereby promoting the region's technological diversification.

Besides, building a unified national market facilitates diversified factor supply, increases the variety of factors involved in regional R&D and innovation activities, and promotes the advancement of regional technological diversification. The formation of a diverse technology environment within a region relies on a diversified supply of factors, particularly the diversity of technologies and knowledge bases inherently present in these factors. When a region's R&D factors are primarily concentrated in areas where the region holds a technological comparative advantage, the development of the region's technological diversification is largely dependent on factors from other regions. Compared with regional market segmentation, the establishment of a unified national market facilitates the free flow and optimal allocation of resources, such as R&D personnel and capital, across different regions. This not only introduces more R&D elements that go beyond the areas of technological comparative advantage of the region, directly supporting the development of regional technological diversification, but also encourages communication and integration among various R&D factors. Such interactions accelerate knowledge spillovers and the creation of new knowledge, thereby further advancing regional technological diversification.

Even more importantly, a diverse regional technology environment helps break down technological isolation, fosters the integration and spillover of different types of technologies, and accelerates technological competition, thus supporting enterprises in enhancing the complexity of their technologies. In the era of open innovation, innovation entities can enhance their technological innovation capabilities by developing competencies across multiple technical fields and pursuing technological diversification. The presence of multiple technologies not only directly supports R&D activities, but also fosters more new inventions and enhances the performance of existing products and technologies through complementary strengths and mutual promotion among different technologies (Lahiri, 2010). Garcia-Vega (2006) also believes that technological diversification facilitates the expansion of innovation resources, enriches innovation experience, enables the sharing of information and knowledge, and reduces the costs and risks associated with technology R&D. Therefore, in terms of regional technological diversification, firstly, it helps promote the deep integration of more diverse knowledge and technologies on a larger scale, accelerates technology spillover across different technical fields and knowledge bases, encourages the generation of new technologies, and provides more differentiated technological sources to support the advancement of enterprise technological complexity. Secondly, the various technological types generated by regional technological diversification can spark competition both among

enterprises and between new and existing technologies (Yang et al., 2022). This dynamic motivates enterprises to develop more complex technologies that entail higher technical barriers and monopoly advantages, thereby enhancing their technological complexity.

Hypothesis 1 (H1): The establishment of a unified national market facilitates the development of regional technological diversification, thereby enhancing enterprise technological complexity.

3.2 Examining the Impact of Both Related and Unrelated Regional Technological Diversification

Technological diversification comprises both related and unrelated types, which embody the distinction between innovation entities in terms of innovation depth and breadth. During the process of technological diversification, if new technologies share similar or even identical basic knowledge with existing technologies, this is classified as related technological diversification. Conversely, if diversified technological innovation activities extend across multiple distinct technical fields and the basic knowledge between new and existing technologies differs significantly, this is considered unrelated to technological diversification (Kim et al., 2016). In the context of regional technological diversification, diverse technologies may be concentrated in one or several technical fields and typically emerge in areas of comparative advantage that are closely related to existing technologies (Petralia et al., 2017). This is referred to as related regional technological diversification, which is characterized by the allocation of innovation resources to a broader range of related technical fields or areas of comparative advantage within the existing technology network. If technological diversification traverses the existing technology network and innovation resources are allocated to unrelated technical fields or areas without a technical comparative advantage, this constitutes unrelated regional technological diversification.

With respect to related regional technological diversification, although new technologies are considered diversified, they generally share the same scientific principles and knowledge base as existing technologies (Miller, 2006). Featuring both diversity and relevance, this combination effectively reflects the advantages of economies of scale and scope in regional technological diversification, thereby accelerating the pace of R&D (Panwar et al., 2021). Therefore, related regional technological diversification can facilitate the creation of new knowledge and new technologies within the existing knowledge domains and areas of technological comparative advantage of the region, thereby enhancing enterprise technological complexity. In terms of unrelated regional technological diversification, while it may dilute innovation resources and raise R&D costs (Pan et al., 2017), the substantial differences in technological foundations and sources of knowledge between new and existing technologies can help broaden the knowledge base of regional innovation entities, enabling them to seize new technological and business opportunities, foster higher-quality technological processes (Katila & Ahuja, 2002), and further mitigate risks associated with technology concentration. Therefore, unrelated regional technological diversification can fully leverage Marshallian

externalities within technical fields and Jacobs' externalities between technical fields, thereby fostering the emergence of new technical fields and enhancing enterprise technological complexity.

Hypothesis 2 (H2): The establishment of a unified national market contributes to the development of both related and unrelated regional technological diversification, which in turn facilitates the enhancement of enterprise technological complexity.

4 Research Design

4.1 Model Construction

To empirically examine the impact of unified national market construction on enterprise technological complexity, this study developed an econometric model as shown in equation (1):

$$Complexity_{rcit} = \alpha_0 + \beta UniMarket_{rt} + \gamma X + \lambda_i + \eta_t + \varepsilon_{rcit}. \quad (1)$$

In equation (1), i, t, r, and c represent the enterprise, year, region, and industry, respectively. *Complexity* denotes the technological complexity of the enterprise, which in this paper is primarily measured by knowledge breadth information derived from the concentration of IPC classification group symbols in industrial enterprise patents. α is the intercept term. *UniMarket* is the core independent variable, indicating the degree of unified market development in the region where the enterprise is located, encompassing the unified national commodity market ($UniMarket^{Commodity}$) and the unified national factor market (including the labor market $UniMarket^{Labor}$ and the capital market $UniMarket^{Capital}$), with its corresponding estimated coefficient β. X represents the set of control variables that may affect the technological complexity of the enterprise, with its corresponding estimated coefficient γ. λ denotes unobservable enterprise fixed effects, η represents unobservable time fixed effects, and ε is the random error term.

4.2 Data Description

In the empirical research process of this paper, we primarily utilized data from Chinese industrial enterprises, the China Patent Database, and regional data by provincial-level regions from 2004 to 2013 (due to significant data deficiencies, the Xizang Autonomous Region, Hong Kong SAR, Macao SAR, and Taiwan were excluded from this research). These three datasets were matched for use in the analysis. Firstly, the measurement of unified national market construction relied on regional data from 30 provincial-level administrative divisions in the Chinese mainland. In fact, market segmentation is especially pronounced at the provincial-level local government level, as seen through the historical evolution of China's current administrative governance model, major models of local government decentralization, and typical cases of local protectionism across regions. Moreover, compared with prefectural-level municipal governments, provincial-level local governments possess

greater authority over fiscal revenue and expenditure as well as more discretionary financial resources, making local protectionism more likely and amplifying its economic and social impacts. Secondly, based on the IPC classification symbol information of micro-level patents from the China National Intellectual Property Administration's patent database, this paper identified the number of categories (main groups), and matched these data with the China Industrial Enterprise Database to obtain patent knowledge breadth, financial data, and basic information at the industrial enterprise level. In the actual research, we excluded data related to mining, as well as production and supply industries for electricity, gas, and water, retaining only samples of manufacturing enterprises. Additionally, we removed samples where total assets were less than or equal to zero, total liabilities were less than zero, or the average net value of fixed assets was less than or equal to zero, and we deleted enterprise samples with fewer than eight employees. To address the issue of missing annual data for certain variables, we primarily used linear interpolation to complete the dataset. Furthermore, to mitigate the impact of outliers on the estimation results, we performed a 1% and 99% winsorization on the data.

4.3 Variable Construction

4.3.1 Construction of a Unified National Market

Identifying the degree to which a unified national market has been established in each region based on relative differences in commodity or factor prices between regions is a relatively suboptimal approach. Therefore, this paper referred to the method of Gui et al. (2006), employing the relative price method to calculate the degree of relative difference in price levels, wage levels, and capital goods prices between a given region and other regions, thereby assessing the extent of a unified national market construction. Specifically, assume that the prices of a certain commodity (factor) in regions m and n are P_m and P_n, respectively. Suppose there are k tradable commodities (factors), and the price difference of commodity (factor) k between regions m and n can be expressed as ΔQ^k_{mnt}. Furthermore, the absolute value form is employed to avoid sign reversal of ΔQ^k_{mnt} caused by swapping the numerator and denominator of prices between regions m and n after taking logarithms. This approach helps eliminate systematic bias in relative prices arising from random fluctuations related to the intrinsic characteristics of the commodities (factors) themselves and the market environment. Suppose $|\Delta Q^k_{mnt}|$consists of the intrinsic characteristics factor α^k of the commodities (or factors) and the market environment factor u^k_{mnt}. To remove the effect of α^k, the average should be calculated for $|\Delta Q^k_t|$ with a given year and a given commodity (factor), and then the average is subtracted from $|\Delta Q^k_{mnt}|$, that is, $|\Delta Q^k_{mnt}| - |\Delta Q^k_t| = (\alpha_k - \overline{\alpha^k}) - (u^k_{mnt} - \overline{u^k_{mnt}})$. Let:

$$q^k_{mnt} = u^k_{mnt} - \overline{u^k_{mnt}} = |\Delta Q^k_{mnt}| - |\Delta Q^k_t|. \tag{2}$$

The degree of construction of a unified national commodity and factor market at the

provincial level (*UniMarket*) can be determined by calculating the variance $Var(q^k_{mnt})$ of q^k_{mnt} in equation (2) and taking its reciprocal. For the unified national commodity market, this paper selected retail commodity price index for items such as food, clothing and shoes, beverages, tobacco and alcohol, textiles, household appliances and audio-visual equipment, cultural and office supplies, daily necessities, sports and entertainment products, and transportation and communication products, as well as the industrial producer price index to reflect manufacturing products. Data were sourced from the *China Statistical Yearbook*. Regarding the labor market, three types of labor price index were selected: average wages of employees in state-owned units, urban collective units, and other units. For the capital market, three types of investment price index were chosen: those for construction and installation projects, equipment and appliances, and other capital goods. Finally, we applied a logarithmic transformation to the measured indexes of the unified national commodity market, labor market, and capital market.

4.3.2 Enterprise Technological Complexity

This paper mainly measured enterprise technological complexity using the patent knowledge breadth index, which is based on the concentration of enterprise patent IPC classification group symbols. Drawing on the methods of Aghion et al. (2019) and Zhang and Zheng (2018), and based on the number of IPC classification symbols from the China National Intellectual Property Administration's patent database—combined with the main group information associated with each patent—the Herfindahl-Hirschman Index approach was applied at the main group level for weighting, namely $Complexity_{nt,\ type} = 1 - \sum\alpha^2$. α indicates the proportion of each main group within the patent classification symbols. The greater the disparity between patent classification symbols at the main group level, the broader the range of knowledge categories and the greater the knowledge breadth reflected in the enterprise's patents, resulting in a higher degree of patent complexity. Given the differences among patent types, this study primarily focused on invention patents and utility model patents. On this basis, we matched patent-level technological complexity to the enterprise level across the dimension of "enterprise–year–patent type" using the mean method. Specifically, the average technological complexity of all patents owned by an enterprise was used as the measurement indicator for that enterprise's technological complexity. This process yielded technological complexity data at the Chinese industrial enterprise level for the years 2004–2013. Overall, this method is more effective in identifying the general level of technological complexity within enterprises. In the robustness test described later, we also utilized the median method as a supplementary approach to assess technological complexity.

4.3.3 Regional Technological Diversification

This paper primarily drew on the measurement method for technological diversification by

Boschma (2005). From the perspective of the entropy method, and based on the number of urban IPC patent categories, a regional technological diversification index (*Diversify*) was constructed as follows:

$$Diversify_{ct} = \sum_{s=1}^{n} Patent_{ct}^{s} \ln\left(\frac{1}{Patent_{ct}^{s}}\right), \text{ and } Patent_{ct}^{g} = \sum_{s \in g}^{g} Patent_{ct}^{s}, \tag{3}$$

where $Patent_{ct}^{g}$ is the proportion of patents in IPC four-digit code technology subclass s to the total number of patents in city c in year t. n represents the number of IPC four-digit code technology subclasses involved. The proportion of patents in an IPC three-digit technology class $Patent_{ct}^{g}$ can be obtained by aggregating the proportions of IPC four-digit code technology subclasses under each corresponding class. On this basis, the relevant diversification level (*ReDiversify*) and unrelated diversification level (*UrDiversify*) of each city can be calculated. The specific equations are as follows:

$$ReDiversify_{ct} = \sum_{g=1}^{G} Patent_{ct}^{g} H_{ct}^{g}, \tag{4}$$

$$UrDiversify_{ct} = \sum_{g=1}^{G} Patent_{ct}^{g} \ln\left(\frac{1}{Patent_{ct}^{g}}\right). \tag{5}$$

In equations (4) and (5), G denotes the number of IPC three-digit code technology classes, where $H_{ct}^{g} = \sum_{s \in g}^{g} (Patent_{ct}^{s}/Patent_{ct}^{g})\ln(Patent_{ct}^{g}/Patent_{ct}^{s})$. It can be observed that both related and unrelated regional technological diversification reflect the changes in entropy in the distribution of regional patents at the IPC three-digit code level. Related regional technological diversification is represented by the entropy-weighted aggregation of technology subclasses, reflecting the diversity of patents within the three-digit code level. Unrelated regional technological diversification considers the diversity of patents among the technology classes at the three-digit code level, indicating that the degree of regional technological diversification partly derives from the diversity among IPC three-digit code technology classes.

4.3.4 Control Variables

To enhance the accuracy of the estimation results, we also controlled for other factors that may affect enterprise technological complexity, including: (1) Enterprise size (*Size*), measured by the logarithm of total assets. (2) Labor input (*Employment*), characterized by the logarithm of the total number of employees at the end of the year. (3) Profit margin (*Profit*), measured by the ratio of the enterprise's total profits to its total assets. (4) Enterprise ownership (*State*), controlled using a dummy variable indicating whether the enterprise is state-owned (state-owned enterprise = 1, non-state-owned enterprise = 0).

Furthermore, we additionally controlled for variables at both the industry and provincial

levels. Among these, the control variable at the industry level refers to the industry concentration (*HHI*) of the industries in which the enterprises operate. This paper measured it using the Herfindahl-Hirschman Index, calculated based on the operating revenue of the enterprises. The control variables at the provincial level include: (1) Regional economic development level (*Economy*). In this paper, the logarithm of per capita regional GDP was used as the measure, and, based on the consumer price index, it was converted to constant 2004 prices. (2) Regional financial development level (*Finance*), measured by the ratio of the year-end loan balance of regional financial institutions to regional nominal GDP. (3) Regional education development level (*Education*), measured by the average years of schooling in the region.[2] (4) Regional openness level (*Open*), measured by the logarithm of the total investment of foreign-invested enterprises in each region. The calculation was converted to RMB units using the actual exchange rate between RMB and USD for the corresponding year. (5) The scale of regional high-tech industries (*Structure*), measured by the proportion of employees in regional high-tech industries to the total number of employees in urban units. (6) Level of support from local governments (*Support*), measured by the logarithm of local government fiscal expenditures on science and technology in each province and region during the observation period.

5 Analysis and Discussion of Estimation Results

5.1 Benchmark Regression Estimation Results

The estimation results for the econometric model described in equation (1) are presented in Table 1. Columns (1), (2), and (3) represent the estimation results for the unified national commodity market, unified national labor market, and unified national capital market, respectively. As shown in column (1), the coefficient measuring the impact of the unified national commodity market on enterprise technological complexity is significantly positive, indicating that the development of a unified national commodity market contributes to enhancing enterprise technological complexity and motivates them to pursue more complex technological innovation. Furthermore, as indicated in columns (2) and (3), during the observation period, both the unified national labor market and the capital market exerted a significantly positive effect on enterprise technological complexity, demonstrating that a unified national factor market also promotes improvements in enterprise technological complexity. During the construction of a unified national market, the trade of commodities and the flow of factors between regions can expand the knowledge scope and increase the

[2] This paper adopts a weighted approach based on populations with different educational backgrounds, using the following formula $H_i = \sum T_n P_{in}$, where T_n denotes the number of years of schooling for the population with the nth educational attainment, and P_{in} represents the number of people with the nth educational attainment in provincial-level region i; n = 1 corresponds to primary school, n = 2 to junior high school, n = 3 to high school, n = 4 to university (including undergraduate and junior college). It is assumed that the years of schooling are six years for primary school, nine years for junior high school, 12 years for high school, and 16 years for university.

technological complexity of enterprise patents, which aligns with our expectations.

Table 1 Estimation Results of Benchmark Regression Model

Variable	(1)	(2)	(3)
$UniMarket^{Commodity}$	0.457***		
	(0.169)		
$UniMarket^{Labor}$		0.375***	
		(0.112)	
$UniMarket^{Capital}$			0.008***
			(0.002)
Size	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)
Employment	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Profit	–0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)
State	–0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)
HHI	–0.060	–0.059	–0.060
	(0.075)	(0.075)	(0.075)
Economy	–0.010*	–0.010**	–0.010*
	(0.005)	(0.005)	(0.005)
Open	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
Finance	0.002***	0.002***	0.002***
	(0.000)	(0.001)	(0.001)
Education	0.042***	0.042***	0.041***
	(0.010)	(0.010)	(0.010)
Structure	0.005	0.005	0.004
	(0.004)	(0.005)	(0.005)
Support	0.008***	0.008***	0.008***
	(0.001)	(0.001)	(0.001)
Constant	–0.191***	–0.184***	–0.201***
	(0.046)	(0.038)	(0.038)
Firm fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Adj. R^2	0.220	0.220	0.2198
Sample size	2,384,307	2,384,307	2,384,307

Note. ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$; and the values in parentheses represent robust cluster standard errors.

5.2 Impact Mechanism Test

According to the previous theoretical analysis, building a unified national market helps enhance the diversity of regional market demand preferences and factor supply structures, thereby accelerating regional technological diversification. This diversification reduces the risk of technological innovation for enterprises, facilitates the broader recombination of differentiated knowledge and technologies, and promotes technological spillovers across different fields and knowledge bases. As a result, it fosters the emergence of new technologies and provides support for increasing enterprise technological complexity. Based on this, we decided to examine the regional technological diversification mechanisms through which the construction of a unified national market impacts enterprise technological complexity, and evaluate the roles and effects of related and unrelated regional technological diversification mechanisms. Building on the previously discussed measurement results for regional technological diversification, related technological diversification, and unrelated technological diversification, we separately examined the effects of building a unified national market—including the commodity, labor, and capital markets—on each type of technological diversification. The estimation results are presented in columns (1), (2), and (3) of Tables 2, 3, and 4, respectively. Column (4) in each table shows the impact of regional technological diversification, related regional technological diversification, and unrelated regional technological diversification on enterprise technological complexity.

Table 2 Impact Mechanism Test Results: Regional Technological Diversification

Variable	*Diversify*			*Complexity*
	(1)	(2)	(3)	(4)
$UniMarket^{Commodity}$	4.205***			
	(1.071)			
$UniMarket^{Labor}$		1.195***		
		(0.318)		
$UniMarket^{Capital}$			0.028***	
			(0.010)	
Diversify				0.004***
				(0.001)
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Adj. R^2	0.667	0.667	0.667	0.220
Sample size	2,359,537	2,359,537	2,359,537	2,359,537

Note. ***$p < 0.01$; the values in parentheses represent robust cluster standard errors.

Table 3 Impact Mechanism Test Results: Related Regional Technological Diversification

Variable	*ReDiversify*			*Complexity*
	(1)	(2)	(3)	(4)
$UniMarket^{Commodity}$	81.014***			
	(19.065)			
$UniMarket^{Labor}$		6.129*		
		(3.374)		
$UniMarket^{Capital}$			0.643*	
			(0.331)	
ReDiversify				0.000***
				(0.000)
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Adj. R^2	0.460	0.460	0.460	0.223
Sample size	2,097,579	2,097,579	2,097,579	2,097,579

Note. ***$p < 0.01$ and *$p < 0.1$; the values in parentheses represent robust cluster standard errors.

Table 4 Impact Mechanism Test Results: Unrelated Regional Technological Diversification

Variable	*UrDiversify*			*Complexity*
	(1)	(2)	(3)	(4)
$UniMarket^{Commodity}$	3.819***			
	(1.348)			
$UniMarket^{Labor}$		1.961***		
		(0.779)		
$UniMarket^{Capital}$			0.006*	
			(0.003)	
UrDiversify				0.004***
				(0.001)
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Adj. R^2	0.638	0.638	0.638	0.220
Sample size	2,358,887	2,358,887	2,358,887	2,358,887

Note. ***$p < 0.01$ and *$p < 0.1$; the values in parentheses represent robust cluster standard errors.

The test results for the impact mechanism of regional technological diversification, as shown in Table 2, indicate that the construction of a unified national commodity market and a unified national factor (labor and capital) market exerts a significantly positive effect on regional technological diversification. This demonstrates that the development of a

unified national market helps enhance the level of technological diversification in regions. The establishment of a unified national commodity market can facilitate regional trade and competition in goods, enhance the diversification of local market demand preferences, and stimulate enterprises to pursue diversified technology R&D. Meanwhile, a unified national labor and capital market promotes the flow of production factors between regions, accelerates the integration and collaboration of factors across different regions, and ensures a diverse supply of factors needed for regional technological diversification. More importantly, as shown by the results in column (4) of Table 2, the impact of a diversified technology environment in the region on enterprise technological complexity is also significantly positive. This suggests that regional technological diversification enables enterprises to access a broader range of knowledge and technological factors, thereby increasing their knowledge breadth. This finding aligns with our expectations and confirms *H1*.

Based on the results in Tables 3 and 4, both the construction of a unified national commodity market and a unified national factor (labor and capital) market have a significantly positive effect on related and unrelated regional technological diversification, indicating that the establishment of a unified national market contributes to enhancing both related and unrelated regional technological diversification. Furthermore, as shown in column (4) of both tables, related and unrelated regional technological diversification have significant positive effects on enterprise technological complexity. This demonstrates that related technological diversification, which leverages the region's original fields of technical comparative advantage and knowledge base, as well as unrelated technological diversification that extends beyond existing knowledge and fields of technological comparative advantage, both contribute to increasing enterprise technological complexity. The above conclusions further validate *H2* proposed in this study.

5.3 Endogeneity and Robustness Tests

5.3.1 Endogeneity Test Using the Instrumental Variable Method

Although this paper has attempted to control for unobservable effects at the enterprise and time levels in the regression model, some important variables may still be omitted, and measurement errors in variables are also a significant source of estimation biases due to endogeneity. Accordingly, this study planned to use the instrumental variable method to test and address potential endogeneity issues. Firstly, drawing on the research ideas of scholars such as Lü et al. (2018), this study selected the average geographical slope of each region, multiplied by the reciprocal of the region's annual total retail commodity price index, as the instrumental variable for the construction of a unified national market. Employing a manual two-stage least squares (2SLS) method, this study further examined the impact of constructing a unified national market on enterprise technological complexity. Regarding the correlation of the instrumental variable, China's administrative boundaries are shaped to follow the contours of mountains and rivers (Han, 2015). As such, geographical slope plays a crucial role in

regional market segmentation and the development of a unified national market. In regions with more complex and undulating terrain, it is more challenging for local governments to advance regional integration and undertake transportation infrastructure projects. These regions tend to have less interaction with the outside world, a higher likelihood of market segmentation, and greater obstacles to the establishment of a unified national market—thus satisfying the correlation criteria for the instrumental variable. In terms of exogeneity of instrumental variables, geographical factors result from long-term geological processes and, historically and presently, cannot be said to directly determine regional disparities (Huang & Li, 2006). Therefore, these factors meet the requirements for exclusivity and exogeneity. The average geographic slope data employed in this study is derived from China's 90-meter resolution digital elevation dataset.

Second, following the method of Yu et al. (2022), this paper selected the pre-1949 historical variable of transportation convenience as an instrumental variable for the construction of a unified national market. The correlation of this instrumental variable lies in the fact that the development of transportation infrastructure and improvements in transportation convenience help to dismantle market segmentation, facilitate the flow of factors and goods across regions, and advance the building of a unified national market. This instrumental variable is a historical variable, and transportation infrastructure constructed before 1949 was mainly driven by the exogeneity condition. This paper primarily utilized the distribution map of railways in China from 1878 to 1948 to obtain the number of railway stations in each provincial-level regions during that period, thereby assessing the level of transportation convenience prior to 1949. In the estimation process, we also used the product of each provincial-level region's transportation convenience in 1949 and the annual total retail commodity price index for each corresponding provincial-level region as the final instrumental variable. Based on the estimation results, the first-stage estimates indicate that the effects of the instrumental variable on the unified national commodity, labor, and capital markets are all significantly positive at the 1% level. This demonstrates that the instrumental variable is highly correlated with all three unified national market indicators. Moreover, the Cragg-Donald Wald *F* values in all three models are much higher than the 10% bias threshold set by the Stock-Yogo weak ID test, suggesting that there is no issue of weak instrumental variable and the requirements for correlation are met. Furthermore, in the second stage, the construction of unified national commodity, labor, and capital markets continues to have a significantly positive effect on the breadth of corporate patent knowledge, indicating that the development of a unified national market enhances enterprise technological complexity. This finding is consistent with the results from the benchmark regression model discussed earlier.

5.3.2 Robustness Test for Measuring Enterprise Technological Complexity Using the Median Method

In the previous benchmark regression model, we assessed enterprise technological complexity

using the mean method, with the average technological complexity of all the enterprise's patents serving as the measurement indicator. Here, we further employed the median method, using the median technological complexity among all of the enterprise's patents as the measurement indicator for its technological complexity. This approach helps to address the issues caused by outliers and highly uneven distributions in the patent portfolio (Zhang & Zheng, 2018). The estimation results show that the construction of all three types of unified national markets has a significantly positive effect on enterprise technological complexity, consistent with the findings from the benchmark regression model.

5.3.3 Robustness Test Excluding Data Samples from 2010

The previous empirical research utilized continuous time sample data from the China Industrial Enterprise Database covering the years from 2004 to 2013. Linear interpolation was employed to supplement missing indicators for 2010. Here, to further verify the robustness of the estimates, this study excluded the data from 2010 and treated 2009 and 2011 as consecutive periods within the sample. The estimation results reveal that the coefficients for the construction of the three types of unified national markets are significantly positive, consistent with the benchmark regression model discussed earlier. This indicates that the empirical findings of this study demonstrate strong robustness.

6 Extended Analysis

6.1 Examining the Impact of the Mechanisms Underlying the Formation of a Unified National Market

In advancing the development of a unified national market, it is essential to eliminate "unnatural market segmentation" among local governments, remove regional barriers and local protectionism, enhance interregional exchange and collaboration, and establish a unified national market driven by local government policies. At the same time, efforts must be made to gradually remove "natural market segmentation" between regions by continuously improving transportation infrastructure. Taking the construction of high-speed railways and expressways as key opportunities, we can enhance market accessibility and interconnectivity between regions, build "physical bridges" for regional communication, and foster a unified national market facilitated by transportation infrastructure. Therefore, policy initiatives by local governments and the development of transportation infrastructure are crucial driving forces for building a unified national market. Firstly, a key aspect of building a unified national market in China is achieving consistency in rules and policies among local governments (Liu, 2022). Therefore, the development of a unified national market places higher requirements on the government's policy formulation and management capabilities. The Guideline also emphasizes the importance of unifying the basic market system, calling for accelerating the elimination and abolition of regulations and practices that hinder a

unified market and fair competition, and dismantling various enclosed small markets and self-contained cycles. Therefore, eliminating institutional barriers and promoting system unification have become top priorities for China in reducing market transaction costs and building a unified national market (Kou & Zhao, 2022). In recent years, as China has carried out its coordinated regional development strategy, promoting domestic regional integration and removing institutional barriers between regions has become a key task for governments at all levels. Local governments have introduced a variety of policies to specifically address regional integrated development and the elimination of local protectionism. Secondly, China places significant emphasis on leveraging transportation infrastructure development to facilitate the formation of a unified national market. Modern transportation infrastructure, including expressways and high-speed railways, is advancing at a rapid pace, continuously enhancing the level of interconnectivity among regions. As a result, China's domestic market is experiencing a historic shift from segmentation to integration, and from segmentation to unification (Bian & Bai, 2021). The driving force of local government policies and the catalytic effect of transportation infrastructure development not only contribute to shaping a unified national market, but also further foster regional technological diversification and enhance enterprise technological complexity.

Based on this, we further investigated the impact of a unified national market promoted by local government policies and a unified national market facilitated by transportation infrastructure development on the technological complexity among enterprises. Specifically, with respect to a unified national market promoted by local government policies, this mainly refers to the way local governments at all levels regulate, constrain, and guide the process of market integration across regions by issuing policies designed to eliminate local protectionism and promote regional integrated development. Therefore, from the perspective of local government policy documents, one can more accurately assess both the extent and overall level of local governments' efforts to advance the construction of a unified national market. In other words, the greater the number of local government policy documents focused on regional integration, the higher the degree of market unity between the provincial-level region in question and other provincial-level regions. This article mainly used "regional integration" and "local protectionism" as keywords[3] and using these terms, conducted a full-text search on pkulaw.com to determine the number of relevant local regulations, local government rules, normative local documents, judicial documents, work documents, and administrative licensing approvals issued by various provincial-level regions in China from 2004 to 2013. These local

[3] The rationale for selecting "regional integration" and "local protectionism" as keywords and employing a full-text search approach lies in the following: Firstly, although local governments pursue regional market integration for various purposes and by diverse means, and the related policy themes vary accordingly, accelerating regional integration and eliminating local protectionism can more comprehensively capture local governments' basic approach and core elements in implementing integrated development, demonstrating a high degree of accuracy. Secondly, this paper adopts a full-text search approach instead of a subject-based search, allowing for the inclusion of policy documents related to the integrated development of the regional economy across all relevant subject areas, thus providing greater comprehensiveness.

government policy documents regulate the actions of local governments in promoting market integration in several aspects, including laws and regulations, administrative standards, and work instructions. Building on this, this paper incorporated interaction terms between local government policies and the unified national commodity, labor, and capital markets into the econometric model specified in equation (1) to examine the impact of a unified national market promoted by local government policies on enterprise technological complexity. A unified national market facilitated by transportation infrastructure development mainly refers to the interconnectivity among different provincial-level regions, enabled by transportation infrastructure, which facilitates the orderly flow of goods and production factors across regions and thereby promotes the integrated development of regional markets. Therefore, compared with regions with underdeveloped transportation infrastructure, areas with more advanced transportation infrastructure have more robust means for commodity trade and factor flow, lower transaction costs, and a higher degree of integration with external markets. This paper primarily quantified the level of transportation infrastructure development by using the expressway mileage open to traffic per square kilometer in each provincial-level region in the corresponding year. The interaction terms between this indicator and a unified national commodity market, labor market, and capital market were incorporated into the econometric model specified in equation (1) in order to examine the impact of a unified national market facilitated by transportation infrastructure development on enterprise technological complexity. The estimation results regarding the driving mechanisms for the development of a unified national market are presented in Table 5.

Table 5 Examining the Test Results of the Driving Mechanisms for the Development of a Unified National Market

Variable	A unified national market promoted by local government policies			A unified national market facilitated by transportation infrastructure development		
	(1)	(2)	(3)	(4)	(5)	(6)
UniMarket^{Commodity}	0.432**			–0.013		
	(0.182)			(0.234)		
UniMarket^{Labor}		0.350***			0.001	
		(0.117)			(0.201)	
UniMarket^{Capital}			0.008***			–0. 012***
			(0.002)			(0.003)
Governance	–0.000	–0.000	0.000			
	(0.000)	(0.000)	(0.000)			
Distance				–4.212**	–3.887**	–0.828
				(1.955)	(1.916)	(2.053)

(*To be continued*)

(*Continued*)

Variable	A unified national market promoted by local government policies			A unified national market facilitated by transportation infrastructure development		
	(1)	(2)	(3)	(4)	(5)	(6)
$UniMarket^{Commodity}$ × *Governance*	0.001					
	(0.003)					
$UniMarket^{Labor}$ × *Governance*		0.002				
		(0.002)				
$UniMarket^{Capital}$ × *Governance*			−0.000			
			(0.000)			
$UniMarket^{Commodity}$ × *Distance*				15.577**		
				(6.080)		
$UniMarket^{Labor}$ × *Distance*					11.413**	
					(4.908)	
$UniMarket^{Capital}$ × *Distance*						0.182**
						(0.082)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.220	0.220	0.220	0.220	0.220	0.220
Sample size	2,384,307	2,384,307	2,384,307	2,384,307	2,384,307	2,384,307

Note. ***$p < 0.01$ and **$p < 0.05$; the values in parentheses represent robust cluster standard errors.

Based on the results presented in columns (1), (2), and (3) of Table 5, the interaction terms between the unified national commodity market and local government policies, the unified national labor market and local government policies, and the unified national capital market and local government policies all yield coefficients that are not significant at the 10% level. This indicates that local government policies have not exerted a significant impact on the enhancement of enterprise technological complexity during the process of promoting the construction of a unified national market. Although local governments in China have implemented a variety of policies and measures to dismantle different forms of local protectionism and strengthen regional integration, these initiatives have not had a significant effect on facilitating the orderly flow of goods and factors during the period of economic transformation. As a result, they have not directly contributed to the enhancement of technological complexity within enterprises. The estimation results presented in columns (4), (5), and (6) of Table 5 indicate that the interaction terms between the unified national commodity market and transportation infrastructure development, the unified national labor market and transportation infrastructure development, as well as the unified national capital market and transportation infrastructure development, all have a significantly positive effect on enterprise technological complexity. This suggests that the flows of goods and factors

enabled by interconnected transportation infrastructure across regions not only promote the formation of a unified national market but also enhance enterprise technological complexity.

6.2 Examining the Impact of Spatial Correlations within a Unified National Market

During China's economic transformation, the combined effects of institution-related factors and transportation infrastructure have created spatial linkage characteristics in market segmentation between regions (Yu et al., 2022), leading to spatial correlations in the level of unified national market development across provincial-level regions. This is reflected in the following aspects: Firstly, local governments are more inclined to pursue integrated development with correlated regions, and the formation of such integration is mutually reinforcing. When one local government proactively promotes integrated development, its correlated regions often follow suit; conversely, if a local government adopts strategies of local protectionism and market segmentation, its correlated regions are likely to take the same approach (Zhang, 2018). Of course, when selecting correlated regions, local governments tend to prioritize adjacent regions, as these regions have closer geographical, economic, social, and cultural distances to their own region. Secondly, in the context of transportation infrastructure development, regional interconnectivity based on such developments most commonly occurs between correlated regions. In particular, compared with non-adjacent regions, both the feasibility and necessity of linking high-speed railways and expressways between adjacent regions are significantly higher. More importantly, the spatial correlation characteristics of the construction of a unified national market are also crucial factors influencing both technological innovation and enterprise technological complexity. Specifically, when the level of unified market construction is higher in a given region and its adjacent regions, the scale of commodity and factor flows between these regions increases, leading to greater regional technological diversification. This, in turn, can promote the advancement of technological complexity among enterprises within the region. Therefore, this paper further explored how the spatial correlation characteristics of unified national market construction affect enterprise technological complexity.

Specifically, this paper drew on the idea of the Spatial Lag X (SLX) Model and the method of Bian and Bai (2021). It defined the regional associations based on spatial adjacency, constructed a 0–1 binary spatial weight matrix, and applied weighted processing to the three types of unified national markets to derive the spatial lag term for the development of a unified national market (*w_UniMarket*). This spatial lag term was then substituted into the econometric model shown in equation (1), thereby forming a spatial self-lag model. The estimation results reflecting the spatial correlation characteristics of unified national market development are presented in Table 6. The results shown in columns (1), (2), and (3) indicate that the construction of unified national markets for commodities, labor, and capital all has a significantly positive effect on enterprise technological complexity. Furthermore, the coefficients of the spatial lag terms for the construction of all three types of unified national

markets are also significantly positive. This indicates that, when controlling for the level of a unified national market development within a region, a higher degree of unified market development in adjacent regions corresponds to greater technological complexity among local enterprises—an outcome that aligns well with our expectations. The diversified technology environment created by unified market development in adjacent regions produces spillover effects on the local area, further motivating enterprises within the region to pursue more complex technological R&D and enhance their technological complexity.

Table 6 Examining the Estimation Results of Spatial Correlations in the Construction of a Unified National Market

Variable	(1)	(2)	(3)
$UniMarket^{Commodity}$	0.467***		
	(0.166)		
$w_UniMarket^{Commodity}$	0.001*		
	(0.000)		
$UniMarket^{Labor}$		0.369***	
		(0.112)	
$w_UniMarket^{Labor}$		0.001*	
		(0.000)	
$UniMarket^{Capital}$			0.008***
			(0.002)
$w_UniMarket^{Capital}$			0.001*
			(0.000)
Control variables	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Adj. R^2	0.220	0.220	0.220
Sample size	2,384,307	2,384,307	2,384,307

Note. ***$p < 0.01$, and *$p < 0.1$; the values in parentheses represent robust cluster standard errors.

6.3 Examining the Impact of Enterprise Ownership and Sector Heterogeneity

Another important aspect to consider when examining how the construction of a unified national market enhances enterprise technological complexity is the heterogeneity among enterprises. This is primarily reflected in two aspects: The first is heterogeneity of ownership nature. Overall, compared with non-state-owned enterprises, China's state-owned enterprises possess a greater abundance of internal resources for technological innovation, which enables them to effectively support independent R&D. Consequently, they tend to be less sensitive to changes in the external environment. In other words, state-

owned enterprises can often obtain the diverse technological supplies required to enhance their technological complexity from within the organization, resulting in relatively low reliance on the regional technological diversification environment brought about by the development of a unified national market. By contrast, non-state-owned enterprises have fewer technological innovation resources themselves, and as they increase technological complexity, they are more sensitive to external differentiated technological resource supplies and the diversity of regional technology environments. Therefore, the development of a unified national market may be more beneficial for enhancing the technological complexity of non-state-owned enterprises. The second is sector heterogeneity. The sector heterogeneity highlighted in this study primarily refers to the differences between high-tech industries and non-high-tech industries. Generally speaking, enterprises in high-tech industries engage in more intensive technological innovation activities, their production processes are more complex, their technical standards are higher, and their innovation processes are more sensitive to external factors and changes in the external environment. During the establishment of a unified national market, the development of regional technological diversification will support and incentivize enterprises in high-tech industries to enhance their technological complexity. However, for enterprises in non-high-tech industries, technological innovation activities are less intensive, and the increase in technological complexity is less affected by changes in the external environment. Therefore, compared with enterprises in non-high-tech industries, the construction of a unified national market may have a more significant impact on the enhancement of enterprise technological complexity in high-tech industries.

Based on this, the heterogeneity characteristics of the two aspects mentioned above are examined. Regarding heterogeneity in the ownership nature of enterprises, this paper used the registration types in the China Industrial Enterprise Database to classify state-owned enterprises and collectively-owned enterprises as state-owned enterprise samples and other enterprise types as non-state-owned enterprise samples. We examined the effect of the construction of a unified national market on the technological complexity of non-state-owned enterprises and state-owned enterprises separately. The estimation results are presented in Table 7. For sector heterogeneity, we referred to the classification standards from scholars such as Li and Zheng (2016) to divide the sample into high-tech and non-high-tech industries.[4] We then examined the effect of the construction of a unified national market on enterprise technological complexity within non-high-tech industries and high-tech industries, respectively. The corresponding estimation results are presented in Table 8.

[4] High-tech industries in the manufacturing sector mainly include the manufacturing of chemical raw materials and chemical products, chemical fiber manufacturing, general equipment manufacturing, special equipment manufacturing, transportation equipment manufacturing, electrical machinery and apparatus manufacturing, pharmaceutical manufacturing, communication equipment manufacturing, computer and other electronic equipment manufacturing, as well as instrumentation and cultural and office machinery manufacturing. Other industries are classified as non-high-tech industries.

Table 7 Unified National Market Construction and Enterprise Technological Complexity: Heterogeneity of Ownership Nature

Variable	Non-state-owned enterprises			State-owned enterprises		
	(1)	(2)	(3)	(4)	(5)	(6)
$UniMarket^{Commodity}$	0.401**			0.739		
	(0.160)			(0.739)		
$UniMarket^{Labor}$		0.451***			−0.072	
		(0.123)			(0.373)	
$UniMarket^{Capital}$			0.009***			−0.004
			(0.002)			(0.008)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.207	0.207	0.207	0.297	0.297	0.297
Sample size	2,162,388	2,162,388	2,162,388	209,847	209,847	209,847

Note. ***$p < 0.01$ and **$p < 0.05$; the values in parentheses represent robust cluster standard errors.

Table 8 Unified National Market Construction and Enterprise Technological Complexity: Sector Heterogeneity

Variable	Non-high-tech enterprises			High-tech enterprises		
	(1)	(2)	(3)	(4)	(5)	(6)
$UniMarket^{Commodity}$	0.153			0.919**		
	(0.121)			(0.368)		
$UniMarket^{Labor}$		0.362			0.123*	
		(0.212)			(0.073)	
$UniMarket^{Capital}$			0.007			0.008**
			(0.005)			(0.003)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.183	0.183	0.183	0.234	0.234	0.234
Sample size	1,519,530	1,519,530	1,519,530	821,729	821,729	821,729

Note. **$p < 0.05$ and *$p < 0.1$; the values in parentheses represent robust cluster standard errors.

The estimation results presented in Table 7 indicate that the construction of the three types of unified national markets has no significant effect on the technological complexity of state-owned enterprises; however, it does have a significant positive effect on the advancement of technological complexity in non-state-owned enterprises. This demonstrates that while the construction of a unified national market does not significantly promote the technological complexity of state-owned enterprises, it does significantly enhance the technological

complexity of non-state-owned enterprises. This is essentially in line with our expectations; specifically, compared with state-owned enterprises, increases in technological complexity among non-state-owned enterprises demonstrate greater sensitivity to the development of a unified national market. According to the estimation results presented in Table 8, the construction of the three types of unified national markets does not have a significant impact on the improvement of enterprise technological complexity within non-high-tech industries. However, it does exert a significant promotive effect on the advancement of enterprise technological complexity within high-tech industries. This indicates that, compared with non-high-tech enterprises, high-tech enterprises' improvements in technological complexity are more sensitive to unified national market construction, which also confirms our expectations.

7 Conclusions and Policy Implications

Based on the perspective of regional technological diversification, this paper empirically investigates the impact mechanism of the construction of a unified national market on enterprise technological complexity from both the commodity and factor markets. The findings are as follows: Firstly, the impact coefficients for the construction of unified national commodity, labor, and capital markets on enterprise technological complexity are all significantly positive. This indicates that building unified national markets for commodities and factors facilitates the improvement of technological complexity in enterprises and stimulates them to pursue more complex technological innovation. Secondly, the test results for the impact mechanism show that constructing a unified national market can promote regional technological diversification, thereby enhancing enterprise technological complexity. With regard to both related and unrelated regional technological diversification, each has a significant positive impact on the process by which constructing a unified national market elevates enterprise technological complexity. Thirdly, the effect of a unified national market promoted by local government policies on enterprise technological complexity is not significant. In contrast, the effect of a unified national market facilitated by transportation infrastructure development on enterprise technological complexity is significantly positive. This indicates that local governments have not notably enhanced enterprise technological complexity through regional integrated development policies, whereas the commodity and factor flows facilitated by interconnected transportation infrastructure across regions contribute to the advancement of enterprise technological complexity. Fourthly, the construction of a unified national market across regions exhibits spatial correlation characteristics. The diversified technology environment arising from unified market development in adjacent regions generates spillover effects locally, further motivating enterprises within the region to pursue more complex technological R&D, thereby increasing technological complexity. Fifthly, the establishment of a unified national market significantly promotes technological complexity in non-state-owned enterprises and those in high-tech industries, whereas its effect on the technological complexity of state-owned enterprises and those in non-high-tech industries is

not significant.

In the current stage of accelerating the transformation of the economic development model and pursuing scientific and technological self-reliance, building a unified national market and leveraging the advantages of the vast domestic market are not only key measures for establishing a new development paradigm with domestic circulation as the mainstay, but also vital means to encourage enterprises to enhance complex technology R&D and accelerate breakthroughs in core technologies in key fields. The policy implications of this study are as follows:

First, China should develop a robust and diversified technology environment to incentivize enterprises to pursue complex technology R&D. The diversified development of regions in both related and unrelated technical fields not only fosters new combinations of technologies, but also enhances competition and substitution among technologies, providing enterprises with support and incentives to advance R&D of complex technologies. Therefore, in implementing the innovation-driven development strategy, while encouraging each region to pursue technological specialization, it is also essential to support regional technological diversification. This involves assisting regions in deploying technological resources both within established areas of technological comparative advantage and across other related and unrelated technical fields. Specifically, this can be achieved by building a diversified market demand structure and a differentiated innovation resource supply structure, thereby fostering a diverse innovation network and cultivating a varied regional technology environment.

Second, China should leverage policies among local governments to advance the development of a unified national market and enhance enterprise technological complexity. This study finds that, at present, the policies and measures implemented by local governments in China to promote regional integration have not effectively enhanced enterprise technological complexity. Therefore, it is necessary to further improve the policy system supporting the development of a unified national market. Future efforts should not only encourage local governments at all levels to introduce policies that dismantle local protectionism and market segmentation and promote regional integration, but also ensure the orderly coordination of policies across different regions. It is essential to establish a variety of mechanisms for inter-local government visits and joint meetings to foster mutual understanding and trust among different regions. This will enhance the coordination and cooperation of regions in the policy-making process for integrated development and industrial policies, reduce policy redundancy and conflicts, and enable the government to play a more effective role in promoting the construction of a unified national market.

Third, the development of transportation infrastructure should be continued to advance between regions to further improve interregional connectivity. Transportation infrastructure development is a key initiative to break through natural market segmentation. It serves as a crucial medium for facilitating the orderly flow of various goods and factors between regions, playing a significant role in advancing regional technological diversification and enhancing enterprise technological complexity. Therefore, in future work, further improvement of

transportation infrastructure is needed. Efforts should be made to leverage high-speed railways, expressways, and similar systems to build a multi-layered, three-dimensional regional transportation network, thereby forming comprehensive transportation, logistics, and innovation circles. This will help lower the costs of goods and factor flows between regions and use transportation infrastructure to ensure the smooth operation of domestic circulation.

Fourth, the spatial linkage between regions should be emphasized during the process of integrated development and cultivate a holistic perspective. The spatial correlation between adjacent regions in the development of a unified national market is also a critical factor in enhancing enterprise technological complexity within those regions. Therefore, in the process of building a unified national market in China, it is essential to adopt a holistic perspective and fully leverage the economies of scale provided by the unified market. Regions should establish close and collaborative relationships. Whether for introducing policies and measures for regional integrated development or accelerating the interconnection of transportation infrastructure, emphasis should be placed on communication and cooperation with other correlated regions. Coordinated regional development should be achieved on the basis of safeguarding the interests of each region. By capitalizing on the scale advantages of a unified market across regions, a regional technological diversification environment with a higher degree and larger scale can be fostered. This environment enables interregional technology spillover and drives the enhancement of technological complexity among enterprises in all regions.

Fifth, to promote the enhancement of enterprise technological complexity through the construction of a unified national market, we should also pay attention to the pertinence and targeting of policies and measures. The rise in technological complexity among different types of enterprises shows varying responses to the development of a unified national market. Notably, constructing a unified national market can particularly enhance the technological complexity of non-state-owned and high-tech enterprises. Therefore, future efforts must place a high priority on elevating technological complexity in state-owned and non-high-tech enterprises. During the advancement of a unified national market, it is essential to enable them to participate more fully in market competition and motivate them to develop more complex technologies. Focus should also be placed on boosting the technological intensity of non-high-tech enterprises, driving their transformation and upgrading through innovation, and enhancing their market competitiveness by leveraging complex technologies.

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