Innovation-Driven Development in Northeast China: A Perspective of Regional Transition

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Abstract

Innovation plays a key role in economic transition and industrial upgrade of China. However, some regions, especially the old industrial regions suffer from a low level of innovation capacity and lag behind other advanced regions during the process of China’s regional economic transition. This paper investigates the innovation-driven development of the Northeast Old Industrial Base through a comparative analysis of the innovation capacities of 31 provinces in China. The empirical analysis shows that the innovation capacity of the Northeast Old Industrial Base is poorly developed. The main causes lie in the region’s institutional system and operational mechanism. A market-led regional innovation system should be constructed to inspire innovation.

Key words: regional innovation system, innovation capacity, economic transition, the Northeast Old Industrial Base

1. Introduction

Technological innovation is the driving force for economic and industrial development of a country.\(^1\)\(^2\) Innovative capacity is the key element for countries to achieve and maintain contemporary competitiveness in globalised, knowledge-based economy.\(^3\) As stated in the previous studies, innovation is not a linear relation between investment and output. Innovation is an interactive and path-dependent act, the effectiveness of which is determined by


pattern of knowledge generation, transmission and distribution within the country.\footnote{1}\footnote{2}

Many concepts and theories are put forward to conceptualize national capability in undertaking innovative activities. The term of NIS conceptualizes innovation as a systemic interaction of different innovative agents. And the nation’s institutional, financial, law and policy system influence this process.\footnote{3}\footnote{4}\footnote{5}\footnote{6} Lundvall\footnote{7} indicates the core elements of NIS are (1) firms (2) inter-firm relationship (3) public sector (4) institutional set-up of the financial sector (5) R&D intensity and R&D organizations. Sun et al.\footnote{8}\footnote{9} investigated the structure and main components of National Innovation System of China and concluded that China’s NIS differs from developed countries in many aspects.

In the meanwhile, some scholars put forward that the region, a sub-aggregated level compared to the country, due to its industrial specialization and certain institutional, organizational and policy environment, is more practical for analysing innovation capacity.\footnote{10}\footnote{11}\footnote{12}\footnote{13} Theory of regional Innovation System (RIS) points out that region is a repertoire of certain rules, norms and values that guides the innovation activities.\footnote{14}\footnote{15}\footnote{16}\footnote{17} Cooke\footnote{18} concludes the two main elements of RIS as innovation agents, such as firms, universities, research institutions, funding organizations, technology transfer agencies, and

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the linkage between them in forms of investment, collaboration and knowledge learning.\(^1\)\(^2\) Besides, evolutionary economics\(^3\) and new regional economics\(^4\) provide different perspectives for investigating regional innovative development. A combination of these theories rather than focusing on an ideal one should be used to analyze regional innovation development.\(^5\) The measurement of regional innovation capacity usually includes the core components of RIS due to its strong empirical focus.

Innovation is a crucial element in the economic and industrial development in Asia. It is especially important for China who is in rapid industrialization.\(^6\)\(^7\) During China’s economic transition, technological change in its industrial and corporate sector, from imitation and exploitative innovation, to more self-incentive, explorative innovation is vital.\(^8\)

The innovative ability in different regions in China is greatly different. Enterprises such as Huawei and Xiaomi from the advanced regions become leading innovators in the global market, while enterprises in most of the other regions, especially the old industrial bases fail to catch up with the technological development and show a low level of innovation capability. Different regions in China are at different stages of development and vary significantly in the degree of industrial development. Due to this unbalanced development of China, innovation should be studied on a regional level to gain a more comprehensive understanding of China’s innovative development.

Northeast Old Industrial Base is China’s important heavy-industrial zone and production base for raw materials and energy. The Northeast mainly includes Liaoning, Jilin and Heilongjiang provinces, with industrial sectors encompassing oil, metallurgy, petrochemical, coal, heavy machinery, automobile and shipbuilding etc. However, due to historical reasons, the region shows on the whole an investment-led and extensive development mode, which creates barriers for regional economic transition. The Chinese government implemented a series of science and technology policies in 2003 to promote the economic growth, R&D activities and other related infrastructure construction in the Northeast.

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Although the economic condition is noticeably improved, there are still many problems, such as poor infrastructure development, unfavorable industrial structure and lagged development of state-owned enterprises (SOE). Especially from 2012, these problems have affected negatively the regional economy and dragged down the economic growth rate. Instead of top-down policy approaches and investment, economic growth and economic transition in the Northeast should be promoted by stimulating and vitalizing regional innovation capacity. An innovation-driven development of the region is urgent, in order to turn the uncompetitive industries into new and innovative industries, liberate the firm’s impetus for innovation and eventually change the economic structure and regional development mode.

In this paper, through an in-depth analysis of the status of innovative development of the Northeast and a comparative analysis with other regions in China, the causes of the backward development of the Northeast are discussed. Referring to the analytical frameworks used in the literature\[1,2\] and reports\[3,4,5\], a new analytical framework of evaluation of innovation capacity is proposed and utilized for a comparison of 31 regions in China, since the policy formulation in 2003 and a later year of 2012 to shed light on the effect of policy implementation. The framework includes three major aspects of innovation system, which are innovation resources, firm innovation and innovation environment. Using global entropy weight method, a weighted evaluation of the indicators is conducted based on the data of 2003 and 2012 to give an overall evaluation on the innovative development of different regions. Through the empirical analysis of innovation status of the Northeast, the factors that hinder the innovation-driven development are discussed, and some policy suggestions are provided.

The content is structured as follows. Section 2 is the theoretical bases and introduction to the analytical framework and methods used in the paper. Section 3 is the result and analysis of the weighted evaluation on the innovative capacity of 12 selected regions. Section 4, 5 and 6 are the comparative analysis and discussion on the innovation resources, firm and innovative environment of the Northeast compared to the other provinces. Section 7 is the conclusions and policy recommendations.

2. Methodology and Data

2.1 Analytical Framework

In conducting evaluation on and comparison of innovation capacity across nations and regions, various analytical frameworks have been proposed. Furman and Porter\(^1\) based on ideas-driven endogenous growth theory, and the theory of national industrial competitive advantage\(^2\) and national innovation systems,\(^3\) proposed a framework for evaluating national innovation capacity. The framework includes three major aspects which are infrastructure, innovative milieu in cluster and linkage between them.

As for the regional innovation capacity, similar analytical frameworks have been utilized. Doloreux\(^4\) concludes the main components of regional innovation are firms, institutions, infrastructures, policy-oriented innovations as well as the interaction mechanisms, such as interactive learning, proximity and social embeddedness. Buesa et al.\(^5\) utilizes an outline that includes firm, civil service and regional innovation environment to study the RIS in Spain. ArCo is an indicator developed by Archibugi and Cosco\(^6\) for measuring technological capabilities which takes into account the creation of technology, technological infrastructure and development of human skills. Moreover global organizations like OECD, EU and WEF publish annual reports on innovative development, namely, OECD “Science, Technology and Industry Scoreboard 2015”,\(^7\) EU “Regional Innovation Scoreboard”\(^8\) and WEF technology index from the “Global Competitiveness Report”\(^9\) to compare and evaluate innovative development of different countries. A comprehensive set of indicators for evaluating national innovative capacity are developed and utilized in these reports.

In this paper, we proposed a new analytical framework for evaluating regional innovative capacity of China. Our framework includes three main components: innovation resources, firm innovation and innovative environment. Referring to the reports of OECD, EU and WEF, various indicators are utilized for the measurement of these three aspects.

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(1) Innovation resources

Innovation resources measure the region’s efforts in science and technology as well as the capability to undertake technological activities. It is a broad concept that includes public institution, human capital and regional knowledge accumulation etc. First, public institutions play a key role in the allocation and distribution of a region’s R&D apparatus. It represents the region’s innovative efforts of public organizations like government, universities and research organizations which are the crucial player during the creation, development, transfer and utilization of knowledge. Various indicators can be used for the measurement of innovative activities conducted by public institutions such as R&D expenditure, spending on higher education and quality of scientific institution. In our framework, we included the R&D expenditure of the region as a measurement of the innovative effectiveness of regional public institutions. Second, human capital for innovation is the main source of creative ideas of the region. Various indicators are utilized in the reports to measure innovative human capital. These indicators include R&D personnel, number of doctorate degree holders, trained workers, educated population and scientists and engineers. In our framework, the full-time equivalent R&D personnel is included as a measurement of innovative talents in the region. Third, innovation resource also includes the accumulated knowledge of the region. The regional knowledge assets that are created from R&D activities in the past indicate the level of the region’s capability and expertise in undertaking innovative activities. Accumulated knowledge also forms the bases of further R&D development. The EU reports include most cited publications and WEF reports use scientific publications to account for the accumulated knowledge. In this paper, we include the regional patent to account for the regional accumulated knowledge.

(2) Firm innovation

Firms play a central role in R&D activities and build the technological “micro” bases for industrial development and economic growth of the region. They are the knowledge producers,

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users and also responsible for learning and diffusion of knowledge by interacting with other innovative actors. The indicators of firm innovation mainly measure firms’ human and financial resources devoted to R&D activities in the region. The OECD reports include “firm innovation” as a main component which has sub-indicators like business R&D expenditure, business patent, government support for business R&D and R&D tax incentives.[1] The EU reports argue that firm activities include firm investments, linkage, entrepreneurship and intellectual assets which are measured by indicators such as firm R&D and non-R&D investment, SME innovation and public private co-publications.[2] The WEF reports use company R&D spending, firm technology adoption and firm technology transfer to measure the firm innovative activities.[3]

In our analysis, we use three indicators to measure the firms’ efforts in R&D development. First, regional firm number can reflect the overall industrial activeness of the region. Hence, industrial firm number is included as a measurement of firm activity. Second, regional firm profitability is included as it is an important indicator of overall industrial competitiveness of the region. Third, the last indicator is regional firm new product sale which mirrors the firms’ innovative capacity of transforming innovation into application.

(3) Innovative environment

Innovation is not an independent process of the organizations and a variety of factors internal and external to organizations exert effect on their innovative activities.[4][5] In our analytical framework, innovative environment indicates these contextual effects. Innovative environment is a broad concept pertaining to various institutional and social contexts that have direct influence on innovative activities.

Firstly, interaction among different innovative actors should be considered as an important aspect of innovative environment. The diffusion of new knowledge is crucial to regional innovative development, the process of which is mainly accomplished through the interaction among innovative agents such as universities, firms and research organizations. Interaction among organizations within and outside the region can bring novel technologies to the region. The linkage and interaction among different innovative actors is measured with different methods in previous studies. The OECD reports include “connecting for knowledge” as a main component and use indicators such as scientist mobility, scientific and patent collaboration, citation impact.

and open access journal publishing.\textsuperscript{[1]} WEF reports use technology transfer, innovative collaboration and FDI to account for the innovative interaction.\textsuperscript{[2]}

Secondly, innovative environment also includes the development of financial system, policy system and infrastructure in the region that are needed for the creation and diffusion of technology. Venture capital is included in all of the three reports to measure the development of financial system for innovation. Besides, intellectual property protection is included in WEF reports as an important aspect of innovative environment.\textsuperscript{[3]}

Thirdly, regional infrastructure construction that is needed for the creation and diffusion of knowledge is a crucial aspect of innovative environment. WEF includes ICT diffusion in the society as a main component, and uses indicators such as internet subscripts and use, mobile subscripts and telephone subscripts.\textsuperscript{[4]}

Apart from internet and telephone uses, OECD also includes the development of E-business and E-government as an indicator of social infrastructure development.\textsuperscript{[5]} Besides, measurement of general social and economic development of the region such as GDP, regional export and development of education can be included as indicators of innovative environment.

In our analysis, we consider three aspects, specifically the interactions among different innovative actors, intellectual property protection as well as marketization level of the region. R&D collaborations among organizations can be used to shed light on the level of innovative interaction. The number of co-inventions in the patents of the region is considered as a measurement of innovative interaction. It is the number of patents applied by innovative organizations (universities, research institutions and firms) in the region that have collaborative assignees. Second, as for the intellectual property protection, we include the yearly intellectual protection lawsuit number as the measurement of the effectiveness of intellectual protection in the region. Third, the market environment of the region would significantly influence the innovative activities of the firms. For developing countries like China, market environment differs across regions, with the eastern coastal regions showing a high marketization level than the inner-land regions. Our analysis includes marketization index as an indicator of regional marketization level. Due to the unavailability of data, the marketization index of 2009 instead of 2012 is included in the weighted evaluation.

2.2 Methods

In this paper, global entropy weight method is used to conduct a weighted evaluation on

\begin{itemize}
\end{itemize}
Table 1
Indicators for Innovative Capacity Measurement

<table>
<thead>
<tr>
<th>OECD</th>
<th>Investing in knowledge, talent and skills: spending on higher education, R&amp;D expenditure, tertiary education graduates, doctorate holders, R&amp;D personnel, quality of scientific production etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unlocking innovation in firms: business R&amp;D expenditure, R&amp;D expenditure on information industries, production innovation, tax incentives, venture capital investment etc.</td>
</tr>
<tr>
<td></td>
<td>Connecting to knowledge: international students enrolled, international scientific collaboration, open access journals, international co-patenting etc.</td>
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<tr>
<td></td>
<td>Empowering society with Science and Technology: internet users, digital natives, E-government use etc.</td>
</tr>
<tr>
<td></td>
<td>Connecting in global economy: R&amp;D specialization, E-businesses, start-ups etc.</td>
</tr>
<tr>
<td>EU</td>
<td>Enablers: new doctorate graduates, tertiary education youth above secondary education, R&amp;D expenditure, international scientific publication, most cited publication, venture capital investment etc.</td>
</tr>
<tr>
<td></td>
<td>Firm activities: firm R&amp;D expenditure, firm non-R&amp;D expenditure, SME innovation, public-private co-publication, PCT patents, community trademarks, community design etc.</td>
</tr>
<tr>
<td></td>
<td>Output: knowledge intensive service exports, high-tech product exports etc.</td>
</tr>
<tr>
<td>WEF</td>
<td>R&amp;D innovation: patents, tertiary enrolment, quality of scientific institutions, scientists and engineers, company R&amp;D spending, university-industry collaboration, intellectual property protection etc.</td>
</tr>
<tr>
<td></td>
<td>Technological adoption: firm technology adoption, FDI, technological transfer, latest technology availability, etc.</td>
</tr>
<tr>
<td></td>
<td>ICT diffusion: internet subscripts and use, mobile and telephone subscripts</td>
</tr>
<tr>
<td>In our framework</td>
<td>Innovation resources: R&amp;D expenditure, full time equivalent R&amp;D personnel</td>
</tr>
<tr>
<td>our framework</td>
<td>Firm innovation: firm number, firm profitability, firm new product sale</td>
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<tr>
<td></td>
<td>Innovative environment: co-inventions in patents, intellectual protection lawsuit number, marketization index</td>
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</tbody>
</table>

*Source: Author’s organization.*
the regional innovative capacity and make comparison among different regions. Entropy weight method is a method to measure the objective weight of a criterion. For a certain criterion, if there is a large difference among the objects of the criterion, this criterion gives a large amount of information and can be regarded as an important factor of the analysis of alternatives; if all the objects of a criterion are almost the same this criterion has no effect in the evaluative analysis. Based on the difference among the objects of criterions, the weight of each criterion can be calculated to have a multi-criterion evaluation.

Global entropy weight method has the same approach, while researchers can use time series data rather than cross-sectional data and apply the same weight for each year to analyse the dynamic change of the objects. Assume that objects for evaluation and evaluation criteria form matrix \( X = (x_{ij})_{m \times n} \), the entropy-weight method are expressed as follows:

First, \( X = (x_{ij})_{m \times n} \) is normalized for each criterion using Eq1 (positive value) or Eq2 (negative value):

\[
x_{ij} = \frac{x_{ij} - \min x_j}{\max x_j - \min x_j} \times 99 + 1 \\
i=1,2,...m; j=1,2,...n \quad \text{(Equation 1)}
\]

\[
x_{ij} = \frac{\max x_i - x_{ij}}{\max x_i - \min x_j} \times 99 + 1 \\
i=1,2,...m; j=1,2,...n \quad \text{(Equation 2)}
\]

Second, the proportional form \( p_{ij} \) is calculated using Eq3:

\[
p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} \sum_{j=1}^{n} x'_{ij}} \\
i=1,2,...m; j=1,2,...n; t=1,2,...T \quad \text{(Equation 3)}
\]

Third, the Entropy of criterion \( j \) is calculated by Eq4:

\[
H_j = -k \sum_{i=1}^{m} \sum_{t=1}^{T} p_{ij}^t \ln p_{ij}^t \\
i=1,2,...m; j=1,2,...n; t=1,2,...T \quad \text{(Equation 4)}
\]

in which \( k \) is a constant, let \( k = \frac{1}{\ln mT} \); and if \( p_{ij}^t = 0 \), then \( p_{ij}^t \ln p_{ij}^t = 0 \).

Then, the Entropy weight for criterion \( j \) is calculated by using Eq5:

\[
W_j = \frac{1 - H_j}{\sum_{j=1}^{n} 1 - H_j} = \frac{1 - H_j}{n - \sum_{j=1}^{n} H_j} \\
i=1,2,...m; j=1,2,...n \quad \text{(Equation 5)}
\]

Statistical method is used for the comparative analysis of each indicators in the framework.

2.3 Data


3. The Innovative Development in Northeast China

From 31 provinces in China, 12 provinces including the three provinces in the Northeast are selected to measure the weighted regional innovative capacity. The selected provinces include advanced provinces in the south and southeast coastal region as well as industrial regions similar to the Northeast like Tianjin and Hebei. By applying global entropy weight method using the data in the year of 2003 and 2012, the entropy weights for each criterion and index in the analytical framework are calculated and displayed in Table 2. Innovative capacity of different parts of China differs significantly, showing different level of development concerning the three main aspects of regional innovation system.

From the entropy weight in Table 2, we can see that the three main criterions for evaluating innovative capacity, innovation resources, firm innovation and innovative environment show different level of importance, with innovation resources having a criterion weight of 0.32, and firm and innovative environment showing a criterion weight of 0.34. For the innovation resources, R&D personnel has the highest index weight of 0.36, which means that R&D personnel in the regions during the observation years differs widely. The next is the index of patent with a weight of 0.34 and index of R&D expenditure with a weight of 0.30. For the criterion of firm, firm number has the highest index weight of 0.43, while the index weight of firm profit is 0.21 which is relatively low. The index weight of firm new product sale is 0.36. For the innovative environment,
collaboration shows the highest index weight of 0.52, followed by the intellectual property lawsuit, with a weight of 0.37. The influence of marketization index on regional innovative capacity is relatively low, with an index weight of 0.11.

Using the entropy weight of criterions and indicators calculated above, we can attain the weighted evaluation on the regional innovative capacity of 12 provinces in 2003 and 2012. The result is shown in Table 3 and Table 4.

The score and rank of weighted regional innovative capacities of different regions are calculated and displayed in Table 3. From the result we can see that the ranking of the Northeast does not change in 2012 compared with 2003, with Liaoning ranking 6th in both years, and Jilin and Heilongjiang ranking 10th and 11th. The ranking of the southeast coastal regions undergoes a slight change, with Shanghai falling down from 4th to 5th, and Jiangsu ascending to 2ed from 5th in 2003. For the regions in the southern part, Guangdong remains the 1st in the country, with other regions such as Fujian and Guangxi showing no big change. As we can see from the weighted evaluation, the growth of the innovative capacity of the Northeast is slow with Liaoning ranking at a medium level and losing its advantageous position, and being left behind by advanced regions like Beijing, Tianjin, Jiangsu and

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Guangdong</td>
<td>82.97</td>
<td>1</td>
<td>27.36</td>
<td>1</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>75.95</td>
<td>2</td>
<td>11.81</td>
<td>5</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>56.04</td>
<td>3</td>
<td>17.18</td>
<td>2</td>
</tr>
<tr>
<td>Beijing</td>
<td>44.92</td>
<td>4</td>
<td>15.74</td>
<td>3</td>
</tr>
<tr>
<td>Shanghai</td>
<td>33.58</td>
<td>5</td>
<td>12.55</td>
<td>4</td>
</tr>
<tr>
<td>Liaoning</td>
<td>21.57</td>
<td>6</td>
<td>6.55</td>
<td>6</td>
</tr>
<tr>
<td>Fujian</td>
<td>20.14</td>
<td>7</td>
<td>5.65</td>
<td>7</td>
</tr>
<tr>
<td>Tianjin</td>
<td>16.87</td>
<td>8</td>
<td>4.73</td>
<td>9</td>
</tr>
<tr>
<td>Hebei</td>
<td>15.26</td>
<td>9</td>
<td>5.26</td>
<td>8</td>
</tr>
<tr>
<td>Jilin</td>
<td>9.43</td>
<td>10</td>
<td>2.07</td>
<td>11</td>
</tr>
<tr>
<td>Heilongjiang</td>
<td>8.46</td>
<td>11</td>
<td>4.16</td>
<td>10</td>
</tr>
<tr>
<td>Guangxi</td>
<td>7.19</td>
<td>12</td>
<td>1.92</td>
<td>12</td>
</tr>
</tbody>
</table>
Table 4

Weighted Evaluation of Main Components of Innovation Capacity

<table>
<thead>
<tr>
<th>Province/Indicator</th>
<th>Innovation Resource (rank)</th>
<th>Firm Innovation (rank)</th>
<th>Innovative Environment (rank)</th>
<th>Innovation Resource (rank)</th>
<th>Firm Innovation (rank)</th>
<th>Innovative Environment (rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>59.12 (3)</td>
<td>14.27 (9)</td>
<td>62.66 (2)</td>
<td>15.60 (2)</td>
<td>2.73 (10)</td>
<td>28.87 (3)</td>
</tr>
<tr>
<td>Tianjin</td>
<td>18.98 (8)</td>
<td>20.50 (8)</td>
<td>11.33 (8)</td>
<td>3.13 (10)</td>
<td>3.46 (9)</td>
<td>7.47 (8)</td>
</tr>
<tr>
<td>Hebei</td>
<td>12.79 (9)</td>
<td>24.42 (7)</td>
<td>8.34 (9)</td>
<td>4.13 (7)</td>
<td>3.61 (8)</td>
<td>7.95 (7)</td>
</tr>
<tr>
<td>Liaoning</td>
<td>21.58 (6)</td>
<td>30.19 (5)</td>
<td>12.95 (7)</td>
<td>9.20 (6)</td>
<td>4.36 (5)</td>
<td>6.32 (9)</td>
</tr>
<tr>
<td>Jilin</td>
<td>6.56 (11)</td>
<td>13.30 (10)</td>
<td>8.17 (10)</td>
<td>2.48 (12)</td>
<td>1.74 (11)</td>
<td>2.02 (12)</td>
</tr>
<tr>
<td>Heilongjiang</td>
<td>9.49 (10)</td>
<td>9.20 (12)</td>
<td>6.77 (11)</td>
<td>3.79 (11)</td>
<td>3.71 (7)</td>
<td>4.93 (10)</td>
</tr>
<tr>
<td>Shanghai</td>
<td>39.13 (5)</td>
<td>30.64 (4)</td>
<td>31.49 (5)</td>
<td>9.80 (3)</td>
<td>8.93 (3)</td>
<td>18.68 (4)</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>94.29 (1)</td>
<td>100.00 (1)</td>
<td>35.26 (4)</td>
<td>15.22 (2)</td>
<td>9.73 (2)</td>
<td>10.80 (5)</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>46.99 (4)</td>
<td>66.18 (3)</td>
<td>54.13 (3)</td>
<td>10.85 (4)</td>
<td>6.65 (4)</td>
<td>33.45 (2)</td>
</tr>
<tr>
<td>Fujian</td>
<td>19.89 (7)</td>
<td>27.30 (6)</td>
<td>13.20 (8)</td>
<td>4.12 (6)</td>
<td>3.88 (6)</td>
<td>8.79 (6)</td>
</tr>
<tr>
<td>Guangdong</td>
<td>83.13 (2)</td>
<td>82.41 (2)</td>
<td>83.40 (1)</td>
<td>23.48 (1)</td>
<td>10.72 (1)</td>
<td>47.53 (1)</td>
</tr>
<tr>
<td>Guangxi</td>
<td>6.47 (12)</td>
<td>10.60 (11)</td>
<td>4.43 (12)</td>
<td>1.00 (12)</td>
<td>1.23 (12)</td>
<td>3.43 (11)</td>
</tr>
</tbody>
</table>
Guangdong. The overall weighted innovation capacity of the Northeast has not been improved since the incentive policy in 2003.

Table 4 is the scores and ranks of the weighted evaluation on each of the three innovative criteria for 12 selected regions. From the analysis, we can see that the ranking of different regions in 2012 is slightly altered compared with 2003. As for the innovation resources, Jiangsu went up to be the 1st in 2012 from the 3rd in 2003, and Guangdong dropped to the 2nd. As for the firm innovation, Jiangsu is also in the 1st place followed by Guangdong and Zhejiang. Beijing does not occupy a superior place with a rank of 10th. As for innovative environment, Guangdong ranks the 1st in the country, followed by Beijing and Zhejiang. In the Northeast, innovation resource and firm of Liaoning run at a medium level ranking the 6th and 5th. Innovative environment of Liaoning ranks the 9th in 2003 and slightly improved to the 7th in 2012. Jilin and Heilongjiang fell behind in terms of all of the three indicators. The innovation resource and firm of Heilongjiang dropped down to the 10th and 12th in 2012.

Through the weighted measurement, we can have a systemic evaluation on the innovation status of the Northeast. The development of innovative capacity of the three provinces in the Northeast is relatively slow compared with other regions. Liaoning runs at a medium level and Heilongjiang and Jilin run at the last according to the overall score of innovation capacity. As for the three components, the Northeast region shows a low performance, especially Heilongjiang and Jilin province which are lagged behind compared with other similar regions in terms of most of the indicators. The ranking of the three provinces in terms of all the three indicators does not show change, which means that the incentive policies in 2003 did not bring much improvement to the Northeast. The poor development of innovative capacity is caused by several factors ranging from improper distribution of innovation resources, unbalanced development of firms, shortage of innovative linkages and poor development of intellectual property protection. The empirical analysis mirrors the systemic barriers in the innovative development and economic transition of the Northeast, including its poor institution system, industrial structure and cultural environment. We come to several streams of discussions about innovation resources, firm innovation and innovative environment as well as the underlying factors that hinder the innovative development of the Northeast.

4. Innovation Resources

Innovation resources are the main source of innovative activities. The quantity and distribution of innovation resources can reflect the public institutional system and management pattern of the innovative activities within the region. Based on the measurement of the three indicators, R&D expenditure, patent and R&D personnel, we come to a discussion on the causes of improper distribution and inefficient
use of the regional innovation resources in the Northeast.

(1) R&D expenditure

Figure 1 shows the R&D expenditure of different provinces in 2012. We can see that, in 2012, Jiangsu and Guangdong have the largest amount of R&D expenditure, exceeding 120 billion yuan. Liaoning has R&D expenditure of 40 billion yuan running the 7th in the country, while those of Heilongjiang and Jilin are below 20 billion yuan, ranking the 18th and 21th. From the distribution of R&D expenditure by performers we can see that except for Beijing, industrial enterprises have the largest share of R&D expenditure. In the Northeast, Liaoning, Heilongjiang and Jilin have 76%, 65% and 57% of R&D expenditure on industrial enterprises respectively; and R&D expenditure of Jilin on research institutions and universities exceeds most of the regions.

Figure 2 is regional R&D expenditure of state-owned enterprises (SOE) and the percentage of SOEs in 31 provinces. As can be seen, Liaoning has a large share of R&D expenditure of SOEs ranking the 2nd in the country and exceeds those provinces with similar number of SOEs. It means that in Liaoning, the non-state owned enterprises, especially the private enterprises, do not have enough investment in their R&D activities. Heilongjiang and Jilin also have a large R&D investment on SOEs, while the share of SOEs number among all the enterprises is also large with the proportions being 83% and 68%, which is the main cause of the result. In general, both the total number of SOEs and R&D expenditure of SOEs are significantly high in the Northeast compared to the other regions.

(2) Patent

Figure 3 displays the patents of different regions in China. From the organizational distribution, it can be concluded that except for Beijing, Shanghai and Zhejiang, most of patents are applied by local industrial enterprises. However, in the Northeast, the number of patents applied by industrial enterprises is relatively smaller, with Liaoning having an enterprise patent share of 50% and Heilongjiang...
and Jilin both having a share of 30%. It stands out that most of the patents in the Northeast are applied by universities and research institutions. Especially for Jilin and Heilongjiang, the share of patents applied by industrial enterprises is smaller than most of the other regions.

Innovation resources in the Northeast are improperly distributed and inefficiently utilized, the main cause of which lies in the regional institutional system. Institution plays an important role in regional innovation system as it determines the allocation and distribution of innovation resources as well as creates an environment of stable social interaction that is necessary for innovation activities. The institutional system in the Northeast is inherited during the planned economy and operates under a government-led mode. A market-led institutional system that stimulates innovative actors’ impetus for continuous innovation has not been developed in the Northeast. The market is vulnerable to government intervention as it has limited power and has not fully developed a self-renovating function. Besides, due to the region’s low marketization level, factors such as unfair competition and poor intellectual property protection cause the shortage of innovative impetus of the firms, as innovation has not become firms’ main way of profiting.

Under the government-led institutional system, government has a centralized control over the distribution and allocation of innovation resources. However, government fails to play a main role in conducting and supervising major innovative activities,

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nor does it take the responsibility to reduce risks and increase profits for firms through infrastructure construction, public services and policies.\textsuperscript{[1]} Government views GDP and fiscal revenue as the main performance evaluation criteria and invests a large amount of resources into heavy industries that can yield profit fast, which intensifies the rigidity of the traditional industries. The imbalance of power and responsibility in government departments also leads to the extension of personal interest in the system.

The state-owned organizations (enterprises, universities, and research institutions) represent a dominant share of the market and enjoy preferential treatments in terms of resource investment and allocation which are extended through government policies on energy, raw material and equipment industries. The state sectors, though possessing high share of resources, due to the ineffective task-oriented management pattern, are not efficient in transforming resources into output. Besides, although the state-owned organizations are the basic units of the creation, application and transformation of technologies in the region, the disposal, transformation and profiting of the technologies must get approval from the central fiscal ministry, educational ministry or Chinese Academy of Science through long-cycle procedures. The managerial pattern becomes inappropriate because technological life-cycle gets shorter and shorter. The state-owned organizations fail to establish a proper operational mechanism for the generation and transformation of technological assets and as a result are unable to develop their innovation capacity.

The construction of the innovation infrastructure also undertakes a planned economy mode. The government invests in and leads the construction of innovative projects such as innovation platforms, Science and Technology Parks and industrial alliances,

while does not make efforts in realizing the true objectives of these projects, such as gathering regional innovation resources, cultivating innovative capacity and promoting industry upgrade. Consequently, the regional innovation system lacks a proper operational mechanism, wastes a large quantity of resources. The innovative activities distort the nature of innovation as they are conducted aiming at completing government goals.

(3) R&D personnel

Innovative human capital is a major part of regional innovation resources. The quantity, distribution of innovative human capital and talent management mechanism should be analysed to have a better understating of the utilization of regional innovation resources in the Northeast. Figure 4 shows the total number and distribution of the full equivalent R&D personnel of 31 provinces in 2012. From the figure we can see that Guangdong has the largest number of R&D personnel, reaching 500,000 persons. In the Northeast, Liaoning ranks the 14th and Jilin and Heilongjiang rank the 17th and 18th respectively. Except for Beijing, industrial enterprises have the largest share of R&D personnel in most of the regions. In the Northeast, industrial enterprises have 40%-65% of the total R&D personnel, and the share of R&D personnel in universities is larger than that in research institutions. Comparably speaking, a high share of R&D personnel is owned by the universities and research institutions in the Northeast.

Although the Northeast is traditionally an area of large quantity of talents, at present, it suffers from serious shortage of innovative human capital caused by ineffective talent utilization, outflow of educated population and lack of entrepreneurs etc. Firstly, the full potential of the highly educated population cannot be realized due to the institutional and management barriers. The traditional management style in most of the SOEs cannot provide platforms for personal development. A proper education, training and development system for the educated population has not been fully established in the region. Second, the Northeast
suffers from severe outflow of innovative human capital. The reasons lie in various aspects such as difficulties in the transformation of research achievements and lack of public service and innovative platforms. The outflow of technological and management talents and teams takes away a large quantity of research achievements. Consequently, the Northeast pays for the cost of the education and development of these professionals without benefiting from their achievements. Third, the Northeast suffers from a shortage of entrepreneurs that are the pioneers of the innovative activities and businesses. The reasons lie in various aspects such as government intervention in business activities, difficulty in financing and poor intellectual property protection.

5. Firm Innovation

Firm activities and industrial development differ across regions in China. Firms in some regions are competitive and profitable, while firms in other regions grow slowly. In this section, an analysis on firm activities and innovativeness is conducted, comparing specifically three indicators, firm number, firm profitability and firm new product sales of different regions. Based on the empirical analysis, the existing problems in firm innovation and industrial development in the Northeast are discussed.

(1) Firm number and size distribution

Figure 5 depicts the total number and size distribution of firms in different regions. Firm sizes are classified as large (number of employees exceed 1000, revenue exceed 400 million yuan), medium (number of employees between 300 to 1000, and revenue between 20 to 400 million yuan) and small (number of employees less than 300, revenue less than 20 million). From the Figure we can see that the number of firms in Liaoning reaches 17347 and runs at the 6th after Jiangsu, Guangdong, Shandong, Zhejiang and Henan. The firm number of Jilin and Heilongjiang runs at the 16th and 21st. The firm size distribution shows that most of the regions have larger number of small-size enterprises which occupies about 80% of the total number of firms than large-size enterprises and medium-size enterprises. The three provinces in the Northeast also show the same characteristics.

(2) Firm profits

Figure 6 displays the total profit of industrial enterprises by regions. In 2012, industrial enterprises in Liaoning profits 243.57 billion yuan, ranking the 7th in the country and Heilongjiang and Jilin ranks the 18th and 20th respectively. In Liaoning, small-size enterprises contribute the most to the total profits, while large-size enterprises contribute the least. On the contrary, for Heilongjiang and Jilin, large-size enterprises contribute the most, occupying 75% and 50% of the total profits.

(3) Firm new product sales

Figure 7 shows the new product sales of industrial enterprises by region. In 2003, the new product sales do not show large difference across regions, with most of the regions having
a small number of new product sales. Shanghai, Guangdong, Jiangsu, Shandong and Zhejiang rank high, and Liaoning, Heilongjiang and Jilin rank the 8th, 18th and 23th respectively. In 2012, Jiangsu, Guangdong and Shandong achieve a big leap in the industrial enterprises new product sales, while Liaoning, Heilongjiang and Jilin in the Northeast fall down, ranking the 12th, 16th and 24th respectively. The result indicates that the new product output of the Northeast is low and the overall innovativeness of industrial firms is lagged behind compared with the eastern coastal regions where firm innovativeness grows rapidly.

The empirical analysis reflects the practical situation of firm competitiveness and development in the Northeast. Although the Northeast underwent ten years of revitalization and development, its firms have not become the primary actors of innovation. In the Northeast, industrial enterprises occupy a large share of innovative resources and possess a high proportion of intellectual property. However, enterprises fail to realize their market function in that they lack the impetus for continuous innovation and the capability to integrate the regional innovation value chains. Most of the firms in the Northeast, especially the SOEs, possess a large quantity of innovative resources. However, after they purchased the high-end technologies from abroad, they conduct simple imitation and copying rather than effectively learn and absorb these technologies. Besides, these SOEs are at a superior position in the region, receive favourable policies from the government and have a low pressure in the market competition, which further diminish their endogenous motivation for innovation. In addition, a mutual beneficial interaction and development pattern among the foreign enterprises, private enterprises and SOEs have not been established.

The SOEs are a major part of the market in the Northeast. However, the competitiveness and innovativeness of the SOEs are poorly developed. Most of the SOEs in the Northeast belong to traditional industries and possess a large number of innovation resources.
SOEs have administrative positions which are the extension of government function, thus sharing a common interest with the government. As a result, the government constantly support the SOEs through subsidies, investment and tax reduction, which adds to the rigidity of the traditional industries and the path-dependency of the region. High-end innovation resources of the SOEs is mostly concentrated in the national defence and security sector. However, these firms cannot match the market demand due to small quantity of military order, unique technical requirement and high pricing, the technical standard, cost, sales channel and service system etc. Besides, most of these high-end innovation resources are directly controlled by the central government and the local transformation of the technologies is difficult. Due to this technological and institutional barriers, the high-end technologies of the SOEs cannot realize successful industrialization in the region. Also, the direct control and management of the government constrains the innovative impetus of the SOEs.

The private firms in the Northeast have not conducted a successful learning and absorption of technologies from the foreign enterprises during regional marketization and internalization process. The foreign enterprises in the Northeast fail to contribute to the upgrade of local industries and simply contribute to value adding and export increase of the region. Besides, the private firms in the region do not have enough learning and absorptive capacity to effectively interact with and learn from the foreign enterprises and the spill-over among the firms is insignificant. Due to the narrow market space and poor learning capacity, the private firms are incapable of becoming the primary actors of innovation. Consequently, although the number of private firms in the Northeast increased significantly over the years, they in general lack competitive technologies and fail to become the proactive actors during the introduction and diffusion of technologies in the region. In the meanwhile, due to the lack of innovative
capability of private firms, the overall activeness in the locus of industrial innovation is low in the Northeast.

In the meanwhile, the Northeast lacks a solid industrial base for successful economic transition. The industrial sector runs short of core technologies and innovative capability.

Firstly, the industrial structure of the Northeast is severely unbalanced and the pillar industries lack the core technological capability. Due to the traditional heavy-industry layout inherited from the planned economy, a large quantity of the innovation resources in the Northeast is gathered in the “heavy” industrial sectors such as equipment manufacturing, processing and energy, which causes the rigidity of regional structural transformation. Petrochemical industry and equipment manufacturing industry that are dominated by the SOEs are the pillar industries in the region, which leads to the over-simplification of the regional industrial structure. Most of the traditional industries rely on foreign technologies, lacking innovative capability for further development.

Secondly, the development of high-tech industry in the Northeast is lags behind other advanced regions in China. The high-tech industries in the Northeast fail to become new growth poles of regional economic development. And they cannot support the upgrade of the traditional industries. Industries like optoelectronics industry, software industry, biopharmaceutical industry and ICT industry are not on a massive scale and fail to lead the regional economic development. The optoelectronics industry fails to be large-scaled and lacks leading innovative firms. The software industry, especially software service outsourcing in cities like Dalian and Shenyang has been developed for a long time, while remaining at the low end of the value chains. The biopharmaceutical industry prevails in its operational mechanism compared with other high-tech industries, while failing to become a lead industry in the region. As for the ICT industry which is seen as a sign of high-tech development throughout the world, its development is also unsuccessful. Since 1990s, advanced regions in China like Shanghai and Shenzhen have developed ICT industry at a rapid speed following ICT technological development.
including consumer electronics, computers and integrated circuits, software and information services and big data, cloud computing and internet of things. For these regions, ICT industry has become the new growth pole for regional economic development and also promotes the upgrade of traditional industries. However, the ICT industry in the Northeast has not formed a complete value chain and fails to lead high-tech industries development of the region. The unbalanced industrial structure, lack of core technologies and underdevelopment of high-tech industries lead to the situation that innovation-driven development in Northeast Old Industrial Base lacks solid industrial base.

6. Innovative Environment

Innovative environment is a major part of regional innovation system and includes many aspects. We analysed the innovative interaction, intellectual property protection and marketization level of different regions through the comparison of the three indicators, patent collaboration, number of intellectual property lawsuits and marketization index in our analytical framework. Besides, other aspects of innovative environment such as venture capital development, policy system and regional innovative culture were also discussed in this section.

(1) Innovative collaboration

The interaction among different innovative actors is crucial to the regional innovation development. In the Northeast, the level of collaboration among universities, research institutions and firms as well as the interaction among firms is low. As a result, the region fails to form an integrated innovative value chain. Figure 8 shows the patent collaboration network in the Northeast. In the figure, the circle nodes represent organizations from Liaoning, triangle nodes represent organizations from Heilongjiang and diamond nodes represent organizations from Jilin. From the figure we can see that the patent collaboration in the Northeast is mainly centred on the universities like Dalian University of Technology, Northeast University, Harbin Engineering University and Jilin University. The level of collaboration within each region is relatively low. Also, the cross-regional collaboration among the three provinces is at a very low level.

Figure 9 shows the patent collaboration network in the Southeast, in which circle nodes represent organizations from Shanghai, triangle nodes represent organizations from Zhejiang, and diamond nodes represent organizations from Jiangsu. The collaboration network is dense and mainly centred on universities like Fudan University, Southeast University and Changzhou University. We can see that both within-region and cross-region collaborations are very common. From comparison between Figure 8 and Figure 9, we can see that the patent collaboration in the Southeast is denser and the degree centralities of the nodes are higher than in the Northeast. Also, the cross-regional collaboration in the Northeast is significantly weaker than in the Yangtze River Delta region.
The analysis of the regional patent collaborations shows that innovative collaboration among the three provinces should be further promoted in the Northeast. The low level of innovative interaction among the innovative actors and lack of industrial clusters lead to the poor development of regional innovation value chain both horizontally and vertically. Horizontally, the innovative chain of research, manufacturing and sales of innovative products is not integrated. The collaboration among firms at the low end of value chain is rare. Also, the collaboration among research, manufacturing, marketing, and services within each industry is not close. Vertically, the chain from the research to technological transformation is not successfully integrated. Innovative activities of universities, research institutions and firms are not connected as the firms lack core technological capabilities and are not closely linked compared with other regions. Consequently, most of the firms in the region remain at the low end of innovation value chain, making it difficult for the region to form an industrialization channel for innovative products.

(2) Intellectual property protection

The intellectual property (IP) protection system is an important part of regional innovative environment as it ensures the innovators to have the right to benefit from innovative efforts and thus promoting incentives for innovation. The number of closed intellectual property lawsuits can reflect to some extent the effectiveness of the IP protection in the region. Figure 10 shows the number of closed IP lawsuits of each region in 2003 and 2012. In 2012, Zhejiang, Guangdong and Shandong have the largest number of IP lawsuits, and Liaoning and Jilin rank the 11th
and 13th, achieving a large increase compared with 2003. However, in general, the intellectual property protection system of the Northeast lags behind the advanced regions in China. Also, the Northeast has not developed a complete and well-operating intellectual property service system.

The protection of intellectual property needs to be substantially strengthened in the Northeast. As a large number of small businesses continue to emerge in the region, IP related issues, such as serious fake and shoddy, infringement of intellectual property rights, malicious competition and chaos of market order become common. Many firms do not want to devote their creative resources to fundamental research, because the intellectual property protection of the region is not strong. The laws regarding patents, copyright, trademarks, trade secrets and designs are not fully developed and implemented in the region. Consequently, most of the firms that invest heavily in the research and development of new products, find that their intellectual property or trademarks have been stolen. The poor condition of intellectual property protection would diminish the organizations’ incentives for innovation and hinder the development of innovation.

(3) Market environment

The construction of a sound market environment is crucial to the regional innovative development, especially for the Northeast which is deeply affected by the planned economy. Market environment will influence firm innovation activities. A liberal market economy can promote technological diffusion in the society. The marketization index can reflect the soundness of market environment in the region. Figure 11 shows the marketization index of each region in 2003 and 2009. In 2009, Zhejiang,
Jiangsu, Shanghai, Guangdong and Beijing have high degrees of marketization; Liaoning, Jilin and Heilongjiang rank the 9th, 18th and 23rd, showing a slight increase compared with 2003. Since the incentive policy in 2003, the market environment in the Northeast has improved significantly, while it is still at medium to low level compared with other regions in China. In particular, factor markets need to be further enhanced. The marketization process of Jilin and Heilongjiang have been slow, which hinders the innovation-driven transformation of the Northeast Old Industrial Base.

Apart from the three aspects analysed above, the innovative environment of the Northeast also exists other problems such as poor development of technological and financial service industries, ineffective policy implementation and lack of innovative and entrepreneurial culture. The financial and technological service industries such as venture capital, private equity funds and patent evaluation institutions are not well developed in the Northeast. In the Northeast, the government does not take the responsibility for regulating and guiding the development of these industries. As a result, innovative firms and start-ups do not receive enough technological and financial services during the initial phases of the development.

In addition, the policy system in Northeast are ineffective in promoting innovation activities due to various reasons. The output-based performance evaluation system makes the innovative policies ineffective in solving practical problems. Also, the investmented policies in the Northeast leads to a waste of resources. Due to the output-based evaluation standard and investment-led operational system, the innovation policies of the government overemphasize facility construction, and neglect innovation in the regional institution and operational mechanism. As a result, the incentive policy of the Northeast fails to foster regional endogenous motivation for innovation and results in firms' dependence on government investment.
As for the innovative culture cultivation in the region, although the Northeast started industrialization early, due to historical reasons, the culture paradigm of the Northeast was established by early settlers’ and immigrants’ activities. Also, the social structure and culture have been destructively affected by Japan, and Former Soviet Union. After the foundation of PR China, the planned economy devoid the civil capability to undertake independent economic activities. Consequently, the local culture which is compatible with market economy has not yet been established in the region. There is a clear contradiction between the regional culture represented by traditional industrial community with the planned institutional background and value system represented by market economy. Hence, the Northeast fails to form a local culture base to foster innovation and entrepreneurship compared with other regions in China. The slow culture transformation has a negative influence on the innovative development and economic transition of the region.

7. Conclusion and Recommendation

The innovation-driven development is the key to regional economic transition and structural transformation in the Northeast. From the empirical analysis, we can conclude that the innovation capacity of the Northeast, especially Heilongjiang and Jilin, lags behind other advanced provinces in China. The causes lie in many aspects ranging from institutional system, industrial structure and innovation environment. Among all, the government-led institutional system is the main barrier of regional innovative development which fails to create a free market-oriented environment and operational mechanism that foster endogenous innovative impetus of the innovative actors. Also, the government-led development mode of the region creates barriers for infrastructure construction, industrial development and policy implementation and makes it inefficient for the innovative agents to conduct innovative activities.

A transformation of government role, institutional system, operational mechanism
in the region is necessary to realize the full potential of the innovative actors and vitalize the innovative development of the region. Based on the existing problems, combined with the practical status of the Northeast, we come to several policy recommendations.

First, it is important to delegate more power of government to the lower level by authorizing and transferring of right and to transform the government function from intervention to service and surveillance. The government should emphasize institutional development and market regulation rather than investment and construction of facilities. The government should avoid direct investment in particular industries or enterprises and formulate general applicable fiscal policies. It is important to increase the transparency of the government operation, including government science and technology funding and regulatory mechanism, and establish a proper accountability system to increase the efficiency of the government.

Second, a sound market environment that promotes free competition among various market entities should be fostered. A firm-oriented, market-led regional innovation system should be constructed. It is important to promote the institutional transformation of SOEs by removing their administrative functions. Monopoly of enterprises in the region should be avoided. More importantly, it is urgent to ensure that the private firms share the same right as SOEs in the application of government R&D fund, bank loans and government bidding etc. Firm should be the primary actors of innovation. Firm innovation demand and innovation impetus should be promoted through incentive policies.

Third, it is urgent to cultivate firm innovative capacity through the improvement of infrastructure and public services. Intellectual property protection in the region should be strengthened to promote the free competition among SOEs, private firms and foreign firms. Innovative service industries such as asset valuation, technology transferring, consulting and incubation should be promoted in major cities to provide financial and technological services to innovative actors. Government should make efforts in regulation and surveillance of innovative product market to satisfy firm innovation demand, replace old technologies, and reduce excess production capacities by promoting market competition.

Fourth, it is important to promote the collaboration among universities, research institutions and firms. The government should encourage the universities and research institutions to provide technological services to firms in forms of training of R&D personnel, innovation strategic alliance and sharing of research equipment and transformation of research achievements to products. It is crucial to reform the technological evaluation and reward system. The incentive evaluation criteria should be formulated according to the specific types of innovative agents. Specifically, basic scientific research should be evaluated through peer-review focusing on scientific value; applied technologies should be evaluated by experts.
and consumers from the third party focusing on research targets; technology transformation should be evaluated by market and consumers focusing on its contribution to industrial development.

Fifth, innovation-promoting policies should create favorable environment and guidance innovation activities rather than offer direct investment. The policies should promote the interaction among innovative agents in the regional innovation system and stimulate technology transmission from science to industry. The incentive policies should emphasize institution and mechanism construction to promote innovative impetus of firms and transform industrial structure of the region rather than simply set up large science and technology projects. Also, incentive policies should consider the transitional context of the Northeast to have an influential effect on regional development. Short-term decline in economic growth should be tolerated to achieve regional structural transformation and sustainable development.

Lastly, it is necessary to reform the talent management and evaluation system, upgrade the salary system, support and guide technology transformation of personal research achievements. It is important to cultivate innovative and entrepreneurial culture, promote openness and communication of the society through media and education. It is important to abolish constrains of talent flow in and across the region. The policies should put efforts in providing fair, free, innovative and entrepreneurial environment for talents who will be the core intelligence during the revitalization of the Northeast.

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