Firm size, ownership, industry characteristic and enterprises’ R&D behaviour – based on survey to the agricultural leading enterprises of Jiangxi Province

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Abstract: A field survey about R&D behaviour of Jiangxi province agricultural leading enterprises was conducted. R&D behaviour of agricultural leading enterprise was analysed through R&D department setting, R&D intensity, R&D frequency and R&D mode. Most enterprises had set up specific R&D department, adopted independent R&D and cooperative R&D mode, but R&D intensity of vast majority enterprises was at lower level. Only a third of enterprises had continuous R&D activities. Then the correlation between firm size, ownership, industry type and R&D behaviour was analysed. There was a positive and weak correlation between firm size and R&D department setting, R&D intensity, R&D frequency. Ownership and industry type had no significant relation with R&D behaviour.

Keywords: agricultural leading enterprise; R&D behaviour; firm size; ownership; industry type.


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1 Introduction

China put forward innovation-driven development strategy in 2012. For accelerating agricultural science and technological innovation, China should build new agricultural science and technology system, and pay more attention to agricultural leading enterprises playing a guiding role (McGowan and Hu, 2014).

Agricultural leading enterprises were recognised by government when they reached specific standard in matter of scale and sale revenue. For example, the standard of state-level agricultural leading enterprises in eastern China was that its total assets should above 100 million RMB and sales revenue should above 150 million RMB. Agricultural research and development (R&D) was high risk, costly and time-consuming. Only enterprises be a certain size and strength, can they effectively and continuously engaged in R&D.

We conducted a field survey of 191 agricultural leading enterprises of Jiangxi Province in China, made a descriptive statistics on R&D behaviour from four aspects which respectively was R&D department setting, R&D intensity, R&D frequency and R&D mode (Hu and McGowan, 2014; Hu, 2011), and found that most enterprises had set up specific R&D department, adopted independent R&D and cooperative R&D mode, but R&D intensity of vast majority enterprises was at lower level. Only a third of enterprises had continuous R&D activities.

There were many factors to influence enterprises’ R&D behaviour. We studied the correlation between firm size, ownership, industry characteristic and R&D behaviour. The findings were as follows: firm size had a positive and weak correlation between firm size and R&D department setting, R&D intensity, R&D frequency; ownership and industry type had no significant relation with R&D behaviour.

2 Literature review

It has always been a hot topic for scholars to research enterprise’s R&D behaviour. In summary, scholars carried out researches on influence factors of enterprise’s R&D from three different perspectives, such as enterprise, industry and government (Hu and McGowan, 2014; Hu, 2011).

Schumpeter creatively explored the influence of firm size on enterprise’s R&D behaviour, and raised the famous argument that firm size could promote corporate R&D (Joseph, 1994). Firm size was the influence factors that scholars focused on the most. There were lots of theoretical and empirical research literatures on this topic, but not reached a consensus yet (Syrneonidis, 1996). For example, Villard (1958) found that the proportion of enterprise engaged in R&D activities would rise along with the firm size;
Scherer (1965) and Soete (1979) believed there was an inverted U-shaped relationship between firm size and R&D activities, but Pavitt et al. (1987) draw the opposite conclusion (Henry, 1958; Scherer, 1965; Soete, 1979; Pavitt et al., 1987).

Some scholars studied the relationship between ownership and enterprise’s R&D behaviour according to the practical situation of China. Zhou and Luo (2005) discovered that private enterprise of large size was more innovative as defined by amount of patent. Foreign firm’s R&D intensity was the highest, while state-owned and collective-owned enterprise was the lowest (Tongliang et al., 2006). Wu (2009) carried systematic researches on the issue, firstly found that state-owned property rights had significant positive influence on R&D personnel, then found that R&D expenditure of private enterprise was highest, and no significant difference with foreign enterprise and state-owned enterprise (Wu, 2006, 2009, 2012). Lin et al. (2010) draw the analogous conclusion. Some other scholars draw different conclusions, Li and Song (2010) pointed out that R&D intensity of state-owned firm was greater than private firm.

Different industries had different characteristics, such as degree of competition, technological level, which lead to endogenous difference in enterprise’s R&D behaviour (Tongliang et al., 2006). There was an inverted U-shaped relationship between market concentration (measured by four firm concentration) and intensity of R&D personnel (Scherer, 1967), intensity of R&D expenditure (Levin et al., 1985). Kamien and Schwartz (1975) pointed out that market concentration has a slight positive influence on enterprise’s R&D activity. Cohen et al. (1987) argued that about 50% of the discrepancy of enterprise’s R&D intensity can be explained by industry technological disparity. An et al. (2006) found R&D intensity of medical manufacturing was 10.25%, far higher than 0.25% of oil processing and coking industry. Zhang et al. (2007) discovered that enterprise was more inclined to independent innovation in high technological opportunity industry, while was more inclined to technology import or imitation innovation in traditional industry.

There were not a consistent conclusion on enterprise’s R&D behaviour and its influence factors due to the complexity of enterprise’s R&D behaviour. After a comprehensive literature review, we found:

1. scholar’s researches mainly focused on R&D expenditure, it was necessary to expand to other aspects of enterprise’s R&D behaviour (Hu and McGowan, 2014)
2. scholars mainly focused the research object on manufacturing enterprises, less concerned on agricultural enterprises.

3 Questionnaire design and data collection

We designed a questionnaire with five parts, respectively were enterprise’s basic information, enterprise’s R&D behaviour, satisfaction to technological innovation policy, internal factors, and external factors. The main content of the questionnaire were shown in Table 1, a total of 98 questions.

There were 472 provincial-level agricultural leading enterprises in Jiangxi Province. From July 2012 to September 2013, we had done field survey to these enterprises, collected 211 questionnaires. 191 were valid after eliminated some invalid questionnaires.
Table 1  Main content of questionnaire

<table>
<thead>
<tr>
<th>Five parts of questionnaire</th>
<th>Main content of each part</th>
<th>Items of each part</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise’s basic information</td>
<td>Ownership, industry, revenue, R&amp;D person, patent, new products, etc.</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Enterprise’s R&amp;D behaviour</td>
<td>R&amp;D department setting, R&amp;D investment, R&amp;D mode, R&amp;D frequency, support from government, etc.</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Satisfaction to technological innovation policy</td>
<td>Evaluation to familiarity and satisfaction about financial subsidies, tax incentives, government procurement, patent protection policies.</td>
<td>24</td>
<td>Include some items to every sub-policies.</td>
</tr>
<tr>
<td>Internal factors</td>
<td>Enterprise technology capacity, product innovation strategy, risk preference, innovation culture, etc.</td>
<td>23</td>
<td>Include some items to every main factors.</td>
</tr>
<tr>
<td>External factors</td>
<td>Industry competition, technical level, market changes, regional research resources, etc.</td>
<td>26</td>
<td>Include some items to every main factors.</td>
</tr>
</tbody>
</table>

4 Descriptive statistics on R&D behaviour of agricultural leading enterprise

Behaviour was a kind of coordination and response when organism faced internal or external stimulus (Levitis, 2009). Corporate R&D behaviour was a kind of externalisation and visible activities in terms of R&D when enterprise response to external stimulus. The article mainly described enterprise’s R&D behaviour from the following perspectives as R&D department setting, R&D intensity, R&D frequency, and R&D mode.

There were 148 enterprises had set R&D department, accounted for 77.5% in all 191 enterprises, 43 enterprises had not set R&D department, accounting for 22.5%, reflected that most enterprises attached importance to R&D.

R&D intensity was the most important enterprise’s R&D behaviour. We used the ratio of R&D expenditure to sale revenue to represented R&D intensity. 61 enterprise’s R&D intensity was less than 1%, 51 was between 1%–2%, 53 was between 2%–3%, 21 was between 3%–5%, and five was above 5%. R&D intensity of vast majority enterprises (165 enterprises, accounting for 86%) was below 3%, at low level. R&D intensity of multinational corporations generally were about 10%, some even were 15%–20%. For example, Monsanto, the giant international agricultural enterprise, its sale revenue was $10.502 billion, and its R&D input was $1.205 billion. In contrast, there was a huge gap of Chinese agricultural leading enterprises.

We designed the question of ‘frequency of R&D activities in last three years’. The result showed that 63 enterprises had continuous R&D activities every month, 86 enterprises had discontinuous R&D activities every quarter or year, 29 enterprises engaged emergency R&D activities only in necessary, and 13 enterprises almost had no R&D activities. Only about a third of enterprises had continuous R&D activities.

R&D mode was the way enterprise engaged in R&D activities. There were different classifications about enterprise R&D mode. R&D mode was divided into depth innovation and breadth innovation (Nelson, 1993); internal innovation, external
innovation and cooperative innovation; fundamental innovation, architectural innovation, incremental innovation and modular innovation (Afuah and Bahram, 1995).

We divided R&D mode into independent R&D, cooperative R&D and delegation R&D according to R&D behaviour agent. Independent R&D was that enterprise completed R&D activity self-directed and independently, cooperative R&D was that enterprise carried out R&D activity through cooperation with other institutions, delegation R&D was that enterprise entrusted R&D activity to other institutions. In the questionnaire, there was seven multiple selectable options, which were independent R&D, cooperative R&D with other enterprise, cooperative R&D with R&D institution, cooperative R&D with university, delegation R&D to other enterprise, delegation R&D to research institution, and delegation R&D to university.

Table 2  R&D mode selection statistics

<table>
<thead>
<tr>
<th>Independent R&amp;D</th>
<th>Cooperative R&amp;D</th>
<th>Delegation R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative R&amp;D with other enterprise</td>
<td>Cooperative R&amp;D with research institution</td>
</tr>
<tr>
<td>96</td>
<td>34</td>
<td>91</td>
</tr>
</tbody>
</table>

Note: The options were multiple selectable, so the total was not equal to 191.

The survey result showed that independent R&D and cooperative R&D were the most frequency R&D modes adopted by agricultural leading enterprises there were rarely R&D cooperation between same industrial firms. This might be due to enterprises worry about technology leaks and competition between industrial firms. In fact, more and more multinational companies have increasingly reinforced technical cooperation and built strategic alliance. From this point of view, Chinese corporate should learn cooperation and sharing, and shift business philosophy from ‘competition’ to ‘competition and cooperation’.

5  Analysis on the main influence factors to agriculture leading enterprise’s R&D behaviour

Many factors could influence enterprise’s R&D behaviour. We mainly discussed the three factors as firm size, ownership and industrial type.

5.1  Influence of firm size to R&D behaviour

To analyse the influence of firm size to R&D behaviour, we should assign the variable firstly. The assignment rule showed as Table 4.

We respectively conducted Pearson analysis with firm size to R&D department setting, R&D intensity, R&D frequency, the results showed in Table 5.
Table 3 Assignment rules to variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>Assignment rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm size</td>
<td>0, sales revenue less than 50 million RMB; 1, sales revenue above 50 million RMB</td>
</tr>
<tr>
<td>R&amp;D department setting</td>
<td>0, no setting; 1, setting</td>
</tr>
<tr>
<td>R&amp;D intensity</td>
<td>0, less than 3%; 1, above 3%</td>
</tr>
<tr>
<td>R&amp;D frequency</td>
<td>1, continuous R&amp;D activity; 2, discontinuous R&amp;D; 3 emergency R&amp;D; 4, almost no R&amp;D activity</td>
</tr>
</tbody>
</table>

Table 4 Correlation coefficient of Pearson analysis

<table>
<thead>
<tr>
<th></th>
<th>R&amp;D department setting</th>
<th>R&amp;D intensity</th>
<th>R&amp;D frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm size</td>
<td>0.224**</td>
<td>0.222**</td>
<td>–0.361**</td>
</tr>
</tbody>
</table>

Note: **Significance level less than 0.01

Table 5 Statistics of firm size and R&D mode selection

<table>
<thead>
<tr>
<th>Firm size</th>
<th>Independent R&amp;D</th>
<th>Cooperative R&amp;D</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>71</td>
<td>59</td>
<td>130</td>
</tr>
<tr>
<td>0</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>96</td>
<td>84</td>
<td>180</td>
</tr>
</tbody>
</table>

Note: Assignment rule of firm size was same as above, 1 as larger firm size and 0 as smaller firm size.

The correlation coefficient of firm size and R&D department, R&D intensity was 0.224 and 0.222, which means a weak positive correlation existed between firm size and R&D department setting, R&D intensity. The correlation coefficient of firm size and R&D frequency was –0.361, which means a moderate positive correlation existed in these two variables.1

As mentioned above, we divided R&D mode into independent R&D, cooperative R&D and delegation R&D according to R&D behaviour agent. The statistical results of R&D mode selection showed in Table 2. The options were multiple selectable, R&D mode of some enterprises was not unique value, so that we could not conduct correlation analysis between firm size and R&D mode. Then we made the following treatments:

1 cooperative R&D included different agents as other enterprise, research institution and university, no matter which kind of cooperative agent, we all treated them as cooperative R&D mode, same with delegation R&D mode

2 after the simplified process as treatment-1, R&D mode still had some multi-options, from the perspective of enterprise participation to R&D activity, the highest level of involvement was independent R&D, followed by cooperative R&D, the lowest was delegation R&D mode.

We could further simplify as that we only recorded R&D mode of the highest level of involvement, then R&D mode had the unique value. For example, if enterprise selected both independent R&D and cooperative R&D, then we recorded R&D mode as
independent R&D; if enterprise selected both cooperative R&D and delegation R&D, then we recorded R&D mode as cooperative R&D. We found most enterprises selected either independent R&D or cooperative R&D, only seven enterprises (less than 4%) selected delegation R&D, and four enterprises did not select any options. Based on this, we focused on the only two R&D mode of independent R&D and cooperative R&D in this article, the data after edited showed in Table 5.

We used chi-square test to analyse the relationship between firm size and R&D mode. The calculation formula of chi-square was:

$$X^2 = \sum_{i=1}^{K} \frac{(A_i - E_i)^2}{E_i}$$

The chi-square value was 0.31. The critical value was 3.84 when significance level was 0.05 and degree of freedom \((df) = (2 - 1) \times (2 - 1) = 1\). The chi-square value was less than critical value, which means there was no difference between observed frequency and expected frequency, so firm size was uncorrelated to R&D mode.

Sum up the above analysis, we found that firm size was an important influence factor to R&D behaviour, which was positive correlated to R&D department setting, R&D intensity, and R&D frequency, but was uncorrelated to R&D mode. That was to say, larger enterprise conducted R&D activities more systemically and continuously than smaller enterprise.

We should realise that firm size of Chinese agricultural leading enterprise was still very small compared with international giant agricultural company. In seed industry, the total sale revenue of Chinese all over 6,000 seed companies were less than Monsanto. The gap was geometric order of magnitude between Chinese seed companies and multinational companies (Li and Li, 2011).

5.2 Influence of ownership to R&D behaviour

Among the 191 enterprises, 163 was private enterprise (accounting for more than 85%), eight was stated-owned enterprises, 13 was Sino-Foreign joint ventures, and seven was foreign enterprises. We divided the enterprises into two groups, one group was private enterprise, another group was non-private enterprise which included stated-owned, Sino-Foreign and foreign enterprise. We used Chi-square test to analyse relationship between ownership and R&D department setting, R&D intensity, R&D frequency, R&D mode. The results showed in Table 6.

The Chi-square value of ownership and R&D department setting was 4.44, greater than the critical value, which means significant difference of private enterprise and non-private enterprise in R&D department setting. The proportion of R&D department setting in private enterprise was lower than non-private enterprise. This might be due to two reasons, one was that the private enterprise’s size generally was smaller than non-private enterprise (stated-owned, Sino-Foreign, and foreign), according to the above analysis result, firm size had a weak positive influence to R&D department setting; the other one was that private enterprise’ owners might pay more attention to short-term interests, and were more cautious to R&D activities which were high input and high risk.

The chi-square values of ownership and other R&D behaviour were all lower than critical value, which means no significant difference of private enterprise and non-private enterprise in the matter of R&D intensity, R&D frequency and R&D mode.
<table>
<thead>
<tr>
<th>Ownership</th>
<th>R&amp;D department setting</th>
<th>R&amp;D intensity</th>
<th>R&amp;D frequency</th>
<th>R&amp;D mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Non-private</td>
<td>26</td>
<td>2</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Private</td>
<td>122</td>
<td>41</td>
<td>63</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>148</td>
<td>43</td>
<td>79</td>
<td>112</td>
</tr>
</tbody>
</table>

Chi-square value 4.44  3.37  7.68  2.36
Degree of freedom (df) 1 1 3 1
Critical value* 3.84  3.84  7.81  3.84

Note: *Significance level is 0.05.
5.3 Influence of industrial type to R&D behaviour

The survey result of industrial type showed in Table 7. Some enterprises engaged in multi industries.

<table>
<thead>
<tr>
<th>Planting</th>
<th>Breeding</th>
<th>Handicraft</th>
<th>Transportation</th>
<th>Tourist</th>
<th>Biological</th>
<th>Food</th>
<th>Other industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>72</td>
<td>12</td>
<td>9</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>46</td>
</tr>
</tbody>
</table>

Note: The options were multiple selectable, so the total was not equal to 191.

In order to make the variable (industrial type) a unique value, we divided the enterprises into four categories, respectively as planting industry (only select the option of planting industry), breeding industry (only select the option of breeding industry), combination of planting and breeding (select the options of planting and breeding at the same time), and other (select other options). After reclassified, there were 53 enterprises in planting industry, 47 enterprises in breeding industry, 25 enterprises in combination of planting and breeding, 66 enterprises in other industry. We used chi-square test to analyse relationship between industrial type and R&D department setting, R&D intensity, R&D frequency, R&D mode. The results showed in Table 8.

The chi-square values were all lower than critical value, which means no significant difference between different industrial enterprises.

6 Conclusions

We systematically observed R&D behaviour of agricultural leading enterprises in Jiangxi Province through field survey. Enterprise’s R&D behaviour was influenced by numerous factors. Based on scholars’ studies, this paper analysed the relationship between firm size, ownership, industrial type and R&D behaviour. Some conclusions and suggestions were drawn as following.

Firstly, as a whole, the agricultural leading enterprises had not carried out R&D activities systemically, continuously and effectively, which shown as enterprise’s R&D intensity was at lower level, R&D intensity of vast majority enterprises was below 3%. In addition, most agricultural leading enterprises failed to continuous engaged in R&D activities.

Secondly, firm size had significant influence to R&D behaviour, ownership and industrial type had no significant influence to R&D behaviour. There were a certain positive correlation between firm size firm and R&D department setting, R&D intensity, and R&D mode. Chinese agricultural enterprises should establish enterprises strategic alliance and R&D strategic alliance, improve R&D ability, share responsibility for R&D input and risk, and share with R&D achievement. Government should give priority to support some agricultural enterprise with large scale and strong R&D ability, encourage them be bigger and stronger.

Finally, it should be pointed out that this article had some shortcomings, we analysed the relationship between firm size, ownership, industrial type and R&D behaviour one by one. Next, we should establish econometric model contain multi independent variables to analyse the influence effect to R&D behaviour.
Table 8: Statistics of industrial type and R&D behaviour

<table>
<thead>
<tr>
<th>Industrial type</th>
<th>R&amp;D department setting</th>
<th>R&amp;D intensity</th>
<th>R&amp;D frequency</th>
<th>R&amp;D mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-----</td>
<td>----</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>Planting</td>
<td>44</td>
<td>9</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td>Breeding</td>
<td>35</td>
<td>12</td>
<td>30</td>
<td>17</td>
</tr>
<tr>
<td>Combination of planting and breeding</td>
<td>21</td>
<td>4</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Other</td>
<td>48</td>
<td>18</td>
<td>38</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>148</td>
<td>43</td>
<td>112</td>
<td>79</td>
</tr>
</tbody>
</table>

Chi-square value: 2.64, 3.05, 4.38, 4.99
Degree of freedom (df): 3, 3, 9, 3
Critical value*: 7.81, 7.81, 16.92, 7.81

Note: *Significance level is 0.05.
Acknowledgements

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References


Note

1 Value of variable ‘R&D frequency’ was smaller means R&D activities were more frequent. So the negative correlation coefficient reflected the positive correlation between firm size and R&D frequency.