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Can Private Enterprises Improve Their Technological Innovation by Joining the Military Business? Evidence from China

Jingyu Yang[1], Renfang Liu[2*]

[1]*School of Philosophy, Wuhan University*
No. 299 Bayi Road, Wuchang District, Wuhan, Hubei Province, China
E-mail. yangjingyu007@gmail.com

[2]*Academic Periodical Office, Chongqing Technology and Business University*
No.19, Xuefu Ave., Nanan District, Chongqing, China
*E-mail. nange_137@126.com; *Corresponding author*

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Military-civilian integration is an effective way to promote the development of defence engineering, but existing studies have not given a clear answer whether the participation of private enterprises in military business is conducive to promoting technological innovation of enterprises. In this study, A-shared listed companies in China from 2001 to 2018 were sampled, and the influence of their participation in military business on technological innovation was investigated using a multi-period difference-in-difference (DID) method. Results show that: (1) by joining the military business, private enterprises can significantly strengthen their R&D inputs and substantive innovation, thus promoting their technological innovation. (2) The participation of enterprises in military business acts upon substantive innovation outputs and further affects their technological innovation through R&D input intensity. (3) Participation in military business exerts a stronger positive promoting effect on enterprises in regions with a high marketization level than in regions with a low marketization degree. By joining the military business, SMEs are driven to enlarge their R&D inputs, while large enterprises can enhance their innovation outputs. The policy implications of the obtained conclusions indicate that it requires to be strengthened for private enterprises participating in military business to help reduce their technological innovation risks and improve the construction level of defence engineering projects.

Keywords: *Military-Civilian Integration; Military-Industrial Development; Technological Innovation; Defence Engineering.*

Introduction

The global economy has suffered a huge blow in recent years due to the impacts of the COVID-19 pandemic. Thus, how to effectively enhance enterprises' technological innovations to facilitate global economic recovery has become a current research hotspot. According to Schumpeter's Theory, economic growth is promoted by technological innovation instead of production factors, such as capital and labor. From a micro level, technological innovation is an internal impetus for the survival and development of enterprises. However, technological innovation is, in essence, characterized by the coexistence of risks, uncertainties (Storch-de-Gracia *et al*., 2022), and high remunerations. By investing large amounts of research and development (R&D) funds; enterprises may either gain generous returns or harvest nothing and cause a waste of resources due to market uncertainties, which is even more obvious for private enterprises. Hence, technological innovation is a "double-edged sword" for enterprises.

The innovation of military-civilian integration technology is an important means to promote the development of defence engineering and sharing of military-civilian integration technology and industrial upgrading. The government of China (GOC) is devoted to the longitudinal development of military-civilian integration since the 21st century. On the one hand, some state-owned military-industrial enterprises begin to make scientific research, development, and production of products in the civil field (Brandt, 1994). On the other hand, private enterprises are encouraged to participate in military-industrial development. Many technologies for defence engineering and military services can be transformed for civil purposes. In addition, enterprises in the civil field can serve military purposes directly with existing basis or develop technologies, devices, and products for military uses on the basis of existing elements. Technologies with double attributes and functions realize mutual promotion and collaborative development through resource sharing and interest-driven institutional arrangement, which improves technological innovation and transformation efficiency in the whole economic system (Gao & Song, 2018).

Military-civilian integration has two meanings. On the one hand, defence engineering and military enterprises apply their military technologies to civil fields through technological transfer (Rood & Ann, 2001). On the other hand, enterprises and research institutes in civil fields apply their technological achievements in the military field. After the Cold War, the United States and the Soviet Union raised a trend of transferring military technologies to civil purposes (Cronberg, 1994; Thompson *et al*., 2019). China is devoted to the application of military technologies to the civil field (Narang & Talmadge, 2018; Tyroler-

Cooper & Peet, 2011). Given the whole economic system, military and non-military enterprise participation in research, development, and production of civil and military products can increase resource allocation efficiency of an economy respectively (Huang *et al.,* 2017). Moreover, they serve as an important supporter and promoter in military-civilian interaction in research, development, and production of national defence technologies and weapons, tight combination of national defence and civil industries, and scientific overall planning of national defence security and economic development (Li & Zhang, 2021). Chinese private enterprises have accumulated various advanced technologies and products through introduction, absorption, transformation, and autonomous R&D, thus becoming the main force of national economic construction and the fresh force of national defence and army building. Up to the end of 2017, nearly 10,000 out of 27,260,000 Chinese private enterprises joined the national defence and military industry, as well as army building and security, mainly engaging in weaponry R&D, production, maintenance, and technical services. By the end of December 2018, over 1,500 Chinese state-owned enterprises and private enterprises gained access to the military industry to take part in weaponry and military equipment construction. Therefore, by joining in the military business, private enterprises with relatively strong innovation capabilities can further enhance their technological innovations by means of knowledge communication (Misevic & Tomasevic, 2021), technology transfer, and personnel flow. In this way, they can improve the national technological innovation level and boost high-quality economic development. Meanwhile, the market demand for military goods is relative to that for civilian goods (Cai & Zhang, 2021). Hence, to some extent, private enterprises participating in military business can mitigate the innovation risks brought by market uncertainties and further promote their ability to conduct technological innovations. For this reason, exploring the participation of private enterprises in military business has strong realistic significance.

Existing studies concerning military-civilian integration emphasize state-owned military enterprises in civil businesses (Li *et al.,* 2021; Chen & Zhou, 2021). Research contents mainly focus on connotation, development significance, measurement method, existing problems, and development strategies (Kulve & Smit, 2003; Zhao *et al.,* 2015). In the existing literature, multi-indicator empowerment is mainly adopted to measure military-civilian integration through macroscopic, mesoscopic, and microscopic calculations, all of which are susceptible to certain subjective factors because scoring is required (Li *et al*., 2018). However, the participation of private enterprises in military business has been scarcely investigated. A possible reason is that such information is seldom disclosed due to confidentiality agreements, and the sample collection is difficult. Moreover, private enterprises develop backwardly in the military business, so this has been less of a concern for researchers. In the few relevant studies, the problems and suggestions with regard to the participation of private enterprises in military business have been explored mainly from a theoretical level. It is widely believed that when participating in the military business, private enterprises are subjected to a wide range of barriers, such as unsmooth information channels, many entry/exit obstacles, unfair treatment, high costs spent in military business, and financing difficulties (Han *et al*., 2020).

In this study, the listed private enterprises with certificates of military industry were chosen as the research objects. The participation degree of private enterprises to military-industrial development, known as the military-civilian integration degree, was measured by types and the number of access certificate (AC) of the military industry. An empirical study on the changes in technological innovation before and after gaining the AC to the military industry through the multi-point difference-in-difference (DID) method. Conclusions provide some references for private enterprises in deciding whether to participate or not in military-industrial development. Moreover, this study has certain practical significance to promote the development of military-civilian integration and improve the level of defence engineering.

The main innovations and contributions of this study are summarized as follows. 1) Private enterprises gaining access to relevant military industries were sampled to explore the influence of participating in military business on their technological innovation. The samples were novel, thus supplementing the literature regarding military-civilian integration. 2) The military-civilian integration of micro-enterprises could be objectively measured based on the category and quantity of admission qualifications to the military industry. 3) An empirical analysis was performed using the multi-period difference-in-difference (DID) method, which enriched empirical studies on military-civilian integration.

The remainder of this study is organized as follows. Section 2 is a literature review concerning the military-civilian investigation. A possible reason is that such information is integrated, points out shortcomings of existing studies, and proposes research hypotheses according to existing research theories. Section 3 introduces the data source and construction modes of variables in this study including research methodologies in the empirical study. Section 4 is an empirical study based on a measurement model to test hypotheses that are deduced from theoretical parts. Section 5 discusses the research results of the present study. Section 6 concludes and summarizes shortcomings.

Literature Review and Research Hypothesis

Military-Civilian Integration and Technological Innovation

By investigating the influence of the private enterprises' participation in military business on their performance, the results demonstrate that the military business of private enterprises exerts an insignificant effect on their performance and can markedly relieve its fluctuation. Furthermore, the fluctuation of enterprise performance declines more obviously in the case of deeper military-civilian integration (Liu *et al.,* 2020). In other words, given the more specific demands for military goods relative to civilian goods, private enterprises can, to some extent, reduce the innovation risks brought by market uncertainties after participating in military-civilian integration. Hence, private enterprises are more motivated to strengthen their technological innovation by enlarging their R&D inputs without "fear of attacks from behind."

Private enterprises face a strict accession threshold to participate in military-industrial development due to the uniqueness of the military industry. Among them, gaining AC in the military industry is an essential requirement. AC to military industries has four types, namely, confidentiality certificate (CC) for weapon research, development, and manufacturing units; weapon quality management system certificate (QC); weapon manufacturing certificate (MC); and weapon research, development, and production certification (PC). CC and QC are prerequisites to acquire QC and MC. Weapon research, development, and production activities refer to scientific research and production activities for general, system, and special accessories of weapons. PC can be further divided into types I and II according to the importance of weapons and special accessories. CC can be divided into levels 1, 2, and 3 according to company conditions and confidentiality degree of products, where level 1 is the highest. Types and the number of ACs determine the scope and degree for private enterprises to participate in military-industrial development (You *et al.,* 2017).

To take part in the military business, private enterprises must possess superior technological levels. As they are driven to enhance their R&D inputs to gain access to the military industry, they are likely to continuously improve their technological innovation level (Zhang, 2003; Wadhwa *et al.,* 2017). Meanwhile, private enterprises' participation in military business embodies a national-level technical approval and represents an intangible social capital that can be more favored by investors and win financial support. In this way, enterprises infuse more capital into their R&D activities, which promotes technological innovation. Moreover, an exit mechanism is set by relevant sectors for the admission qualification to the military industry. If the technological level of private enterprises already participating in military business fails to reach the latest technical requirement, the certificate will not be extended upon expiry. In turn, this motivates enterprises to enhance their R&D inputs and continuously conduct technological innovation. Based on such information, Hypothesis 1 is proposed:

H1: Participating in military business encourages private enterprises to implement technological innovations.

Enterprise Scale and Technological Innovation

The extant research on the relationship between enterprise size and technological innovation has an early start, but no unified research conclusion has been formed yet. According to relevant research conclusions, the relationship between enterprise size and technological innovation can be classified into three types. First, enterprise size is positively correlated with technological innovation (*i.e*., enterprises' technological innovation can be further promoted under a larger enterprise size) (Blundell *et al.,* 1995; Vaona & Pianta, 2008; Booyens, 2011; Przychodzen & Przychodzen, 2018). Second, enterprise size is negatively correlated with technological innovation (*i.e.,* the technological innovation of small and medium-sized enterprises (SMEs) can be further boosted than that of large enterprises (Shefer & Frenkel, 2005; Laforet, 2013; Ferreira *et al.*, 2019). Third, enterprise size presents an inversely U-shaped nonlinear relationship, which means that enterprise size promotes technological innovation from the beginning, but technological innovation will be inhibited when enterprise size reaches a certain level (Jafferson, 1988; Aghion *et al.,* 2005; Bovkun & Korodyuk*,* 2019).

The inconsistency in the above conclusions mainly derives from the differences in the industry and period involved in relevant studies. As for technological innovations characterized by small capital input, low technological content, and short R&D period, SMEs are more flexible than large enterprises, so they are more prone to this type of technological innovation. For technological innovations characterized by large input, high technological content, and long R&D period, large enterprises are more capable of technological innovations with better manpower and financial capital. The R&D innovation of military goods belongs to the latter type, so a larger enterprise size can better promote such technological innovations. Hence, Hypothesis 2 is proposed:

H2: Compared with small enterprises, large private enterprises are further promoted to perform technological innovations by participating in military business.

Marketization Degree and Technological Innovation

Regarding the relationship between marketization progress and technological innovation, the existing literature reveals the uncertainties in how exactly the elevation of industrial or regional marketization degree improves the inputs into technological innovation and its efficiency. Specifically, the elevated marketization degree generates varying effects on industries with different technical complexities (Qiao *et al.,* 2021). It is widely believed that the marketization degree exerts a significant positive effect on technological innovation efficiency (Gene *et al.,* 2004; Lei *et al.,* 2009). It has also been pointed out that the administrative monopoly and regional market segmentation degree are directly relieved by the elevated marketization degree (Lu *et al.,* 2019). In turn, this strengthens market competition, renders impetus and pressure for enterprises to conduct technological innovation, inversely forces them to improve production efficiency through technological progress, and maintains their vantage ground and market shares in market competition (Yang *et al.,* 2009; Ye & Liu, 2020). According to the empirical research of Andrea *et al.* (2008), market competition degree has a significant negative correlation with technological innovation efficiency, while Bas and Berthou (2017) stated that the rate of return on autonomous R&D may be reduced by enhancing marketization. Therefore, the interaction between marketization progress and technological innovation remains uncertain.

Most private enterprises joining military business are technological R&D-type enterprises characterized by large R&D inputs that require continuous study and innovation. In addition, their R&D inputs are associated with the marketization degree (Zhong *et al.,* 2017). This means that the R&D inputs of enterprises in regions with high marketization degrees are generally large. Hence, we are inclined to the idea that enterprises' technological innovation is positively influenced by the enhanced marketization progress. Based on such information, Hypothesis 3 is proposed:

H3: Compared to enterprises in regions with a low marketization level, the technological innovations of those in regions with a high marketization level can be further promoted by participating in military business.

Methodology

Model Construction

Since the military industry has set a market access threshold, enterprises to participate in the military business need to obtain the military industry access qualifications evaluated by third-party institutions, and the "military-civilian integration" policy is a policy of exogenous enterprise behavior for private enterprises, which is a quasi-natural experiment. Moreover, the time for each enterprise to obtain qualifications is different, and the time to participate in military products is also different, which is suitable for using a multi-time point double difference model for estimation. This study refers to the method of Thorsten Beck et al. (2010), constructs a multi-time double differential fixed-effect model, and deeply analyzes the impact of the "military-civilian integration" policy on the technological innovation of private listed enterprises.

$$TechInno_{it} = \beta_0 + \beta_1 treat_{it} + \delta_0 time_{it} + \delta_1 did_{it} + \sum control_{jt} + \mu_j + \delta_t + \varepsilon_{it} \quad (1)$$

In Model (1), the dependent variable $TechInno_{it}$ indicates that the company's technological innovation in the *t*-year. The explanatory variables include $treat_{it}$, $time_{it}$ and did_{it}. The variable $treat_{it}$ denotes whether enterprises have gained AC to military-industrial development. The variable $time_{it}$ reflects progresses of enterprises in applying the AC. The variable did_{it} denotes the intersection of $treat_{it}$ and $time_{it}$, it is used to test the impact of private enterprises' participation in military business on enterprise technological innovation. Similarly, $control_{jt}$ is the control variable, while μ_j and δ_t are the industrial and annual dummy variables.

Data Source

Chinese-listed A-share non-financial private companies from 2001 to 2018 are selected. Among them, ST enterprises, enterprises gaining AC in and after 2018, and enterprises with missing index data are deleted. Finally, 8,112 observation values are collected. AC information of private enterprises was obtained from Chinese financial websites, including China Information Net, East Money Net, Straight flush Net, and so on. Financial data were collected from the China Stock Market Accounting Research database. In this study, financial data variables (except the dummy variable) were processed by 1 % winsorize to overcome the influences of abnormal values. Enterprises that gain AC were the treatment group (107 samples), and those without were the control group (1,328 samples).

Variables

Explained variables. In the existing literature, technological innovation indexes are measured mainly through three methods: (1) input method, where R&D inputs are mostly used to investigate the R&D-related decisions and capabilities of enterprises (Romijn & Albaladejo, 2002; Schoenecker & Swanson, 2002; Hagedoorn, 2003); (2) output method, where the number of patents is generally used to explore innovation results and efficiency(Liu *et al.,* 2016; Howell, 2016); and (3) comprehensive indexes, such as total factor productivity (TFP) and capital stock, which are required to calculate TFP. However, the data on capital stocks are not provided by the National Bureau of Statistics of China, leading to great differences in TFP acquired by different researchers. In some studies, technological innovation is measured using the number of patents granted. Nevertheless, patent licensing is generally subjected to a time delay of 1-2 years and is influenced by many subjective factors that can be avoided by patent application (Griliches, 1990).

According to *Rules for the Implementation of the Patent Law of the People's Republic of China*, patents applied by enterprises are classified into three types: invents, utility models, and appearance designs, among which patents for inventions are novel technical proposals for improving products, methods or processes with strict examination and approval, long validity period, and high technology content, thus belonging to substantive innovations. Comparatively speaking, patents for utility models and appearance designs represent the innovation of product structure and appearance with low technology content; thus, they can be regarded as strategy-type innovations.

This study mainly investigates whether participating in military business drives private enterprises to value technological innovation more to strengthen their technological innovation level. Referring to Foreman-Peck (2013), Kouam & Tapsoba (2019) and Cao et al.(2022), R&D input intensity (*RDint*), which is the amount invested into R&D/operating revenue, was used in the current study to measure whether enterprises placed greater emphasis on technological innovation. Next, we used the total sum of patents applied, the number of patents applied for inventions, and the sum of patents for utility models and appearance designs to measure the levels of overall (*pat*), substantive (*pat1*), and strategy-type innovations (*pat2*), respectively.

Explanatory variables. Military-civilian integration: currently, most scholars measure military-civilian integration degrees from the regional or state levels. The index weight method is the main measurement method (Li *et al.,* 2018; Li *et al.,* 2012). However, this method has certain subjectivity because it scores the weights of various indexes. Hence, this study measures military-civilian integration by whether enterprises have gained AC to military-industrial development, expressed by did . did is the product of $treat_{it}$ and $time_{it}$ (where i denotes enterprises and t denotes year). The variable $treat_{it}$ denotes whether enterprises have gained AC to military-industrial development. If $treat_{it}$ values 1, then the enterprise has AC to military-industrial development, and otherwise if $treat_{it}$ values 0. The variable $time_{it}$ reflects progresses of enterprises in applying the AC. This variable values 1 from the first to fifth year after the gaining of AC (considering that the period of validity of the certificate is 5 years, the study period is set to 5 years after gaining the AC); otherwise, such variable values 0. Given that the time to obtain various certificates is different, this study determines the time when research samples gain the last certificate as the time of certificate gaining of enterprises. Values of did are introduced as follows: when two dummy variables of $treat_{it}$ and $time_{it}$ value 1, did_{it} is 1, indicating that the private enterprise is a military-civilian integration enterprise. Under other conditions, did_{it} is 0, indicating that the private enterprise is not a military-civilian integration enterprise.

Control variables. Following some scholars, enterprise-scale, capital structure, enterprise performance, share ratio of the first majority shareholder and earnings per share are chosen as control variables (Adams & Almeida, 2005; Beiner *et al.,* 2006; Cheng, 2008). Both industry dummies and annual dummies are controlled.

Descriptive Statistics

The descriptive statistical information on the main variables in this study is reported in Table 1. As can be seen, the medians of *RDint*, *pat*, *pat1*, and *pat2* were all smaller than the mean values, especially for the *RDint* variable with a large standard deviation, indicating that enterprises differed greatly in terms of R&D input intensity and the number of patents applied. For most enterprises, the R&D input and number of patents applied were small. Other data showed slight variations in mean value and median, basically following a normal distribution.

Table 1

Descriptive Statistics of the Main Variables

Var	Sam	Mean	Std	Med	Min	Max
RDint	8112	5.000	4.492	0.070	3.775	26.420
pat	5341	2.545	1.141	0.000	2.485	8.864
pat1	5342	1.688	1.119	0.000	1.609	8.149
pat2	5342	1.843	1.340	0.000	1.792	8.302
did	8112	0.028	0.166	0.000	0.000	1.000
roe	8112	0.075	0.075	-0.245	0.072	0.296
size	8112	21.549	0.958	19.652	21.458	24.294
lev	8112	0.336	0.182	0.035	0.317	0.775
top1	8112	33.092	13.531	8.930	31.370	69.220

Results Analysis

Regression Analysis

Regression Result Analysis for the Full-Sample

The regression results of the multi-period DID fixed effect model of "military-civilian integration" on enterprises' R&D input and innovation output are listed in Table 2. The results showed that the *did* coefficient was significantly positive in the regression of R&D input intensity (*RDint*) and substantive innovation level, indicating that by participating in the military business, private enterprises were driven to significantly strengthen their R&D inputs and elevate their substantial innovation level. This supports Hypothesis 1. From the aspect of R&D input intensity, the R&D input of enterprises participating in military business would be 26.6% higher than that before substantial innovation output. The innovation results revealed that participation in military business increased substantial innovation outputs by 26.6%. The average substantive innovation output of listed private enterprises in China was roughly 1.688, which was converted into about 4.41 patents (*Exp (1.688)-1=4.41*). This indicated that if Chinese listed private enterprises joined the military business, their average number of patents for inventions would increase by 1.17 and the innovation output would be considerably enhanced.

Table 2

Military-Civilian Integration and Technological Innovation: the Full-Sample

Var	Input	Output		
	RDint	***Overall innovation***	***Substantive innovation***	***Strategy-Type innovation***
did	2.0337*** (4.9970)	0.1286 (1.4898)	0.2658*** (2.8833)	-0.0210 (-0.2335)
size	-0.1965*** (-3.6620)	0.3998*** (16.9491)	0.3878*** (16.6568)	0.3312*** (12.8979)
lev	-4.7554*** (-17.0675)	-0.0557 (-0.5615)	-0.0230 (-0.2306)	0.1237 (1.1445)
roe	-3.5109*** (-5.4958)	1.8965*** (7.7369)	1.8721*** (7.3941)	1.4111*** (5.5036)
top1	-0.0129*** (-4.6347)	0.0025** (2.2580)	0.0006 (0.5261)	0.0032*** (2.7292)
_cons	9.5456*** (6.9067)	-8.0872*** (-14.6214)	-7.5125*** (-14.3614)	-5.1660*** (-9.0862)
N	8112	5341	5342	5342
r^2	0.4070	0.2112	0.1680	0.3267
r^2_a	0.4009	0.2002	0.1565	0.3174

*Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1 %, 5 %, and 10 %, respectively.*

Regression Result Analysis for the Type of Military Civilian Integration

This study divided military-civilian integration enterprises into "enterprise group with a certificate" and "enterprise group without a certificate" to examine the impact of the degree of military-civilian integration on the technological innovation of enterprises. Given that four types of certificates exist, four groups of tests were carried out.

Table 3

Military-Civilian Integration and Company's R&D Investment: the Group-Based Regression about Types of Certificates

Var	*PC*		*MC*		*QC*		*CC*	
	with	*without*	*with*	*without*	*with*	*without*	*with*	*without*
did	1.7650** (2.5722)	0.4746 (0.4363)	2.3132*** (2.8087)	-0.0766 (-0.1072)	1.2500** (2.0653)	-0.2423 (-0.1972)	1.3813** (2.2938)	-1.4551* (-1.7135)
size	-0.7345 (-1.5067)	-0.7831* (-1.8287)	-0.7175* (-1.6987)	-0.2412 (-0.4581)	-0.5338* (-1.6779)	-1.7124 (-0.5417)	-0.6976** (-2.1827)	2.2945*** (3.3569)
lev	-8.5876*** (-3.8393)	-7.0579*** (-3.6780)	-8.8198*** (-4.3769)	-9.7185*** (-3.5361)	-9.1423*** (-6.0984)	1.6341 (0.2918)	-7.8878*** (-5.4423)	-1.5764 (-0.5809)
roe	-2.8011 (-0.6193)	-27.0862*** (-3.7644)	-22.8009*** (-3.3266)	-2.2452 (-0.4418)	-9.2149** (-2.5759)	-19.6366 (-1.3038)	-10.2669*** (-2.6603)	8.9985 (1.3819)
top1	-0.0700*** (-2.7978)	-0.0018 (-0.0852)	-0.0073 (-0.3892)	-0.0186 (-0.6826)	-0.0227 (-1.4901)	0.0452 (0.3881)	-0.0336** (-2.1842)	-0.0910*** (-3.9381)
_cons	25.6141*** (2.6338)	19.9526** (2.2174)	32.7621*** (3.9564)	10.9094 (1.0099)	14.9042** (2.4462)	60.9116 (0.9823)	19.6575*** (3.0788)	-39.4011*** (-2.9578)
N	455	284	392	347	701	38	672	67
r^2	0.4342	0.4352	0.3786	0.5187	0.3703	0.9466	0.4086	0.7870
r^2_a	0.3840	0.3581	0.3213	0.4593	0.3290	0.9060	0.3731	0.6805

*Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1 %, 5 %, and 10 %, respectively.*

Table 3 reports the grouping regression results according to the category of qualifications gained by enterprises, with the dependent variable of R&D input intensity (*RDint*). The coefficients of *did* in all columns presenting the possession of qualifications were positive, ranging from 1.25 to 2.32, with a significance level of 5 %. This indicated that the possession of qualifications was positively correlated with the technological innovations of enterprises. Furthermore, the *did* coefficient of enterprises owning "licenses" and "supplier's certificate" was markedly greater than that of enterprises in possession of "quality certificate" and "confidentiality certificate" suggesting that the deeper military-civilian integration contributed to greater R&D inputs. This also proved that their technological innovation could be promoted by participating in military business.

Table 4

Military-Civilian Integration and Substantive Innovation: the Group-Based Regression about Types of Certificates

Var	*PC*		*MC*		*QC*		*CC*	
	with	*without*	*with*	*without*	*with*	*without*	*with*	*without*
did	0.2578** (2.0559)	0.2555 (0.9744)	0.1392 (1.0680)	0.2492 (1.0548)	0.2161* (1.7347)	0.3592 (1.1291)	0.2384** (2.0450)	0.5389 (1.0897)
size	0.4920*** (5.0110)	-0.0355 (-0.2065)	0.2993*** (2.6584)	0.5835*** (4.1247)	0.3284*** (3.9950)	1.2558* (1.8635)	0.2950*** (3.6574)	0.1404 (0.2732)
lev	0.3228 (0.7788)	2.0102*** (2.7254)	0.6399 (1.1209)	0.7803 (1.3743)	0.8194** (2.1101)	-0.8174 (-0.4986)	0.7243** (1.9698)	4.1965* (1.6958)
roe	1.5604 (1.3620)	4.2920** (2.4157)	3.0612** (2.1368)	1.8648 (1.3956)	2.2271** (2.4133)	-1.1679 (-0.2275)	2.5508*** (2.6301)	3.4286 (0.9122)
top1	0.0055 (0.9964)	0.0025 (0.2488)	0.0042 (0.7169)	0.0045 (0.5973)	0.0072 (1.5617)	-0.1398*** (-4.2790)	0.0029 (0.6351)	-0.0635** (-2.3168)
_cons	-10.5870*** (-5.1866)	-0.4771 (-0.1383)	-4.8495** (-2.0386)	-11.9695*** (-4.0537)	-6.6575*** (-3.9946)	-19.8015 (-1.4722)	-6.3700*** (-3.8148)	0.4248 (0.0385)
N	373	237	323	287	574	36	548	62
r^2	0.3066	0.2359	0.2381	0.2683	0.2234	0.7703	0.2066	0.6641
r^2_a	0.2368	0.1204	0.1598	0.1629	0.1651	0.5768	0.1507	0.4878

*Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1 %, 5 %, and 10 %, respectively.*

Table 4 presents the grouping regression results based on the category of qualifications acquired by enterprises, with the dependent variable of substantive innovation. The coefficients of *did* in all columns indicating the possession of qualifications were positive, ranging from 0.13 to 0.26 with small fluctuations. Moreover, three among the four columns were significant, demonstrating that the possession of qualifications was positively correlated with the substantive innovation level of enterprises. Furthermore, this also proved that their technological innovation could be markedly promoted by participating in military business.

Regression Result Analysis for the Number of Certificates

Private enterprises that gain more ACs participate in a wide and deep scope in military-industrial development. This study further divided enterprises with AC into four groups (Groups 1-4) for the regression test to verify the influences of the military-civilian integration degree on the fluctuation rate of enterprise performance.

Table 5

Military-Civilian Integration and Company's R&D Investment: the Group-Based Regression about the Number of Certificates

Var	*one*	*two*	*three*	*four*
did	-1.1985 (-1.5338)	0.8127 (1.3054)	1.0708 (1.1376)	2.5094*** (2.9670)
size	2.3753*** (3.7214)	-1.4444*** (-4.6297)	-0.7624 (-1.5023)	-1.2698*** (-2.6861)
lev	-2.7119 (-1.4374)	-1.5583 (-1.0870)	-11.4694*** (-4.8938)	-6.8553*** (-3.0345)
roe	4.8147 (0.9838)	1.6091 (0.5568)	-11.2242** (-2.3135)	-7.7226 (-1.1321)
top1	-0.0560*** (-3.1059)	-0.0025 (-0.0957)	-0.0520** (-2.0656)	-0.0683** (-2.4697)
_cons	-45.1844*** (-3.4955)	34.0462*** (4.6784)	30.3990*** (2.9798)	36.2464*** (3.6566)
N	96	70	280	293
r^2	0.8108	0.7203	0.5356	0.4154
r^2_a	0.7432	0.5979	0.4796	0.3460

*Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively.*

Meanwhile, Table 5 presents the grouping regression results based on the number of qualifications gained by enterprises, with the dependent variable of R&D input intensity (*RDint*). As can be seen, except for the first column, the coefficients of *did* in all columns were positive, indicating the positive correlation between military-civilian integration and technological innovations of enterprises. Furthermore, the significance level was 1% for enterprises possessing four admission qualifications to the military industry. Overall, a larger number of qualifications facilitated greater R&D inputs, suggesting that enterprises were more promoted to implement technological innovation with more qualifications and deeper participation in military business.

Table 6

Military-Civilian Integration and Substantive Innovation: the Group-Based Regression about the Number of Certificates

Var	*one*	*two*	*three*	*four*
did	0.6344* (1.6872)	0.5340 (1.4054)	0.4667* (1.7915)	0.0402 (0.3016)
size	0.2484 (0.6077)	-0.8214*** (-3.4616)	0.4499*** (2.9867)	0.4641*** (4.0961)
lev	2.9617 (1.5579)	4.8926*** (5.5407)	-0.2123 (-0.3457)	0.6051 (1.0783)
roe	3.3669 (1.0892)	3.6879 (1.3488)	2.0516 (1.4233)	2.8156* (1.7334)
top1	-0.0613** (-2.4421)	-0.0486*** (-2.9655)	0.0043 (0.5255)	0.0065 (0.9078)
_cons	-3.0896 (-0.3599)	19.4104*** (3.7812)	-7.4632** (-2.3181)	-9.6885*** (-4.0943)
N	89	64	205	252
r^2	0.6761	0.7743	0.2269	0.3655
r^2_a	0.5547	0.6614	0.1090	0.2826

*Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively.*

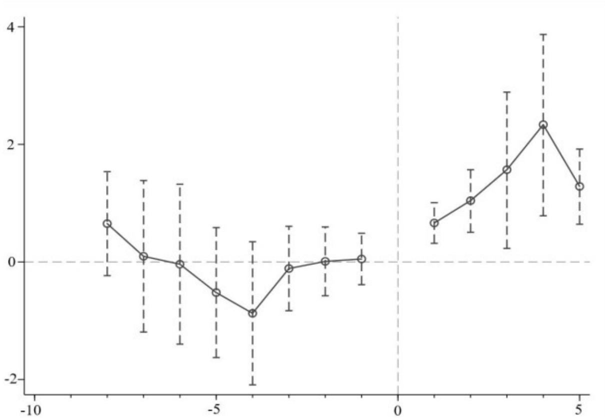
Table 6 presents the grouping regression results based on the number of qualifications gained by enterprises, with the dependent variable of an innovation output index, namely, substantive innovation. Regardless of how many qualifications were possessed, the coefficient of *did* was always positive, and it was significantly positive in two columns. Nevertheless, the coefficients did not increase with the increase in qualifications. In other words, the enterprises more deeply involved in military business tended to make greater investments in R&D, but the same was not true for the innovation outputs.

Parallelism Test

The policy evaluation based on the DID method requires the parallelism test. In this study, the parallelism test was performed by Thorsten Beck et al. (2010). Model (2) is introduced as follows:

$$TechInno_{it} = \beta_0 + \beta_1 D_{it}^{-8} + ... + \beta_{13} D_{it}^{5} + \mu_j + \delta_t + \varepsilon_{it} \quad (2)$$

Figure 1 and *Figure 2* show the results, which are dynamic influences of military-civilian integration on the fluctuation rate of enterprise performance. The period is 13 years, including 8 years before and 5 years after obtaining AC. Both *Figure 1* and *Figure 2* show that the company's technological innovation did not change significantly before obtaining the military salary quality, indicating that the development trend of the processing group and the control group in the sample was the same; and the company's R&D investment intensity and substantive innovation level increased significantly after obtaining the military salary quality.



Note: The dashed line indicates the 95 % confidence interval, the abscissa indicates the year before and after obtaining the qualification, and the ordinate is the percentage.

Figure 1. The Dynamic Influences of Military-Civilian Integration on the Company's R&D Investment Intensity

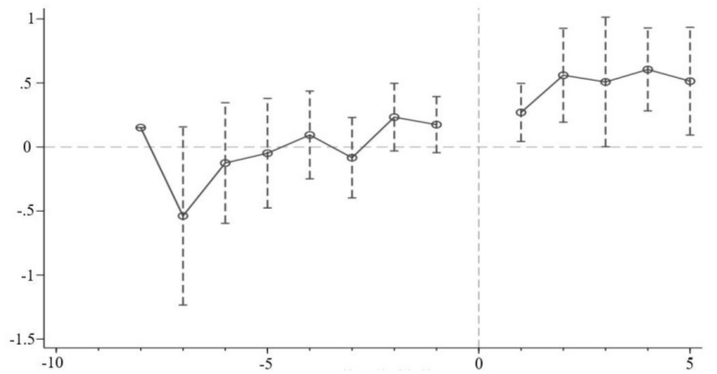


Figure 2. The Dynamic Influences of Military-Civilian Integration on the Substantive Innovation Level

Robustness Test

Replacement of Dependent Variables

To test the robustness of results, in this study, *RDint1* and *RDhum* are reverted as dependent variables, respectively. Columns 1–2 of Table 7 show regression results. After the replacement of dependent variables, private enterprise participation in military-industrial development still can significantly influence the enterprise's technology innovation. Therefore, the conclusions of this study are relatively robust.

Postponement of Patents for Inventions

As it takes time to apply for patents from R&D input, the time of patent application for inventions was postponed for one year and two years in this study. The regression results are displayed in Columns 3–4 of Table 7. It appeared that the substantive innovation outputs of enterprises were still significantly influenced by the participation in military business, which accorded with previous conclusions.

Deletion of Partial Industrial Samples

Considering that most private enterprises participating in military-industrial development are industrial manufacturing, some samples are deleted to further verify the influences of the military-civilian integration on company technology innovation. Only enterprises of five industries, including manufacturing, architectural, transportation, electric thermal production, and non-ferrous metal mining industries, were retained as the control group. Columns 5–6 of Table 7 show the regression results. The influencing coefficient of military-civilian integration on the technology innovation is significantly positive, indicating that the military-civilian integration still can significantly influence the technology innovation after non-industrial enterprises are deleted. This notion completely conforms to previous conclusions.

Table 7

Robustness Test

Var	**Replacement of dependent variables**		**Postponement of patents for inventions**		**Deletion of partial industrial samples**	
	RDint1	*RDhum*	*F.pat1*	*F2.pat1*	*RDint*	*pat1*
did	0.0021* (1.7493)	1.6648* (1.8654)	0.3054*** (2.7098)	0.3025** (2.3659)	2.2984*** (5.1056)	0.2809*** (2.6855)
size	-0.0021*** (-8.6135)	-0.5059** (-2.3742)	0.4031*** (16.0416)	0.4111*** (14.1240)	-0.2373*** (-4.8601)	0.3982*** (15.7066)
lev	-0.0025** (-2.1711)	-9.5376*** (-7.5585)	-0.0989 (-0.9272)	-0.0897 (-0.7269)	-3.9409*** (-14.0699)	-0.0626 (-0.5982)

Var	Replacement of dependent variables		Postponement of patents for inventions		Deletion of partial industrial samples	
	RDint1	*RDhum*	*F.pat1*	*F2.pat1*	*RDint*	*pat1*
roe	-0.0002*** (-3.5958)	-0.0126 (-1.0542)	1.6314*** (5.2995)	1.8832*** (6.0641)	-2.3441*** (-3.9605)	1.1754*** (4.2555)
top1	-0.0000 (-0.4647)	-0.0278** (-2.1302)	0.0004 (0.3508)	-0.0006 (-0.3954)	-0.0095*** (-3.5376)	0.0007 (0.6260)
_cons	0.0740*** (7.6696)	14.9737*** (3.2824)	-9.2669*** (-16.2814)	-9.0588*** (-11.8520)	10.2718*** (5.5595)	-9.3074*** (-14.1194)
N	8112	3825	4392	3383	6790	4731
r^2	0.2817	0.4166	0.1622	0.1586	0.2789	0.1650
r^2_a	0.2744	0.4049	0.1486	0.1416	0.2726	0.1555

*Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1 %, 5 %, and 10 %, respectively.*

Impact Mechanism Analysis

Through the previous analysis, a preliminary conclusion could be drawn: the participation of private enterprises in military business significantly enhanced their R&D input intensity and substantive innovation level, which, in turn, promoted their technological innovation. Deeper military-civilian integration promoted larger R&D inputs; however, it did not represent the more substantive innovation outputs. Therefore, we were able to determine whether the participation of private enterprises in military business influenced their substantive innovation level and further exerted effects on their technological innovation by influencing the R&D inputs. Here, to explore the mediating effect of R&D input, as seen in Model (3), we used the R&D input intensity index ($RDint_{it}$) and its cross-product term with did_{it} as independent variables and the substantive innovation level ($pat1_{it}$) as a dependent variable for regression.

$$pat1_{it} = \beta_0 + \beta_1 RDint_{it} + \delta_0 did_{it} + \delta_1 RDint_{it} \times did_{it} + \sum control_{jt} + \mu_j + \delta_t + \varepsilon_{it} \quad (3)$$

Table 8

Regression Results based on the Mediation Effects Test

Var	***substantive innovation***	***substantive innovation***	***substantive innovation***	***overall innovation***	***substantive innovation***	***strategy-type innovation***
RDint	0.0607*** (12.7835)	0.0602*** (12.6331)	0.0676*** (13.7429)	0.0411*** (8.5581)	0.0676*** (13.7429)	0.0016 (0.3114)
size	0.4129*** (17.4089)	0.4120*** (17.3828)	0.4103*** (17.3627)	0.4139*** (17.1551)	0.4103*** (17.3627)	0.3347*** (12.7419)
lev	0.2392** (2.3957)	0.2418** (2.4227)	0.2633*** (2.6401)	0.1073 (1.0635)	0.2633*** (2.6401)	0.0955 (0.8644)
roe	1.2889*** (4.7940)	1.2928*** (4.7932)	1.3048*** (4.8242)	1.2703*** (5.1188)	1.3048*** (4.8242)	0.8606*** (4.0363)
top1	0.0017 (1.5816)	0.0017 (1.5796)	0.0019* (1.7677)	0.0034*** (3.1289)	0.0019* (1.7677)	0.0034*** (2.9081)
did		0.1099 (1.1428)	0.6017*** (4.3842)	0.5173*** (4.0169)	0.6017*** (4.3842)	0.4706*** (3.4758)
RDint×did			-0.0564*** (-4.4990)	-0.0556*** (-5.0727)	-0.0564*** (-4.4990)	-0.0564*** (-5.5114)
_cons	-8.3596*** (-15.7439)	-8.4084*** (-15.7599)	-8.4933*** (-16.0015)	-8.4941*** (-15.0978)	-8.4933*** (-16.0015)	-5.3105*** (-9.1067)
N	5342	5342	5342	5341	5342	5342
r^2	0.1966	0.1968	0.2010	0.2210	0.2010	0.3285
r^2_a	0.1854	0.1855	0.1896	0.2099	0.1896	0.3189

*Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1 %, 5 %, and 10 %, respectively.*

The regression results are seen in Table 8. In Column 1, the coefficient of *RDint* was significantly positive, indicating that enterprises' substantive innovation outputs could be markedly improved by R&D inputs. In the joint presence of *RDint* and *did* in this model, the coefficient of *RDint* was still significant while *did* coefficient was not, indicating that the participation of private enterprises in military business acted upon their substantive innovation outputs and further influenced their technological innovation via *RDint*. However, when the cross-product term of *RDint* and *did* was introduced (Column 3), the coefficient of *RDint×did* was significantly negative. This suggested that after private enterprises took part in the military business, the influence of R&D inputs on their substantive innovation showed a crowding-out effect.

To verify this possible explanation, a regression was further performed for R&D input intensity by means of lagging one and two phases, as seen in Table 9. From all columns in Table 9, we can see that, regardless of whether the R&D input was in the current phase and lagged phase, all coefficients were significantly positive. Furthermore, although the cross-product term coefficient between *did* and *RDint* in each phase was also significantly negative, the absolute value of this coefficient was smaller and smaller as the increase in phases lagged. In other words, as time was lengthened, the crowding-out effect of R&D inputs on enterprises' substantive innovation became increasingly weaker. Hence, the explanation was proven.

Table 9

Regression Results based on the Mediation Effects Test (the Number of Lag Periods)

Var	*pat1*	*pat1*	*pat1*
RDint	0.0676*** (13.7429)		
L.RDint		0.0642*** (11.746)	
L2.RDint			0.0555*** (8.9382)
did	0.6017*** (4.3842)	0.4877*** (3.5578)	0.4028*** (2.8155)
RDint×did	-0.0564*** (-4.4990)		
RDint×did_1		-0.0487*** (-4.1102)	
RDint×did_2			-0.0372*** (-3.0296)
size	0.4103*** (17.3627)	0.4109*** (15.9631)	0.4244*** (14.4945)
lev	0.2633*** (2.6401)	0.1619 (1.4497)	0.0659 (0.5171)
roe	1.3048*** (4.8242)	1.2258*** (4.0711)	1.0974*** (3.3908)
top1	0.0019* (1.7677)	0.0019 (1.5545)	0.0012 (0.8106)
_cons	-8.4933*** (-16.0015)	-7.9909*** (-13.7771)	-8.4122*** (-11.3695)
N	5342	4392	3383
r^2	0.2010	0.1911	0.1792
r^2_a	0.1896	0.1778	0.1631

Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1 %, 5 %, and 10 %, respectively.

Heterogeneity Analysis

Market Environment, Military-Civilian Integration, and Technology Innovation

Enterprises in a different market environment have significant differences in resources and policies due to the imbalance in market development. Enterprise samples were divided into two groups through a mean marketization degree to verify the influences of the marketization degree on technology innovation of military-civilian integration enterprises. Enterprises above the mean are enterprises with a high marketization degree, whereas those below the mean are the ones with a low marketization degree. The estimation results are reported in Table 10. In general, the participation of private enterprises in military business significantly facilitated their technological innovation despite the marketization degree. Both the R&D input and the substantive innovation output of enterprises in regions with a low marketization level were higher than those of enterprises in regions with a high marketization level, which was opposite to Hypothesis 3.

Table 10

The Influences of the Marketization Degree on Technology Innovation of Military-Civilian Integration Enterprises

Var	*RDint*		*pat1*	
	high	*low*	*high*	*low*
did	1.1871** (2.4938)	3.5413*** (4.8502)	0.2295* (1.8662)	0.2757** (2.0368)
size	-0.2391*** (-3.2637)	-0.1986*** (-2.9174)	0.4547*** (13.3008)	0.3481*** (10.0680)
lev	-4.3573*** (-10.7357)	-5.1290*** (-13.5486)	-0.3576** (-2.4532)	0.3404** (2.3607)
roe	-0.0487*** (-14.1776)	-3.6222*** (-4.3370)	1.0092*** (3.0158)	1.1877*** (2.9724)
top1	-0.0134*** (-3.5724)	-0.0145*** (-3.6389)	-0.0000 (-0.0128)	0.0013 (0.7940)
_cons	6.5624*** (3.8371)	9.6329*** (6.8301)	-8.7796*** (-11.7571)	-7.5912*** (-9.1711)
N	4449	3663	2784	2558
r^2	0.4155	0.4152	0.1848	0.1665
r^2_a	0.4055	0.4034	0.1644	0.1455

*Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1 %, 5 %, and 10 %, respectively.*

Enterprise Scale, Military-Civilian Integration, and Technology Innovation

The influences of internal and external factors on enterprise performance are related to enterprise scale. Military products have high technological requirements and require great investment to R&D due to the uniqueness of the military industry, thus resulting in high cost for private enterprises to participate in military-industrial development. *SMEs* face greater difficulties in financing and occupy disadvantageous positions in various market competitions compared with large-sized enterprises. Enterprise samples were divided into large-sized enterprises and SMEs according to the enterprise-scale to verify the influences of the enterprise-scale on technology innovation of military-civilian integration enterprises. The estimation results of differently sized enterprises are displayed in Table 11. From the aspect of R&D input intensity, SMEs could significantly enhance their R&D inputs and improve their technological innovation by participating in military business in comparison to large enterprises. Relative to SMEs, large enterprises could more significantly promote their innovation outputs and further enhance their technological innovation by participating in military business.

Table 11

The Influences of the Enterprise-Scale on Performances of Military-Civilian Integration Enterprises

Var	*RDint*		*pat1*	
	Large	*Small*	*Large*	*Small*
did	0.6259 (1.3133)	3.9285*** (5.9566)	0.3770** (2.4101)	0.1594 (1.4728)
size	-0.2320*** (-3.1926)	-0.1420 (-1.0304)	0.4736*** (8.5665)	0.3964*** (9.0736)
lev	-3.2157*** (-8.2164)	-5.7962*** (-14.1791)	0.0588 (0.3581)	-0.2648** (-2.1118)
roe	-1.1677* (-1.8236)	-0.0483*** (-6.8443)	1.9061*** (3.5102)	0.3452 (1.2630)
top1	-0.0017 (-0.4882)	-0.0292*** (-6.8853)	-0.0006 (-0.3441)	0.0017 (1.2335)
_cons	11.2999*** (5.9339)	11.6339*** (3.7268)	-8.7288*** (-7.5924)	-7.8697*** (-8.6739)
N	3783	4329	2279	3063
r^2	0.4012	0.3957	0.1938	0.0945
r^2_a	0.3885	0.3855	0.1690	0.0746

*Note: The data in the table are the regression coefficients of the respective variables, and the t values in the brackets. ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively.*

Discussion

According to the results of the empirical analysis, private enterprises are capable of strengthening their R&D inputs and substantive innovation and further facilitate their technological innovation by participating in military business. On this basis, a further discussion is presented as follows.

First, the results in Tables 2–5 show that the participation of private enterprises in military business significantly enhances their R&D inputs and elevates their substantive innovation level, coinciding with the research result of Wadhwa *et al.* (2017). Thus, Hypothesis 1 is verified. This can be attributed to several reasons. (1) Private enterprises joining in military business take "military-civilian integration" as a strategic goal, so they tend to input enormous resources in the early stage, including gaining admission qualifications to the military industry, enlarging R&D inputs, and strengthening staff training, expecting to harvest more generous returns. (2) By participating in "military-civilian integration" private enterprises can enjoy relevant national aid and fiscal subsidies with more capital invested into R&D. (3) The admission qualifications to the military industry represent a national-level technical approval and can form social capitals, resulting in enterprises enjoying more favors from investors and gaining easier access to external financial support. (4) By participating in military business, private enterprises are inversely driven to enlarge their R&D inputs, elevate their technological innovation level, enhance their core competitiveness, and further achieve long-term cooperation opportunities.

Second, the results in Tables 6, 8, and 9 indicate that the deeper military-civilian integration contributes to greater R&D inputs, although this does not necessarily indicate the inclination to greater substantive innovation outputs. This means that, after the participation in military business, the influence of R&D inputs on promoting the substantive innovation of enterprises presented a crowding-out effect. This conclusion is consistent with that drawn by Zhao *et al.* (2015) and Qiao *et al.* (2022). This may be explained by several reasons. (1) Great R&D inputs represent the importance attached to technological innovation, supported by adequate strength, but the R&D efficiency is not certainly high. (2) Enterprises deeply involved in military-civilian integration are prone to more complex technologies, greater challenges, and long R&D period, so it is difficult to achieve results within the short term. (3) Researchers lack the corresponding technical experience and need more time accumulating such experience. Thus, their output efficiency is lower than those that develop technologies involving civilian goods. Therefore, after taking part in military business, private enterprises will input more R&D expenses, while substantive innovation outputs are reduced, thus inducing a crowding-out effect. Nevertheless, this effect of R&D inputs on enterprises' substantive innovation will be increasingly weak with the lapse of time.

Third, the results in Table 10 indicate that relative to enterprises in regions with a high marketization level, the participation in military business exerts a stronger positive promoting effect on private enterprises in regions with a low marketization degree. This research conclusion disagrees with that obtained by Gene *et al.* (2004); thus, Hypothesis 2 is not verified. A possible reason is that the regions with a low marketization degree can more easily acquire governmental financial support and subsidies, accompanied by more capitals input into R&D. Meanwhile, the technologies are relatively backward in these regions and the technical difficulty in R&D is relatively low; thus, results can be easily generated.

Fourth, the results in Table 11 indicate that participation in military business can markedly strengthen the R&D inputs of SMEs and significantly elevate the innovation outputs of large enterprises. This research conclusion is inconsistent with that drawn by Booyens (2011); thus, Hypothesis 3 is not verified, although this accords with the reality to a greater extent. Specifically, the R&D period varies with the category and difficulty level of R&D technology. Thus, R&D inputs are not certainly in direct proportion to outputs. Compared with large enterprises, SMEs more intensively utilize capitals. To enhance core competitiveness, SMEs intensively input main capitals into R&D and especially break through certain technologies, so the number of patents for inventions is relatively small. Due to the involvement of many business lines, large enterprises are featured by richer products and a relatively larger number of patents for inventions.

Conclusions and Implications

Conclusions

In this study, A-shared listed companies in China from 2001 to 2018 were sampled. Next, military-civilian integration was measured based on the category and number of admission qualifications of private enterprises to the military business. Furthermore, the influence of their participation in military business on their technological innovation was investigated using a multi-period DID method. Several conclusions were obtained: (1) military-civilian integration can promote technological innovation of enterprises, while the level of enterprise R&D investment and substantive innovation slow down this promotion in a short period of time. (2) For areas with low degree of marketization, military-civilian integration promotes technological innovation of enterprises by significantly increasing R&D investment and substantive innovation level, while for areas with higher degree of marketization, this impact is relatively weak. (3) For small and medium-sized enterprises, military-civilian integration is to promote technological innovation of enterprises by increasing R&D investment, and for large enterprises, military-civilian integration is to promote technological innovation by increasing the level of substantive innovation.

Management and Policy Implications

The policy implications of this study lie in the following aspects. First, the policy support and financial support should be strengthened for private enterprises participating in military business to help reduce their technological innovation risks. For instance, their taxes can be reduced or remitted, and special financial support and rewards can be granted. Moreover, financial institutions can grant priority loans to private enterprises participating in military business, ensuring that they have enough capitals and strength to join in the R&D of military goods, attracting more private enterprises to take apart, and promoting the innovation level of defence engineering.

Second, the exchange of military-civilian dual-purpose technologies should be enhanced, and the transformation efficiency of technological innovation results should be improved. In particular, the existing sharing platforms can be fully utilized to strengthen enterprises' network relationship construction and actively conduct cooperation with institutions, colleges, and universities to enhance the exchange of military-civilian dual-purpose technologies. Moreover, the R&D personnel of private enterprises should be assisted in the process of gaining mastery of relevant technologies, which can improve the transformation efficiency of technological innovation results.

Limitations

However, this study still has some limitations. On the one hand, not all information about private enterprise participation in military-industrial development has been disclosed due to the confidentiality agreement, thus resulting in a small sample size in the present study. On the other hand, private enterprise participation in military-industrial development is in the early exploration stage in China, and most private enterprises have participated in military industrial development for a short period. Hence, the period of military-civilian integration is relatively short in this study. Additionally, influences of private enterprise participation in military-industrial development are not only manifested in technological innovation but also involve multiple aspects, including enterprise performance and financing of enterprises. These aspects will be key research content in future studies.

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Authors' Biographies

Jingyu Yang, Ph.D. candidate, is currently working in School of Philosophy, Wuhan University, His research interests focus on the philosophy of science and technology.

Renfang Liu *(Corresponding author)*, Ph.D., is currently working in Academic Periodical Office, Chongqing Technology and Business University, Her research interests focus on corporate finance.

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