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Financial expansion and economic performance: evaluating the role of research and development expenditures for China

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ABSTRACT

This research targets to investigate the link between research and development expenditures and financial expansion along with other control variables such as natural resources (NRS) and gross domestic product (GDP) for China's economy over the period of 1984–2021. To analyse china's economy, the authors employ time series data relevant to econometrics approaches for long-run relationships (FMOLS, DOLS, and CCR) to monitor changes over time between variables, which is important in actual studies. The models' primary findings are as follows: The cointegration test confirms that there are log-run associations among the targeted variables. Our targeted results show that Research and development expenditures have the largest influence on the financial expansion of the economy. The control variables like NRS decreases financial expansion while GDP boosts financial expansion in china. These results imply that it is very important for policymakers further to change their policy concerning investment in R&D activities.

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1. Introduction

Nowadays, nations' economic progress is increasingly dependent on the production, accumulation, distribution, and use of information (Solarin & Yen, 2016). By producing new and improved knowledge, research and development (R&D) efforts can boost a nation's rate of innovation and its industrial and economic growth (Kumar et al., 2016; Nguyen & Pham, 2011). Moreover, it facilitates the emergence of new ideas, methods, and technologies (Pinto & Teixeira, 2020), fostering innovation (Meo et al., 2013; Rizvi et al., 2022), and enhancing the quality of human capital (Ntuli et al., 2015; Schofer et al., 2000). There is unquestionably a bidirectional causal link between the state of the economy and the quality of scientific findings: on the one hand, R&D activities drive economic growth, and on the other, economic growth fosters higher research production.

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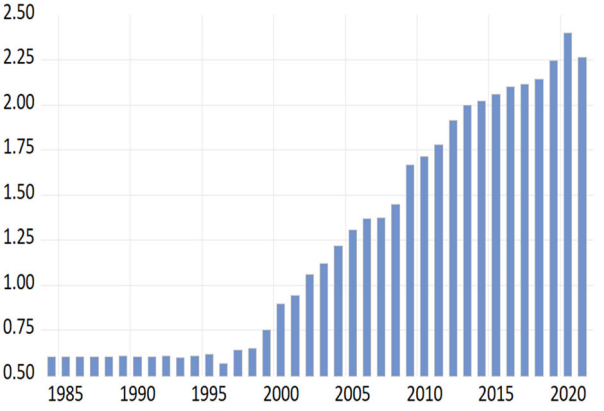
The Research and development expenditures can be viewed as an investment in future discoveries and a body of knowledge that can be used to develop more resource-efficient production methods. As countries invest more money in research and development, they might expect increasing development costs (Umar et al., 2021). The potential benefits of innovations may not directly benefit the persons who bring them due to spillover effects. And this scenario indicates that the business sector will be socially less likely to conduct R&D duties at an optimal level if there is no government involvement. Indirect measures like tax obligation motivations and security of copyright rights, as well as offering direct support like supply and money eases, may be legalised under this circumstance to motivate the R&D activities of the economic sector (Bayarcelik & Taşel, 2012). There has been a significant shift in economists' perspectives on how to value technology developments since the late 1980s. Specifically, (Romer, 1990), under the impact of Schumpeterian custom, has highlighted technological advances as the ultimate resource of development in the framework of market optimisation. Nonetheless, (Romer, 1990) has likewise specified that technological progress is the outcome of the aware tasks of business owners who look for earnings. so there must be alerts and rewards for business owners on the market to get started on research and development tasks (Bayarcelik & Taşel, 2012; Uyar et al., 2022). Subsequently, Roomer's design says that the business owners seeking earnings in their creations have been interiorising technical progression by pursuing new ideas. Three large studies in the R&D-based endogenous growth literature argue that R&D is the primary factor in economic expansion. Three versions developed subsequently (Romer, 1990), as well as (Aghion & Howitt, 1998) are supported by these studies. The basic idea shared by all three variants is a hypothetical forecast of scale consequences. According to conventional wisdom, increasing spending on research and development will inevitably boost economic growth (Uyar et al., 2022). Endogenous growth models, which are based upon R&D and have actually appeared since the 1990s, typically accept R&D activities as the underlying driving pressure of economic development. As a result, R&D expenditures have obtained a new measurement, to which the private and public sectors have attached a great deal of importance, particularly over the past few decades, thanks to their incorporation into these models.

In developing economies by the year 2050, China plans to take the lead in both scientific research and technological advancement. China's goal is to become a global leader in several high-tech industries by 2025, and the 'Made in China 2025' plan, which was unveiled in 2015, outlines this ambition. These industries include but are not limited to robotics, aerospace equipment, medical devices, and others. China spent $370, 6 billion on R&D in 2017, making it the world's second-largest investor in the field after the United States $476.5 billion. Since focussing on R&D and industrial strategy, China has become a global rival in several quickly growing high-tech industries. The nuclear industry, alternative-fuel cars, wind and solar PV, A.I., and several branches of the advanced manufacturing and robotics sectors all fall into this category. Figure 1 presents the annual data from 1984 to 2021 for China's R & D expenditures. The figure mentioned that China has tremendously increased its R & D expenditures with time (Figure 2).



Source: Author's calculation based on the Chinese R&D data (1984-2021) from World Bank.

Figure 1. Research and Development expenditures (% of GDP).
Source: Author's calculation based on the Chinese R&D data (1984–2021) from World Bank.

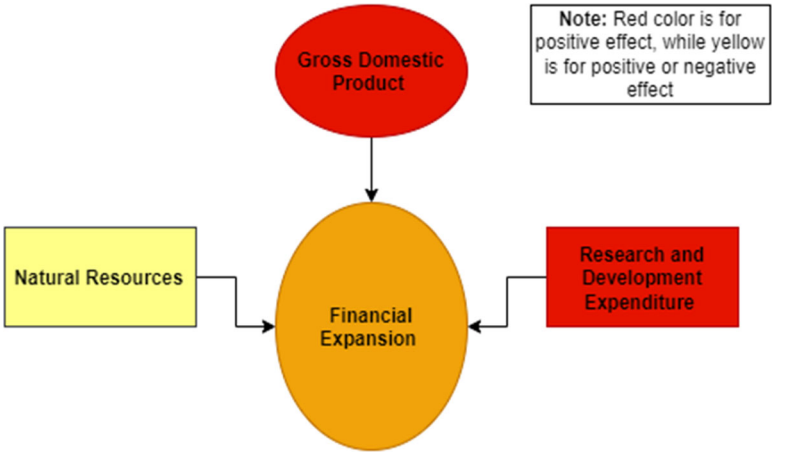


Figure 2. Conceptual framework of this study.
Source: drawn by the authors.

2. Literature review

Some researchers have examined the correlation between R&D expenditures and business efficiencies in developed nations. For example, (Öztürk & Zeren, 2015) evaluated the effect of research and development expenditures on business productivity in the Turkish manufacturing sector. Their findings corroborate the hypothesis that investing in R&D has a positive effect by boosting manufacturing company revenue. Another study (Vanderpal, 2015) examined the impact of research and development expenditures on corporate economic performance and found that research and development expenditures have a substantial positive impact on the value of businesses. In a comparable capillary, (Wang & Fan, 2014) showed that multiple types of R&D financial investment affect the value of listed companies in China. Specifically, companies that depend upon funded R&D financial investment always have a greater

return and supply price, which ultimately increases the country's economic performance (Mirza et al., 2020). On the other hand, research by Bouaziz (2016) found no connection between R&D and firm performance. Some national studies confirmed the link between R&D spending and economic growth, joining those conducted at the regional level. In the case of Japan, for instance, (Jin, 2010) identified Granger-causal relationships between R&D spending and real economic growth, as well as determined causal effects of economic growth on R&D production. Focussing on the South African context, (Dorfleitner & Grebler, 2022; Karim et al., 2022; Odhiambo & Ntenga, 2016) discovered a link between research, development, and economic growth. Despite the findings of (Inglesi-Lotz & Pouris, 2013; Odhiambo & Ntenga, 2016) indicated that research expenditures significantly impacted South Africa's economic growth. In addition, full-sample bootstrap causality studies conducted by Inglesi-Lotz et al. (2014) found no evidence of a causative correlation between research production and economic growth in the United States time. On the other hand, they discovered a unidirectional relationship between GDP and research or the sub-periods of 2003–2005 and 2009, and between research outcome and GDP in 2010. Spending on R & D is seen as a macroeconomic factor that can guarantee significantly more research production (Solarin & Yen, 2016), increase human resources (Berger, 2022; Gao et al., 2021; Inglesi-Lotz et al., 2015), improve accumulated knowledge, and speed up scientific development and technological progress (Lee, 2021; Meo et al., 2013) examined the function of research funding in research study efficiency in Oriental universities and also discovered a significant positive impact of research expenditure on Scientific research Citation Index (SCI) magazines, patents acquired. Further also licencing revenue, indicating that R&D expenditures were one of the major resources for empirical research that further increased human capital and also economic and financial development. Moreover (Wang et al., 2012) analysed the relationship between scientific research funding and research results in ten nations and found that funding has a large role in paper posting and scientific research.

Previous research on natural resources and economic growth is scant. Furthermore, the scholar finalised a distinct outcome. Several studies found that natural resources boost economic growth, but others found the opposite. Positive research findings outnumber negative ones. For instance, between 1996 and 2006, China saw rapid economic expansion, which some attribute to the country's plenty of mineral resources (Karim et al., 2022; Mirza et al., 2020; Yuxiang & Chen, 2011). It was shown that there is a negative correlation between the availability of mineral sources and economic development. It was also found that places with lots of natural resources tend to develop slowly economically compared to places with few natural resources. Examining the direct and indirect effects of oil earnings on economic growth in 17 oil-exporting nations between 2002 and 2010 (Hoshmand et al., 2013). They found that oil money stunted economic growth. Large oil revenues have been shown to have a negative effect on economic development in oil-dependent countries. Between 1995 and 2009, (Kurronen, 2015) analyzed the effect of natural resources on the financial systems of 128 nations. The financial sector is less prominent in economies highly dependent on a limited number of natural resources. From 1992–2017, researchers (Gokmenoglu & Rustamov, 2019) analyzed how natural resource

abundance and the availability of loans from the World Bank helped improve the economies of Kazakhstan's economies, Azerbaijan, Russia, and Turkmenistan. The empirical data showed that there were important correlations between the variables studied. But the data also showed that loans to small businesses worldwide and the money generated from natural deposits contributed to economic expansion. Turkey's natural resources and economic growth were studied (Faisal et al., 2019). Their research included the years 1990 to 2016. Natural resources' favourable but rather minor effect on economic strengthening was proven throughout time. According to the findings of asymmetric causality, the positive shocks of economic expansion and natural resources have mutually reinforced effects. The effect of natural resources and human capital on financial development in OECD nations was assessed between 1990 and 2016 (Zaidi et al., 2019). They found for these countries that it is Significant and long-lasting relationships were discovered to exist between the factors. Nonetheless, the research showed that the use of natural resources is associated with increased economic development. Between 2000 and 2016, Ibrahim (2019) analyzed the possible impact of oil price changes on the banking business in the GCC countries. Therefore, oil price improvements positively impact bank profits, credit score growth, and outcome growth. As with the sharp contraction in auto loans and the deterioration in credit history quality and economic development brought on by negative changes in oil prices, these unfavourable outcomes are also to be expected. For the years 1987–2017, researchers in China (Khan et al., 2020) analyzed the correlation between China's economic development and its abundance of natural resources. The appraisal also takes into account technological progress, human resources, and trade openness. The results show that having a wealthy ancestor can hinder one's economic success. They speculated that the positive impact of natural resources on economic expansion could be mitigated by advances in technology and human resources.

Based on this, earlier research led us to discover two basic ideas that are in direct opposition to one another. The first is that there is a significant connection between R&D expenditures and financial performance, while the second is that R&D does not influence the financial sector of different countries. According to the literature, countries are more likely to exploit their natural resources as their economies develop and embark on industrialisation. The financial sector of an economy is just as vulnerable to the effects of overexploitation of natural resources as the bio-capacity of the country itself. In light of this, throughout our research, we attempted to determine the nature of this connection through R & D expenditures, along with natural resources and gross domestic product in a developing economy in China (Table A1).

3. Theoretical framework

Investment in R&D expenditure leads to gains in productivity and, hence, growth, as noted by the early proponent of the endogenous growth model (Romer, 1990). Investing in research and development, or R&D for short, has traditionally been thought of as one of the most effective ways to ensure a nation's technological potential and, by extension, its capacity for future financial expansion. The R&D expenditures refer to the methodically undertaken creative work that adds to the body of

knowledge, including our understanding of man, culture, and society, and the use of this body of information to develop novel applications. Consequently, increased spending on research and development increases the likelihood that companies and regions will achieve higher technological sophistication. This, in turn, will make it possible for these entities to launch innovative and/or improved products and/or procedures, leading to increased income and financial expansion. Consequently, it is anticipated that research and development expenditure will positively affect financial expansion FEC, i.e., RAD > 0.

According to Beck (2002), natural resources have a detrimental impact on financial growth because they draw skill and capital away from the financial industry, lowering demand and saving rates. Similarly, (Rajan & Zingales, 2003) highlight the interest group hypothesis of financial growth, which contends that established, dominant enterprises will continuously battle financial development by abusing their market power to stay competitive. A lack of financial reforms and a hostile business climate in resource-rich nations hurts manufacturing, which in turn hurts exports and the entire economy. Moreover, resource-rich industries are to blame for the poor showing of capital transfer and the manufacturing labour sector (Mirza et al., 2020; Yarovaya et al., 2021). They crowd out the manufacturing sector and slow economic expansion. On the other side, a surplus of natural resources promotes economic expansion. Moreover, (Bhattacharyya & Hodler, 2014; Xu et al., 2021) argue that greater credit availability aids a country's financial development to consumers and consumers businesses in countries that have an abundance or richness of natural resources. Because of this, it is anticipated that natural resources would either have a positive or negative impact on financial expansion FEC, i.e., NAR < 0 or NAR > 0.

The health of an economy can be gauged by looking at the country's gross domestic product (G.D.P.) (Tufail et al., 2021, 2022). This is significant because theoretical research suggests that economic activity may not be sufficient when GDP is low to generate sufficient demand for financial services, products, intermediaries, and institutions. However, as the economy grows, more people will need access to financial services, which could spur further financial innovation. However, GDP's influence on the progress of the financial sector may not always be upward. At a high level of GDP, a further expansion in economic activity may have a minimal impact on the financial system, either because the latter has reached a higher level of development or because firms' demand for financial services and products is not increasing due to the expectation of future investment opportunities' profitability (Ferrat et al., 2022). Consequently, it is anticipated that GDP will positively impact financial growth on financial expansion FEC, i.e., GDP > 0.

4. Data and model specification

This study intends to examine the impact of R&D expenditures and other control variables like natural resources and gross domestic product on China's financial expansion. The World Bank and world development indicators provide the data for the aforementioned variables (WB, WDI 2020). The general specification of the model is given below.

$$FEC_t = f(RAD_t, GDP_t, NRS_t) \quad (1)$$

In Equation (1), 't' denotes a time period from 1984 to 2021. The basic regression from Equation (1) is given below:

$$FEC_t = \pi^1 RAD_t + \pi^1 \ GDP_t + \ \pi^1 NRS_t + \varepsilon_t \quad (2)$$

where FEC_t represents 'financial expansion', which is domestic credit to the private sector and refers to the financial resources that financial corporations have made available to the private sector, such as loans, purchases of non-equity securities, trade credits, and other accounts receivable that create a claim to repayment. These claims include credit to governmental enterprises for some nations. The RAD_t 'Research and Development Expenditure' represents R&D spending across the private, public, academic, and non-profit sectors. R&D covers basic research, applied research, and experimental development. GDP_t for 'gross domestic product' In economic terms, the value of goods and services to consumers is the sum of their purchase price, applicable taxes, and subsidies not factored into the cost of production. It is computed without factoring in the wear and tear of manufactured assets or the depletion of natural resources. All values are expressed in 2015 U.S. dollars at a constant price. Where NRS_t stands for 'natural resources', it is the total of the rents from oil, gas, coal (both hard and soft), minerals, and forests. Finally, the ε_t Which is the error term. All the targeted variables data are taken from World Development Indicator.

5. Econometric methodology

5.1. ADF unit root test

When studying a time series, numerous distinct factors must be taken into account: for example, the series may have a unit root at some level, making it challenging to conduct some analyses. Finding a long-term association between variables using stationary data can be difficult for several reasons. There are situations when stationary data testing is done. To determine whether or not the series is stationary, this study applies the Augmented Dicky Fuller test, sometimes known as the ADF test (which was named after the statisticians (Dickey & Fuller, 1979)).

The following equation represents the underlying structure of ADF.

$$\Delta Y = a + bT + (r-1)Yt{-}1 + d\Delta Yt{-}1 + e1t \quad (3)$$

5.2. Bayer and Hank (BH) cointegration test

This research uses the Bayer and Hanck Cointegration test, which was made famous by Bayer and Hanck (2013), to determine whether or not certain variables in models are cointegrated. The ability of the test to effectively deliver findings for time series with varying integration orders is one of the primary reasons why it excels in comparison to other cointegration methods. The test's ability to leverage a range of cointegration procedures makes it preferable to other approaches. The techniques of the Johansen (J), Engle-Granger (EG), Boswijk (Bo), and Banerjee (Ba) tests were utilised

in the development of this test. To use the BH test, all variables need to be in a stationary state, as this is a necessary prerequisite. The equation for the test is as follows:

$$EG{-}J = -2\left[\ln\left(P^{EG}\right) + \ln\left(P^{J}\right)\right] \tag{4}$$

$$EG{-}J{-}B_0{-}B_a = -2\left[\ln\left(P^{EG}\right) + \ln\left(P^{J}\right) + \left[\ln\left(P^{B_0}\right) + \ln\left(P^{B_a}\right)\right]\right] \tag{5}$$

5.3. FMOLS, DOLS, and CCR long run estimator

An individual cointegrating vector will be estimated so that the long-term interconnection may be analyzed. In this regard, several econometric methodologies can be applied to examine the long-run associations between the variables that have been calculated. In light of this, this analysis makes use of the fully modified OLS (FMOLS) approach that was created by Hansen and Phillips (1990), as well as the dynamic OLS method and the canonical cointegrating regression (CCR) method respectively proposed by Stock and Watson (1993). By taking into account the impact of serial correlation, these methods make it possible to establish asymptotic coherence. The FMOLS, DOLS, and CCR tests can only be carried out if the predetermined level of cointegration that exists between the variables is satisfied. As a result, the long-term elasticity is calculated using the FMOLS, DOLS, and CCR estimators in this investigation. The FMOLS equation can be wriiten as follows.

$$\hat{\theta} = \begin{bmatrix} \beta \\ \hat{\gamma}_1 \end{bmatrix} = \left(\sum_{t=2}^{T} Z_t Z'_t\right)^{-1} \left(\sum_{t=2}^{T} Z_t y_t^{+} - T\begin{bmatrix} \lambda_{12'}^{+} \\ 0 \end{bmatrix}\right) \tag{6}$$

where $Z_t = (X'_t, D'_t)'$

While for DOLS, the equation is as follows:

$$y_t = X'_t\beta + D_{1t'\gamma_1} + \sum_{j=-q}^{r} \Delta X_{t+'j}\delta + \nu_{1t} \tag{7}$$

5.4. Robustness test

When the values of the dependent variable are different from the significant residuals given by the regression model, the robust least-square M-estimation takes care of the dependent variable's outliner. The robust least-square S-estimation method is a procedure that emphasises outliers in the high-leverage estimator. This method is computationally rigorous. On the other hand, the MM-estimation of robust least square is a grouping of the S-estimation and the M-estimation. In general, robust least square considers outliners in both the independent and the dependent variables, respectively.

Table 1. Nomenclature of variables and sources.

Variables	Measurement unit	Sources
Financial Expansion (FEC)	Domestic credit to the private sector (% of GDP)	World Bank (2021)
Research and Development Expenditure (RAD)	Research and development expenditure (% of GDP)	World Bank (2021)
Gross Domestic Product (GDP)	GDP (constant 2015 US dollars)	World Bank (2021)
Natural Resource (NRS)	Total rent as a percentage of GDP by using different natural resources.	World Bank (2021)

Source: drawn by the authors.

6. Results and discussion

The empirical findings, their interpretations, and a discussion of the estimates are provided in this section. This part begins by analysing the descriptive statistics presented in Table 1. The generated estimates show that all the variables' mean, median, and maximum values are positive. This demonstrates how the variables under discussion are progressive. Additionally, the study noticed a regular discrepancy between the variable range values, indicating an inconsistent observation tendency. This study examines the value of standard deviation to validate the volatile behaviour of FEX, GDP, RAD, and NRS across the chosen period.

Furthermore, Table 2 provides the Augmented Dicky Fuller unit root test results. According to the findings, none of the variables are steady when the level is considered. This finding suggests that both the mean and the variance of these variables change throughout the course of time. In addition, it suggests that the conditional probability distribution for FEX, GDP, RAD, and NRS shifts over time. In addition, once the first difference has been taken, the data are considered stationary, and the conditional probability distribution for variables does not shift over time. This suggests that all variables, i.e., FEX, GDP, NRS, and RAD, are stationary at I(1).

The Bayer-Hanck cointegration test shows a long-term relationship between financial expansion, gross domestic product, research and development expenditures, and natural resources. This is shown in Table 3. Bayer-Hank cointegration confirmed a long-run cointegrating relationship between financial expansion, gross domestic product, natural resources, and research and development expenditure for china.

After establishing the presence of cointegration among the variables, the present study examines the long-run impact of research and development expenditures, gross domestic product, and natural resources on financial expansion. The results of the FMOLS, DOLS, and CCR are illustrated in Table 4. As explicitly stated in the overview section of this research. Table 4 illustrates that a 1 percent increase in research and development expenditure increases financial expansion by 0.14%, 0.18%, and 0.15%, as revealed by FMOLS, DOLS, and CCR long-run estimators, respectively. This illustrates that an increase in research and development expenditure boosts the financial expansion in china. We hypothesise this is because of the specifics of the financial industry being examined. The financial sector is regarded as a capital-intensive industry due to the high level of investment required. When it comes to innovation, big banks and other financial institutions need to put money into a variety of different projects (Umar et al., 2021). Effective use of assets, such as in research and development activities, allows them to earn a large portion of the market, which is reflected in increased sales and ultimately boosts national production. This industry is

Table 2. ADF unit root testing.

	At level at first difference		
Variable(s)	I(0)	I(1)	Order of integration
FEX	−0.639	−6.833***	I(1)
GDP	−1.031	−3.154**	I(1)
RAD	0.321	−4.498***	I(1)
NRS	−1.674	−6.131***	I(1)

Note: The level of significance is determined by 1, 5, and 10 percent denoted through ***, **, and *, respectively.
Source: drawn by the authors.

Table 3. Cointegration test.

(Bayer et al., 2009)

	Engle Granger	Johansen	Banerjee	Boswijk
Statistics	−2.75	93.08***	−2.80	28.97***
p-Values	0.529	0.000	0.284	0.000
Combined statistics	Eagle Granger–Johansen 56.533***		Eagle Granger–Banerjee Boswijk 73.886***	

Note: The level of significance is determined by 1, 5, and 10 percent denoted through ***, **, and *, respectively.
Source: drawn by the authors.

Table 4. FMOLS, DOLS, and CCR long run estimator.

Variables	FMOLS estimator	DOLS estimator	CCR estimator
GDP	0.134094***	0.115464**	0.128790***
	(0.0099)	(0.0311)	(0.0069)
RAD	0.143409*	0.183690**	0.152659**
	(0.0927)	(0.0439)	(0.0512)
NRS	−0.126900***	−0.124076***	−0.126885***
	(0.0000)	(0.0000)	(0.0000)

Note: 1%, 5% and 10% significance is denoted by ***, ** and *.
Source: drawn by the authors.

dedicated to producing high-quality goods and services to enhance people's lives, and its leading firms will stop at nothing to achieve this goal. Spending priorities should therefore centre on research and development, technical solutions, and products and services that will ensure, facilitate, and improve people's lives worldwide while efficiently using the company's resources. Our results are identical to those of (Freihat & Kanakriyah, 2017; Uyar et al., 2022).

A 1 percent increase in natural resources will decrease financial expansion by −0.12%, −0.12%, −0.12% as indicated by FMOLS, DOLS, and CCR, respectively. This result lends credence to the notion that the resource curse hypothesis is real and prevalent in China, which is consistent with the findings of (Wang et al., 2019; Yuxiang & Chen, 2011). The resource curse may emerge due to the rise in natural resource exports and the growth of resource sectors, which may lead to insufficient investment in manufacturing. Other possible causes of China's resource curse include the inefficient use of resources and single industries, particularly in areas that are abundant in their respective resources. This is especially true in regions located in the country's interior.

Our last target variable, which is GDP, its long-run results indicate in Table 4 that a 1 percent increase in the gross domestic product will increase financial expansion by 0.13%, 0.11%, 0.12%, as indicated by FMOLS, DOLS, and CCR respectively. It suggests that a rise in economic activity will create new jobs, which will, in turn, lead to

Table 5. Estimates of robust least square regression.

Variables	Coefficient	SD. Error	z-Statistics	Probability
GDP	0.115560**	0.047917	2.411655	0.0159
RAD	0.179761**	0.081937	2.193903	0.0282
NRS	−0.124311***	0.021737	−5.718919	0.0000
C	0.645996	0.605463	1.066946	0.2860
Robust Statistics				
R^2	0.776349	Adjusted R^2	0.756615	

Note: 1%, 5% and 10% significance is denoted by ***, ** and *.
Source: drawn by the authors.

an increase in the average salaries of all segments of the population. Consumption and investment patterns are expanding due to the current environment, which is driving growth in the market for financial services and accelerating the pace of financial advancement (Tufail et al., 2022). These findings are similar to the results of (Guan et al., 2020; Nawaz et al., 2019).

In this study, we check for robustness using the Robust Least Square Regression model. Table 5 shows that the robustness test results agree with what the FMOLS, DOLS, and CCR models found. The robust least square method results indicate that research and development expenditure has a positive and significant effect on financial expansion in China. Furthermore, the results indicate that natural resources (NRS) and gross domestic product (GDP) are important factors that explain the financial expansion of the china economy.

7. Conclusions

This article examines the link between R&D expenditures and financial expansion in china's economy. The Bayer-Hanck cointegration test and for long-run association FMOLS, DOLS and CCR are applied using the data covering the period of 1990 to 2013. The findings show that such a link exists, implying that R& D expenditures strongly influence financial expansion. Natural resources decrease the financial expansion while gross domestic product boost expansion in the Chinese economy. The results are very important for the period analyzed since they complement the economy's financial sector.

7.1. Policy recommendations

The main important policy recommendations of this study are given below.

7.1.1. Strengthen bank R&D credit support

Due to the high risk and uncertainty of firm R&D operations and the lack of mortgage assets, it is difficult for enterprises to get credit loans from banks, deepening their financing limitations and limiting R&D investment improvement. In response to this dilemma, the government should develop policies and actively guide banks to assist corporate R&D operations. On the one hand, the government can employ discounts and guarantees to lower banks' risk of providing credit for business R&D and

promote bank loans to corporate R&D. The government should update its mortgage guarantee model. For firms with higher credit, they can use intangible assets or equity mortgages or employ a credit guarantee agency to guarantee loans to build a risk-sharing mechanism. This will assist banks to decrease operational risks and boost loans for corporate R&D.

7.1.2. Improve R&D information disclosure sharing

Asymmetry of R&D investment activities is a major cause of business financing problems. Minimising information asymmetry and enhancing the information disclosure system are essential steps in easing financing constraints. First, transparent information is key to fair exchanges. Therefore, it's important to secure confidentiality and timely disclosure of information to fund providers so that both parties may obtain all the required data and eliminate fund providers so companies can better finance themselves. On this premise, the government must improve information disclosure and supervision procedures. Second, the information source and transmission channel should have a supervision and punishment system. At the same time, social oversight should be fully exercised, and the process of designing and executing a business information disclosure policy should be led.

Disclosure statement

No potential conflict of interest was reported by the author.

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Appendix A

Table A1. Summary of the reviewed articles.

Author(s) name	Duration	Country(s)	Major findings
(Öztürk & Zeren, 2015)		Turkey	↑R & D–FD↑
(Vanderpal, 2015)	1979–2013	India	↑R & D–FD↑
(Wang & Fan, 2014)	2007–2012	China	↑R & D–FD↑
(Bouaziz, 2016)	2010–2014	Turkey	↑R & D–FD∧
(Jin, 2010)	1970–2004	Japan	↑R & D–EG↑
(Odhiambo & Ntenga, 2016)	1986–2012	South Africa	↑R & D–EG↑
(Inglesi-Lotz & Pouris, 2013)	1980–2008	South Africa	↑R & D–EG↑
(Inglesi-Lotz et al., 2014)	1981–2011	USA	↑R & D–EG↑
(Lee, 2021)	2009–2017	Korea	↑R & D–FG↑
(Wang et al., 2012)	2009	10 countries	↑R & D–EG, FD↑
(Yuxiang & Chen, 2011)	1996–2006	China	↑NR–FD↓
(Hoshmand et al., 2013)	2002–2010	17 selected oil exporting countries	↑NR–FD↓
(Kurronen, 2015)	1995–2009	128 countries	↑NR–FD↓
(Gokmenoglu & Rustamov, 2019)	1992–2017	KART Countries	↑NR–FD↓
(Faisal et al., 2019)	1990Q1 to 2016Q4	Turkey	↑NR–FD∧
(Zaidi et al., 2019)	1990–2016	OECD countries	↑NR–FD↑
(Ibrahim, 2019)	2000–2016	GCC countries	↑NR–FD↓
(Khan et al., 2020)	1987–2017	China	↑NR–FD↓

Note: ↑ and ↓ presents increase and decrease, respectively. ∧ – no effect, R&D research, and development, FD – financial development, EG – economic growth, NR – natural resources.