Exploring the transmission channels between financial inclusion and green growth: A potential role of ICT diffusion and higher education in China

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Abstract

This research explores the role of financial inclusion in promoting green growth. A theoretical and empirical investigation on the role of financial inclusion in green growth is missing, particularly in combination with other determinants, i.e., higher education and the role of ICT. This research explores the role of financial inclusion, higher education, and ICT on green growth for China from 1995 to 2020. The study employs auto-regressive distributive lag (ARDL) approach for short-run and long-run estimates of green growth. The outcomes of the empirical models reveal that financial inclusion is positively associated with green growth in both long-run and short-run. The effect of higher education and ICT on green growth is significantly positive in the long-run and short-run. The findings thus point to the need for policies that promote financial inclusion, human capital, and ICTs infrastructure as a way of accelerating green growth.

Introduction

Sustainable development has become the common agenda of international agencies, environmental experts, and policymakers. In recent times, the role of green growth has become important in attaining sustainable development. Green growth is not just about the protection of the economy but achieving the economic growth of the economy sustainably. The idea of sustainable economies has grabbed much more attention from the empirics and policymakers who work in the domain of economic growth. The concept of Green growth simply represents the path of sustainable growth of any nation. According to United Nations Economic Social Commission for Asia and Pacific (UNESCAP, 2006) green growth is a phenomenon of transforming the traditional economic system into a green one by careful and sustainable use of natural resources. In other words, a green economy is one in which economic prosperity coincides with environmental sustainability. Organization for Economic Cooperation and Development (OECD, 2011) has defined green growth in the following words “fostering economic growth and development while ensuring that natural assets continue to provide resources and environmental services on which the intergenerational well-being of humankind relies”.

Given the importance of green growth in attaining sustainable development, many experts and professionals have devised various strategies to attain green growth but the construction of green technologies with the help of suitable innovation strategies are considered the most significant, and noticeable (Girouard, 2010). The products, equipment, and technologies that are produced and developed with the efficient and sustainable use of natural resources, and exert less burden on the environment are known as green technology. In other words, technologies that help to preserve and guard the ecological balance of the earth by minimizing the pressures of human activities are known as green technologies. Now the question arises what are the factors that can contribute to the development of green technologies which are essential to decouple economic growth from environmental pollution. In this study, we have focused on factors such as financial inclusion, education, and Information and Communication Technologies (ICTs) as the determinant of green growth.

Indeed, the development of the financial sector has become an integral part of the economic growth strategy of any country (Le et al., 2020). On the other hand, financial inclusion has become the part and parcel of any financial strategy as it helps to stimulate the growth of the financial sector and institutions. The idea of financial inclusion is not too old as it emerges in the early 2000s after the study by Chibba (2009) which considered financial exclusion as the primary reason behind poverty. The World Bank (2018) defines financial inclusion as the availability of a wide variety of financial services such as online and offline transactions, credits and debit cards, saving and insurance schemes, car, and house financing, etc to as many people as possible in a convenient, safe, and responsible way. Greenwood and Jovanovic (1990) have anticipated a theoretical model which is crucial for explaining the information asymmetries in the link between the financial sector and economic growth. According to their viewpoint, a dynamic and well-functioning financial system can handle the problems of adverse selection and moral hazards in an efficient way that will channel the funds towards the most profitable and productive projects. On the other side, King and Levine (1993) have observed that a well-functioning financial system can promote economic growth by incorporating the idea of financial development into the model of endogenous growth. In literature, many studies have noticed the positive impact of financial development on economic growth (Caporale et al., 2015; Tripathy, 2019), but very few have focused on the link between financial inclusion and green growth which is the aim of this study. On one side, businesses can take benefit from financial inclusiveness in the financial system which allows them to invest easily in green energy and technologies that will

promote green growth. On the other side, due to financial inclusiveness individuals can take credits from the banks which will raise their living standards more and allow them to afford more energy-intensive products (Frankel and Romer, 1999). Similarly, financial inclusiveness can also promote industrial and manufacturing activities in the economy that will increase the emissions of carbon and other greenhouse gasses into the atmosphere and move the economy further away from the goal of green and sustainable growth.

Economic growth and education are closely linked to each other (Galor & Tsiddon, 1997). Economists have a strong faith in the notion that human capital can drive the long-term economic growth of a country. Human capital can be developed by educating and training the people and it is used as a crucial input in the production function (Barro, 1991). If we analyze the role of human capital in the context of economic growth, it can be observed that advanced economies have transformed their production technique from labor-intensive to human-capital intensive. Such a transformation has helped these economies to attain sustainable growth without affecting environmental quality. Human capital is a by-product of education and it can replace energy-intensive inputs in the production function and help reduce the burden on the environment caused by human activities. Therefore, human capital can contribute to green growth by decoupling economic growth from CO2 emissions.

ICTs have transformed human societies by making them less dependent on physical resources and more on information resources. This transformation has allowed the economies to substitute books, compact disks, and checkbooks with bytes, MP3s, and clicks respectively, and help the economies to become more weightless and capital free (Usman et al. 2021 and Wei & Ullah 2022). This is an era of globalization and digitalization and most of the business activities these days are performed with the help of the internet. Hence, the role of the internet is increasing in the economic growth of countries (Erumban and Das 2016; Usman et al. 2021). Further, ICTs help to attain economic without damaging the environmental quality due to their contribution to dematerializing the economies (Usman et al. 2021). However, evidence also suggests that the increased production and consumption of ICT-related products causes the energy demand, and consequently CO2 emissions to rise (Erumban & Das, 2020). Hence, we can't predict the impact of ICTs on green growth; therefore, ICTs and green growth relationship should be explored in detail and this study is an effort in this direction.

Model And Methods

Financial inclusion is playing a crucial role in improving the firm's productivity, which will help to achieve sustainable economic development in the economy. In the literature, many studies such as Adegbite & Machethe (2020) and Geng & He (2021) have examined the link between financial inclusion and economic growth. ICTs and higher education have become driving forces that promote economic growth. In this study, we have modified their models a bit and replaced economic growth with green growth, and tried to observe whether financial inclusion, higher education, and ICTs help to attain green growth or not. Therefore, we have developed the following long-run model.

$$GG_t = \mu_0 + \mu_1 FI_t + \mu_2 Education_t + \mu_3 ICT_t + \mu_4 REC_t + \varepsilon_t \qquad (1)$$

In the above specification (1), the green growth (GG) is determined by the financial inclusion (FI), higher education (Education), information and communication technologies (ICT), renewable energy consumption (REC), and random error term (ϵ_t). However, Eq. (1) is a long-run model and only provides us with the long-run estimates, but we are also interested in the short-run estimates. Hence, we have redefined Eq. (1) into the error correction format is presented below:

$$\Delta GG_t = \mu_0 + \sum_{k=1}^{n} \beta_{1k} \Delta GG_{t-k} + \sum_{k=0}^{n} \beta_{2k} \Delta FI_{t-k} + \sum_{k=1}^{n} \beta_{3k} \Delta Education_{t-k} + \sum_{k=0}^{n} \beta_{4k} \Delta ICT_{t-k} + \sum_{k=1}^{n} \beta_{5k} \Delta REC_{t-k} + \mu_1 GG_{t-1} + \mu_2 FI_{t-1} + \mu_3 Education_{t-1} + \mu_4 ICT_{t-1} + \mu_5 REC_{t-1} + \lambda . ECM_{t-1} + \varepsilon_t \qquad (2)$$

Specification (2) can now be called as ARDL model of Pesaran et al. (2001), which provides us with both short and long-run estimates simultaneously. The short-run results can be derived from the coefficients that are connected to first-difference variables, and the long-run results can be interpreted from the coefficients $\mu_2 - \mu_5$ normalized on μ_1. However, in time series analysis, the long-run results are considered spurious unless we find cointegration between them. To that end, Pesaran et al. (2001) proposed a bounds F-test,

which confirms the joint significance of lagged level variables if the calculated value is greater than the tabulated value. Moreover, an alternative test is known as the error correction (ECM_{t-1}) test, which approves the cointegration if the estimate of ECM_{t-1} is negatively significant. Another advantage of this model is that we don't need to check the stationary of the variables because it can deal with I(0) and I(1) variables at the same time. Further, this model can produce efficient results in the case of small sample size (Bahmani-Oskooee et al. 2020). Last but not least, this model allows us to include the dynamic process in the short-run, which highlights feedback effect if any, and control endogeneity and multicollinearity (Ullah & Ozturk, 2020).

Data

The study is exploring the simultaneous impact of higher education, financial inclusion, and ICT on green growth in the case of China for the period 1995–2019. Descriptive statistics, symbols of variables, and definitions are provided in Table 1. The dependent variable, green growth is measured by environmentally adjusted multifactor productivity. Financial inclusion is determined by three measures such as bank branches (bank branches per 100,000 adults), Insurance (life and non-life insurance premium), and ATMs (per 100,000 adults). Higher education is determined by tertiary school enrolment. ICT index is used to measure the impact of information and communication technology. ICT index is composed of internet, mobile, and telephone, while the study has also disaggregated the impact of these measures for testing robustness of results. Renewable energy consumption role is considered as a control variable. The data have been collected from OECD, IMF, EIA, and the World Bank. However, the ICTs index is calculated by the authors.

Table 1
Descriptive statistics

Variables	Definitions	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Sources
GG	Environmentally adjusted multifactor productivity	8.913	8.654	13.13	7.103	1.275	1.705	6.307	OECD
BB	Bank branches per 100,000 adults	6.465	6.465	9.665	3.266	1.958	0.002	1.797	IMF
Insurance	Life and non-life insurance premium volume to GDP (%)	2.474	2.519	3.864	1.007	0.882	-0.058	1.917	IMF
ATMS	ATMs per 100,000 adults	31.03	13.70	91.36	1.033	32.57	0.827	2.048	IMF
HE	School enrollment, tertiary (% gross)	25.09	20.60	58.42	4.390	17.19	0.536	1.988	World bank
ICT	ICT index	33.16	30.39	74.07	0.929	25.25	0.170	1.592	Author's calculation
Internet	Individuals using the Internet (% of population)	25.49	19.30	64.56	0.005	23.45	0.314	1.507	World bank
Mobile	Mobile cellular subscriptions (per 100 people)	51.41	44.01	121.7	0.292	42.13	0.265	1.632	World bank
Telephone	Fixed telephone subscriptions (per 100 people)	16.74	17.12	27.47	3.280	7.113	-0.312	2.132	World bank
RE	Total energy consumption from nuclear, renewables, and other (quad Btu)	1.624	1.604	2.981	0.521	0.842	0.052	1.531	EIA

Results And Discussion

In Table 2, the findings of unit root tests are given. The study has opted DF-GLS unit root test and PP unit root test for retrieving the stationarity properties of the variables. The results of DF-GLS test infer that green growth, ATMs, ICT, internet, mobile, and renewable energy consumption are I(0) stationary variables and left are I(1) stationary variables. The results of PP test infer that green growth is I(0) stationary variables and rest of the variables are I(1) difference stationary variables. Thus, the ARDL approach is feasible for empirical exploration. The precondition of mixed order of integration for the ARDL approach is being fulfilled as shown by the results of both unit root tests. Table 3 reports the long-run and short-run coefficient estimates of the green growth model.

Table 2
Unit root tests

	DF-GLS			PP		
	I(0)	I(1)	Decision	I(0)	I(1)	Decision
GG	-2.635**		I(0)	-2.785*		I(0)
BB	-0.345	-6.654***	I(1)	-0.254	-12.54***	I(1)
TI	-0.612	-7.325***	I(1)	-0.788	-9.689***	I(1)
ATMS	-2.368**		I(0)	0.165	-2.752*	I(1)
HE	0.325	-2.658**	I(1)	1.654	-2.658*	I(1)
ICT	-3.021***		I(0)	0.213	-2.655*	I(1)
INTERNET	-1.687*		I(0)	0.875	-2.865*	I(1)
MOBILE	-3.654***		I(0)	1.203	-2.665*	I(1)
TELEPHONE	-0.654	-1.689*	I(1)	-1.854	-2.865*	I(1)
RE	-2.854***		I(0)	0.625	-6.254***	I(1)

Note: ***p < 0.01; **p < 0.05; *p < 0.1

The study has regressed three separate ARDL models based on three proxies for financial inclusion (i.e., bank branches, insurance, and ATMs). In model 1, long-run findings reveal that bank branches report a significant and positive effect on green growth confirming that financial inclusion plays a significant role in determining green growth. It shows that 1 percent rise in bank branches increases green growth by 1.435 percent in the long run. It is reported that financial inclusion improves green growth through the enhancement in productivity level and capital accumulation. These findings are supported by Jabbour et al. (2015) and Halkos and Polemis (2017), which noted that well-organized financial markets contribute to resource allocation for more efficient and environmental-friendly companies that lead to sustainable green growth. In literature, it is reported that financial inclusion stimulates technological spillovers and reduces environmental pollution, thus promoting green growth. Financial inclusion helps in attracting research and development that facilitates the diffusion of information and technology, which helps in the promotion of green growth in the long-run.

Higher education and renewable energy consumption are insignificantly associated with green growth in the long-run in this model. However, ICT exerts a positive influence on green growth in the long-run. It infers that 1 percent upsurge in the use of ICT leads to 1.297 percent rise in green growth in the long-run. Our findings are supported by the following studies Wu & Zhang (2020) and Jiang et al. (2021), who claiming that ICT contributes a significant role in improving the industrial revolution and enhancing sustainable green growth. It is claimed that the ICT promotes new methods for industrial productions that significantly influence the performance of workers and productivity. ICT diffusion reduces transaction costs and enhancement of technological innovation (Wang et al., 2016). Another study argues that ICT diffusion enhances the performance of transmission systems and increases energy efficiency thus improving green growth. Bastida et al.'s (2019) study denoted that ICT significantly mitigates household consumption of energy, thus helping in enhancing green growth.

In model 2, the long-run results report that insurance and green growth are positively associated reveal that an increase in insurance tends to enhance green growth. It shows that 1 percent rise in insurance leads to 1.307 percent increase in green growth in the long-run. In this model, higher education significantly and positively improves green growth in China in the long-run. It reveals that 1 percent upsurge in the level of higher education tends to intensify green growth by 0.323 percent in the long-run. Our findings display that higher education is positively connected with green growth. This finding is also supported by the study done by (Hofmann & Strietska-Ilina, 2014). It is demonstrated that higher education enhances green growth through the channel of improvement in energy efficiency in the process of production. Economic structures based on highly educated individuals have more awareness regarding the use of energy-saving products (Hao et al. 2021).

However, ICT and renewable energy consumption report insignificant impacts on green growth in the long-run. In model 3, the long-run findings demonstrate that increase in the number of ATMs tends to enhance green growth in the long-run. The coefficient estimate displays that 1 percent escalation in the number of ATMs intensifies green growth by 1.192 percent in the long-run. In this model, higher education, ICT, and renewable energy consumption report significant and positive impact on green growth in the long-run. The coefficient estimates reveal that 1 percent rise in higher education, ICT, and renewable energy consumption results in increasing green growth by 0.327 percent, 0.344 percent, and 0.222 percent in the long-run. In short, the long-run findings of all three models display that financial inclusion contributes significantly to improving the green growth in China. In a similar vein, higher education and ICT also lead to improvement in green growth in the long-run. Thus, the adoption of financial inclusion, ICT, and higher education as policy measures are highly recommended for the achievement of sustainable green growth in China in the long-run.

Table 3
Short and long-run estimates of green growth

	Model 1		Model 2		Model 3	
Variable	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**
Short-run						
BB	1.288	1.089				
TI			0.156	0.124		
TI(-1)			1.634	2.121		
TI(-2)			0.038	0.021		
ATMS					0.183***	4.133
HE	0.025	0.409	0.150	0.538	0.103	0.632
HE(-1)			0.188	0.779	0.209	1.345
HE(-2)			0.456	1.285		
ICT	0.105*	1.781	0.996**	2.383	0.137	0.569
ICT(-1)			0.238	0.432	0.697	1.535
ICT(-2)			1.586***	2.693	0.602*	1.773
RE	1.266	0.129	1.310	0.471	1.355**	1.998
RE(-1)			1.539*	1.710	1.567**	2.261
Long-run						
BB	1.435*	1.677				
TI			1.307**	2.091		
ATMs					1.192***	3.503
HE	0.204	0.521	0.323**	2.005	0.327***	2.926
ICT	1.297**	2.471	0.461	1.012	0.344**	2.329
RE	1.517	0.890	0.652	0.045	0.222**	2.077
C	2.655	1.171	6.278***	5.691	7.160***	4.237
Diagnostics						
F-test	3.754		7.456***		5.124***	
ECM(-1)*	-0.543***	-5.297	-0.480***	-10.01	-0.454***	-6.471
LM	1.365		1.654		0.325	
BP	0.589		0.754		1.258	
RESET	1.112		1.322		1.366	
CUSUM	S		S		S	
CUSUM-sq	S		S		S	

Note: ***p < 0.01; **p < 0.05; *p < 0.1

In the short-run, it is found that bank branches and insurance report insignificant impacts on green growth while ATMs produce a significant and positive impact on green growth. Similarly, higher education is unable to produce a significant effect on green

growth in the short-run as education requires some time lag to make significant structural changes. ICT and renewable energy consumption report significant and positive impacts on green growth in one regression only in the short-run. Some important diagnostic tests have been employed to diagnose the issue of autocorrelation, heteroskedasticity, stability, and correct specification of models. The findings of BP test and LM test display that there is no evidence of autocorrelation and heteroskedasticity in any model. Furthermore, the correct specification of models is confirmed through the findings of Ramsey RESET tests. For confirmation of stability, CUSUM and CUSUM-square tests have been performed which shows that models are correctly specified. In the end, long-run cointegration association is confirmed through the statistically significant findings of F-statistics and negative and significant coefficient estimates of ECM tests. The findings of robust models are also in line with the findings of actual models. Financial inclusion, higher education, and ICT produce a significant and positive effect on green growth in long-run and short-run.

Table 4
Short and long-run estimates of green growth (Robustness)

	Model 1		Model 2		Model 3	
Variable	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**
Short-run						
ATMS	0.055*	1.730	0.148***	2.632	0.188*	1.853
ATMS(-1)			0.169	1.608		
ATMS(-2)			0.132*	1.800		
HE	0.114	1.385	0.308***	3.122	0.144	1.011
HE(-1)					0.342*	1.709
INTERNET	0.245**	2.446				
MOBILE			0.172	1.033		
MOBILE(-1)			0.641**	2.131		
MOBILE(-2)			0.524**	2.163		
TELEPHONE					0.374*	1.686
TELEPHONE(-1)					0.312**	2.103
RE	1.234	1.284	1.836**	2.268	1.613**	2.245
RE(-1)	0.068**	2.253	1.298*	1.818		
Long-run						
ATMS	0.777*	1.751	0.846***	3.053	0.900**	2.271
HE	0.158	1.237	0.410***	2.731	0.519***	2.885
INTERNET	0.340***	2.643				
MOBILE			0.074*	1.860		
TELEPHONE					0.065	0.612
RE	1.494**	2.238	1.717	1.137	1.786**	2.037
C	2.114	0.996	3.185**	2.661	3.666***	11.78
Diagnostics						
F-test	4.536*		4.857*		5.578***	
ECM(-1)*	-0.619***	5.976	-0.651***	6.354	-0.638***	5.407
LM	1.564		1.325		1.587	
BP	1.521		2.033		0.365	
RESET	1.023		0.688		1.204	
CUSUM	S		S		S	
CUSUM-sq	S		S		S	

Note: ***p < 0.01; **p < 0.05; *p < 0.1

Conclusion And Policy Implications

Financial inclusion is considered a critical instrument for green growth and economic development. The role of ICT is undeniable in transmitting green growth in the economy. ICT improves green growth and economic performance through various channels. ICT generates new opportunities such as job creation, innovations, and produces spillover effects. Moreover, ICT act as an engine of green growth as it provides easy access to public services, education, and financial inclusion. Furthermore, higher education contributes significantly to technological innovation by increasing green growth. In this perspective, the present study aims to identify the simultaneous impact of financial inclusion, ICT, and higher education on green growth. The study investigates this nexus by employing the ARDL approach on time-series data for the period 1995–2020. The study ends up with the following results. It is found that all three measures of financial inclusion i.e., bank branches, ATMs, and insurance produce a significant positive effect on green growth in long-run. In a similar vein, ICT and higher education tend to intensify green growth in China in the long-run. In the short-run, it is found that ICT, higher education, and financial inclusion significantly improve green growth in China. The impact of internet, mobile, and telephone is reported significant and positive on green growth in the long-run and short-run in robust models. In the case of control variables, it is found that renewable energy consumption produces a significant positive impact on green growth in China in the long-run and short-run.

Based on these findings, the study provides the following policy measures. The positive impact of financial inclusion, ICT, and higher education on green growth may confirm the belief of decision-making authorities in China on the promotion of these determinants for green growth. It is suggested that the decision-making authorities in China should efficiently manage financial institutions for the production of green and eco-friendly products. To achieve the task of green growth, the Chinese government should promote education and ICT-based infrastructure that plays a significant role in influencing the pattern of energy consumption and behavior of consumers. Chinese governments should promote investment in renewable energy sectors to obtain green growth. Moreover, the government should invest in education to improve the worth of human capital. Despite fruitful implications, the current study observed several limitations. Green credit should be included in the model but the proper data is not available in China. In future studies, the impact of economic policy uncertainty should be explored on digital financial inclusion for China and other developing economies. The current study can be replicated for other regions and economies. Future studies can explore the asymmetric effects of financial inclusion, human development, and ICT on green growth.

Declarations

Ethical Approval: Not applicable

Consent to Participate: I am free to contact any of the people involved in the research to seek further clarification and information

Consent to Publish: Not applicable

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