Analysis of the Configuration and Path of Factors Influencing the Performance of High-Tech Industries

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ABSTRACT

Exploring the joint effects factors affecting high-technology industries’ performance is crucial to enhancing the country’s overall strength. However, maintaining high industry performance levels has always been a complex issue. The literature mainly focuses on the net effects of single factors. In that case, the authors put forward a configurational framework that is the performance of high-tech industries, and does not depend on a single condition. Based on a fuzzy-set qualitative comparative analysis of high-tech industry performance across Chinese provinces, the authors identify eight conditions affecting industry performance under four latitudes – economic environment, scientific research, technological progress, and government support. The results show that high and non-high levels of performance can be achieved through the different configurations of antecedents. Both economic development and science and technology inputs play an irreplaceable role in industrial performance.

KEYWORDS

Configuration analysis, fsQCA, fuzzy-set qualitative comparative analysis, High-technology industries

INTRODUCTION

The development of high-tech industries is crucial to the improvement of a country’s comprehensive strength. According to Petty-Clark’s Law, the industrial structure evolves toward industries with high value added (Clark, 1957), and the diffusion effect of the dominant industry is the main driver of economic growth (Wang & Xu, 2007). In recent years, high value-added emerging industries, such as quantum, semiconductor, new material, and artificial intelligence, are in the stage of continuous theoretical and technological breakthroughs, which are precisely part of high-technology industries. These high-tech industries are playing an increasingly prominent role in regional economic competition and are important practice subjects of technological innovation and national innovation-driven
development strategies (Deng, 2018). High-tech industries with characteristics such as knowledge-intensive and highly innovative (Zhou et al., 2019) show preferences for development factors that are different from those of traditional manufacturing industries, such as high reliance on scientific research and technological progress. Their location distribution also has significant differences from traditional industries. Studies have shown that an innovative environment is a core factor influencing the location choice of high-tech industries (Kuizao, 2015), and there are policy system differences in the innovative environment faced by high-technology industries in different regions (Polder & Veldhuizen, 2012). In the background of peaceful global development, international competition in economics, science, and technology has intensified. Developed countries established high-tech industries earlier, with high economic levels and large investments in science and technology, driving the leading progress of high-tech-related industries. Learning how to create a positive policy environment, break through the shortcomings of the industry, and improve the imbalance in regional development requires further in-depth research on the factors influencing the performance of high-technology industries.

Factors affecting output growth in high-tech industries can be divided into internal factors, such as R&D expenditure and technological progress, and external factors, such as government support and the economic environment. R&D expenditure can promote product innovation and enhance industrial performance in high-tech industries (Hall et al., 2009), and there is a positive relationship between R&D expenditure and technological innovation performance in high-tech enterprises (Yidong & Weijun, 2011).

In contrast, technology shortages lead to a decline of high-tech businesses in labor productivity, and controlling other factors remains unchanged (Bennett & McGuinness, 2009). The specific impact of government policies is uncertain (Karolina & Johan, 1997), while regional economic power is heterogeneous in terms of the effect of government investment on innovation development in high-tech industries (Chen & Luo, 2022). Technology funded with subsidized loans and the construction of high-tech incubators and industrial parks have a positive effect on promoting the sustained growth of high-tech industries (Jenkins et al., 2006). However, the role of government is limited and government policies can also have some negative effects owing to path dependency (So, 2006). In the macroeconomic context, the performance of high-tech industries is closely related to the ratio of R&D expenditure to national GDP (Zhang, 2017).

Economic environment, scientific research, technological progress, and government support are all key to the development of high-technology industries. However, these factors have rarely been considered together from a holistic perspective. There have been many valid explorations in the literature around the performance of high-technology industries, most of which still use traditional regression analysis to examine the net effect of single factors on the results (Roig-Tierro et al., 2016). However, these studies ignore the conditional synergies between variables. Qualitative comparative analysis can address the limitations of traditional research methods. It is suitable for exploring multiple conditional groupings of the same outcome (Yunzhou & Liangding, 2017). Thus, the impact of different factors on industry performance is not independent, and these factors can produce various combinations through linkage matching. These combinations in turn affect the performance of high-tech industries. In addition, changes in the level of economic development in the region are often not taken into account in the research on the factors influencing the development of high-tech industries.

We used a fuzzy-set qualitative comparative analysis (fsQCA) approach to explore the configuration and path of factors influencing the performance of high-tech industries. We posed the following research question: What are the possible combinations of factors that generate high and non-high levels of industry performance? To answer this question, we analyzed the combined effect of economic environment, scientific research, technological progress, and government support on the performance of high-tech industries and identified the pathways through which such effects are realized.

The innovation of our research mainly focused on three points. First, we applied the QCA method to the research on the development factors of high-tech industry, thereby broadening the selection of research methods for small and medium-sized samples in the field
of industrial performance. Second, from the perspective of overall analysis, our method put forward the comprehensive analysis framework of influencing factors of high-tech industry performance. According to the experimental results, we summarized the different paths to achieve high-level performance of high-tech industries. These findings enrich the research on industrial performance and provide inspiration for various regions to improve the performance of high-tech industries according to local conditions. Finally, because it is difficult to empirically analyze the mechanism of high-tech industry to achieve high performance in a single linear regression study, the research method of QCA not only revealed the equivalent driving path and conditional substitution relationship to achieve high performance of the high-tech industry but also showed the combination path leading to the non-high performance of high-tech industry from the perspective of causal asymmetry.

In the remainder of this paper we review the relevant literature on the economic environment, scientific research, technological progress, and government support; construct a theoretical model for achieving high-performance levels in high-tech industries; describe the data collection and QCA experimental analysis results; share the conclusion of the research, reports, and the academic and managerial contributions; and discuss limitations and future work.

LITERATURE REVIEW

Through reading the literature, we found that there are many studies on the factors influencing the development and performance of high-tech industries. The factors that play a prominent role in the performance of high-tech industries at the provincial level are mainly the four aspects of economy, science, technology, and policy, but there is little literature exploring the joint role of these factors at the macro scale.

Economic Environment

In this paper we considered the basic economic environment from two perspectives: the level of macroeconomic development and the internal economic situation of the industry. The level of macroeconomic development implies not only a gap in the government’s ability to support but also a large gap between regions in terms of the level of education and research, as well as the proportion of investment in science and technology. Regions with higher levels of economic development have a greater ability to attract factors such as capital, technology, and talent, positively contributing to the further development of industries in the region, whereas the negative effect becomes more pronounced in economically backward regions with slow industrial development (Myrdal, 1957). This is the reality. The overall level of development of high-tech industries in developing countries lags that of developed countries. The uneven level of economic development is a common phenomenon. Through comparative analysis, scholars have concluded that the scale and speed of development of high-tech industries are consistent with the level of regional economic development, and high-tech industries have been developed more rapidly in the eastern region (Dan, & Xiaobin, 2004). Meanwhile, high-tech industries have the characteristics of high investment, high risk, and high efficiency. A good internal economic condition directly affects the number of resources that can be invested in the industries (Hao, et al., 2016), providing financial security for various business activities (Zipeng & Jinchao, 2018).

Scientific Research

Scientific research specifically includes the building of R&D institutions and the funding of natural science. Some manufacturing industries among high-tech industries are strongly dependent on new scientific discoveries, and industrial development is highly interactive with science (Peng & Jiasu, 2015). Meanwhile, scientific R&D activities can significantly influence the innovation performance of enterprises (Santamaria et al., 2009), and enterprises are more likely to apply their efforts to translate scientific phenomena and theoretical concepts into commercial use and to transform scientific knowledge into basic and specific applied technologies (Autio, 1997). Research institutions play a key role in
R&D in many countries (Lee et al., 2015). In China, basic scientific research is mainly undertaken by universities and research institutions (Xu & Beili, 2021). Therefore, universities are a crucial source of profit for industrial development (Tianzhu et al., 2012), and their research funding influences the innovation performance of high-tech industries to a certain extent (Chen & Chang, 2022).

**Technological Progress**

Production technology research is the key to the development of high-tech industries (Lu & Lin, 1994). Inputs made by enterprises to acquire technology can reflect their pursuit of technological progress, and new research results will be further transformed into technological applications to promote the development of high-tech industries. Technological progress is therefore also an important factor in the growth of industrial output. This growth not only reduces the adverse effects of economic policy fluctuations when the Economic Policy Uncertainty index is high but also boosts industrial output when it is low (Zhu, & Yu, 2022). It can also weaken the international competitive pressures on industrial production and development (Liu et al., 2014). Consequently, technological innovation should be considered to enhance the added value rate of products to realize the high end of high-tech industries (Pietrobelli & Rabelotti, 2004).

**Government Support**

The effects of relevant industrial policies and government financial inputs on high performance of industries are influenced by the differences in many factors across provinces. Integrating them into the theoretical framework of multifactor linkage is necessary. Government policies play an important role in promoting innovation and driving the country toward a high-tech powerhouse (Wonglimpiyarat, 2016). In China’s national context, policies related to high-tech industries are more effective. Active industrial policies can promote the transformation of enterprises’ pre-research results (Wu & Hu, 2013) and effectively increase the market share of high-tech industries (Rong et al., 2017). Some studies have found that increasing government investment in R&D can promote high-tech industries (Zhang & Dong, 2017). However, it has also been proved that the promotional effect of government financial support is compromised in the case of market failure (Ran, 2021).

**Configurational Framework**

Because of the differences in economic environment, scientific research, technological progress, and government support in different regions, the impact of multifactor linkage on the development of high-tech industries is an open question. Its combination path is not fixed, and there are phenomena such as equivalence and asymmetry. In light of this analysis, the theoretical framework of “economy-science-technology-policy” analysis contains eight secondary conditions, including the external economic environment of the region, the internal economic environment of the industry, the funding situation of science funds, the construction of R&D institutions, the technological transformation and acquisition capabilities of enterprises, government financial investment, and relevant industrial policies. Using the QCA approach from a group perspective, we further explored the mechanism of multiple factors behind the high performance of the industry. We considered the actual situation of the development and growth of high-tech industries in various provinces of China (Figure 1).

**DATA ANALYSIS AND EXPERIMENTAL RESULTS**

**Fuzzy-Set Qualitative Comparative Analysis**

The QCA approach is based on the ideas of set theory and Boolean algebra (Ragin, 2008); it assumes that the independent variables act together in an interdependent manner and that there are multiple equivalent paths (Rihoux & Ragin, 2009). It is applicable to the study of complex causal relationships and multiple interactions (Fiss, 2011). We analyzed the multiple driving mechanisms behind the
development of high-tech industries from a group perspective and used the fuzzy-set QCA method with affiliation assignment to improve the accuracy of the study.

First, high-tech industries are influenced by a combination of factors, and the utility of a single factor in influencing industry development is limited; thus, high-tech industry performance is suitable for the QCA (Wang et al., 2022).

Second, high-tech industry development and the level of industry performance are not symmetrical (Misangyi et al., 2017; Chang et al., 2021; Cai, 2022). In general, government policy support can drive regional science industry development, meaning that government policy is a positive element. In practice, however, some regions have achieved desirable science industry performance despite the lack of policy support.

Finally, different from multivalue QCA and crisp-set QCA, fuzzy-set QCA (FSQCA) adopts membership assignment to improve the research quality.

The fsQCA method, on the other hand, is good at comparative analysis of small and medium-sized samples (Misangyi, 2014). This method not only can identify the mechanisms of action of the conditioning variables but also can guarantee the external generalizability of the empirical results to a certain extent. Therefore, we applied fsQCA in this study.

**Measurement**

According to the research logic of the QCA approach, the outcome and condition variables should be set before analyzing the synergistic linkages and interdependencies between the main research condition variables. Because there is a lag between inputs and outputs, the correspondence between antecedent conditions and outcomes is sequential in time. This sequential correspondence takes time for the economic environment, scientific research, technological progress, and government support to have an impact on the performance of high-tech industries. We set a time lag of one year and treated the output indicators (outcome variables) with a lag of one period (Ruoyu et al., 2022). Considering that COVID-19 disrupted the normal development of the industry and relevant data were seriously missing, we selected the outcome variables from the unaffected year 2019 and the condition variables from 2018 (Zhu, 2021). The variables are specified in Table 1.

**High-Tech Industry Performance**

We selected the high-tech industries of 31 provinces in China as the study population to research the group effect of factors influencing the development of high-tech industries. We used high-tech industry...
performance as the outcome variable, measured by the business income of high-tech industries in each province in 2019. The higher the value, the higher the level of development of high-tech industries in the region. Data was taken from the China Statistical Yearbook on High Technology Industry 2020.

Economic Environment

The external economy of a region is used to measure the external economic situation of high-technology industries. The level of GDP in a region reflects the local economic development to a certain extent, and GDP as a measure of national or regional economic growth has been proved to show a significant positive correlation with the innovation performance of the industry under study (González-Serrano et al., 2019). To exclude the effects of demographic differences across provinces, we used GDP per capita in 2018 as a measure of external economic conditions (Shanji et al., 2021). Data was taken from the China Statistical Yearbook 2019.

The internal economy of the industry is used to measure the internal economic condition of the regional high-tech industry. The development of high-tech industries requires a large amount of capital investment, and the project cycle is long. The amount of continuous investment is the material basis for the development of high-tech industries. We selected the amount of investment in high-technology industries by province in 2018 as a quantitative measure of internal economic conditions (Rong et al., 2022). Data was taken from the China Statistical Yearbook on High Technology Industry 2019.

Scientific Research

Foundation funding is used to measure the funding of scientific research in high-tech industries in various regions. We measured this variable using the total amount of funding received by provinces for projects funded by the National Natural Science Foundation of China in 2018 (Ruoyu et al., 2022). Data was taken from the Statistics on NSFC-Funded Projects 2018.

R&D establishments are used to measure the R&D activities of high-tech industries in each region. In general, the higher the number of R&D institutions in high-tech industries, the more active the R&D activities; a low number of R&D institutions is not beneficial to the acquisition and transformation of knowledge and technology, as measured using the number of R&D institutions in high-tech industries by province in 2018 (Chen & Chang, 2022). Data was taken from the China Statistical Yearbook on Science and Technology 2019.

Technological Progress

We measured technological progress in terms of the technology acquisition capacity and technology reform capacity of firms in high-tech industries. In the open economy, the latecomer countries realize technological catch-up by paying attention to and investing in technology introduction and development at different stages (Song et al., 2008).

To a certain extent, the investment made by enterprises in the market to acquire technology can reflect their pursuit of technological innovation, and in general, the input is proportional to the effect (Shi, 2022). Therefore, the technology acquisition capability of enterprises is measured by the technology acquisition input (the sum of expenditure for acquisition of foreign technology and expenditure for purchase of domestic technology); technology renovation capability of enterprises is measured by technological transformation investment (the sum of expenditure for assimilation of technology and expenditure for technical renovation). Data was taken from the China Statistical Yearbook on High Technology Industry 2019.

Government Support

The industry-related policies are used to measure the degree of support for industrial development by the policies related to high-tech industries issued by regional governments. We used the number of policies related to high-tech industry issued by provinces in 2018 to measure (Ruoyu et al., 2022). Specifically, we searched the local regulations, local regulatory documents, and local working
documents officially and publicly released in 2018 in the local policies of the Beijing University’s Faber database by using the names of high-tech industries, pharmaceutical manufacturing, electronic information manufacturing, aerospace manufacturing, and other high-tech industries as keywords. After eliminating lapsed and irrelevant policies, we counted the number of policy texts directly or closely related to the development of high-tech industries in each province.

Government funding is used to measure the extent of regional government support for high-tech industries in terms of R&D funding. From an innovation-driven perspective, government subsidies are a widely used support policy for high-tech industries and most directly reflect the degree of government support. We selected government funds from internal spending on R&D in high-tech industries in each province as a measure of government support (Wei, 2016). Data was taken from China Statistical Yearbook on High Technology Industry 2019.

**Calibration**

Before the specific analysis, we needed to calibrate the antecedent and outcome variables and convert them into a set of variables expressed in terms of fuzzy-set affiliation (Yunzhou & Liangding, 2017). Combining practical needs with theoretical knowledge to calibrate the affiliation scores, we used the 85th percentile (85%), median (50%), and 15th percentile (15%) of the descriptive statistics of the case sample as fully affiliated, crossover, and fully unaffiliated calibration points for the outcome and conditional variables, respectively (Fiss, 2011; Legewie, 2017). The calibrated set of variables has an affiliation between 0 and 1. In addition, to avoid the problem of group attribution in cases where the antecedent condition has an affiliation of exactly 0.5, we subtracted the 0.001 constant from the 0.5 affiliation (Crilly et al., 2012). The calibration information for each condition variable is shown in Table 2.

**RESULTS**

**Necessity Conditions Analysis**

Before conducting a fuzzy-set truth table analysis, we realized that consistency is an important test for a necessary condition; it is a necessary condition for an outcome when the consistency score is greater than 0.9 (Thomas et al., 2018). The necessary condition must exist when the result occurs, but its existence does not guarantee that the result will occur. The formula for consistency is shown in equation (1).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Latitude</th>
<th>Variable</th>
<th>Symbol</th>
<th>Measurement methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>Industry performance</td>
<td>Performance of high-tech industries</td>
<td>EP</td>
<td>Business income of high-tech industries</td>
</tr>
<tr>
<td></td>
<td>Economic environment</td>
<td>External economy of a region</td>
<td>GDP</td>
<td>GDP per capita</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal economy of the industry</td>
<td>FIN</td>
<td>Amount of investment in high-tech industries</td>
</tr>
<tr>
<td></td>
<td>Scientific research</td>
<td>Foundation funding</td>
<td>FUN</td>
<td>Total funding from the NSFC-funded projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R&amp;D establishments</td>
<td>RDI</td>
<td>Number of R&amp;D institutions</td>
</tr>
<tr>
<td></td>
<td>Technological progress</td>
<td>Technology Acquisition</td>
<td>TA</td>
<td>Expenditure for technology acquisition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technology renovation</td>
<td>TR</td>
<td>Expenditure for technology renovation</td>
</tr>
<tr>
<td></td>
<td>Government Support</td>
<td>Industry-related policies</td>
<td>NUM</td>
<td>Number of policies related to high-tech industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Government funding</td>
<td>GOV</td>
<td>Government funds from internal spending on R&amp;D in high-tech industries</td>
</tr>
</tbody>
</table>
In addition to the consistency index, coverage is usually used to measure the explanatory power of conditional variables to result variables. The greater the coverage is, the more significant the promoting effect of conditional variables on the occurrence of results. For example, when the coverage of a variable is 0.8, it indicates that the combination containing the conditional quantity can explain 80% of the sample cases. The formula for calculating the coverage index is shown in equation (2).

\[
Coverage(X_i \leq Y) = \sum \left[ \min \left( X_i, Y \right) \right] / \sum Y
\]

We entered the calibrated fuzzy values shown in equations (1) and (2) into the fsQCA 3.0 software and performed a necessary conditions analysis. We entered the calibrated fuzzy values shown in the previous section into the fsQCA 3.0 software and performed a necessary conditions analysis. The consistency and coverage of each variable were calculated according to equations (1) and (2), the results are summarized in Table 3. Note that the level of consistency for all conditions is less than 0.9 for both high and non-high levels of performance in high-tech industries (Misangyi et al., 2014; Bell et al., 2014; Gupta et al., 2020). This finding indicates that the outcome variables under the four latitudes of economic environment, scientific research, technological progress, and government support have a weak ability to independently explain the performance of high-tech industries. Thus, conducting a configuration analysis of the linkage matching effects of these conditional variables is necessary.

### Sufficient Solutions
We used fsQCA 3.0 to analyze data from a sample of 31 provinces. The relevant parameters were set as follows. We chose different consistency thresholds for different contexts, such as 0.80 (Yunzhou & Liangding, 2017) and 0.75 (Schneider & Wagemann, 2012). We set the raw consistency threshold to 0.8 based on the case realities, while to avoid simultaneous subset relations in the outcome and result negation for a given histology, the PRI consistency threshold should be no lower than 0.5 (Greckhamer et al., 2018). The frequency threshold should be determined by the sample size. For
small and medium-sized samples, a threshold of 1 is appropriate (Schneider & Wagemann, 2012; Hossain et al., 2021). The threshold for the number of combined frequencies with consistency greater than 0.8 and PRI consistency no less than 0.5 was therefore set at 1. Combining the above criteria, we obtained a truth table that met the requirements after computing with fsQCA 3.0 and transformed it into linkage matching paths. The results are shown in Table 4.

The research results identified four paths that could lead to high-level performance of high-tech industries, and the overall consistency of the solutions was 0.966, indicating that the linkage matching of all conditional variables had a high level of significance. The overall coverage of the solution was 0.727, indicating that these four pathways could explain 72.7% of the cases of high-level performance in high-technology industries. Three pathways were further identified that could lead to non-high-level performance, with an overall consistency of 0.985 and coverage of 0.619. We summarized a logical scheme of the eight pathways from a theoretical perspective (Ragin, 2008), and proposed three types of high performance in high-technology industries with different combinations of core conditions—capital-input-led, science and technology-led, as well as low-input and high-output—and three types of non-high performance where the core conditions for R&D institutions and technological progress are absent: regional economic underdevelopment, industrial policy and regional economies supporting, and underdeveloped regional economy with industry-related policies and internal economy supporting.

By comparing the variables of the four grouping conditions, we summarized four technological routes to achieve a high level of performance of high-technology industries. Config(1a), (2a), (2b), and (3a) contain eight variables in four latitudes: economic environment, scientific research,
technological progress, and government support. Config(1a) does not include the number of R&D institutions owned by high-tech industries, the environmental base layer of which includes the regional external economic level and government scientific research fund support. The science and technology investment layer includes science fund funding and technology acquisition expenditure; we can say it is the capital input-oriented path. Configuration (2a) does not contain the quantity variable of policies related to high-tech industry issued by the government, and configuration (2b) does not contain the investment variable of high-tech industry, which measures the internal economic situation of the industry. However, both have the core conditions of the external economy of the environment base layer, as well as all the core conditions of the scientific research and technology latitude of the resource input layer. Therefore, configuration (2a) is a science- and technology-oriented path under the initial scale of internal investment in the high-tech industry, and configuration (2b) is a science- and technology-oriented path under the auxiliary support of relevant policies of the high-tech industry. Configuration 3a is the low-input and high-output mode at the beginning of industrial development in less developed areas without government support.

Configurations (4a), (5a), and (5b) all have a lack of core conditions that are the output of scientific research institutions. They also do not fully solve the problem of technological progress. The difference lies in that configuration (4a) is an economically underdeveloped region, while the external economic environment of configuration (5a) and the internal economic environment of industry of configuration (5b), as well as industry-related policies existing in both groups, play a complementary role. However, it is still difficult to change the result of non-high-level performance of high-tech industries.

**Configurations for High Levels of High-Tech Industry**

When the relevant variable exists as the core condition, it is framed with a solid line, and the path points to a solid line (Figure 2). A line indicates that when the edge condition exists, the variable

<table>
<thead>
<tr>
<th>Antecedent condition</th>
<th>1a</th>
<th>2a</th>
<th>2b</th>
<th>3a</th>
<th>4a</th>
<th>5a</th>
<th>5b</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP ●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>⊗</td>
<td>●</td>
<td>⊗</td>
</tr>
<tr>
<td>FIN ⊗</td>
<td>●</td>
<td>⊗</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>FUN ●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>RDI ●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>⊗</td>
<td>⊗</td>
<td>⊗</td>
</tr>
<tr>
<td>TA ●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>⊗</td>
<td>⊗</td>
<td>⊗</td>
</tr>
<tr>
<td>TR ⊗</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>⊗</td>
<td>⊗</td>
<td>⊗</td>
</tr>
<tr>
<td>NUM ⊗</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>GOV ●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

### Table 4.
**Configurations strongly related to high-tech industry**

<table>
<thead>
<tr>
<th>Antecedent condition</th>
<th>EP</th>
<th>~EP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw coverage</td>
<td>0.196</td>
<td>0.197</td>
</tr>
<tr>
<td>Unique coverage</td>
<td>0.082</td>
<td>0.048</td>
</tr>
<tr>
<td>Consistency</td>
<td>0.939</td>
<td>0.975</td>
</tr>
</tbody>
</table>

Note: ● = core casual condition (present), ⊗ = core casual condition (absent), ● = peripheral casual condition (present), ○ = peripheral casual condition (absent). Blank spaces indicate "do not care."
uses the solid line frame, and the path points to the dotted line. When the relevant variable exists as the peripheral condition, it is framed with a solid line, and the path points to a dotted line (Figure 3). When a condition is missing, the variable is framed with a dotted line.

**Capital Input-Oriented Path.** In configuration (1a), \( \text{GDP*FIN*FUN*TA*TR*NUM*GOV} \) constitutes sufficient conditions for high-level performance of regional high-tech industries (the condition variables of the configuration path are separated by “*”). The regions belonging to this path are Beijing, Tianjin, and other regions. This path can explain about 19.6% of high-level performance cases in high-tech industries. In addition, only about 8.2% of high-level performance cases in high-tech industries can be explained by this path. The core conditions are regional external economy, scientific funding, technology acquisition, and government investment, whereas the others are peripheral absent conditions. The combination of financial input from the four latitudes of economic environment, scientific research, technological progress, and government support can effectively break the constraints on the development of high-technology industries imposed by the industry’s internal economic level, government policies, and other objective endowment conditions.

Provinces with more developed regional economies can consider this path, make full use of regional university resources, obtain funding for natural science foundation projects, rely on the regional government’s continuous investment in scientific research, purposefully enhance the technology acquisition capability of high-tech industries, introduce advanced science and technology, and capitalize on the advantages of strong financial investment to achieve a high level of performance in high-tech industries (Figure 2).

**Science- and Technology-Oriented Path.** In configuration (2a), \( \text{GDP*FIN*FUN*RDI*TA*TR*GOV} \) constitutes sufficient conditions for high-level performance of regional high-tech industries. The regions belonging to this path are Guangdong, Jiangsu, and other regions. This path can explain about 57.1% of high-level performance cases in high-tech industries; however, only about 9% of high-level performance cases in high-tech industries can be explained by this path.

In configuration (2b), \( \text{GDP*FUN*RDI*TA*TR*NUM*GOV} \) constitutes sufficient conditions for high-level performance of regional high-tech industries. The regions belonging to this path are

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**Figure 2.**
Capital input-oriented path
Jiangsu, Zhejiang, and other regions. This path can explain about 46.1% of high-level performance cases in high-tech industries, but only about 0.7% of high-level performance cases in high-tech industries can be explained by this path.

The core conditions of configurations (2a) and (2b) corresponding to Figure 3 are the same, except for the existence of edge conditions. Therefore, we gave the two configurations the same name, science and technology-oriented path. As the two path diagrams in Figure 3 show, the marginal conditions of the environmental base layer are respectively “Internal economy of industry” and “Industry-related policies,” and the related path directions have been shown by dotted lines. Regions with high levels of scientific research and technological progress, under the basic environment of relatively developed external economy and large government investment in R&D funds, internally, should encourage local high-tech industries to cooperate with universities and research institutions, promote the innovation and transformation of scientific research results and the organic integration of industry, university and research. Externally, governments should make full use of abundant technology acquisition expenditures to introduce advanced science and technology and promote the transformation of scientific research achievements of high-tech industries within the region. Thus, governments can use internal and external measures to achieve a high level of industrial performance in the region (Figure 3).

Combining the actual data, we focused on analyzing the Guangdong Province, which is the most consistent with the pathway of configuration (2a). Guangdong Province attaches great importance to the development of high-tech industries (Figure 4). In 2018, the Eleventh Five-Year Plan for the Development of High-tech Industry in Guangdong Province was formulated to vigorously develop high-tech industries, such as communication equipment, new materials, and biomedicine, introduce leading high-tech enterprises to invest and start businesses in high-tech zones, pay attention to cultivating and developing endogenous high-tech enterprises, guide the high-tech industry to develop into high-end links, focus on developing headquarters economic clusters, and strive to improve industrial competitiveness and added value. Relevant statistics show that in 2018, Guangdong’s high-tech industry spent 43.04 billion yuan on technology acquisition and reform, and its high-tech industry’s operating revenue in 2019 was 467475 billion yuan, ranking first in China.

**Low-Input and High-Output Path.** In configuration (3a), \(-GDP*FIN*-FUN*RDI*-TA*TR*-NUM*-GOV\) constitutes sufficient conditions for high-level performance of regional high-tech industries. The regions belonging to this path are Jiangxi, Henan, and other regions. This path can explain about 17.3% of high-level performance cases in high-tech industries, and only about 6.5%
The regions shown in Figure 6 indicate that data of related variables in other provinces and cities are distributed intensively. However, it can be intuitively seen that in the typical case of configuration (3a), Jiangxi and Henan, the performance level of high-tech industry ranks in the middle and upper reaches of the country, achieving a relatively high-level of industrial performance. At the same time, the projection of the number of R&D institutions and technical transformation expenses in the core condition of the configuration path is above 0.5 in the three-dimensional figure. Combining the calibration data, in addition to the high-tech industry investment, the number of R&D institutions, and the expenditure of technological transformation, we found that other variables in the configuration path of the case area are all below 50% in the national ranking. This finding indicates that other variables play a little role in the path. It accords with the path characteristics of low input and high yield of this configuration.

**Configurations for Non-High Levels of High-Tech Industry**

Three configurations produce non-high-level performance in high-tech industries, and the core conditions of these three configurations are the same, as shown in Table 4. Both the raw coverage
Figure 5.
Low-input and high-output path

Figure 6.
The interpretation case for configuration (3a) (fsQCA 3.0 Output)
and the unique coverage of configuration (4a) are higher than those of configurations (5a) and (5b), indicating that configuration (4a) is the most empirically relevant configuration, and suggesting that low levels of economic development, lack of technological inputs, and output of R&D institutions will produce low levels of performance in high-tech industries. The nonregional economic level and nontechnological progress latitude variables are the core conditions. The nonindustrial internal economic level and nongovernment support latitude variables are the peripheral conditions. The regions belonging to this path are Tibet, Heilongjiang, Qinghai, and Shanxi. The consistency of configuration (4a) is 0.992, the unique coverage is 0.385, and the raw coverage is 0.539. This path can explain about 53.9% of high-level performance cases in high-tech industries, and only about 38.5% of high-level performance cases in high-tech industries can be explained by this path.

Configuration (5a) shows that when there is insufficient investment in the technological progress latitude and a lack of scientific research, the performance of high-tech industries is not high, even if the external economic level of the region plays a supporting role and government policies are present. This path explains 10.7% of the cases of non-high performance of high-tech industries, typically in Inner Mongolia. Configuration (5b) shows that, in the absence of the same core conditions, the performance of high-tech industries is not high even when the internal economic conditions are not very bad and government policies are supportive. This path explains 19.7% of the non-high level performance cases of high-technology enterprises, with Guangxi being the typical province. In summary, we found that in the absence of the main core condition technological progress latitude factor, producing the desired performance in the high-tech industry sector—regardless of changes in economic development, scientific research, and policy conditions—is difficult.

Robustness Checks
QCA robustness tests can be conducted by raising the consistency threshold, increasing the PRI consistency, adding other conditions, and adding or removing cases (Yunzhou & Liangding, 2017). Usually, one of these four methods can be selected. We used the method of raising the case consistency threshold from 0.8 to 0.85. The robustness test shows that the new configuration results are consistent with the above analysis results (Table 4), indicating that the results have good robustness.

DISCUSSION
Taking high-tech industries in 31 provinces of China as case samples, we used the fsQCA method to conduct conditional configuration analysis; explore the linkage effect and driving path of eight antecedent variables in the four latitudes of economic environment, scientific research, technological progress, and government support on the development of high-tech industries; and reveal the core conditions affecting the development of high-tech industries and the nature of their complex interaction.

First, none of the factors in the economic, scientific, technological, and policy latitudes can stand alone as a necessary condition for high levels of performance in high-technology industries. In terms of results, high and non-high levels of industrial performance can be achieved through the linkage of antecedent conditions. Based on the coordinated combination of different factors at the environmental base and resource input layers, we proposed three types of high-level performance of high-tech industries with different combinations of core conditions: capital input-led, science and technology-led, as well as low-input and high-output.

Second, the development of high-tech industries is the synergy of multiple factors. The effective combination of all factors improves industrial performance in a way that leads to the same destination. Under certain conditions, investment in science and technology can break through the restrictions of internal economic and policy conditions. In economically developed areas, high investment in scientific research can effectively promote the development of high-tech industries. In economically underdeveloped areas, science and technology are important factors driving the development of high-tech industries.
Finally, there are three types of paths for the non-high-level performance of high-tech industries that lack the core conditions of R&D institutions and technological progress: regional economic underdevelopment, industrial policy and regional economies supporting, and underdeveloped regional economy with industry-related policies and internal economy supporting. Overall, regions with a relatively low level of economic development or scientific and technological research have difficulty in achieving high levels of performance. This finding reflects the irreplaceable role played by both economic development and scientific and technological investment in the development of high-tech industries.

THEORETICAL CONTRIBUTIONS

First, based on the perspectives of the four latitudes of economic environment, scientific research, technological progress, and government support, we constructed a theoretical model of the performance of high-tech industries, thus revealing the influence mechanism for high-tech industrial development. Second, we extended this research by exploring the mechanism of the factors influencing the performance of the high-tech industry from a holistic perspective. The development of high-tech industries is driven by interactions between basic environmental conditions and scientific and technological input conditions, rather than by any single factor. Finally, we applied the QCA method to the research on the development factors of the high-tech industry and broadened the selection of research methods for small and medium-sized samples in the field of industrial performance. Our research revealed not only the substitution relationship between the different paths of multidimensional capital input and science and technology input but also other combination paths leading to the non-high level of industrial performance from the perspective of causal asymmetry.

Practical Implications

This study provides practical management enlightenment for the improvement of regional high-tech industry performance levels.

Improve the Rational Allocation of Funds

Each region should take into account its own characteristics, advantages, endowments and external environment to find a suitable path to achieve a high level of performance. Second, each region should grasp the strength of financial investment and make up for the shortcomings in the process of technological adaptation, absorption, and transformation by taking advantage of the first-mover advantage. Finally, regions should take overall efficiency enhancement as a long-term goal and create maximum value with limited financial investment by optimizing the combination of advantages such as science foundation funding, government funding, and technology acquisition capability. The above three suggestions are all effective ways to achieve high performance in high-tech industries.

Encourage Output from Universities and R&D Institutions

Universities and research and development institutions should be guided by the feasibility of transforming research results. They should strengthen cooperation between production, university, and research, and they should share the work of a technological attack with high-tech enterprises. While improving the sustainable acquisition ability of technology, they should ensure that the technology is absorbed and finally applied to solve practical problems.

Promote Industrial Technology Upgrading

High-tech enterprises should be oriented toward long-term development and transform from traditional low-value-added technologies to fully mastering core technologies as soon as possible. The path of
low input and high output only considers immediate benefits without long-term planning, which is not desirable. The only way is to establish a positive technology acquisition and transformation mode to remain invincible in the increasingly fierce industrial competition in the future.

**Limitations and Future Research**

This study has the following limitations. The content of the study is cross-sectional data that cannot reflect the changes of the interaction of various factors on the level of industrial performance over a long period of time. We mainly analyzed the performance level of high-tech industries in 31 provinces of China and did not make a more specific analysis of a province. The inclusion of samples from other countries in QCA can further enrich the research.

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