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Article

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Journal of Business Economics and Management (JBEM)

Provided in Cooperation with:

Vilnius Gediminas Technical University (VILNIUS TECH)

Suggested Citation: Jiang, Yanhui; Wang, Danping; Zeng, Qianfang (2021) : Can founders' dual roles facilitate innovation? From the perspective of founders' R&D network characteristics, Journal of Business Economics and Management (JBEM), ISSN 2029-4433, Vilnius Gediminas Technical University, Vilnius, Vol. 22, Iss. 5, pp. 1288-1307, <https://doi.org/10.3846/jbem.2021.14950>

This Version is available at:

<https://hdl.handle.net/10419/317523>

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CAN FOUNDERS' DUAL ROLES FACILITATE INNOVATION? – FROM THE PERSPECTIVE OF FOUNDERS' R&D NETWORK CHARACTERISTICS

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Received 18 May 2020; accepted 18 February 2021

Abstract. Founders are crucial for the start-ups, which in turn makes it very important to study how founders' behaviour affects the development of the start-ups. Based on the data of the companies listed on Growth Enterprise Market (GEM) and Small & Medium Enterprise (SME) board from 2014 to 2017 in China, this paper explores the impact of founders' dual roles of R&D and management on enterprises' innovation performance from the perspective of founders' R&D network characteristics. The empirical research reveals that the more an enterprise's founders participate in the R&D activities and the more central they are in the R&D network, the better the enterprise's technological innovation performance. It is because the high network centrality enables founders the stronger ability of innovation and opportunity identification and draws their attention to innovation. This research further discloses that the promotion effect is restrained when enterprises obtain more government subsidies and founders have more power. It also finds that founders' R&D role does not transform the innovation output into enterprises' value effectively though the role increases the innovation output, instead, it even restrains the transformation.

Keywords: founders, network centrality, government subsidies, founders' power, enterprises' innovation.

JEL Classification: M13, O31, Z13.

Introduction

Innovation is a subject that has been widely discussed. It can be thought as a kind of activity focusing itself on knowledge commercialization (Wildowicz-Giegiel, 2011). Along with the competition's intensifying, enterprises need to maintain their competitive edges and innovation is one of the elements to help them keep the dominant position (Janoskova & Kral, 2015). Innovation is highly related to founders' characteristics because founders play a significant role in business operation (Wasserman, 2003).

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Entrepreneurs' characteristics influence the entrepreneurial behavior significantly (Álvarez-Herranz et al., 2011). Some entrepreneurs engage in companies' inventive activities, which enhances firms' absorptive capacity (Mueller et al., 2020) and spurs firms' survival and growth (Haeussler et al., 2019). These entrepreneurs usually own the dual roles of inventors and founders. As the carrier of an enterprise's core technology and key knowledge, entrepreneurs play an important role in enterprises' innovation through abilities and decision-making, tremendously influencing the innovation performance. Entrepreneurs have to be responsible for enterprises' whole operating process from setting the strategic objectives to approving each project. As the technical experts, can entrepreneurs with dual roles of inventor and founder bring better innovation performance for enterprises? As enterprises grow, do entrepreneurs with dual roles still devote themselves to R&D activities? Does the devotion have a positive impact on the enterprises' innovation performance? If it does, how do the founders participate in R&D so as to improve the enterprises' innovation? The questions are the jumping-off point of the research aiming to find the relationship between entrepreneurs' dual roles of founders and inventors and enterprises' innovation.

Based on the data from 634 companies listed on Growth Enterprise Market (GEM) and Small & Medium Enterprise (SME) board, this paper makes an empirical validation to disclose the relationship between founders' R&D network centrality and enterprises' innovation performance. This research enriches extant literature on founders since little attention has been paid to the impact of founders' participation in R&D on firms' innovation performance. In practice, the founders with technical background have become a phenomenon being worthy of exploration. Differing from prior work, this research selects founders' characteristics in a novel way – it chooses founders' position in the R&D network to measure the impact of founders' characteristics on firms' innovation performance.

The rest of the paper is structured as the follows: First, it reviews the related empirical and theoretical work. Second, it explains the research design including sampling, data collecting, modeling and variable measuring. After that, it presents the empirical results from the basic analysis, moderating effect analysis and value effect analysis of founders' R&D network centrality and enterprises' innovation. It also discusses the theoretical and practical implications of the findings in the conclusion part.

1. Literature review and research hypothesis

1.1. Literature review

Being focused on the role of founders' characteristics and network centrality within firms' innovation activities, the section is intended to provide a context for the key research question – *Can founders' R&D network characteristics benefit enterprises' innovation?* In order to approach this question, it is important to explore how founders' characteristics and network centrality have been examined in literature on entrepreneurship and innovation.

Founders and enterprises' innovation

A founder (also known as entrepreneur) is the soul of entrepreneurship, which has made the related research a hot subject of enterprise management and inspired many studies in

terms of founders' behavior and personal traits recently. Extant literature of the relationship between founders and enterprises' innovation has been categorized into two research streams: one is focused on the influence of founders on enterprises' innovation activities while the other emphasizes the influence of founders on enterprises' innovation output. The characteristics of founders that catch much attention include their professional characteristics (e.g. executive identity, shareholding ratio, etc.) and ability characteristics (e.g. human capital, social capital, etc.).

Enterprises' innovation activities are usually implemented inside or outside of the organizational boundary simultaneously. The internal innovation activities mainly depend on the R&D investment of enterprises. Different conclusions have been drawn from the research as to founders and R&D investment, being specified to different characteristics of founders. One of those characteristics is founders' human capital, which sends a positive signal to the capital market, resulting in the alleviation of funds insufficiency and the rising of R&D investment (Honjo et al., 2014; Cao & Im, 2018). Since the human capital enables founders to cope with high risks and uncertainties with R&D projects, founders are more likely to invest in R&D (Kato, 2020). However, from the perspective of founders' professional characteristics, founders would restrain the R&D investment of enterprises due to the risk concern (Chen & Liu, 2012). The external innovation activities are often carried out by virtue of external cooperation, such as R&D alliance. Founders' work and innovation experience have impact on firms' innovation alliance strategy, and the probability of R&D cooperation would increase if founders are rich of work and innovation experience (Okamuro et al., 2011). Founders' characteristics can also influence the type of innovation alliance: when their shareholding ratio is high, the enterprises funded by business venture capital would be inclined to establish the exploratory innovation alliance, while the enterprises funded by individual venture capital would have less preference for this kind of innovation alliance (Galloway et al., 2016).

The innovation output of enterprises is also affected by founders' characteristics. Founders' characteristics including age, age of entrepreneurship, age gap between founders and CEOs and so on could influence the degree of innovation (Zhou & Gong, 2014). Founders' positive emotion can improve their creativity, resulting in the better innovation performance of enterprises (Baron & Tang, 2011). Different types of human capital have different impact on innovation: founders' specific human capital could directly improve enterprises' innovation performance, while generic human capital could improve enterprises' R&D investment, resulting in the improved innovation performance indirectly (Kato et al., 2015). The mechanism of entrepreneurs' impact on enterprises' innovation can be explained by upper the echelons theory and the attention-based view. Entrepreneurs' educational and professional background in science and engineering has a positive effect on enterprises' technological capability and innovation attention; Innovation attention partially intermediates between entrepreneurs' educational degree, major and enterprises' technological capability; Neither entrepreneurs' age nor their occupational background has a significant impact on enterprises' technological capability and innovation attention (Guo et al., 2018).

Network centrality and enterprises' innovation

Network centrality describes the extent to which an actor is close to the core of a network exchange system (Burt, 1992). Network centrality represents the degree of concentration of

groups' interaction, while individuals' network centrality reflects the degree of their importance or authority in a group. Network centrality is the key part of the research on social network structure. The social network scholars have been exploring the influence of power or position owned by individuals or organizations in the social network on their behavior for a long time. The relationship among the network members, the centrality of network nodes and the trend of centrality reflects the structural characteristics of the network members. The structural characteristics have a great impact on the information dissemination among the network members, the work performance of network individuals, and the individual and organizational knowledge creation and transfer.

The existing research of network centrality is usually made from the perspective of enterprises or individuals. From the perspective of enterprises, network centrality benefits enterprises' innovation. Network centrality is able to increase firms' technological innovation performance (Tao, 2013). However, the positive effect is not monotonic. Prior research has manifested that there is an inverted U-shaped relationship between enterprises' innovation performance and centrality of the R&D network because the excessive network centrality causes enterprises' over dependence on the knowledge within the network, which makes it hard to innovate by breaking knowledge boundary (Zeng & Wen, 2015). From the perspective of individuals, the social network centrality of venture capitalists significantly improves enterprises' innovation performance, which is moderated by the uncertainty of industry structure and enterprise life cycle: when the industry structure uncertainty is strong or the enterprise is at the nascent stage of life cycle, the moderating effect becomes stronger (Yan et al., 2018). For inventors, the more they own the cooperation relationships in a network, the higher they achieve patent output (Luan et al., 2008). Inventors' cooperative network structure hole has a positive impact on enterprises' exploratory innovation, and the relationship between cooperative network centrality and enterprise exploratory innovation is inversely U-shaped (Fu et al., 2018).

Through reviewing extant literature, the research finds that both the professional characteristics (executive identity, shareholding ratio, incumbent, etc.) and the personal ability characteristics (human capital, social capital, etc.) of founders have an impact on enterprises' innovation performance. The characteristics of founders, on the one hand, act on the interior of enterprises, affecting their innovation performance (Baron & Tang, 2011; Zhou & Gong, 2014; Kato et al., 2015; Guo et al., 2018). On the other hand, as the innovation performance signal, founders' characteristics affect the entry of external resources, which in turn influences enterprises' innovation performance (Honjo et al., 2014; Cao & Im, 2018). The impact of network centrality on innovation takes an effect mainly through the resource mechanism. Individuals in the network center have the opportunity to obtain more abundant resources including knowledge and property (Luan et al., 2008; Tao, 2013; Yan et al., 2018). The more the two kinds of resources, the more beneficial they are to enterprises' innovation. Too high centrality may also have a negative effect on enterprises' innovation (Zeng & Wen, 2015), but generally speaking, it is beneficial to improve network centrality appropriately. There has been little prior work on the impact of founders' R&D experience on enterprises' innovation performance. However, the R&D experience of founders of start-ups is usually directly related to enterprises' innovation. Therefore, this research starts with the R&D experience

of founders of start-ups and explores the influence of founders' R&D network centrality on enterprises' innovation performance based on the network structure theory.

1.2. Research hypothesis

Integrating the research of founders and network centrality, the paper is targeted over founders' R&D network centrality. The social network theory is focused on the relationship and structure among different nodes, as well as the resources contained in the network relationship. Founders' R&D network centrality reflects their position in the R&D activities of enterprises. The higher the founders' centrality in the R&D network, the more the cooperation and connection between the founders and other R&D members are, and the more they obtain network resources. Based on the resource-based view (RBV), these resources enable the unique competitive advantage of enterprises. Particularly, the network resources contained in founders' R&D network centrality mainly affect enterprises' innovation from the following two aspects.

First, founders' R&D network centrality improves their innovation ability. The essence of knowledge innovation lies in the new integration of the existing knowledge (Zhang & Lang, 2013). When the founders engage in R&D with more members, they have more access to the knowledge different from their own repository. The diversified knowledge enables the founders to gather complementary knowledge, avoiding the limitation of inertial thinking. Moreover, the integration of heterogeneous knowledge helps the founders to obtain inspirations and make breakthroughs from the existing paradigm, resulting in improved innovation performance of enterprises.

Second, founders' R&D network centrality enhances their ability of opportunity identification. The higher the founders own the R&D network centrality, the more frequent the communication occurs between the founders and other R&D member. The high-frequency communication enables the founders to access more R&D related information (Xu & Cai, 2011). Meanwhile, the higher the founders own the R&D network centrality, the more likely they meet the members with high network centrality who deliver more accurate and reliable information than those with low network centrality (Hovland et al., 1953), leading to the high-quality R&D information received by the founders. The abundant and high-quality information deepens the founders' interpretation on the value of enterprise R&D projects, enables them to identify more valuable R&D projects, and improves their ability to identify innovation opportunities. The ability to identify innovation opportunities is of great significance for enterprises' innovation. With the development of various R&D projects, more resources need to be invested, especially at the later stage of the project development which requires the value identification and the project deployment to ensure the success rate of R&D (Kavadias & Chao, 2008). The higher the founders own the ability to identify the innovation opportunities, the more they focus on the superior innovation projects when allocating the enterprise resources, so as to avoid wasting the valuable R&D resources and improve the success rate as well as the efficiency of R&D.

Furthermore, based on the attention-based view, the founders with higher network centrality usually occupy the more important positions in the R&D network, which represents

their authority. When the founders, as the crucial members of enterprise R&D activities, spend a lot on R&D in daily activities, the stronger innovation orientation inside the enterprises is yielded, which would facilitate the resources transfer to innovation activities so as to improve the innovation performance.

In summary, the research believes that founders' R&D network centrality improves their ability of innovation and opportunity identification. Meanwhile, it draws founders' attention to innovation activities, which in turn facilitates enterprises' innovation. Therefore, this paper proposes:

H1: Founders' R&D network centrality can improve enterprises' innovation performance.

2. Research design

2.1. Sampling and data source

This research collected data of the companies listed on GEM and SME board from 2014 to 2017 in China and made the further screening: (1) This research filtered the companies marked with ST and *ST since their financial abnormalities would interfere with the accuracy of research; (2) It removed the finance and insurance companies since their special accounting processing would also interfere with the accuracy of data; (3) It removed the samples with incomplete data. After screening the data, the research finally got 634 effective samples and 1668 data records.

Compared with the firms listed on the main board market, the size of the companies listed on GEM and SME board are usually small. To some extent, the founders of small-sized companies are absolutely the leading figures of the organizations and they influence the enterprises' strategy and decision-making tremendously. From the industrial perspective, most of these companies are usually from the emerging industries and own the strong innovation capability, which explains why this paper selected the enterprises listed on GEM and SME board. Concerning that the national strategy of "mass entrepreneurship and innovation" was first proposed in 2014 and CSMAR database only provided the data till 2017, this research sets the research period from 2014 to 2017.

This research obtained both the financial data of companies and the data of founders' personal characteristics from China stock market & accounting research (CSMAR) database. In addition, this research manually collected the data of inventors of enterprises' annual patent from INCOPAT patent database so as to calculate founders' R&D network centrality and R&D network relationship strength.

2.2. Modeling and variable measurement

Referring to extant literature, this paper adopted the following model to test the impact of founders' R&D network centrality on enterprises' innovation:

$$\begin{aligned} Innovation = & \alpha_0 + \alpha_1 Centrality + \alpha_2 Asset + \alpha_3 Ownership + \alpha_4 Age + \\ & \alpha_5 LEV + \alpha_6 ROA + \alpha_7 RD + \alpha_8 FounderAge + \alpha_9 FounderEducation + \varepsilon, \end{aligned} \quad (1)$$

where *Centrality* is founders' R&D network centrality, and *Innovation* is enterprises' innovation. This research chose the logarithm of the number of enterprises' patents to measure

innovation. According to Fu, Liu, and Ma (2018), this paper defined network centrality based on the direct connections between the founders and other members. After identifying the founders by virtue of the data of patents inventors, this research calculated how many inventors the founders cooperated with in annual R&D activities and adopted it as a measurement of the founders' R&D network centrality. α_0 is a constant, α_1 – α_9 represent the estimated coefficients of the corresponding variables, and ε is the random error. Definitions and descriptions of the variables are shown in Table 1. According to the descriptive statistics (Table 2 and Table 3), the average patent application of the companies is 31.35, and the standard deviation is 89.89, indicating the significant differences in innovation performance of the sample companies. The weighted average number of patent applications is 11.74 and the mean of founders' R&D network centrality is 6.645, which indicates that, on average, the founders have cooperative relationships with 6 members every year. On average, the sample enterprises obtain government subsidies of 15.76 million yuan every year, which implies

Table 1. Definitions of variables

Variable name	Variable code	Variable description
Innovation performance 1	Patent	enterprise's annual patent applications from CSMAR database
Innovation performance 2	Patent2	weighting the invention patent, utility model and design according to the proportion of 3:2:1 on the basis of the patent variable
Founder's R&D network centrality	Centrality	measured with the annual number of the R&D members whom the founders cooperate with
Government subsidies	Subsidy	annual subsidies that enterprise obtains from government (from CSMAR database)
Founder's power	Power	virtual variable which is measured by whether the founder concurrently serve as CEO and chairman of the board
Enterprise profit	Profit	enterprise's annual profit (unit:10 million yuan) from CSMAR database
Enterprise asset	Asset	logarithm of enterprise' annual asset (from CSMAR database)
Ownership concentration	Ownership	Share-holding ratio of top ten shareholders (from CSMAR database)
Age of enterprise	Age	obtained by subtracting the time of establishment from the sample year
Enterprise LEV	LEV	from CSMAR database
Enterprise ROA	ROA	from CSMAR database
R&D investment	RD	logarithm of enterprise' annual R&D investment (from CSMAR database)
Founder's age	Founder Age	age of founder (from CSMAR database)
Founder's education	Founder Education	Educational background of founder: 1 – middle school or below, 2 – college degree, 3 – bachelor's degree, 4 – master's degree, 5 – doctorate

that government has provided sufficient support for the enterprises' R&D. The proportion of the founders who concurrently serve as CEOs and chairman of the board is 0.459, which means that nearly half of the founders have the strong power of corporate management. The average age of the founders is 53.18 years old, which is relatively old, and most of them obtain a bachelor's degree or above. The correlation coefficient is less than 0.05, indicating that the correlation among the variables is low. The correlation coefficient between founders' R&D network centrality and enterprises' innovation output is significantly positive, which preliminarily validates the hypothesis.

Table 2. Descriptive statistics analysis

Variable Name	Means	Standard Deviation	Minimum	Maximum
Patent	31.35	89.89	1	1639
Patent2	11.74	34.12	0.167	693
Centrality	6.645	22.03	0	554
Subsidy	15.76	1.517	6.908	20.50
Power	0.459	0.498	0	1
Profit	20.54	48.79	−109.5	1237
Asset	21.41	0.794	19.62	24.66
Ownership	59.48	12.95	19.77	92.74
Age	14.85	4.844	4.907	37.36
LEV	0.283	0.161	0.0128	0.800
ROA	0.0459	0.0592	−0.949	0.312
RD	17.71	0.976	13.73	22.23
Founder Age	53.18	6.536	36	77
Founder Education	3.301	0.886	1	5

3. Results

3.1. Hypotheses testing

Table 4 depicts the regression analysis of founders' R&D network centrality and enterprises' innovation. In the two models, the coefficients of the R&D network centrality are 0.0107 and 0.0108 respectively, which are both significant at the level of 1%. It proves the hypothesis that the higher the founders' R&D network centrality, the better the enterprises achieve the innovation performance.

3.2. Robustness testing

Considering the lag of innovation activities, this paper involved the next period of patent output in the robustness test. The regression result shown in Table 5 indicates that there is a significantly positive relationship between founders' R&D network centrality and innovation output of enterprises at the significance level of 1%, with the coefficients of 0.0111 and 0.0112

Table 3. Correlation matrix

	Patent	Patent2	Centra- lity	Subsidy	Power	Profit	Asset	Owner- ship	Age	LEV	ROA	RD	Founder Age	Foun- der Educa- tion
Patent	1													
Patent2	0.983***	1												
Centrality	0.329***	0.306***	1											
Subsidy	0.206***	0.211***	0.095***	1										
Power	0.092***	0.090***	0.075***	0.006	1									
Profit	0.310***	0.328***	0.067***	0.245***	-0.0160	1								
Asset	0.429***	0.462***	0.061**	0.323***	-0.041*	0.680***	1							
Ownership	0.062**	0.050**	-0.023	-0.056**	0.047*	0.020	-0.071***	1						
Age	-0.065***	-0.048**	-0.006	-0.075***	-0.057**	0.046*	0	-0.007	1					
LEV	0.098***	0.102***	0.017	0.121***	0.041*	0.034	0.308***	-0.136***	-0.018	1				
ROA	0.086***	0.074***	0.083***	0.094***	0.0120	0.320***	0.011	0.242***	0.0150	-0.278***	1			
RD	0.332***	0.345***	0.119***	0.383***	0.0210	0.384***	0.624***	-0.168***	-0.033	0.255***	0.068***	1		
Founder Age	-0.063**	-0.063**	-0.035	0.011	-0.179***	-0.001	0.039	-0.125***	0.158***	0.008	-0.023	0	1	
Founder Education	0.062**	0.073***	0.085***	0.047*	0.082***	0.015	0.039	-0.056**	0.0210	-0.015	0.027	0.119***	-0.179***	1

Note: Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4. Result of OLS regression on patents

	Patent	Patent2
Centrality	0.0107***	0.0108***
	(0.00126)	(0.00125)
Asset	0.0995*	0.0514
	(0.0602)	(0.0597)
Ownership	0.00505**	0.00427*
	(0.00233)	(0.00231)
Age	−0.00544	−0.00227
	(0.00598)	(0.00593)
LEV	0.112	0.159
	(0.199)	(0.197)
ROA	1.322**	1.281**
	(0.514)	(0.509)
RD	0.406***	0.451***
	(0.0481)	(0.0477)
Founder Age	0.00718	0.00704
	(0.00453)	(0.00449)
Founder Education	0.0808**	0.0893***
	(0.0346)	(0.0344)
_cons	−8.014***	−8.587***
	(1.440)	(1.429)
Year	control	control
Industry	control	control
N	1668	1668
R2	0.300	0.290

Note: Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

respectively, which implies the reliability of this research.

Table 5. Robustness test

	Patent	Patent2
Centrality	0.0111***	0.0112***
	(0.00173)	(0.00171)
Asset	0.113	0.0615
	(0.0816)	(0.0808)
Ownership	0.0102***	0.00955***
	(0.00301)	(0.00298)
Age	−0.0107	−0.00589
	(0.00775)	(0.00767)

End of Table 5

	Patent	Patent2
LEV	0.139	0.237
	(0.261)	(0.258)
ROA	1.755***	1.671**
	(0.676)	(0.669)
RD	0.401***	0.441***
	(0.0629)	(0.0623)
Founder Age	0.00932	0.00827
	(0.00580)	(0.00574)
Founder Education	0.106**	0.111**
	(0.0457)	(0.0453)
_cons	-6.786***	-7.240***
	(1.439)	(1.424)
Year	control	control
Industry	control	control
N	982	982
R2	0.311	0.297

Note: Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4. Additional tests

4.1. Founders' R&D network centrality and enterprises' innovation: moderating effect analysis

The empirical study has verified hypothesis 1 that the higher the founders' R&D network centrality, the better the enterprises achieve innovation performance. Based on it, this re-search expects to explore other factors' moderating effect on the relationship between found-ers' R&D network centrality and enterprises' innovation performance. Since this research discussed the impact of founders' R&D network centrality on enterprises' innovation per-formance from the perspective of resource-based view and attention-based view, further analysis based on the two tracks was made.

The moderating effect of government subsidies

According to the resource-based view, the scarce and unique resources possessed by enter-prises are the source of their sustainable competitiveness. Resources can be categorized into property resources and intellectual resources. Property resources refer to the specific assets and property right of enterprises, including enterprise funds, contracts and so on while intel-lectual resources exist in the form of special skills such as technical capability and innova-tion capability (Miller & Shamsie, 1996). Based on the definitions, founders' R&D network centrality and founders' R&D network relationship strength represent the capability as well as knowledge resources of enterprises. Due to the high risk of innovation activities and in-formation asymmetry, the innovative enterprises encounter the serious financing constraints,

which makes it difficult for them to obtain R&D funds. Since the property resources are relatively scarce for the innovative enterprises, knowledge resources are especially important for them.

Due to the importance of R&D activities, government has become an important force to promote or facilitate enterprises’ R&D innovation to some extent. As one of the government’s policies, government subsidies complement the scarce property resources of innovative enterprises. When the innovative enterprises have more sufficient property resources, the knowledge resources are no longer the unique resources they own because they can leverage the property resources to implement R&D innovation. This paper proposes that the property resources and knowledge resources can substitute for each other in the innovation activities. As a result, when the enterprises obtain government subsidies, which enables them more property resources, the effect of knowledge resources shown by the founders’ R&D network characteristics on enterprises’ innovation would decrease. Consequently, the paper proposes that government subsidies negatively moderate the relationship between founders’ R&D network centrality and enterprises’ innovation.

This paper constructed the following model to verify this conjecture. Table 1 shows the description of relevant variables.

$$\begin{aligned} Innovation = & \alpha_0 + \alpha_1 Centrality + \alpha_2 Subsidy + \alpha_3 Centrality \times Subsidy + \alpha_4 Asset + \\ & \alpha_5 Ownership + \alpha_6 Age + \alpha_7 LEV + \alpha_8 ROA + \alpha_9 RD + \alpha_{10} FounderAge + \\ & \alpha_{11} FounderEducation + \varepsilon. \end{aligned} \tag{2}$$

Based the regression analysis in Table 6, this research reveals that both the interaction term coefficients of government subsidies and founders’ R&D network centrality, which are −0.00961 and −0.0106 respectively, are negatively significant at the significance level of 1%, indicating that government subsidies replace the knowledge resources originating from founders’ R&D network centrality during the process of enterprises’ innovation.

Table 6. The moderating effect of government subsidies

	Patent	Patent2
Centrality	0.178***	0.195***
	(0.0248)	(0.0245)
Centrality*Subsidy	−0.00961***	−0.0106***
	(0.00142)	(0.00140)
Subsidy	0.135***	0.149***
	(0.0236)	(0.0234)
Asset	0.0703	0.0192
	(0.0597)	(0.0590)
Ownership	0.00359	0.00266
	(0.00230)	(0.00227)
Age	−0.00709	−0.00410
	(0.00588)	(0.00581)
LEV	0.0487	0.0897
	(0.195)	(0.193)

End of Table 6

	Patent	Patent2
ROA	1.197**	1.143**
	(0.507)	(0.501)
RD	0.376***	0.418***
	(0.0482)	(0.0476)
Founder Age	0.00586	0.00558
	(0.00445)	(0.00440)
Founder Education	0.0594*	0.0656*
	(0.0341)	(0.0337)
_cons	-8.860***	-9.522***
	(1.420)	(1.402)
Year	control	control
Industry	control	control
N	1668	1668
R2	0.325	0.322

Note: Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The moderating effect of founders' power

The power of managers refers to managers' ability to influence enterprises' decision-making according to their own wishes, and the ability to make enterprises' strategy follow their own wishes (Liu, 2015). Managers' power can influence firm's decision significantly (Finkelstein, 1992). The greater the power, the more significant the influence is (Dalton & Kesner, 1987).

According to the attention-based view, the decision-makers' actions and the subsequent organizational actions depend on what questions and answers the decision-makers pay attention to, which further depends on the context where the decision-makers exist. Attention which is limited, perishable and highly substitutable is the scarcest resource for senior managers (Wu & Xiao, 2016). Therefore, the attention of decision makers should be concentrated in a small number of specific issues. In other words, the executives have to face the situation that their attention is taken by competition. Based on the attention-based view, this paper proposes that the increased power of founders would divert their attention from innovation activities. Since managers' reputation and career prospects are closely related to enterprises' performance, founders' attention would be transferred to enterprises' operation in order to obtain better reputation and career prospects. Because of high risk and the uncertainty, the innovation activities usually increase the risk of business failure. As a result, the managers who pay more attention to operating activities are inclined to avoid the innovation activities to ensure the high performance. Therefore, when founders own the greater power, the promotion effect of founders' R&D network characteristics on enterprises' innovation performance would weaken. Based on it, this paper proposes that founders' power have a negative moderating effect on the relationship between founders' R&D network centrality and enterprises' innovation.

This paper constructed the following model to verify this conjecture, and the relevant variables are explained in Table 1.

$$\text{Innovation} = \alpha_0 + \alpha_1 \text{Centrality} + \alpha_2 \text{Power} + \alpha_3 \text{Centrality} \times \text{Power} + \alpha_4 \text{Asset} + \alpha_5 \text{Ownership} + \alpha_6 \text{Age} + \alpha_7 \text{LEV} + \alpha_8 \text{ROA} + \alpha_9 \text{RD} + \alpha_{10} \text{FounderAge} + \alpha_{11} \text{FounderEducation} + \varepsilon. \quad (3)$$

According to the regression analysis in Table 7, this research discloses that the interaction terms of founders' power and founders' R&D network centrality is significant at the significance level of 1%, with the coefficients of -0.0268 and -0.0279 respectively, indicating that founders' power negatively moderates the relationship between founders' R&D network centrality and enterprises' innovation performance.

Table 7. The moderating effect of founders' power

	Patent	Patent2
Centrality	0.0350*** (0.00408)	0.0361*** (0.00404)
Centrality*Power	-0.0268*** (0.00428)	-0.0279*** (0.00424)
Power	0.175*** (0.0620)	0.188*** (0.0614)
Asset	0.0931 (0.0600)	0.0455 (0.0595)
Ownership	0.00437* (0.00231)	0.00355 (0.00229)
Age	-0.00703 (0.00592)	-0.00391 (0.00586)
LEV	0.0666 (0.197)	0.111 (0.195)
ROA	1.322*** (0.508)	1.281** (0.503)
RD	0.419*** (0.0477)	0.464*** (0.0473)
Founder Age	0.00691 (0.00452)	0.00681 (0.00448)
Founder Education	0.0624* (0.0344)	0.0700** (0.0341)
_cons	-8.173*** (1.436)	-8.770*** (1.422)
Year	control	control
Industry	control	control
N	1668	1668
R2	0.317	0.309

Note: Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Founders' R&D network centrality and enterprises' innovation: value creating of innovation

After the moderating effect analysis, this paper further analyzed whether founders play an important role in promoting the value of enterprises by virtue of innovation channels. This section concentrates on what role founders play in the process of transforming patent into enterprises' performance. It has been proved that the product innovation of enterprises would significantly affect firms' performance (López-Cabarcos et al., 2019). Patents bring firms the high growth and profitability. The new patented technology developed by firms would replace the old one. When the companies owning the new patented technology obtain the monopoly advantage, they are able to leverage the advantageous market share to improve the sales and obtain premium profits (Phillips & Wrase, 2006). Nevertheless, acquiring the new patented technology is only the first step of R&D process. Only after a series of R&D activities such as pilot test, industrialization and commercialization are completed, can the technology be transformed into the acceptable products (Nanda & Rhodeskropf, 2013). Since founders have helped enterprises to complete the first step successfully, what role does their R&D network centrality play during the subsequent process?

Based on the attention-based view, this research proposes that the characteristics of the entrepreneurs who are founders as well as inventors in the R&D network reflect that the founders' recognition of their identity as inventors and allocate more attention to such identity. As the managers directly involved in the R&D activities, the founders devote a lot to R&D activities. However, creating value from enterprises' innovation relies on not only the technological innovation but also the context of market, which makes the knowledge about market directly affect new products' commercialization (Dabrowski, 2019). On the one hand, enterprises need to have the thorough understanding of market so as to forecast the application prospect of a patent, which would benefit its commercialization. For the innovative firms, the market-oriented innovation is more beneficial to the improvement of enterprises' performance than the technology-oriented innovation (Jin et al., 2019); on the other hand, the patent that has been applied to the production also need a series of marketing activities to increase the sales. The more the founders pay attention to R&D, the less they usually pay attention to the marketing activities, thus restraining the commercialization of the patent. Therefore, this paper proposes that founders' R&D network centrality has the negative moderating effect on the relationship between enterprises' patents and their financial performance.

This research constructed the following model to verify this conjecture, and the relevant variables are explained in Table 1.

$$\begin{aligned} Sale = & \alpha_0 + \alpha_1 Centrality + \alpha_2 Innovation + \alpha_3 Centrality \times Innovation + \alpha_4 Asset + \\ & \alpha_5 Ownership + \alpha_6 Age + \alpha_7 LEV + \alpha_8 ROA + \alpha_9 RD + \alpha_{10} FounderAge + \\ & \alpha_{11} FounderEducation + \varepsilon. \end{aligned} \quad (4)$$

By virtue of the regression analysis in Table 8, this research discloses that there is a significantly positive relationship between enterprises' patents and their financial performance, indicating that enterprises' patents are beneficial to the improvement of enterprise value. The

interaction between founders' R&D network centrality and patent is significantly negative, which proves the conjecture that the higher the founders' R&D network centrality, the weaker the enterprises have the capability of improving their value through patents.

Table 8. Analysis of value improvement function

	Patent	Patent2
Centrality	0.0350***	0.0361***
	(0.00408)	(0.00404)
Centrality*Power	-0.0268***	-0.0279***
	(0.00428)	(0.00424)
Power	0.175***	0.188***
	(0.0620)	(0.0614)
Asset	0.0931	0.0455
	(0.0600)	(0.0595)
Ownership	0.00437*	0.00355
	(0.00231)	(0.00229)
Age	-0.00703	-0.00391
	(0.00592)	(0.00586)
LEV	0.0666	0.111
	(0.197)	(0.195)
ROA	1.322***	1.281**
	(0.508)	(0.503)
RD	0.419***	0.464***
	(0.0477)	(0.0473)
Founder Age	0.00691	0.00681
	(0.00452)	(0.00448)
Founder Education	0.0624*	0.0700**
	(0.0344)	(0.0341)
_cons	-8.173***	-8.770***
	(1.436)	(1.422)
Year	control	control
Industry	control	control
N	1668	1668
R2	0.317	0.309

Note: Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Conclusions

Founder's roles are vital to entrepreneurial firms as dual roles of founders most likely influence firms resource allocation. It is very important to study how founders' role affects the development of the start-ups. Based on the data of the companies listed on Growth Enter-

prise Market (GEM) and Small & Medium Enterprise (SME) board from 2014 to 2017 in China, this paper explores the impact of founders' dual roles of R&D and management on enterprises' innovation performance from the perspective of founders' R&D network characteristics. The empirical research reveals that the more an enterprise's founders participate in the R&D activities and the more central they are in the R&D network, the better the enterprise's technological innovation performance. It shows that high network centrality enables founders the stronger ability of innovation and opportunity identification and draws their attention to innovation. This research further discloses that the promotion effect is restrained when enterprises obtain more government subsidies and founders have more power. It also finds that founders' R&D role does not transform the innovation output into enterprises' value effectively though the role increases the innovation output, instead, it even restrains the transformation.

The research enriches the literature related to enterprises' innovation and founders. The primary novelty of this research is to import social network to the research of founders' characteristics. This research provides the empirical evidences for entrepreneurs' innovation. Founders with the ability of innovation should try to occupy the central position in the R&D network, and cooperate with the R&D members as much as possible, so as to improve the technological innovation performance of enterprises. With the increase of founders' power in the enterprises, the promotion effect would weaken, which means the founders with more power probably devote less to innovation. Government should involve founders' R&D network characteristics in subsidization criteria. For enterprises where founders own the high R&D network centrality, subsidies should be appropriately reduced because this type of enterprises usually own the abundant knowledge resources and depend less on the financial resources. Finally, it is important to note that although founders' R&D network centrality is beneficial to enterprises' innovation output, it restrains the transformation from innovation output into enterprises' value, which requires more for founders' ability. Therefore, how to balance founders' attention to innovation activities and operating activities would be involved in further exploration.

Though this study presents a careful analysis of the impact of founders' dual roles of R&D and management on enterprises' innovation performance from the perspective of founders' R&D network characteristics, like any empirical study, it does have several limitations. One limitation lies in that this study focuses on the single characteristic of R&D network, which makes it necessary to involve other characteristics such as network intensity in the future work. Another potential limitation arises from the depth of knowledge, which is also an important element for innovation except for the breadth of knowledge. Though this paper has proved that the R&D network centrality increases the breadth of knowledge, the relationship between the depth of knowledge and the R&D network centrality has not been discussed due to the limited space, which would be left to the future research.

Funding

This work was supported by National Social Science Fund of China (Grant No. 19BGL257); National Natural Science Foundation of China (Grant No. 72074071).

Author contributions

Jiang and Zeng conceived the study and were responsible for the design and development of the data analysis. Wang was responsible for writing the first draft of the article in English and paper revision.

Disclosure statement

The authors declare no conflict of interest.

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