An Analysis Framework to Study the Effects of Green Finance on Sustainable Smart Cities

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Abstract

Despite the fact that many countries around the world have adopted green growth as their strategy for economic development and those studies have investigated the factors that influence green growth from a variety of perspectives in sustainable smart cities, there is a paucity of literature that focuses on the impact that fintech and green finance have on green growth. This study attempts to design a complete index to assess the green growth of regional economies from the point of view of the development of fintech. The index will be based on an in-depth examination of the effect mechanism that green finance has on green growth. Additional study reveals that innovations in fintech mostly foster green economic development by means of green lending and green investment. As a result, advancements in fintech have the potential to foster green productivity expansion by elevating the development degree of green finance. This is a field that has a great deal of reference importance for most nations. The development of financial technology has the opposite effect on the building of sustainable smart cities. This is mostly because both the development and commoditization of fintech need more resources, and these resources also come at a greater price.

Keywords: Financial; Sustainability; Green Financial; Financial Technology; FinTech; Smart City

1. Introduction

Fintech, shorthand for "financial technology," refers to the use of computer systems and other mechanisms to enhance traditional financial services. The primary ways in which it aids businesses, particularly banks, in gaining an edge over the competition are via reduced expenses and enhanced productivity. Fintech is rapidly becoming to be one of the most significant financial sector developments in recent history. By reducing costs, raising service standards, and diversifying and stabilising financial markets, fintech has the potential to radically alter the financial services sector. In addition, the Covid 19 epidemic has been ongoing since the start of 2020, causing economic and psychological disruption across a variety of industries. Therefore, there was a dramatic surge in the use of technology and creativity to address the problems brought on by the many preventative measures implemented by governments, such as municipal and/or nationwide lockdowns. Applications in the field of financial technology have recently emerged to speed up a variety of activities in the workplace and beyond. Businesses can be bolstered and enormous data can be processed into relevant information; it's ubiquitous, cheaper, and safer than traditional techniques; and these are just a few of the many benefits it offers[1]–[3]. Furthermore, Fintech removes the need for the middlemen normally involved in the provision of financial services. It's not only the financial services industry that's struggling with high operating expenses; it's every industry. In the time since Europe's shutdown began, the number of people using Fintech apps has surged by 72%. This

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investigation was driven by the current worldwide trends and the requirement for more timely and cheaply available financial services[4]–[6].

The international banking industry has been playing an increasingly crucial role in recent years due to emerging worldwide patterns in international commerce. Financial institutions have difficulty in identifying promising Fintech investments that will boost their competitiveness and allow them to meet the needs of new clients in a variety of markets. One of the most fundamental causes for increased competitiveness in the European financial sector is Europe's key position in terms of worldwide commerce. European financial institutions are stepping up their focus on R&D, customer service, product innovation, and internal efficiencies in order to meet this issue head-on[7]–[10].

There is an urgent need for proactive green finance strategies since the financial limitations that developing nations confront raise the risk of poor environmental performance. When it comes to green finance systems, it is up to authorities in emerging economies to create and enact legislation. Green bonds and other sustainable financing vehicles are increasingly being used to back environmental initiatives. Green bonds are a kind of bond that is issued specifically to finance green initiatives. These bonds often come with several tax benefits in order to encourage adoption and decrease the green finance gap.

Emerging economies now prioritise green financing as a policy priority. The business sector is urged to take a more active part in sustainable development according to a proposal included to establish a green finance system. Sustainable bonds are popular with investors because of their ability to boost the value of their companies over time. China is making green finance a priority, but there are still many obstacles to overcome at the macro, meso, and micro levels[11]–[13].

Green Finance is showing promising outcomes, even though more coordination among regulators and key players is still needed. Clean energy spending reduces carbon dioxide (CO2) output. Without substantial investments in human capital and technology innovation, green finance will not be enough to ensure the success of environmental protection programmes. When it comes to achieving the Paris Agreement's climate change goals, "green finance" is widely regarded as a key factor. Developing nations with stable political environments and substantially high levels of credit risk are the primary beneficiaries of pioneering efforts in green finance around the world.

The success of green finance projects is complicated by multiple sources of risk. For instance, there are substantial dangers for banks associated with carbon financing. The long-term success of green finance organization relies on banks' ability to protect themselves from potential losses. Green finance has a negative impact on the short-term achievement of heavily polluting firms, despite the fact that it decreases emission levels markedly over the long-term.

2. Financial Growth

Fintech, in its core, is a kind of technical development and innovation resulting from the natural merging of the financial sector with the information technology sector. Fintech's effect on the economy may be seen most clearly in its contribution to sustainable development. Therefore, fintech's effect on sustainable development is one of a kind. Bernanke and Gertler's "financial accelerator hypothesis" states that when a company is favourably or badly impacted in the business, its net worth will grow or decrease, as well as the debt market will amplify the effect on the economy and the surroundings. Financial institutions will be better able to filter borrower information due to the advances, which will in turn reduce economic swings caused by financial resistance arising from information inequality[14]–[16]. Some researchers argue that technical development is the key to ending the "resource curse," enhancing environmental quality, and achieving sustained economic growth. There is a strong link among resource usage, ecological harm,

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and economic growth, and these elements all stem from developments in finance and technology[9], [17], [18]. Historically, China's green growth has fluctuated from year to year; this pattern is exacerbated by the country's rapid economic and technical progress. Researchers have discovered that while larger financial organizations and a more robust stock market would undoubtedly lead to more erratic green growth, the synergy among financial progress and technology advancement may greatly dampen such instability. Positive effects on the natural environment, efficiency, and economical system are all highlighted in the report as ways in which green financing fosters high-quality job expansion. Therefore, advancements in fintech rely heavily on developments in areas such as big data, AI, cloud computing, blockchain, and similar technologies. The optimization of industry structure, enhancement of resource allocation efficiency, reduction of financial friction, and enhancement of the natural systems are all ways in which innovations in financial technology and scientific research contribute to green economy[19]–[21].

3. Sustainable Smart City

Green finance, or ecological finance as it is more often called in international academic circles, is a method of developing green the financial sector in order to address environmental concerns and advance sustainable growth. There are both positive and undesirable externalities that might result from addressing ecological concerns from a purely economic perspective. External costs, Coase's theorem, government action, and the Pareto principle are all related ideas. In addition to having positive internal impacts, the growth of green finance will have positive external benefits in the areas of environmental preservation, energy conservation, reducing emissions, and economic development. However, the greater costs incurred by financial institutions as a natural result of positive external effects make it very difficult to achieve Pareto optimum asset mix, and the financial industry is not incentivized to apply green finance[22]–[24]. Figure 1 shows the sustainability of smart city.

Figure1: Sustainability of smart cities.

What is meant by "green finance," or sustainable financial management, is that it serves as a liaison among the two sectors of the economy, the financial sector and the environmental sector. Market research informs green finance, a financial technique used to enhance quality of the environment and share the associated risks. To that purpose, green finance sector have quickly become the dominant paradigm in the field of economic growth. Although the idea of "green finance" is well-known, its sluggish growth is due in part to the absence of a comprehensive assessment mechanism. In order to examine the operational performance issues of banking green service channels, several academics have built assessment index systems, using genuine data from reputable financial institutions. They devised a five-factor index rating system based on the results of an examination and examination of their strategic plan and its individual components. A number of studies show

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that the credit risk caused by loans is reduced despite the increased expense of following the "equatorial principle."[10], [25], [26]

There are two main schools of thought when it comes to what constitutes "green finance" throughout the world. The first school of thought defines "green finance" as "investment," which entails the funding of projects with the goal of enhancing environmental quality. A key concept in this view is the need to "fill in the investment gap". Changes in ecological costs, risk coefficients, and the yields and returns from doing business are all examples of environmental elements that may be directly included into the area of financial investing. Green finance is said to have emerged due to the interdependence of the financial sector and environmental protection [5]. Green finance takes ecological considerations into account in a variety of financial services. This includes, but is not limited to, bank funding and reception choices, post-loan monitoring, and involvement in environmental evaluation during risk mitigation. The aforementioned pair of classes is both distinct and interconnected[27], [28].

Over time, academics from other countries have also commented on a number of problems with green finance's evolution. In addition, the total capital income is not lower than that of other index funds, and it actually increases with the length of the stock market.

Despite the widespread interest in the emerging field of "fintech," no one, comprehensive definition has emerged. Nonetheless, the word "fintech" first appeared in the appropriate Citibank study in 1993. Efforts to bring technology into the financial industry got off to a slow start, but they've picked up steam thanks to the growing sophistication of online banking and the ongoing improvement of financial sector reform. It's safe to say that fintech is already deeply embedded in people's daily lives, even though most people aren't aware of it. The Board on Financial Stability (FSB) defines fintech as "technology innovation that has the potential to profoundly alter financial markets, organisations, and services," which is achieved primarily via novel economic models, application techniques, process methodologies, and product kinds.

Fintech's meaning has been fleshed out via years of study. Most academics agree that fintech is a term for any technology approach that has the potential to revolutionise the financial services sector. They see fintech as a new sector that will boost the standard of banking and finance via technological advancements. The scientific and technological sector is a potentially disruptive sector of the economy. To accomplish change in the current economic paradigm, it relies heavily on digital and information technologies [7, 8]. Fintech, in a nutshell, is the term used to describe the financial sector's embrace of technological advancements. Financial business processes have shifted due to the increased tech assistance provided by big data, blockchain, ai, and cloud computing. Furthermore, modern business models are a threat to traditional economics. As a result of fintech's ability to increase financial efficiency and decrease risk, it has stoked the flames of many sectors related to the financial sector. However, fintech is more complicated than just the combination of these two terms. Traditional financial services are being continuously promoted through the transformation and upgradation of innovative technologies and financial sectors.

The concept of a "smart city" was developed from the "Smart Earth" initiative. In 2008, IBM presented its "Smart Earth: Next Generation Managerial Agenda" report to the public in New York. The report's "Smart Earth" concept encompasses the integration of the Internet of IoT The use of supercomputers and cloud technology to incorporate the Internet of Things, and the widespread deployment of embedded sensors in hospitals, electrical grids, railroads, bridges, tunnels, major roads, houses, and other artefacts around the world.

There is no agreed-upon definition of "smart city" because its development lacks a discrete methodology. When first imagining a "smart city," it's important to keep in mind the business operations, strategic planning, and trying to plan efficiency of automation and robotics solutions in areas like energy, transportation, infrastructural facilities, distribution and requires to function, economic growth, and service provision. A clearer and more workable concept of a "smart city" is progressively being developed with the growing trend of "smart" urbanisation. To encourage long-term economic development, improved quality of life, and responsible resource management, it is important to put money into social capital as well as old and new communication networks. Put an emphasis on the importance of computer systems. Consider smart cities as a means of enhancing production, ultimately leading to the city's success and the good of its residents. Scholars have

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started to define "smart cities" from an online perspective. They see smart cities as a sophisticated system with competing goals. More and more international researchers are incorporating the idea of smart cities, with their emphasis on technological solutions to environmental problems, into their work on sustainable development.

Assessing the effectiveness of smart cities is a topic that has also been studied by academics. Evaluation job on smart cities was conducted in a variety of countries [18] using a wide range of criteria, including the construction of inventive cities, geographical green cities, standard of living, digital government, and so on, all with the aim of fostering the smart cities' long-term growth and prosperity. In subsequent years, academics have conducted empirical research, proposed models for trying to measure smart city achievement, and carried out assessments of smart city effectiveness.

To encourage the upgrade and transformation of finance, and as a significant force in advancing green finance, fintech is founded on "science and technology". This research analyses the significant role played by green finances and financial technologies in the development of smart cities and investigates the influence of financing on this front from the standpoint of innovation.

3. Suitability and Green Financial

Technology advancements that aim to save power while decreasing waste, environmental damage, air pollution, and power usage are what make up GI . In today's business world, GIis essential for reducing the negative impacts of climate change. Additionally, GI may be characterised in this research as going green, electronic transfers, internet payments, green and sustainable strategy, and ecological marketing strategy, all of which assist banks lessen their impact on the environment, both locally and globally. Studies have shown that green innovation greatly improves results in sustainability. Adegbile et al. claim that a company's environmental management style is tied to its level of GI, which in turn enhances environmental performance. In addition, studies have shown that GI dramatically lessens a company's negative environmental influence while simultaneously enhancing organisational financial performance via cost and waste reduction. There is a favourable correlation among GI and organisational performance, particularly sustainable practices, as shown by Wang et al. Kraus et al. found the same thing, that GI affects air quality. Notwithstanding, Edeh et al. found that technical innovation greatly boosted export performance. There have been a number of research done on GI and EP, however the findings have been mixed so far. Thus, the goal of this research is to provide empirical support for the hypothesis that GI is really correlated with SP in the financial services sector.

4. Methodology

Given that 2013 is often referred to be the "first day of Fintech industry," it is the starting year for the time-series data used in this article. This paper used 7 years of data (from 2013 to 2019) to analyse the relationship among sustainable finance, technology, and smart cities. This allows the reader to more confidently depend on the most recent data available. Indexes are used to compile the information. 7 distinct metrics are used to measure green finance: green loans, municipal bonds, green innovation funds, green reinsurance, green equities, green investing, and carbon financial management. The city ranking takes into account technological advancements, economic growth, social progress, and ecological sustainability. Figure 2 shows the framework of this study.

Figure 2: The framework and algorithms of this study

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Time series data were utilised for both the unrelated and variate, therefore the following is how a typical linear regression model would be set up to analyse this data:

$$R_t = C + \sum_{i=1}^{k} BX_{it} + w$$
(1)

In order to directly estimate the LDL set of parameters, it is necessary to have more data samples than are available in the real data. The RDL model is therefore used in this study, using the following expression:

$$R_t = C + \frac{e(Q)H^q}{(Q)} X_t + w = C + \frac{e0+e(Q)H^1+\cdots\ldots e(Q)H^q}{1-Q-B^2-\cdots\ldots\ldots-sQ^s} X_t + w$$
(2)

By combining multiple 10 epochs technicians, the RDL model is able to describe subtler shifts in power spectrum weight training, which improves its ability to fit the data. Here, is employed to portray the dead time (the lag before an independent variable begins to have an effect on a dependent variable), represents the Decomposition Pattern, and needs to reflect the exclusion of the auto - correlation weight.

Model discovery, statistical inference, and modeling diagnosis are the three main tenets of the Box-Jenkins dynamic model building technique, which will be used in this study. When the Crate dynamic model generation technique is initiated, the essential preprocessing activities are done in sequence on the raw data to facilitate the future modelling process.
First, transform the sequences of the variables of the study into stable sequences by asymmetrical processing.
(2) Design of its products the sequence of predictor factors to produce the perturbations sequencing of the moving average (arma model (ARMA model) of the sequences of predictor factors, which is a fair skinned process.

Perform a Ljung-Box community test on the specified number of lagged terms and compute the bridge function (CCF) of something like the sequences and. Justify the initial lags in the predictor variables succession if the null hypothesis is dismissed. It is recommended that this independent variable be included in the RDL model since at least a single of the terms shows a strong nonzero relation to the dependent variable. Figure 3 shows the flowchart of this methodology.

The ARMA model is computed as:

$$\alpha = C + \frac{\varphi(Q)}{\theta(Q)} X_t$$
(3)

$$\beta = C + \frac{\varphi(Q)}{\theta(Q)} R_t$$
(4)

The ARIMA model can be computed by the following equation:

$$\varepsilon = \frac{\theta(Q)\vartheta(Q)}{\varphi(Q)\sigma(Q)} \nabla\alpha$$
(5)

The LTF model is computed as

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$$R_t = C + v_0 X_t + v_1 X_t + v_2 X_t \ldots\ldots\ldots v_k X_t + \frac{1}{(1-Q_s)(1-Q_1)}\alpha$$

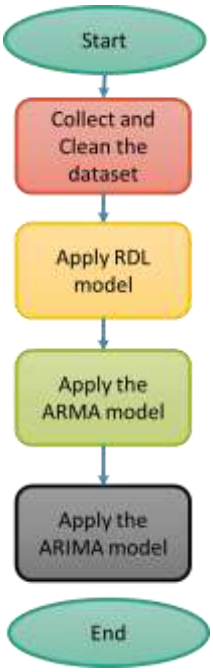

Figure 3: The flowchart of this paper.

4.1 The EDAS Method

The fields of management decision-making and MAGDM are currently active and exciting research areas. MADM and MAGDM have been the subject of a great deal of study. The EDAS approach is one of the simplest and easiest to implement. In this strategy, we evaluate the alternatives by measuring how far they are from the reference point, both positively and negatively. Finally, the positive distance plus negative distance score is developed as the instrument to assess the benefits and drawbacks of options. Using the EDAS model, Tian et al. evaluated the effectiveness of their suppliers. Traditional EDAS technique and indicated unique possibility degree were created by Liu and Zhang based on extended hesitant fuzzy linguistic word environment. Interval-valued neutrosophic EDAS model was created by Li et al.

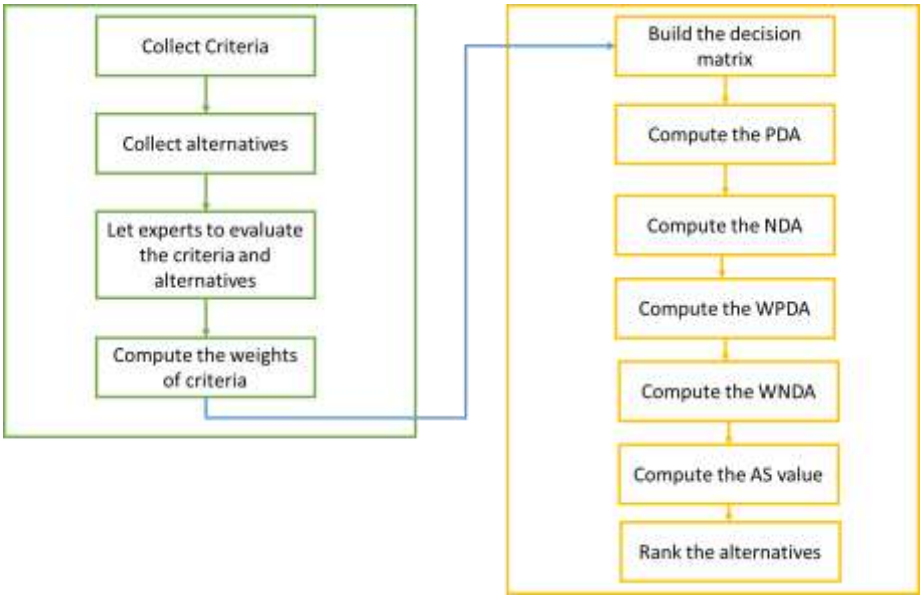

Figure 4: The steps of the EDAS method.

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To address this deficiency, this research recommends establishing an EDAS model as a more efficient and user-friendly MAGDM approach to assisting decision-makers in selecting a reasonable and reliable optimum choice as quickly as feasible in an increasingly complicated environment of uncertainty. Figure 4 shows the steps of the EDAS method.

5. Outcomes and Discussion

The RDL model's parameters are calculated using the optimal likelihood estimation approach based on the values given in the feature recognition phase. Figure 5 displays the obtained outcomes.

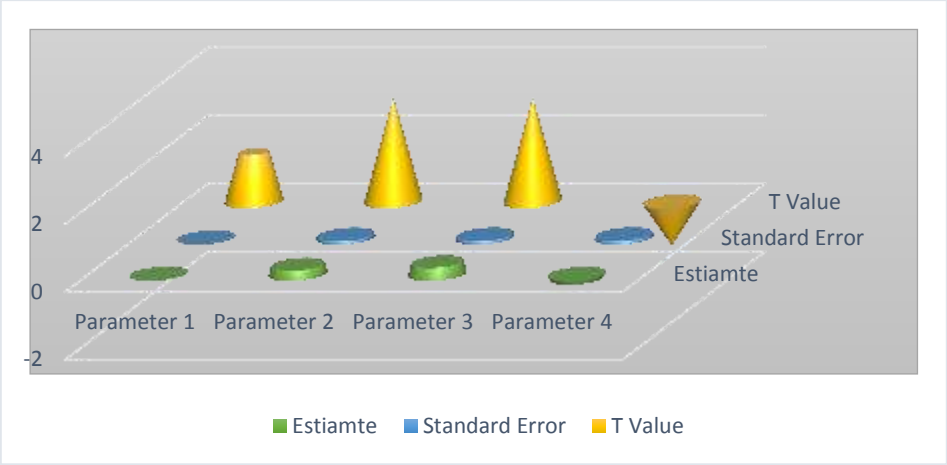

Figure 5: Results of the green financial RDL.

Based on the data in figure 5, it seems that neither the seasonal component of the error terms nor the molecule quadratic parameter of the predictor variables component of RDL are statistically meaningful. Figure 5 displays the predicted outcomes of the updated RDL model. This shows that all of the parameters are statistically significant.

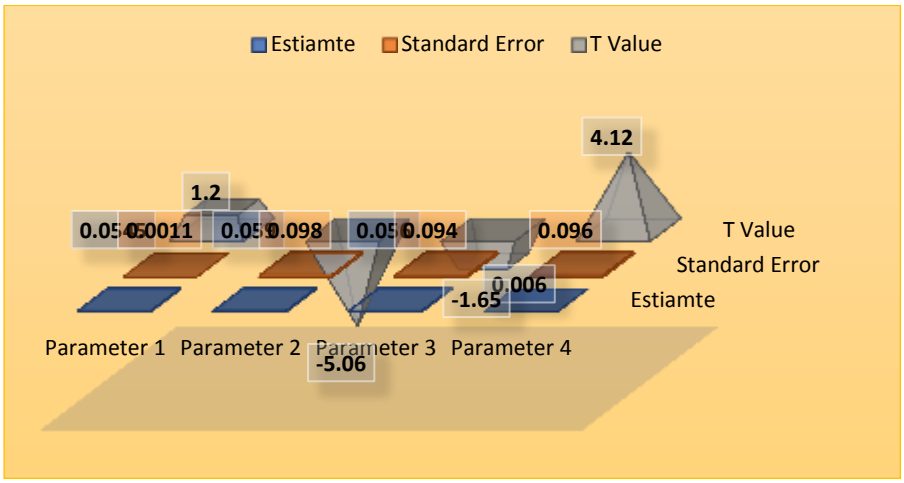

Figure 6: Results of fintech RDL model.

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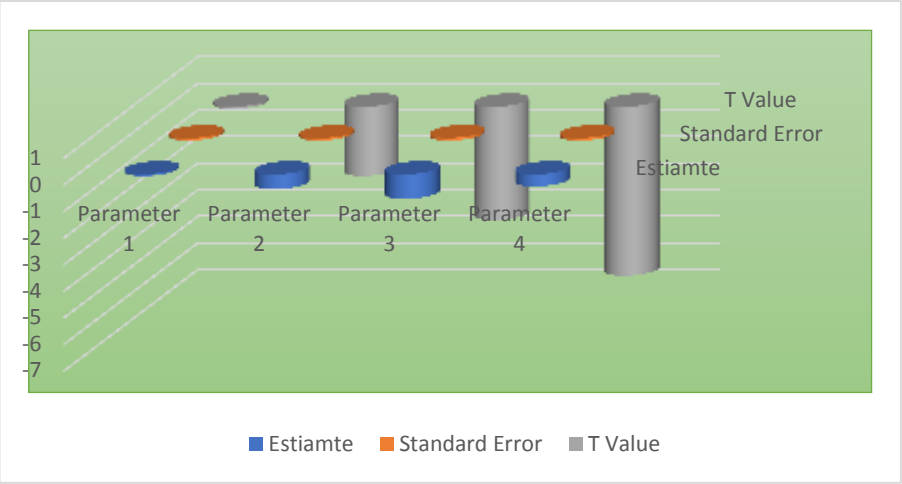

Figure 7: The results of ARIMA model.

Figures 6, 7 show the results of this work. Based on the findings of the model's estimate and diagnosis, we can infer that green financing has a very favourable effect on the development of smart cities, and that this effect will become fully manifest nine months later. Negative effects on smart cities from fintech are severe and appear 14 months after fintech's introduction. Results from the modeling diagnostic reveal that the particles of the Curatorial models and the ARIMA model developed in this work have similar variables. It's possible that the findings of their unique parameter estimate will fluctuate due to the impact of shared factors. Table 1 shows the results of ARIMA method.

Table 1: The results of ARIMA method.

Parameter	Estimate	Standard Error	T Value
Parameter 1	-0.064	0.086	-0.08
Parameter 2	-0.56	0.082	-2.6
Parameter 3	-0.925	0.096	-4.26
Parameter 4	-0.454	0.091	-6.35

The first is to modernise the financial sector by fostering the growth of new types of finance such computer banks, technological microcredit firms, and financial leasing businesses. Expand diverse financing channels on the premise of adhering to the law of technology advancement advancement and use mechanism advancement as a key driver to bolster internal rewards. Ensure that evaluations are fair and unbiased, and work to strengthen safeguards like insurance and compensation in the event of an accident. The other is to advance high-yield connection and capital bond financing techniques and promote exhaustively the financing and repayment of intellectual property pledges by innovating financial products and making efficient use of differential appetite for risk to endorse science and technology credit. The emergence of novel finance strategies: fourthly, concentrating on the career advancement of E banking digitalization, cultivating "Internet thoughts," and actively encouraging "networks" "Process" model; developing Online banking, maximum service systems, digital payment, online going to revolve loans, and fifthly, breaking the traditional service prototype of financial intermediation, economic team and equity, and angel investors investment and borrowing linkage.

Green finance growth centres on banks and other financial institutions. The genuine need for green finance just on market necessitates those financial institutions increase their consciousness of sustainability and social preservation and carry out focused green finance marketing and education for company employees. The balance between corporate social responsibility and individual gain is a factor that must be considered while making business choices. Every action we do should further environmental and social sustainability. All operations are guided by a strict sense of social responsibility to safeguard the environment. Green finance development should always be a priority for the financial sector. When promoting the growth of sustainable banking as a lengthy strategy for

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operations, banking firms need to embrace a unified and logical perspective of the social duty and self-realized advantages of firms. The government should try to spread the word about green finance, share its plans for expanding this sector, and outline the ways in which citizens' daily life and place of employment stand to benefit from this shift. This paves the way for businesses to take an active role in furthering the growth of green finance.

5.1 The EDAS Results

Researchers and policymakers have increasingly turned their attention to green finance, or the incorporation of environmentally conscious ideas into financial system development. Project investment and financing, project operation, risk management, and so on are all examples of the types of green financial services that contribute to environmental improvement, climate change adaptation, and resource efficiency. Many businesses committed to the idea of green environmental preservation have been baffled by funding challenges. For this reason, developing a reliable assessment model to aid financial institutions in choosing suitable green businesses to provide green credit to has become a pressing concern in the field of green finance. It is the responsibility of a bank to assess the environmental impact and creditworthiness of five different businesses. We used four criteria and five alternatives. We compute the weights of criteria. The c1 is the best criteria and c3 is the worst criteria. Table 2 shows the weights of criteria. Build the decision matrix. Then compute the values of PDA and NDA for positive and negative criteria in table 3,4. Then compute the rank of alternatives in table 5. Alternative 4 is the best alternative and alternative 5 is the worst alternative.

Table 2: The weights of criteria.

Criteria	Weights
C1	0.36
C2	0.3
C3	0.15
C4	0.19

Table 3: The PDA Values.

	C1	C2	C3	C4
A1	0	0	0.428571	0.551724
A2	0.090909	0.363636	0.071429	0.37931
A3	0	0	0	0
A4	0.090909	0.212121	0.607143	0.37931
A5	0.090909	0.060606	0	0

Table 4:The NDA Values.

	C1	C2	C3	C4
A1	0.060606	0.090909	0	0
A2	0	0	0	0
A3	0.212121	0.545455	0.642857	0.655172
A4	0	0	0	0
A5	0	0	0.464286	0.655172

Table 5. The Rank of alternatives.

Alternatives	Values
A1	0.273232
A2	0.311946
A3	0.360087
A4	0.360422

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A5	0.222368

6. Conclusion

This research employs a random effect model to show the connection between green financing, financial technology, and smart city building from 2013 to 2019. The following inferences may be made: First, smart city building, and green credit are encouraged by green financing. There will be a nine-month lag before we can see the impact of green financial indicators like green bonds, green innovation funds, green reinsurance, green stocks, green investing, and carbon financing on the growth of smart cities. Simulations have shown that the nectar lake financing index has a negative impact on the development of smart cities. This is mostly because of the prohibitive financial burden associated with fintech study, commercialization, and profitability, which in turn slows the development of smart cities. There will be noticeable results after 14 months. In this study, the effect method of fintech current and relevant on sustainable technology is examined, and the broader development index that accords. The findings demonstrate that (1) green growth is aided by fintech solutions because it fosters the expansion of sustainable finance via green credit, green investment, and other methods. If (2) is true, then the degree of innovation in financial scientific and technological may greatly enhance green economic development.

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