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# Natural resource abundance, technological innovation, and human capital nexus with financial development: A case study of China

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ABSTRACT

The discourseon the impact of natural resource endowment and its effect on financial development has been an important research area in the last few decades. This study attempts to test the "resource curse" hypothesis in case of China for the period of 1987–2017. Unlike others, we introduce additional variables such as technological innovations, human capital, and trade openness into the finance demand function. We used an augmented Dickey-Fuller unit root test with and without structural breaks and Carrion-i-Silvestre et al.'s (2009) generalized least squares based test to examine the stationary properties of the variables. Similarly, to examine the presence of the cointegration relationship between financial development and its determinants, the Maki cointegration with multiple structural breaks approach is applied. The empirical results support the presence of the resource curse; that is, natural resources negatively affect financial development in China. Nonetheless, technological innovations, trade openness, and human capital affect financial development positively. The interaction of human capital and technological innovations is also positively linked with financial development. Our empirical findings have robust policy implications, highlighting the need to promote technological innovations and human capital development for effective use and management of natural resources to promote the development of financial sector.

## 1. Introduction

The role of natural resources and their effect on the economy has been under discussion for quite some time. Well-known economists like David Ricardo (1911) and Smith (1776) consider natural resource abundance in the form of minerals, gas, and oil as important factors which contribute to the development of an economy (Tsani, 2013; Badeeb et al., 2017). However, in recent times, many regions abundant in natural resources such as the Middle East, Africa, and Latin America, are lagging in terms of economic growth behind other countries with fewer natural resources (Badeeb et al., 2017). The phenomena linked with natural resource abundance and lagging economic performance as compared with those countries with fewer resources are known as the "resource curse hypothesis" which was coined by Auty (1993). In the recent development and policy discourse, the resource curse dominates the existing economic development literature. After the 1980s, the resource curse emerged as an influential area of research for economists and practitioners, especially in the developing world, challenging the conventional opinion of considering natural resources as a blessing (Papyrakis and Gerlagh, 2004; Humphreys et al., 2007; Apergis and Payne, 2014; Xu et al., 2016 among others). Various mechanisms have been used to identify the possible resource curse effect of natural resource abundance on economic growth (Badeeb et al., 2017). However, the conventional approaches provide naive channels for establishing the link between the economy and resource based sectors (Prebish, 1950). To stimulate economic growth and effectively utilize natural resources, there is a dire need for a sound and efficient financial system (Pradhan et al., 2016). The role of financial development is integral to achieving higher economic growth (Zaidi et al., 2019; Nawaz et al., 2019). For instance, Rajan and Zingales (2003) link financial

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development as a source for turning the resource curse into a blessing with innovation, human capital, and political institutions.

On the positive side, natural resource endowment is argued to be a blessing as opposed to a curse for resource rich countries (Aragona et al., 2015). Norway, for example, is one of the world richests economies. This is mainly attribted to its oil endowment. Similarly the abundance of some resources, such as diamonds in case of Australia, South Africa, and Botswana, has been a conributing factor to the fast growth of these economies (Boschini et al., 2007). The nexus between natural resource abundance and financial development has been under investigation by researchers theoretically and empirically. Nonetheless, the findings emerging from such studies are still conflicting and inconclusive. The findings of Corden and Neary (1982), Gelb (1988), Sachs and Warner (2001), Mehlum et al. (2006), and Elbadawi and Soto (2016) suggest lower financial development for countries with an abundance of natural resources.

This study focuses on China, with a population of 1.4 billion, whose economy accounted for 30% of the total global economic growth over the last eight years (World Bank, 2019). Since the economic reforms in 1978, China's economy has been shifting gradually from a planned to a market-based economy and has experienced, on average, an annual 10% economic growth rate since then. However, since the global financial crisis of 2007–2008, China's economic growth fell to 6.6% in 2018 from 14.2% in 2007 and is projected to fall to 5.5% in 2024 (Morrison, 2018, Del Rio Lopez and Gordo Mora, 2019). China's falling economic growth is linked with lower technological innovation, declining investment, and trade tensions with the United States (Del Rio Lopez and Gordo Mora, 2019). To overcome such challenges, foster economic growth, and develop a strong financial market, the Chinese government is focusing on technological innovation by modernizing the manufacturing sector via an initiative called "Made in China 2025" (World Bank, 2019). Under such conditions, it is important to trace the role of natural resource abundance in financial development, especially considering technological innovations, human capital, and trade openness as additional determinants.[1]

To extend the argument further, this study contributes to the literature in following ways: First, it takes into account the role of technological innovations, human capital endowment, and natural resource abundance in financial development during the period from 1987 to 2017 in China. Second, the interactive effects of human capital and technological innovations on financial development are also investigated. Third, the robustness is checked by adding two new independent variables i.e., foreign direct investment (FDI) and gross domestic product (GDP). Furthermore, three different proxies, such as $M_2$ to GDP, Liquid Liabilities to GDP, and deposits money banks assets to GDP are used for financial development to verify the outcomes. Fourth, to examine the integrating properties of the variables, we apply first generation, that is ADF, and third generation GLS unit root tests from Carrion-i-Silvestre et al. (2009) with multiple structural breaks. Lastly, Maki (2012) cointegration approach is applied considering the structural breaks in the series while investigating cointegration between financial development and its determinants. Our empirical evidence reports the presence of cointegration between financial development and its determinants. Further, the resource curse hypothesis is validated, that is, natural resource abundance deters financial development. Technological innovations, trade openness, and human capital add significantly to financial development. Similarly, foreign direct investment and gross domestic product add significantly to financial development. With three different proxies for financial development, the results still hold for human capital, natural resources abundance, trade openness and technological innovations.

The remainder of the paper is organized into five different sections: Section 2 reviews previous studies. The methodology adopted for analysis is detailed in Section 3. Section 4 presents the estimation strategy, and Section 5 discusses the empirical findings. Conclusions are drawn in Section 6 and policy implications are discussed.

## 2. Literature review

Classical resource abundance studies highlight resources as a blessing for those countries that own them. However, the advent of theories like the "Resource curse" and "Dutch disease," indicates that the blessing appears to be impeding economic growth and development of the countries concerned. The most recent literature indicates that the major reason for the transformation of the blessing into a curse is the low literacy rate, weak institutional management, lack of long run orientation, rent-seeking dependency, and Dutch disease, among others (Sachs and Warner, 2001; Dwumfour and Ntow-Gyamfi, 2018; Shahbaz et al., 2018). The resource curse is evident in countries with resource abundance (Beck and Poelhekke, 2017). The rent-seeking habit of entrepreneurs could lead to risk averse behavior and the opportunity cost of the avoidance of other manufacturing industries might be much higher than the current resource rent (Mehlum et al., 2006; Torvik, 2002). Resource dependency varies from country to country and depends on the priorities of the country as to whether they engage in rent seeking or transform the resources into finished goods. The blessing of natural resources is evidently challenged in the literature and the concept of the "resource curse" has emerged (Auty, 2007).

### 2.1. Resource abundance and financial development

In the debate on natural resource abundance and its association with economic growth, earlier proponents, including Smith (1776) and David Ricardo (1911), state that countries with higher levels of natural resources should grow faster. However, the phenomena of real exchange rate deterioration, increases in natural resource prices, and competitive advantage in the global market in the 1970s and 1980s despite the abundance of natural resources came to be known as "Dutch disease" (Zhang and Brouwer, 2019). Countries with abundant natural resources increase exports of these natural resources instead of transforming them into manufactured goods (Sachs and Warner, 2001; Dwumfour and Ntow-Gyamfi, 2018). In such countries, higher exchange rates lead to higher exports to earn revenue and more competitiveness in international markets. Consequently, the strategic planning for industrial manufacturing is impeded and countries get stuck in stagnant economic growth. A country's stagnant position damages its prospective growth despite the higher potential for growth (Humphreys et al., 2007). This situation makes the non-natural resource sectors, such as manufacturing, 'fall under a shadow' and the economy concerned becomes less diversified (Gylfason, 2001). "Dutch disease" theoretically creates the negative macroeconomic externalities associated with the resource curse. In resource rich countries, rent-seeking behavior causes the resource curse and the economic rent of resource exploitation is likely to increase opportunities for rent-seeking and corruption. In this way, resource abundance hampers financial development (Yuxiang and Chen, 2010).

Resource abundance helps to raise the funds level in a given economy. The funds in turn help to create higher liquidity in economic markets. This phenomenon leads to a higher circulation of funds in the form of public and government revenue. Therefore, the banking system in a resource-rich country might be boosted, leading to the possibility of bank credit on easy terms. Consequently, institutions play an important role and institutional quality is inevitably necessary to enforce smooth contracts (La Porta et al., 2005; Amin and Djankov, 2009). Theoretically

[1] There is very little literature that focuses on the role of technological innovation with human capital, trade openness, natural resource abundance, and their effect on financial development. For example, Shahbaz et al. (2018), Nawaz et al. (2019), Zaidi et al. (2019), Erum and Hussain (2019), and Zallé (2019) do not consider the role of technological innovation in the finance demand function.

the quality of institutions can help to reduce the effect of the resource curse (Mehlum et al., 2006, Mehlum et al., 2006). To date, there is ample empirical evidence to validate the link between natural resources and financial development around the globe. For example, in the case of African countries, Dwumfour and Ntow-Gyamfi (2018) indicate that institutional quality may help to minimize the resource curse. It has also been observed that a negative association exists between rent seeking and financial development in countries where political institutions are weak. However, improvement in institutional quality has resulted in the decrease of negative effects, resulting in countries with weak political institutions being financially under-developed and vice versa (Bhattacharyya and Hodler, 2014). It seems that studies on the link between natural resource abundance and financial development are contradictory and the subject therefore warrants further investigation including the consideration of potential macroeconomic factors. Moreover, the moderating role of technical innovations, human capital, and trade openness cannot be ignored. Human capital in the form of college graduates may transform natural resources into other long-run oriented industries, which may shift the curse into a blessing for resource rich countries. For instance, Marchand and Weber (2015) report that high wages attract students and even teachers to private industry in Texas. Similarly, Rickman et al. (2017) find that higher education may build an environment of better growth in the presence of resource abundance.

### 2.2. Trade openness, and financial development

A large body of literature examines the positive and negative aspects of the role of trade openness and technological innovations in financial development. Trade openness is considered a critical factor that contributes to the financial development of a country, but also achieves higher economic growth (Niemeyer, 2004; Law, 2009; Zhang et al., 2015). Similarly, deepening in financial markets is linked to the opening up of trade with other countries (Do and Levchenko, 2004; Huang and Temple, 2005; Adak, 2015). Moreover, Ibrahim and Sare (2018) report that in Africa, the interaction of human capital and trade openness affects financial development positively. In Asian countries, trade openness and institutional quality has positively contributed in financial development and financial depth during 1995–2011 (Le et al., 2016).

### 2.3. Technological innovations, human capital and financial development

In the modern era, the key factor that facilitates fast economic growth and promotes financial development is technological innovation. Technological innovations not only foster economic growth but also improve financial systems by increasing the competitiveness of firms in achieving higher profits (Aghion et al., 2009; Hsu et al., 2014; Laeven et al., 2015). The relationship between financial development and technological innovation is bidirectional; countries with advanced technology have a higher level of innovations which provides a sound equity market and vice versa (Hsu et al., 2014). In the United States, educational spending is found to be positively connected with resource abundance with higher revenue. In some cases, resource abundance has been found to hinder education as in the case of coal in the Eastern United States (Douglas and Walker, 2017). Similarly, Sibel et al. (2015) note that human capital significantly promotes financial development in the Turkish economy. On the basis of prior literaute, the interaction of human capital and technological innovation may also provide a new path for the financial development.

A deep screening of the existing literature on the association between resource abundance and financial development shows that most previous studies have been conducted in the United States and African contexts. However, there is little empirical evidence on the role of human capital and its links to resource abundance and financial development. China hosts 20% of the world population, is a great source of human capital and therefore, an appropriate context for examining such links. An empirical investigation into the role of human capital may yield new insights into the nexus between resource abundance and financial development. We hypothesize that financial systems are likely to be under-developed in the presence of natural resources with low human capital and low technological innovations.

## 3. Theoretical framework and empirical modelling

Financial development is determined by technological innovation, human capital, and trade openness ,which in turn, affects economic growth (Rajan and Zingales, 2003; Yuxiang and Chen, 2010; Hoshmand et al., 2013; Ibrahim and Alagidede, 2018; Nawaz et al., 2019). The stability of any country's financial system as per the updated literature is based on trade openness and physical capital (Shahbaz et al., 2018). Natural resource abundance is important for economic growth (Smith, 1812; Viner, 1952; Badeeb et al., 2017); however, the role of human capital and technological innovation is important for utilizing natural resources effectively (Tiba and Frikha, 2019). Natural resources abundance is also found to be negatively associated with economic growth in some countries and regions, and such findings support the resource curse hypothesis (Sachs and Warner, 2001; Abou-Ali and Abdelfattah, 2013; Zuo and Jack, 2014; Xu et al., 2016 among others).

The mechanism through which natural resources negatively affect financial development is explained by Beck (2002) who suggests that natural resource sectors draw skills and investment away from financial sectors, simultaneously lowering demand and saving rates. Similarly, Rajan and Zingales (2003) indicate the interest group theory of financial development, which proposes that in order to avoid competition, existing powerful firms will always oppose financial development by using their market power. Countries with abundant natural resources normally experience lagged growth, fewer financial reforms, and a weak business environment which in turns affects the manufacturing sector, reducing exports and negatively affecting all economic variables including the financial sector (Sachs and Warner, 2001; Humphreys et al., 2007). Similarly, Song et al. (2018) argue that capital transfer and the manufacturing labor sector underperform because of resource rich sectors. They crowd the manufacturing sector out and hinder economic growth (Arvanitis and Weigert, 2017). On the contrary, Nawaz et al. (2019) support that natural resource abundance affects financial development positively. Further, Bhattacharyya and Hodler (2014) suggest that countries abundant or rich in natural resources have more credit available to households and firms which contributes to financial development of an economy. Besides, natural resource abundance, financial development, and human capital are closely linked (Midrigan et al., 2017). The role of the knowledge base and human capital is considered as one of the important sources of economic growth, as indicated by Romer (1994) and Lucas (1988) in endogenous growth theory. Human capital helps in the efficient utilization of natural resources and stabilizes the financial system, contributing to economic growth (Becker, 2009; Shahbaz et al., 2018; Dwumfour and Ntow-Gyamfi, 2018; Zaidi et al., 2019). In addition to natural resource abundance and human capital, the role of technological innovations is also important for a sound financial system and achieving economic growth (Hanley, 2011; Corrado et al., 2013; Hsu et al., 2014; Laeven et al., 2015; Pan et al., 2019). Technical innovations help to ensure higher growth of firms and also increase their competitiveness which in turn, expands domestic production, contributing to financial development (Bessen and Maskin, 2009; Kumar 2017; Im and Shon, 2019). Deepening in financial markets is also linked with trade openness (Do and Levchenko, 2004; Huang and Temple, 2005). Trade openness helps firms to attract more external financing, competition, and investment opportunities; promotes economies of scale; and improves production processes which paves the way for financial deregulation (Rajan and Zingales, 2003; Adak, 2015).

Considering the above discussion, a modified framework is developed by introducing technological innovation, human capital, and trade openness into the examination of the effect of natural resource abundance on financial development in the Chinese economy. The general form of the finance demand function also incorporates the interaction between human capital and technological innovation (technological innovation and human capital), which are also incorporated into the general form of the finance demand function in the presence of structural break dummies and without dummies. The general form of the finance demand function is modelled as follows[2]:

$$F_t = f(R_t,\ H_t, T_t,\ O_t) \tag{1}$$

where, $F_t$ indicates financial development which is measured by domestic credit provided to the private sector as a share of GDP (Shahbaz et al., 2018; Pan et al., 2019); $R_t$ represents natural resource abundance indicated by the total rents from oil, gas, mineral, and forest (Dwumfour et al., 2017; Dwumfour and Ntow-Gyamfi, 2018); $H_t$ is human capital measured by the total number of graduates including all PhDs, Masters, and Undergraduates (Shahbaz et al., 2018; Zaidi et al., 2019); $T_t$ indicates technological innovations which are the total number of patent applications (registered by residents and non-residents) as it represents technological advancement and the result of research & development activities (Pan et al., 2019); and $O_t$ represents trade openness being the sum of exports and imports as a share of GDP (Kim et al., 2010; Pan et al., 2019). The data for the analysis is mainly collected from the National Bureau of Statistics (2019) and World Development Indicators (2019). All the variables are measured per-capita (except education) and taken in natural-log form for empirical purposes (Shahbaz et al., 2018). The empirical equation of the finance demand function is modelled as follows:

$$lnF_t = \gamma_0 + \gamma_1 lnR_t + \gamma_2 lnH_t + \gamma_3 lnT_t + \gamma_4 lnO_t + \varepsilon \tag{2}$$

where $\gamma_0$ is the intercept, $\gamma_1,\ \gamma_2, \gamma_3$ *and* $\gamma_4$ are the parameters and $\varepsilon$ is the residual term. The expected sign based on the theoretical framework hypothesis that natural resource abundance affects financial development is $\frac{\partial F_t}{\partial R_t} \neq 0$, indicating an effect but including the uncertainty of whether it is positive or negative. $\frac{\partial F_t}{\partial H_t} > 0$ for human capital shows that human capital is positively linked with financial development, $\frac{\partial F_t}{\partial T_t} > 0$ shows the role of technology is expected to be positive, and $\frac{\partial F_t}{\partial O_t} > 0$ shows that trade openness is positively linked with financial development. Additionally, to check for the robustness of results, this study uses additional covariate such as foreign direct investment ($\mathrm{FDI_t}$) and gross domestic product with an expected sign of $\frac{\partial F_t}{\partial FDI_t} > 0$ and $\frac{\partial F_t}{\partial Y_t} > 0$ respectively. Similarly, this study also uses three different proxies for financial development to check for the robustness of the results. These proxies include broad money to GDP denoted by ($\boldsymbol{F}_t^1$), deposit money banks assets to GDP ($\boldsymbol{F}_t^2$) a measure of financial depth and Liquid liabilities to GDP ($\boldsymbol{F}_t^3$) which also indicate financial depth.

## 4. Estimation strategy

### 4.1. Unit root testing

In order to examine integrating unit root properties of the variables, we apply a simple ADF unit root test with and without structural breaks. Using a simple unit root test without structural breaks loses the size and power of the test which leads to spurious empirical results. For example, Perron (1989) developed a unit root test under the null hypothesis of non-stationarity, but it failed because of the assumption that a priori break data is known which is found to be incorrect and it also loses power and distorts the size (Hecq and Urbain, 1993). Further, several unit root tests allowing for unknown structural breaks have been developed by Zivot and Andrews (2002) and Kim and Perron (2009); however, they have not been useful for covering the shortcomings in assumptions.

To solve this issue, Carrion-i-Silvestre et al. (2009) developed a new approach to overcome the shortcomings of previous unit root tests (Shaeri and Katircioğlu, 2018). This test allows for up to five structural breaks in level as well as in slope. In this test, the Bai and Perron (2003) algorithm is used to estimate break dates for different kinds of data. Further, this unit root test also incorporates Elliott et al. (1996) Q-GLS for detrending to improve its power and also takes the M-class unit root tests (*MSB*, $MZ_t$ *and* $MZ_a$) developed by Stock and Watson (1999), Ng and Perron (2001), and Perron and Rodríguez (2003). The empirical equation for Carrion-i-Silvestre's approach is given as follows:

$$Z_t = X_t + \varnothing_t \tag{3}$$

$\varnothing_t = \alpha\varnothing_t + \ \pi_t$ where. $t\ = 0, \ldots\ldots, T$

The null hypothesis of unit root is tested under five different statistics as follows:

$$\frac{P_T(\vartheta^o) = [[SD\ (\overline{\alpha}, \vartheta^o) - \overline{\alpha}\, SD(1, \vartheta^o)]}{SD^2(\vartheta^o)} \tag{5}$$

where $SD$ is the spectral density and $P_T$ is the Gaussian point optimal statistic.

$$MP_t(\vartheta^o) = \frac{c^{-2}T^{-2}\sum_{t=1}^{T}\widetilde{Z_{t-1}^2} + (1-\overline{c})T^{-1}\widetilde{Z_T^2}}{SD(\vartheta^o)^2} \tag{6}$$

$$MZ_a(\vartheta^o) = \left(T^{-2}\widetilde{Z_T^2} - \ SD\left(\vartheta^o\right)^2\right)\left(2\ T^{-2}\sum_{t=1}^{T}\widetilde{Z_{t-1}^2}\right)^{-1} \tag{7}$$

$$MSB(\vartheta^o) = \left(SD(\vartheta^o)^{-2}T^{-2}\sum_{t=1}^{T}\widetilde{Z_{t-1}^2}\right)^{1/2} \tag{8}$$

$$MZ_t(\vartheta^o) = \left(T^{-1}\widetilde{Z_T^2} - \ SD\left(\vartheta^o\right)^2\right)\left(4\ SD\left(\vartheta^o\right)^2 T^{-2}\sum_{t=1}^{T}\widetilde{Z_{t-1}^2}\right)^{1/2} \tag{9}$$

### 4.2. Maki (MBk) cointegration approach

There are several cointegration approaches with structural breaks in the existing literature. These approaches include Hatemi-J (2008) and Gregory and Hansen (1996) cointegration tests for structural breaks. However, these approaches failed to perform better than the MBk cointegration approach in allowing for multiple structural breaks. The MBk approach is computationally easy to perform and also provides up to five unknown structural breaks stemming from the data while investigating the cointegration relationship. Therefore, we adopted the MBk approach to test for the cointegration relationship between financial development and its determinants. Further, we employed the regime shift approach which allows for structural breaks in regressors ($\omega$) and levels ($\sigma$), as well as the regime shift model with trend for structural breaks ($\tau$), regressors ($\omega$), and levels ($\sigma$). The null hypothesis suggests no cointegration relationship among the variables and the alternative suggests the existence of cointegration (Çagli and Mandaci, 2013). The empirical equation form of *MBk* is modeled as follows:

Regime Shift

$$F_t = \sigma + \sum_{i=1}^{k}\sigma_i Z_{it} + \tau t + \vartheta^{'}\omega_t + \sum_{i=1}^{k}\vartheta^{'}\omega_i Z_{it} + \varepsilon_t \tag{10}$$

Regime Shift with Trend

$$F_t = \mu + \sum_{i=1}^{k}u_i Z_{it} + \pi t + \sum_{i=1}^{k}\pi_i t Z_{it} + \alpha^{'}x_t + \sum_{i=1}^{k}\alpha^{'}{}_i x_i Z_{it} + u_t \tag{11}$$

In equation-10, $t$ indicates the time period such as $\mathrm{t} = 1, \ldots\mathrm{T}$; $F_t$ is the

[2] Table of variables definition is provided in Appendix-II.

dependent variable; and $\omega_t = (\omega_{1t}.....\omega_{mt})'$ is the set of regressors, that is, natural resources abundance, technological innovations, human capital, and trade openness. Moreover, the value of $Z_{it}$ is 1 if $t > T_{Bi}(i = 1, ....K)$ and $= 0$ if $< T_{Bi}$. $T_{Bi}$ denotes the different structural break periods, while $K$ is the maximum number of lags. The MBk model will provide us with both the cointegrating relationship among the variables and structural breaks in the model.

### 4.3. The ARDL bounds testing approach to cointegration

We also apply ARDL bounds testing to determine the long run and short run relationship between natural resource abundance, technological innovations, human capital, trade openness, and financial development. We furthermore incorporate dummies obtained via the MBk test. The ARDL approach to cointegration is flexible enough to have different orders of integration for the variables, that is, I(1) or I (0); it provides unbiased results for small samples, ensures unbiased long run parameters results, deals with autocorrelation, overcomes the issue of endogeneity based on selecting optimum lags, and different lags can be used for each variable (Rahman and Kashem, 2017, Ali et al., 2019). Following Pesaran et al. (2001), Shahbaz et al. (2013), and Rahman and Kashem (2017), the specification for the ARDL bounds testing approach to cointegration is modeled as follows:

$$F_t = f(\mathrm{H}_t, \mathrm{T}_t, \mathrm{O}_t, \mathrm{R}_t, D_1 1992_t, D_1 2008_t, D_1 2010_t) \tag{12}$$

where all the regressors indicate the same definition as in equation-1; while $D_1 1992$, $D_2 2008$, and $D_3 2010$ are the year dummies for the structural breaks. The general specification of the ARDL is as follows:

$$\begin{aligned}\Delta F_t = {} & \alpha_0 + \gamma_1 F_{t-i} + \gamma_2 H_{t-i} + \gamma_3 T_{t-i} + \gamma_4 O_{t-i} + \gamma_5 R_{t-i} + \theta_1 D1991_{t-i} \\ & + \theta_2 D2008_{t-i} + \theta_3 D2011_{t-i} + \sum_{i=1}^{s} \pi_i \Delta F_{t-i} + \sum_{j=1}^{u} \rho_j \Delta H_{t-j} + \sum_{v=1}^{k} \sigma_v \Delta T_{t-v} \\ & + \sum_{w=1}^{y} \tau_w \Delta O_{t-w} + \sum_{m=1}^{b} \omega_\mu \Delta R_{t-\mu} + \sum_{m=1}^{b} \psi_s \Delta D1991_{t-\mu} + \sum_{q=1}^{l} \varnothing_q \Delta D2008_{t-q} \\ & + \sum_{c=1}^{h} \varpi_c \Delta D2010_{t-c} + \varepsilon_t \end{aligned} \tag{13}$$

In equation-13, $\alpha_0$ is the intercept in the model, while $\pi_i$, $\rho_j$, $\sigma_v$, $\tau_w$, and $\omega_\mu$ *are* coefficients. Similarly, $\psi_s$, $\varnothing_q$, and $\varpi_c$ are the dummy variables and short run parameters in the model. The long run parameters are represented by $\gamma_1$, $\gamma_2$, $\gamma_3$, $\gamma_4$, $\gamma_5$, $\theta_1$, $\theta_2$, and $\theta_3$. The null hypothesis suggests no cointegrating relationship between financial development and its determinants including $D_1 1991_t$, $D_1 2008_t$, and $D_1 2010_t$. The decision to accept or reject the null hypothesis is based on the calculated ADRL-F statistic (Pesaran et al., 2001). The optimal lags selection for the model, which is helpful to avoid the autocorrelation problem, is selected via the SBC. The null ($H_0$) and alternative ($H_1$) hypotheses of the empirical model are given as follows:

$$H_o : \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \theta_1 = \theta_2 = \theta_3 = 0$$

$H_1$: At least one is different.

Similarly, if ARDL-F statistic shows a cointegration relationship among variables then the following long run equation for the model is estimated:

$$\begin{aligned} F_t = {} & \beta' + \sum_{i=1}^{q} \pi_i' F_{t-i} + \sum_{j=1}^{p} \rho_j' H_{t-j} + \sum_{v=1}^{k} \rho_v' T_{t-v} + \sum_{x=1}^{z} \rho_x' O_{t-x} + \sum_{w=1}^{y} \tau_w' R_{t-w} \\ & + \sum_{w=1}^{y} \psi_s' D1991_{t-w} + \sum_{m=1}^{b} \varnothing_\mu' D2008_{t-\mu} + \sum_{s=1}^{f} \omega_w' D2010_{t-s} + \mu_t \end{aligned} \tag{14}$$

where $\pi'$, $\rho_j'$, $\rho_v'$, $\rho_x'$, $\tau_w'$, $\psi_s'$, $\varnothing_\mu'$, and $\omega_w'$ show the long run parameters. Once the long run relationship is established, then the following model is estimated for the short run dynamics of the model via the error correction mechanism (*ECM*):

$$\begin{aligned} \Delta F_t = {} & \beta^* + \sum_{i=1}^{q} \pi_i^* \Delta F_{t-i} + \sum_{j=1}^{p} \rho_j^* \Delta H_{t-j} + \sum_{k=1}^{o} \rho_v^* \Delta T_{t-v} + \sum_{l=1}^{n} \rho_x^* \Delta O_{t-x} \\ & + \sum_{n=1}^{m} \tau_w^* \Delta R_w + \sum_{o=1}^{l} \psi_s^* \Delta\, D1991_{t-s} + \sum_{p=1}^{k} \varnothing_w^* \Delta D2008_{t-w} \\ & + \sum_{q=1}^{j} \varpi_\mu^* \Delta D2010_{t-\mu} + \lambda ECM_{t-1} + \varepsilon_t \end{aligned} \tag{15}$$

The short run coefficients are shown by $\pi_i^*$, $\rho_j^*$, $\rho_v^*$, $\rho_x^*$, $\tau_w^*$, $\psi_s^*$, $\varnothing_w^*$, and $\varpi_\mu^*$; whereas the coefficient of $ECM_{t-1}$ shows the speed of adjustment (Pesaran et al., 2001).

## 5. Empirical results and their discussion

For examining the unit root properties of the variables, we applied an ADF unit root test with and without structural breaks stemming from the series. The empirical results of the ADF are given in Table 1. We find that financial development, human capital, and trade openness contain unit root problems, but technological innovations and natural resources are found to be stationary in the presence of structural breaks. After the first difference, all the variables are stationary in the presence of structural breaks stemming from the series. This shows that the variables have a mixed order of integration. Because ARDL bounds testing is also applicable if variables contain a mixed order of integration (Pesaran et al. 1999, 2001), we proceed in estimating the long run and short run dynamics between financial development and its determinants.

As mentioned in the methodology, using a simple unit root test without structural breaks loses the size and explanatory power of the test which further leads to spurious empirical results. Therefore, to avoid such issues, Carrion-i-Silvestre et al. (2009) unit root test is applied. The empirical results of Carrion-i-Silvestre et al. (2009) unit root are reported in Table 2, containing multiple structural breaks in each series. We allow only up to three lags in each series as the data are for 31 years. The empirical results indicate that financial development, natural resource abundance, technological innovations, human capital, and trade openness are nonstationary at level, i.e. I(0) in the presence of multiple structural breaks. This shows that the empirical results do not reject the null hypothesis of a unit root. After the first difference, we note that all the variables are stationary in the presence of multiple breaks that stem from the series. We find that all the series have a unique order of integration, that is, I(1). The breaks in the results reveal key events in the development of China's economy. The break dates from 1991-1994 show important phases in China's economic growth which are attributed to the fact that the economic reforms of 1992 contributed positively to the Chinese economy. China's trade relations with rest of the world grew faster and recorded high growth rates in these years. Export growth rose sharply from 3% to 10% in the post-economic reforms period (Li et al., 2012). The economic reforms of 1992 helped China to accelerate growth in its major sectors, especially in exports. China joined the WTO in December 2001 which helped to improve its financial institutions (Allen et al., 2007). The break dates in the 2007–2008 period indicate the global slump due to the financial crisis. The Chinese economy is amongst those that were badly affected by the global financial crisis. According to the IMF World Economic Outlook (2010) and Li et al. (2012), China's economic growth was badly affected by the global financial crisis. The figures declined from 14.20% in 2007 to 9.60% in 2008, with a further decline to 9.22% in 2009. The financial crisis also affected China's FDI and most of the investors faced losses which caused a decline in total FDI from \$143.06 billion to \$70.32 billion in 2009 (Li et al., 2012).

Because the Carrion-i-Silvestre et al. (2009) unit root test confirmed the existence of multiple structural breaks in each series, we cannot

**Table 1**
ADF unit root analysis with and without structural breaks.

| Variables | Level | | First Difference | | | |
|---|---|---|---|---|---|---|
| | ADF without SB | ADF with SB | ADF without SB | ADF with SB | Order Without SB | Decision with SB |
| $\mathbf{R_t}$ | 0.82 (−1.53) | 4.91** (−4.11) | −0.09 (−5.33) | – | I(1) | I(0) |
| $\mathbf{F_t}$ | 0.61 (−2.45) | −4.08 (−4.23) | −0.033*** (−5.31) | −5.22** (−4.09) | I(1) | I(1) |
| $\mathbf{H_t}$ | 0.97 (−0.32) | −3.16 (−4.22) | 0.14*** (−6.70) | −5.11** (−4.19) | I(1) | I(1) |
| $\mathbf{T_t}$ | 0.55 (−2.51) | −4.34 (−4.23) | −0.15*** (−5.85) | – | I(1) | I(0) |
| $\mathbf{O_t}$ | 0.73 (−2.04) | −3.95 (−4.20) | 0.08*** (−4.78) | −5.31** (−4.25) | I(1) | I(1) |
| $F_t^1$ | 0.83 (−1.57) | −4.31** (−4.20) | −0.04** (−5.67) | – | I(1) | I(0) |
| $F_t^2$ | 0.79 (−1.76) | −3.43 (−4.20) | 0.37 (−3.21)** | −4.95** (−4.09) | I(1) | I(1) |
| $F_t^3$ | 0.90 (−1.36) | −3.16 (−4.17) | 0.29** (−4.01) | −4.92 (−3.89) | I(1) | I(1) |
| $\mathbf{Y_t}$ | 0.86 (−1.35) | −2.27 (−4.17) | 0.65* (−2.04) | −5.10** (−4.21) | I(1) | I(1) |
| $\mathbf{FDI_t}$ | 0.83 (−1.85) | −4.04 (−4.07) | 0.19** (−3.96) | −4.13 (−3.86) | I(1) | I(1) |

Note: *, ** and *** denote the level of significance at 10%, 5%, and 1%, respectively. SB indicates a structural break. The ADF without SB critical values at 1%, 5%, and 10% are −4.56, −3.89 and −3.59, respectively. The ADF with SB critical values are given in brackets.

**Table 2**
GLS-unit root test (Carrion-i-Silvestre et al., 2009).

| **Variables** | **Level** | | | | | |
|---|---|---|---|---|---|---|
| | $P_T$ | $MP_T$ | $MZ_a$ | MSB | $MZ_t$ | Break Year |
| $\mathbf{R_t}$ | 17.80 (7.78) | 18.53 (7.78) | −14.23 (34.08) | 0.18 (0.12) | −2.63 (4.11) | 1999-2003-2008 |
| $\mathbf{F_t}$ | 21.07 (8.38) | 22.06 (8.38) | −13.74 (−36.12) | 0.18 (0.11) | −2.59 (−4.23) | 1993-2003-2008 |
| $\mathbf{H_t}$ | 30.05 (8.28) | 30.62 (8.28) | −9.45 (−36.06) | 0.21 (0.11) | −2.06 (−4.22) | 1994-2000-2005 |
| $\mathbf{T_t}$ | 19.08 (7.96) | 20.20 (7.96) | −14.34 (−36.08) | 0.18 (0.11) | −2.62 (4.23) | 1991-1998-2007 |
| $\mathbf{O_t}$ | 20.31 (8.22) | 21.61 (8.22) | −13.44 (−35.80) | 0.19 (0.11) | −2.59 (−4.20) | 1994-2001-2004 |
| $F_t^1$ | 20.21 (8.31) | 20.61 (8.31) | −14.16 (−35.69) | 0.18 (0.11) | −2.63 (−4.20) | 1991-2002-2007 |
| $F_t^2$ | 21.91 (7.93) | 22.98 (7.93) | −12.25 (−35.63) | 0.19 (0.11) | −2.44 (−4.20) | 1994-2002-2008 |
| $F_t^3$ | 24.46 (8.32) | 25.96 (8.32) | −11.20 (−35.29) | 0.21 (0.11) | −2.36 (−4.17) | 1992-1998-2007 |
| $\mathbf{Y_t}$ | 32.49 (8.18) | 34.34 (8.18) | −8.08 (−35.10) | 0.23 (0.11) | −1.91 (−4.17) | 1998-2002-2008 |
| $\mathbf{FDI_t}$ | 18.29 (7.91) | 19.12 (7.91) | −13.77 (−33.46) | 0.18 (0.12) | −2.59 (−4.07) | 1993-2002-2010 |
| **First Difference** | | | | | | |
| $\mathbf{\Delta R_t}$ | 5.16** (6.98) | 6.45** (6.98) | −13.88** (12.43) | 0.10** (0.12) | −2.62** (−4.023) | – |
| $\mathbf{\Delta F_t}$ | 7.36** (7.53) | 7.50** (7.53) | −14.49** (−13.67) | 0.10** (0.12) | −2.68** (−4.09) | – |
| $\mathbf{\Delta H_t}$ | 6.20** (7.91) | 6.58** (7.91) | −12.97** (−11.47) | 0.10** (0.11) | −2.53** (−4.19) | – |
| $\mathbf{\Delta T_t}$ | 5.93** (6.60) | 5.06** (6.60) | −14.25** (−13.76) | 0.11** (0.12) | −2.64** (−4.10) | – |
| $\mathbf{\Delta O}$ | 7.91** (8.25) | 7.66** (8.25) | −13.30** (−12.42) | 0.10** (0.11) | −2.57** (−4.25) | – |
| $\Delta F_t^1$ | 7.45** (8.38) | 8.20** (8.39) | −14.34** (−13.32) | 0.11 (0.12) | −2.66 (−4.10) | – |
| $\Delta F_t^2$ | 7.32** (7.95) | 7.89** (7.95) | −15.67** (−14.89) | 0.13** (0.15) | −2.47** (−4.09) | – |
| $\Delta F_t^3$ | 7.12** (7.69) | 7.54** (7.69) | −13.47** (−12.49) | 0.13** (0.14) | −2.48** (−4.15) | – |
| $\mathbf{\Delta Y_t}$ | 6.79** (8.16) | 7.11** (8.16) | −13.89** (−11.98) | 0.10 (0.11) | −2.55** (−4.21) | – |
| $\mathbf{\Delta FDI_t}$ | 6.58** (6.83) | 6.79** (6.83) | −13.57** (−12.86) | 0.12** (0.10) | −2.58** (−3.86) | – |

Note: ** indicates a significance level of 5%. Results are provided for first difference; all the variables reject the null hypothesis at the 5% significance level. The values in brackets indicate critical values obtained through bootstrapping as in Carrion-i-Silvestre et al. (2009).

apply simple cointegration tests to examine the cointegration relationship between the variables. For instance, the empirical results of Gregory and Hansen (1996) and Hatemi-j (2008) cointegration approaches are inefficient when compared with the MBk if the series has more than two breaks (Maki, 2012). Therefore, we apply the MBk cointegration approach to determine the cointegrating relationship between financial development and its determinants with three structural breaks. The empirical findings of the MBk given in Table 3 suggest the existence of a cointegration relationship with structural breaks in regime shift and regime shift with trend between the variables. This empirical evidence confirms the existence of cointegration between financial development and its determinants in the presence of structural breaks in the series. These results are consistent with Ilyina and Samaniego (2011), Shahbaz et al. (2018) (Dwumfour and Ntow-Gyamfi, 2018), and Zaidi et al. (2019) among others. Further, to incorporate the structural break effect,

**Table 3**
Maki (2012) Cointegration analysis with structural breaks.

| Regime | **Test – Statistic** | **CV(5%)** | **CV(1%)** | **Break Year** |
|---|---|---|---|---|
| **Regime Shift** | −11.19** | −8.11 | −8.67 | 1994-2005-2010 |
| **Trend and Regime shift** | −12.40** | −8.81 | −9.43 | 1992-2008-2010 |

Note: *, ** indicate significance level at 5% and 1%.

we developed three dummies, $D_1$1992, $D_2$2008, and $D_3$2010, from the regime shift model with trend to trace whether its effect on financial development is positive or negative. For this purpose, we apply the ARDL model with dummies and interactions for human capital with

**Table 4**
Bound testing cointegration analysis.

| Model(s) | F-Statistic |
|---|---|
| $\mathbf{F_t} = \mathbf{f}(\mathbf{H_t}, \mathbf{T_t}, \mathbf{O_t}, \mathbf{R_t})^1$ | 6.44*** |
| $\mathbf{F_t} = \mathbf{f}(\mathbf{H_t}, \mathbf{T_t}, \mathbf{O_t}, \mathbf{R_t}, \mathbf{H}*\mathbf{T})^2$ | 22.54*** |
| $\mathbf{F_t} = \mathbf{f}(\mathbf{H_t}, \mathbf{T_t}, \mathbf{O_t}, \mathbf{R_t},, \mathbf{D_1 1992_t}, \mathbf{D_1 2008_t}, \mathbf{D_1 2010_t})^3$ | 6.68*** |
| $\mathbf{F_t} = \mathbf{f}(\mathbf{H_t}, \mathbf{T_t}, \mathbf{O_t}, \mathbf{R_t}, \mathbf{H}*\mathbf{T}, \mathbf{D_1 1992_t}, \mathbf{D_1 2008_t}, \mathbf{D_1 2010_t})^4$ | 15.13*** |

Note: *, **, *** denote the 10%, 5%, and 1% significance levels, respectively. [1, 2, 3, 4] denote Model-I (simple one), Model-II (interactive term), Model-III (With Dummies), and Model-IV (Dummies and interactive term) SBC, respectively.

technological innovations following Orhunbilge and Nihat (2014).

The empirical results of the ARDL bounds testing approach are reported in Table 4. We have incorporated the structural break dummies identified by the MBk cointegration, that is, $D_1 1992$, $D_2 2008$, and $D_3 2010$, along with the interaction between technological innovations and human capital. Before applying the ARDL, it is imperative to select the optimum lags for the model.[3] We follow the SBC for selecting the lag length of the variables. Once the lag length is selected, the bounds testing approach is employed to verify the existence of a cointegrating relationship between financial development and its determinants along with the three breaks in all four models (simple model without the interactive term or dummies, with the interactive term only, with dummies only, and with both the interactive term and dummies). The ARDL-F statistics are shown in Table 4. We find that the calculated ARDL-F statistic exceeds the upper critical bounds for all four models. This shows the confirmation of the four cointegrating vectors in the finance demand function which further confirms the presence of cointegration between the variables. We may say that the cointegration determined by the ARDL bounds testing corroborates the empirical findings of the MBk cointegration approach. This shows the robustness of the empirical findings.

Once the cointegrating relationship is established, we find the presence of a short run relationship among the variables. The short-run results as reported in Table 5 reveal the negative association between natural resource abundance and financial development for all four models. A 1% increase in natural resource abundance causes financial development to decrease by −0.10%–0.12%. In the case of human capital, financial development is positively affected. A 1% increase in human capital increases financial development by 0.19%–1.28% in all four models. These results are consistent with earlier arguments that investment in human capital via education and job training as well as health care boost economic growth (Arezki et al., 2012), and that human capital accumulation may reverse the resource curse (Bravo-Ortega and De Gregorio, 2005; Boschini et al., 2007). Shahbaz et al. (2018) also noted that education (a proxy for human capital) and financial development have a positive association. Human capital, in turn, boosts financial development by increasing firm financial efficiency. It increases financial development because education increases human skills (Hatemi-J and Shamsuddin, 2016). Moreover, Outreville (1999) reports that, in the case of 57 developing countries, education has improved financial development. It is argued that investment in human capital should be focused on to create a viable financial sector. Policy should focus on the allocation of more funds to investment in education because significant improvement may be gained through the accumulation of human capital through education. Along with primary and secondary education, investment in research should be the goal to build human capital through skill building.

Similarly, trade openness (technological innovation) increases financial development by 0.49%–0.95% (0.032–1.60%). It has been found that trade openness is a significant determinant of financial

[3] Lags were selected through the SBC using the Eviews-10 automatic lags selection option.

**Table 5**
Short-run analysis.

| | [1]Model-I | [2]Model-II | [3]Model-III | [4]Model-IV |
|---|---|---|---|---|
| **Variables** | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) |
| $D(NR)$ | −0.1094*** (0.0000) | −0.1246*** (0.0000) | −0.0683* (0.0643) | −0.0738** (0.0102) |
| $D(HC)$ | 0.1952*** (0.0045) | 0.7485 (0.0006)*** | 0.2330*** (0.0001) | 1.2865*** (0.0000) |
| $D(TO)$ | 0.72483** (0.0435) | 0.9558** (0.0335) | 0.6130 (0.7145) | 0.4958* (0.0912) |
| $D(TI)$ | 0.03231* (0.0548) | 0.4170* (0.0562) | 0.0530* (0.06212) | 1.6006 (0.0000) |
| **HC*TI** | – | 0.9174** (0.0360) | – | 0.0608* (0.07813) |
| $D(D_1 1992)$ | – | – | 0.0015 (0.6004) | 0.01469* (0.06912) |
| $D(D_2 2008)$ | – | – | −0.0048* (0.0923) | −0.0077*** (0.0000) |
| $D(D_3 2010)$ | – | – | 0.0026 (0.2735) | 0.0018 (0.8328) |
| $\pi$**(-1)** | −0.9495*** (0.0000) | −0.5677*** (0.0000) | −0.4777 (0.0000) | −0.6994*** (0.0000) |

Note: *, **, *** denote the 10%, 5%, and 1% significance levels, respectively. [1, 2, 3, 4] denote Model-I (simple one), Model-II (interactive term), Model-III (With Dummies), Model-IV (Dummies and interactive term) SBC.

development (Baltagi et al., 2009). Pradhan et al. (2016) also note that the development of financial sector and innovative capacity of countries contributes to long term economic growth. The interactive term for human capital with technological innovations increases financial development significantly. The effect of dummy variables on financial development with and without the interactive term are statistically significant for two models. However, the direction of each dummy is similar in the long run. The term $\pi$(-1) indicates the error correction term showing deviation or disequilibrium corrected in the long run. The speed of adjustment in the first model is high and converges quickly towards equilibrium as it is −0.94%, followed by −0.56%, −0.47%, and −0.69% for model-II, model-III, and model-IV, respectively.

The empirical results reported in Table 6 suggest that in all four models, natural resource abundance affects financial development negatively. A 1% increase in natural resource abundance retards financial development by −0.10%–0.21%. This finding confirms the

**Table 6**
Long-run analysis.

| | [1]Model-I | [2]Model-II | [3]Model-III | [4]Model-IV |
|---|---|---|---|---|
| **Variables** | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) |
| $\mathbf{R_t}$ | −0.1059** (0.0116) | −0.2194*** (0.0006) | −0.1430** (0.0397) | −0.1056*** (0.0072) |
| $\mathbf{H_t}$ | 0.1265*** (0.0014) | 0.6389*** (0.0027) | 0.4363* (0.0535) | 1.3353** (0.0116) |
| $\mathbf{O_t}$ | 0.3672* (0.05223) | 0.8141*** (0.0002) | 0.2832 (0.7273) | 0.9315* (0.09135) |
| $\mathbf{T_t}$ | 0.03402** (0.0364) | 0.7186*** (0.0007) | 0.1709* (0.0762) | 1.0187** (0.0143) |
| $\mathbf{H_t}*\mathbf{T_t}$ | – | 0.8623*** (0.0000) | – | 0.1029** (0.0176) |
| $D_1 1992$ | – | – | 0.0319* (0.0892) | 0.0081** (0.0272) |
| $D_2 2008$ | – | – | −0.0102* (0.0963) | −0.0016* (0.0561) |
| $D_3 2010$ | – | – | 0.0035 (0.3503) | 0.0036 (0.1887) |
| **Constant** | 0.1665*** (0.0000) | −1.5061** (0.0183) | 0.1899 (0.0000) | 0.1352** (0.0123) |

Note: *, **, *** denotes the 10%, 5%, and 1% significance levels, respectively. [1, 2, 3, 4] denote Model-I (simple one), Model-II (interactive term), Model-III (With Dummies), Model-IV (Dummies and interactive term) SBC.

existence of the resource curse in the case of China, which is in line with Hu and Xiao (2007), Yuxiang and Chen (2010), Zuo and Jack (2014), Zeng and Zhan (2015), Xu et al. (2016), Zhao et al. (2016), and (Dwumfour and Ntow-Gyamfi, 2018). The resource curse may happen because of the increase in the export of natural resource products and the expansion of resource industries which leads to insufficient investment in manufacturing industries (Zhang and Brouwer, 2019). Zhang and Brouwer (2019) further argue that resource dependence may also reduce local investment and FDI which further lowers the degree of openness. The other possible reasons for the resource curse in China are mainly due to inefficient resource utilization and single industry structures, especially in the resource rich regions (Martinez-Fernandez et al., 2012; Qian et al., 2019); in some cases lower human capital investment is also linked with lower growth (Zhang, 2017). Similarly, more investment is devoted to fixed assets which crowds-out investment in other important areas such as human capital, technological innovations, and economic openness (Fu and Wang, 2010). Poor infrastructure, lower investment in science and technology, the crowding-out of manufacturing sectors, low investment in territory industry sector, and lower human and physical capital investment are the main causes of the existence of the resource curse in the case of China (Zhou and Chen, 2014; Zhang and Brouwer, 2019). Human capital is measured by the quality of human resources available to an economy. The empirical results show that there is a positive association between human capital and financial development. A 1% increase in human capital increases financial development by 0.12%–1.33%. The statistical significance of the effect of human capital on financial development is different in all models. These results confirm the findings of previous studies that show that human capital plays a vital role in financial development (Hu and Xiao, 2007; Zhao et al., 2016; Ibrahim and Sare, 2018; Shahbaz et al., 2018). Technological innovations play a critical role in promoting financial development. The results on the association between technological innovations and financial development show that a 1% increase in technological innovations increases financial development by 0.03%–1.01%. These empirical findings are similar to de Oliveira et al. (2018). Likewise, trade openness increases financial development significantly. A 1% increase in trade openness leads to an increase in financial development of between 0.28% and 0.93%. These results for trade openness suggest trade openness for China is helpful as it shall improve and promote financial development. Similar to African countries, where financial development is positively affected by trade openness (Ibrahim and Sare, 2018), the findings of Zhang et al. (2015) based on China indicate that openness of trade improves the financial efficiency which help to promote financial development.

The empirical findings further show that the interactive or multiplicative effect of both human capital and technological innovations have a positive and statistically significant effect on financial development. A 1% increase in the interactive term increases financial development by 0.86% (0.10%) in a model without dummy variables. This shows that education, especially higher education, such as masters and graduate levels, along with the expansion of technological innovations are crucial factors for the development of financial sector in China. The dummy variable for the structural break in 1992 has a positive effect on financial development. This highlights that the economic reforms started in the 1990s brought the economy onto the path of stability and development. The coefficients of 0.0319 and 0.0081 indicate that the average increase in financial development is higher by 0.0319% and 0.081% compared with the pre-structural break or pre-reforms period. Economic reforms in the 1990s helped China's economy to grow faster and improve financial sector and other relevant sectors (i.e. manufacturing sector) by helping China to strengthen its trade competitiveness (Li et al., 2012). The dummy variable for 2008 has a negative effect on financial development. This is attributed to the global financial crisis in 2008. Similar to other advanced economies, China's economy also suffered badly with a decline in GDP growth, FDI, and exports (Li et al., 2012). The coefficients of −0.010 and −0.001 indicate that the post global financial crisis has an inverse relationship with financial development. It causes the average growth of financial development to decrease by −0.010% and −0.001%. The dummy variable for 2010 indicates that the average growth of financial development post 2010 is high, by 0.0035% and 0.0036%, but statistically insignificant. The positive effect of the post structural break is due to the stimulus package announced by the government of China which is approximately $600 billion or 4000 billion yuan. The key objective was to lower the effect of declining exports by injecting new investments into the economy (Zhao, 2017).

Table 7 provides robusntness analysis by including foreign direct investment and gross domestic product per-capita as new independent variables along with natural resources, human capital, technological innovations and trade openness. The findings for natural resources, technological innovations, human capital and trade openness are similar to results reported in Table 5 and Table 6. Financial development is negatively affected by natural resources while it is positively affected by technological innovations, human capital, trade openness and foreign direct investment. The results suggest that 1% increase in foreign direct investment leads to 0.24% increase in financial development. The positive relationship between FDI and financial development is mainly due to increase in market friendly regulations, improved governance and protection to investors (Soumaré and Tchana Tchana, 2015). These results are in line with the findings of Soumaré and Tchana Tchana (2015) as their study, based on 29 emerging economies including China as one of the sampled country. Similarly, rise in gross domestic product in the presence of natural resources and other controlled covariates causes to increase financial development in case of China. These results indicate that economic activities increase financial development. As economic activities provide more opportunities for job which in turn causes to increase the income level for sectors of the population. The rise in income causes both investment and consumption to rise and also increase the demand for financial services which at the end, increases financial development (Shahbaz et al., 2018).

Table 8 check for robustness of the result by using different proxies for financial development and financial depth. The key proxies used are broad money to GDP, deposit money banks assets to GDP and liquid liabilities to GDP. The findings obtained in Table 8 are consistent with the findings of long and short run results in Table 5 and 6 using domestic credit to private sector as a proxy for financial development. Natural resource abundance retards financial depth while human capital, technological innovations and trade openness increase financial depth for China. For all three proxies such as $F_t^1$, $F_t^2$ and $F_t^3$, a 1% rise in natural resources abundance cause an average decline of −0.10%, −0.09% and −0.073% decline in financial depth. On the other hand, on average financial depth increased by 0.096%, 0.036%, 0.093% via human capital, 0.12%, 0.15% and 0.083% by technological innovations and 0.98%, 0.52% and 0.14% due to trade openness.

In addition to the short run and long run results with robustness check, diagnostic tests such as normality of the data, checking for serial correlation, heteroscedasticity, and stability of the models. The results indicate no serial correlation and heteroscedasticity problems in any of the models as in both cases our models failed to reject the null hypothesis. The normality test results indicate that residuals for all four models are normally distributed. The cumulative sum of recursive residuals (CUSUM) and square of Cumulative sum of recursive residuals (CUSUMsq) were used to test the stability of the models. The empirical results suggest that the parameters of all four models are stable and fall within the range of 5% confidence interval. The results for diagnostic tests and stability tests are given in Appendix-I and III.

## 6. Conclusion and policy recommendations

This study explored the relationship between financial development and natural resource abundance by considering technological

**Table 7**
Robustness check including FDI.

| Variables | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) |
|---|---|---|---|---|---|---|---|
| $FDI_t$ | 0.249** (0.042) | 0.207* (0.063) | 0.172*** (0.000) | 0.108*** (0.003) | 0.124*** (0.005) | 0.12*** (0.000) | 0.079*** (0.000) |
| $R_t$ | | −0.185* (0.062) | −0.158*** (0.000) | −0.124*** (0.000) | −0.101** (0.015) | −0.084*** (0.000) | −0.085*** (0.000) |
| $H_t$ | | | 0.246*** (0.000) | 0.125*** (0.006) | 0.109* (0.090) | | 0.15* (0.087) |
| $T_t$ | | | | 0.119*** (0.007) | 0.144* (0.053) | | 0.12*** (0.000) |
| $O_t$ | | | | | 0.495* (0.056) | | |
| $Y_t$ | | | | | | 0.25*** (0.000) | 0.12*** (0.001) |
| Constant | 0.220*** (0.000) | 0.233*** (0.000) | 0.0965*** (0.000) | 0.106*** (0.000) | 0.115*** (0.000) | −0.10*** (0.000) | 0.234*** (0.000) |
| R-squared | 0.172 | 0.273 | 0.951 | 0.961 | 0.962 | 0.947 | 0.968 |

Note: *, **, *** denotes the 10%, 5%, and 1% significance levels, respectively.

**Table 8**
Robustness Check using Different Measures for Financial Development.

| | $F_t^1$ | $F_t^2$ | $F_t^3$ |
|---|---|---|---|
| Variables | Coefficients (P-Values) | Coefficients (P-Values) | Coefficients (P-Values) |
| $R_t$ | −0.1089*** (0.001) | −0.0985** (0.014) | −0.0735** (0.041) |
| $H_t$ | 0.0966** (0.013) | 0.03635** (0.018) | 0.0939* (0.090) |
| $T_t$ | 0.1225*** (0.005) | 0.1508*** (0.009) | 0.0839* (0.066) |
| $O_t$ | 0.9807* (0.089) | 0.5290* (0.086) | 0.1465*** (0.002) |
| Constant | 0.1159*** (0.000) | 0.1481*** (0.000) | 0.1389*** (0.000) |

Note: *, **, *** denotes the 10%, 5%, and 1% significance levels, respectively.

innovations, human capital, and trade openness in the finance demand function for the Chinese economy over the period of 1987–2017. In addition, interactive or multiplicative terms for human capital and technological innovations are also added along with three dummies obtained through the MBk cointegration analysis. To test the unit root properties of each variable, the ADF for stationarity and the GLS-based test by Carrion-i-Silvestre et al. (2009) for both stationarity and structural breaks are employed. Moreover, the MBk cointegration is employed to obtain the cointegrating relationship in the existence of multiple structural breaks in the model. The breaks obtained from the MBk are then incorporated into the ARDL model to find the long run and short run relationship between financial development and its determinants.

The empirical results suggest the existence of the resource curse in the case of China; that is, natural resource abundance is negatively linked with financial development. Moreover, technological innovations, human capital, and trade openness are the leading factors that promote financial development. The multiplicative or interactive term for human capital with technological innovation is found to be positively associated with financial development. Moreover, all three structural break dummies for 1992, 2008, and 2010 are also tested with and without the multiplicative term. The structural break dummy for 1992 is found to be positively and statistically significantly associated with financial development. The positive effect is mainly due to the market based economic reforms implemented by the Chinese government. By contrast, the break dummy for 2008 is found to be negatively and significantly associated with financial development. This negative effect is mostly linked to the global financial crisis of 2007–2008. However, the 2010 break dummy is found to affect financial development positively but is statistically insignificant. Furthermore, the robustness checks results including new covariates such as FDI and GDP is found to be supportive factors for financial development. Similarly, adding three different proxies for financial development such as broad money to GDP, deposit money banks assets to GDP and liquid liabilities to GDP also confirm similar results to the main variable for financial development, i.e. domestic credit to private sectors.

Based on these findings, we provide the following recommendations: first, the most serious issue is to manage natural resources to support financial development; natural resources can be transformed into value added exports to enhance export revenues and promote financial development. Therefore, we suggest revisiting natural resource abundance utilization for a more productive output. Secondly, technical innovations and human capital can be more effective as they already contribute to financial development. Policies regarding technical innovations should be sustained and the formation of human capital should be focused. The role of human capital in financial development may dominate as its interaction with technical innovations also support financial development. Third, the international financial position may also be considered on serious grounds because, in the era of globalization, international financial markets can also affect China's financial development as they did in 2008. Lastly, strategies for trade openness with the rest of world could be enhanced to improve the efficiency of the financial sector and hence financial development in China. Future investigation of this phenomenon in different countries may lead to more generalizable results, as financial policies and natural resources vary from country to country. Future studies may incorporate the interactive role of governance with natural resources to re-investigate financial development using other measures.

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## Declaration of competing interest

None.

## CRediT authorship contribution statement

**Zeeshan Khan:** Conceptualization, Writing - original draft. **Muzzammil Hussain:** Methodology. **Muhammad Shahbaz:** Supervision. **Siqun Yang:** Writing - review & editing. **Zhilun Jiao:** Supervision.

## Appendix-1

Diagnostic Tests:

| Model | $\chi^2$ | $F_{stats}$ |
|---|---|---|
| Serial Correlation | | |
| Model-I | 2.4931 (0.2858) | 1.6734 (0.2141) |
| Model-II | 4.6498 (0.2036) | 1.3072 (0.2735) |
| Model-III | 3.4742 (0.1760) | 1.2442 (0.3106) |
| Model-IV | 4.7898 (0.4489) | 1.8602 (0.1976) |
| Normality | | |
| Model-I | 0.8373 (0.6579) | – |
| Model-II | 0.7826 (0.6761) | – |
| Model-III | 2.1431 (0.3424) | – |
| Model-IV | 1.6860 (0.4303) | – |
| Heteroscedasticity | | |
| Model-I | 9.1955 (0.3261) | 1.1602 (0.3671) |
| Model-II | 12.0771 (0.6001) | 0.7136 (0.7319) |
| Model-III | 6.8545 (0.2170) | 1.5680 (0.2022) |
| Model-IV | 18.5728 (0.2914) | 1.3205 (0.3100) |

Note: () contains p-value for each test.

## Appendix-II

Definition of Variables:

| Variables | Definitions | Sources |
|---|---|---|
| Financial Development (FD) | *It indicates the financial resources in the form of domestic credit given to the private sector by financial corporations. It includes trade credits, loans, purchases of non-equity securities etc.* | *The World Bank's World Development Indicators Global Development Finance databases* |
| Natural Resources (NR) | The total amount of rents obtained from the sum of natural gas, coal including both hard and soft, mineral, oil and forest. | The World Bank's World Development Indicators |
| Trade Openness (TO) | It indicates the ratio of trade to the total GDP which shows the relative importance of international trade for an economy. It is obtained by summing exports and imports and then dividing it by GDP from the respective period. | The World Bank's World Development Indicators |
| Technological Innovation (TI) | It is measured through the number of patents provided to both resident and non-resident in a given time period. | The World Bank's World Development Indicators |
| Human Capital (HC) | Human capital is measured through the total number of graduates such as undergraduates, masters and Ph.D. degree holders in a given time period say one year. | The World Bank's World Development Indicators |
| Foreign Direct Investment (FDI) to GDP | These are the net inflows in terms of investment for lasting management interest. It is the sum of reinvestment earnings, short and long term capital provided in balance of payment and equity capital. | The World Bank's World Development Indicators Global Development Finance databases |
| $M_2$ to GDP | It is a measure of broad money covering outside banks currency, demand deposits excluding government, savings, foreign currency and time deposits of the residents sectors. It also covers travellers checks, other securities including commercial paper, certificate of deposit and banks checks. | The World Bank's World Development Indicators Global Development Finance databases |
| Liquid Liabities to GDP | It measure is the measure of financial depth. It covers demand, interest bearing liabilities of banks plus currency and other financial intermediaries. | The World Bank's World Development Indicators Global Development Finance databases |
| Deposits Money Banks assets to GDP | It is also a measure of financial depth. It covers the total asset held by deposit money banks as a share of total GDP. These assets cover domestic real non-financial sector including local, state and central government and also non-financial private sector and public enterprises. Despoit money banks covers financial insitutions, commercial banks which accept demand and transerable deposits. | The World Bank's World Development Indicators Global Development Finance databases |

Note: All the variables are taken in log and Per-Capita form.

## Appendix-III

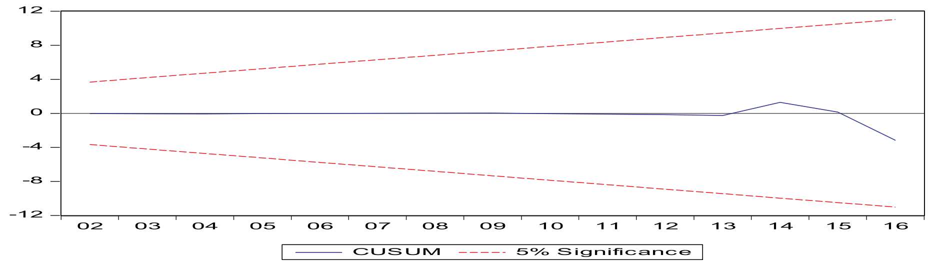


**Fig. 1.** Parameter stability test Cumulative sum of Recursive Residuals.

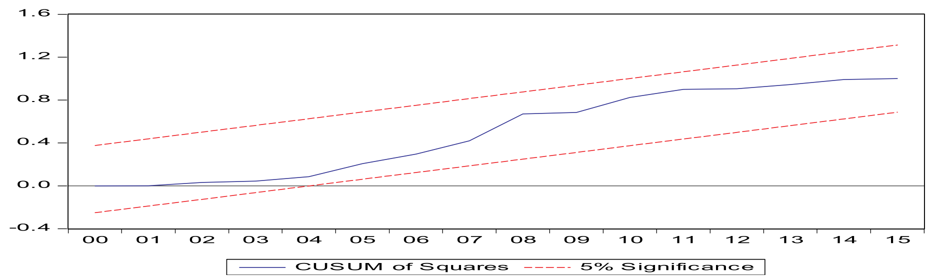


**Fig. 2.** Parameter stability test Cumulative sum of Squares of Recursive Residuals.

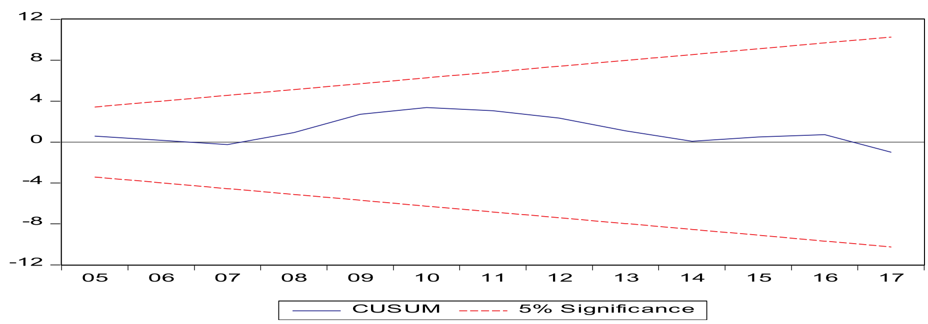


**Fig. 3.** Parameter stability test Cumulative sum of Recursive Residuals.

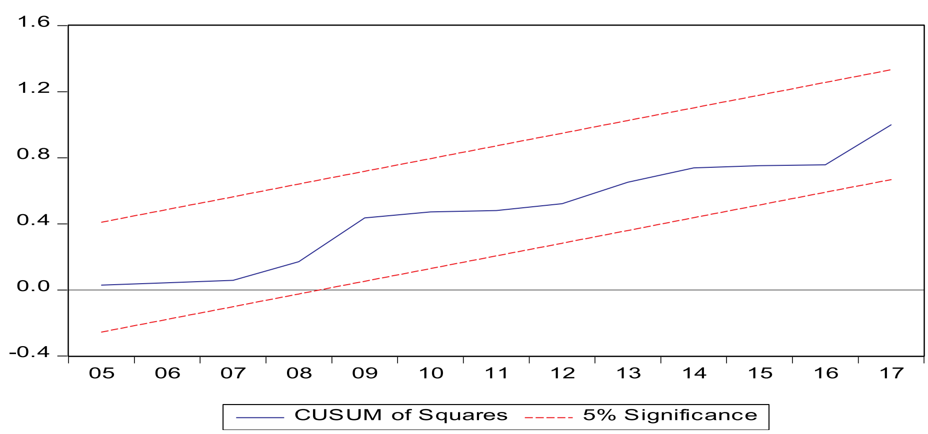


**Fig. 4.** Parameter stability test Cumulative sum of Squares of Recursive Residuals.

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