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Presenting a Model of the Relationship between Green Finance, Fintech, and Economic Development in Iran

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Abstract

In this study, we aim to present a model of how green finance, fintech, and economic development are related in Iran. To this end, using the Principal Component Analysis (PCA) model in the first section, the green finance index was calculated, and in the second section, utilizing the Markov-Switching regime change model (MS), the effect of the studied variables was analyzed on an annual basis over the period from 1996 to 2022. Based on the weights obtained for the green finance index, the share of renewable energies has the most significant impact on the composite index of green finance. Following that, energy efficiency and real GDP per capita have the next highest impacts. According to the estimated results of the model, during periods of economic boom, for each unit increase in green finance, fintech, employment, education, and capital, the country's economic development increases by 21, 7, 17, 19, and 14 units, respectively. Green finance can affect the economic development index through various factors, such as the faster adoption of advanced technologies from developed countries, increased benefits from research and development programs, achieving larger economies of scale, reducing price deviations and fluctuations, and thus, more efficient use of domestic resources across sectors, and faster supply of new goods and services. The increase in economic development, accompanied by a rise in GDP, will lead to higher production and exports, which, while requiring an increase in green finance, also influences economic development. Therefore, attention to the issue of maintaining economic development stability in the country should be among the issues that are prioritized by officials and government authorities above all else.

Keywords: Green finance, fintech, economic development, recession and boom, Markov-Switching regime change model

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1. Introduction

In recent years, the convergence of financial technology (fintech) and green finance has emerged as a critical driving force behind sustainable economic development. The potential of fintech to enhance the efficiency, accessibility, and inclusivity of financial services is well-documented, but its intersection with green finance, particularly in fostering environmentally sustainable projects, represents a relatively nascent area of inquiry (Bayram et al., 2022).

Fintech plays a vital role in reshaping financial landscapes by making financial services more accessible, affordable, and efficient (Chatterjee, 2023). Particularly in emerging economies, fintech is regarded as a tool to democratize access to credit, savings, and investments. As Aziz (2024) highlights, peer-to-peer (P2P) lending platforms are transforming traditional banking systems by allowing startups and SMEs, especially in agriculture, to access much-needed capital. This is not only essential for economic growth but also critical for reducing poverty and boosting productivity. The integration of fintech into traditional finance systems, such as microfinance and digital payments, has transformed how businesses operate and grow, particularly in sectors that have traditionally been underserved, like agriculture (Atikah, 2023; Aziz, 2024).

In line with this, the role of fintech in promoting sustainability has attracted increasing attention, particularly in developing economies where access to financial resources is often constrained by traditional financial systems (Guo et al., 2023). The application of fintech can help address the barriers that prevent efficient and equitable allocation of resources, which is crucial for sustainable development. A growing body of literature supports the argument that fintech can directly contribute to green finance initiatives by facilitating the flow of capital into environmentally sustainable projects (Chen et al., 2021; Jiang et al., 2020). As Liu et al. (2023) suggest, fintech innovations, particularly in green credit, can lower the cost of financing for renewable energy projects, reduce carbon emissions, and support the development of sustainable infrastructure.

The combination of fintech and green finance offers a dual benefit of economic growth and environmental protection. The increasing focus on sustainable development goals (SDGs) has made green finance a key tool for fostering an economy that balances economic progress with environmental responsibility. As noted by Li et al. (2022), green finance initiatives that integrate fintech solutions can not only promote technological innovation but also support the transition to a low-carbon economy. This is particularly relevant in the context of Iran, where the need to diversify the economy away from oil dependence and embrace renewable energy sources is critical for long-term economic stability and growth (Farahani et al., 2022). The adoption of green finance, supported by fintech, can enable Iran to achieve its sustainability targets while fostering economic resilience.

In terms of economic development, the potential of fintech to improve access to credit and investment opportunities is profound. As Dahi (2024) observes, fintech has a significant role in empowering SMEs, particularly in underdeveloped regions where traditional banking services are scarce. The use of digital platforms to facilitate financial transactions, including lending, investments, and savings, has made financial services more inclusive. This is especially important for countries like Iran, where economic sanctions and banking restrictions have often limited access to international capital markets. Through fintech, Iran has the opportunity to bypass these constraints and create a more robust financial infrastructure that can support both domestic and international investments in green projects (Kazachenok et al., 2023).

Moreover, green finance is pivotal in addressing environmental challenges, particularly in sectors such as energy, transportation, and manufacturing, which are significant contributors to carbon emissions. Gong (2024) provides empirical evidence from China, demonstrating how green finance can improve green total factor productivity in sectors like forestry. In the case of Iran, the transition to a green economy necessitates large-scale investments in renewable energy sources and the modernization of existing infrastructure to reduce carbon emissions. Fintech can streamline this process by providing innovative financing solutions, such as blockchain-based platforms and smart contracts, which can improve transparency, reduce transaction costs, and increase the efficiency of green investments (Puschmann, 2024).

One of the most compelling advantages of integrating fintech into green finance is its ability to foster financial inclusion. Digital financial services can significantly lower the barriers to entry for small and medium-sized enterprises (SMEs) and individuals who have traditionally been excluded from the financial system (Dahi, 2024; Saha, 2024). In rural areas, where access to banking services is limited, fintech platforms provide a way to reach underserved populations, offering them the tools they need to participate in the economy and invest in sustainable projects. This is crucial for achieving economic development goals, as it ensures that all segments of society can contribute to and benefit from the country's economic growth (Nor et al., 2021; Nuryitmawan, 2023).

At the macroeconomic level, fintech and green finance contribute to the stability of the financial system by mitigating the risks associated with climate change and environmental degradation. As noted by Zhang et al. (2023), the integration of green finance into the financial system can reduce systemic risks by encouraging investment in sustainable sectors and discouraging investment in industries that contribute to environmental harm. The ability of fintech to process large amounts of data in real-time makes it an invaluable tool for assessing the risks associated with green investments, such as those posed by climate change or regulatory shifts (Guo, 2023). This capability is critical for countries like Iran, which are vulnerable to environmental and economic shocks.

Fintech also plays a crucial role in addressing the financing gaps that exist in the green economy. Traditional financial institutions often struggle to assess the risks associated with green projects, particularly in emerging markets where the regulatory environment may be uncertain, and data availability is limited. By leveraging big data, machine learning, and blockchain technologies, fintech can provide more accurate risk assessments and credit scoring for green investments (Langley & Rodima-Taylor, 2022). This can help bridge the gap between investors and projects, facilitating the flow of capital into sectors that are crucial for sustainable development (Pawłowska et al., 2022).

The growing role of fintech in green finance also aligns with global efforts to achieve the SDGs. Fintech's ability to increase financial inclusion, promote sustainable investments, and reduce transaction costs makes it a valuable tool for countries striving to meet their sustainability targets (Wang et al., 2022). In particular, the application of fintech in renewable energy financing is critical for reducing the carbon footprint of developing economies and ensuring that economic growth does not come at the expense of environmental sustainability (Zheng & Ye, 2022). The case of China, as highlighted by Du et al. (2022), demonstrates how fintech can support corporate environmental, social, and governance (ESG) performance, which is increasingly recognized as a key factor in long-term economic stability and growth.

In conclusion, the intersection of fintech and green finance presents a promising pathway for sustainable economic development, particularly in emerging markets like Iran. The ability of fintech to enhance financial inclusion, promote innovation, and streamline the flow of capital into green projects makes it an indispensable tool for achieving economic growth while safeguarding the environment. As countries around the world continue to grapple with the challenges of climate change and environmental degradation, the integration of fintech into green finance will become increasingly critical for building resilient and sustainable economies. By leveraging the potential of fintech, Iran can accelerate its transition to a green economy, ensuring that economic growth is both inclusive and sustainable. The objective of this study is to investigate the relationship between green finance, fintech, and economic development in Iran, using a comprehensive model to assess how these factors contribute to sustainable economic growth. The study aims to provide a quantitative analysis of the impact of green finance and fintech on economic development, focusing on periods of economic boom and recession, and how these variables interact over time.

Methodology

In the first stage, the variables reflecting the green finance index are calculated using Principal Component Analysis (PCA). An important issue in aggregating the indices is the application of an appropriate weighting method. However, considering the research literature and the conditions of Iran's economy, it appears that these different sectors do not carry equal weights in creating green finance in Iran's economy. Therefore, it is necessary to employ a variable weighting method. In various studies, including Stoney et al. (2018), Aboura and Van Roy (2017), and Semler and Chen (2018), the method of cyclical regression has generally been used. In this method, the cyclical component of each variable that is used in constructing the composite index is first regressed with the cyclical component of a reference variable (such as production growth) for which the composite index is constructed to explain. The correlation coefficient obtained is then used as the weighting criterion for the composite index in green finance, based on Equation (1):

$$(1)\ W_k = \frac{r_k^2}{\sum_{k=1}^{n} r_k^2}$$

Accordingly, in this study, to obtain the overall green finance index, after calculating the green finance index in various sectors, including real per capita GDP, energy efficiency, carbon efficiency, carbon emission coefficient, and the share of renewable energy, the cyclical component of variables in each sector is regressed with the cyclical component of production growth. The resulting correlation coefficient, based on formula (1), is the basis for calculating the different weights in the overall green finance index for the economy. Therefore, after calculating the green finance index, its effects on economic development will be examined using the Markov-Switching regime change model.

$$(2)\quad (٢)\ SD_{i,t} = \begin{cases} \alpha_0 + \beta_1 SD_{i,t} + \beta_2 GreenGDP_{i,t} + \beta_3 FINTECH_{i,t} + \beta_4 L_{i,t} + \beta_5 EDU_{i,t} + \beta_6 CAP_{i,t} + u_t & S_i = 1 \\ \gamma_0 + \theta_1 SD_{i,t} + \theta_2 GreenGDP_{i,t} + \theta_3 FINTECH_{i,t} + \theta_4 L_{i,t} + \theta_5 EDU_{i,t} + \theta_6 CAP_{i,t} + u_t & S_I = 2 \end{cases}$$

Various studies use different indices to indicate the level of sustainable development (SD) of countries. In this study, the sustainable development index provided by the World Bank, which offers the latest and most comprehensive information on global development, is used. This index measures a country's success in dimensions such as poverty, health, hunger, global warming, gender inequality, water scarcity, energy, and environmental degradation and is ranked on a scale of 0 to 1. A higher score indicates countries with high levels of economic development, while a lower score indicates countries with less economic development (World Bank, 2020).

GREENgdp: Green finance, calculated by obtaining the green finance index in various sectors, including real per capita GDP, energy efficiency, carbon efficiency, carbon emission coefficient, and the share of renewable energy. The cyclical component of variables in each sector is regressed with the cyclical component of production growth, and the resulting correlation coefficient, based on formula (1), is used as the basis for calculating the different weights in the overall green finance index for the economy.

Fintech: Following the study by Sedigho et al. (2020), fintech is measured as the ratio of transaction values through the internet and mobile for online purchases and bill payments to GDP.

Labor: Employment rate.

EDU: High school enrollment as a percentage of the total population, representing human capital. Human capital refers to the stock of skills, knowledge, and social and personal characteristics, including creativity, that enable individuals to perform tasks that create economic value. It is a comprehensive economic view of active individuals in the economy, capturing economic interactions or explicit exchanges. In most studies, literacy rates are used as an indicator of human capital.

CAP: Physical fixed capital, referring to the stock of physical capital, measured as the total capital goods such as factories, machinery, etc. When converted and aggregated using a common unit of measurement, this serves as an indicator of the society's stock of physical capital. In most studies, the logarithm of the gross fixed capital formation in the machinery, equipment, and construction sectors, measured at constant prices, is used as an indicator of physical capital.

The statistical population of this study consists of data related to Iran's economy from 1996 to 2022, selected for model estimation. The Markov-Switching (MS) model will be employed to estimate the model using OxMetrics software.

Markov-Switching Regime Change Model

The Markov-Switching model was first introduced by Quandt (1972) and Quandt and Goldfeld (1973), and later, Hamilton (1987) applied it to extract and develop business cycles. The main idea of the Markov-Switching Vector Autoregressive (VAR) models is that the parameters of the VAR model depend on the regime variable StS_tSt, which is unobservable, and its probability is inferred. Unlike nonlinear methods such as STAR and ANN, where regime switching occurs gradually (Gradual Switching), in the Markov-Switching model, regime changes occur suddenly (Sudden Switching). In this model, the assumption is that the regime at time ttt is not observable and depends on an unobservable process StS_tSt. If the model assumes two regimes, StS_tSt takes on values of 1 and 2. A two-regime AR(1) model can be represented as follows:

$$(3)\ y_t = \begin{cases} \varphi_{0,1} + \varphi_{1,1} y_{t-1} + \varepsilon_t & if \quad s_t = 1 \\ \varphi_{0,2} + \varphi_{1,2} y_{t-1} + \varepsilon_t & if \quad s_t = 2 \end{cases}$$

or more succinctly:

$$(4)\ y_t = \varphi_{0,s_t} + \varphi_{1,s_t} y_{t-1} + \varepsilon_t$$

To complete the model, the properties of S_t must be specified. In the Markov-Switching model, S_t is assumed to be a first-order process, meaning that S_t depends only on the previous regime S_t. The transition probabilities from one state to another are introduced as follows:

$$p(s_t = 1/s_{t-1} = 1) = p_{11}$$
$$p(s_t = 2/s_{t-1} = 1) = p_{12}$$
$$p(s_t = 1/s_{t-1} = 2) = p_{21}$$
$$p(s_t = 2/s_{t-1} = 2) = p_{22}$$

The above probabilities $P_{i,j}$ represent the probability of transitioning from state i at time t-1 to state j at time t , and these probabilities are always non-negative. The following conditions apply to them:

$$p_{11} + p_{12} = 1$$
$$p_{21} + p_{22} = 1$$

Findings and Results

The first step in estimating the model is to calculate the green finance index. As discussed, this index consists of five subcomponents: real per capita GDP, energy efficiency, carbon efficiency, the carbon emission coefficient, and the share of renewable energy. After performing the calculations to separate the trend from the cycle in each of the variables, using the Hodrick-Prescott method, the weight of each sub-index in the composite green finance index must be determined.

Table 1. Relative Importance of Variables in the Composite Green Finance Index

Variable Name	Relative Importance of Variables (%)
Real Per Capita GDP	21
Energy Efficiency	24
Carbon Efficiency	11
Carbon Emission Coefficient	17
Share of Renewable Energy	27
Total	100

Table 1 shows the relative importance of the components of the overall index, broken down by the selected variables in the cyclical regression method. According to the weights obtained, the share of renewable energy has the most significant impact on the composite green finance index. Following this, energy efficiency and real per capita GDP have the next highest impacts. The overall green finance index is calculated based on the sum of the weighted values of the five variables presented in Table 1.

According to the results, the value of the LR test statistic is 485.96, and the probability level is below 5%, leading to the rejection of the null hypothesis and the acceptance of the alternative hypothesis. Consequently, the non-linear Markov-Switching model is used to estimate the model.

The next step in estimating Markov models is to determine the optimal number of regimes. Initially, the model is estimated with different regimes, and the model with the lowest Akaike and Schwarz criteria and the highest maximum likelihood function is selected as the optimal regime. The model is then estimated and interpreted based on the results of the optimal regime. Table 2 presents the values of the Akaike, Schwarz, and maximum likelihood criteria.

Table 2. Values of Criteria for Model Estimation

Model	ML Statistic	AIC Statistic	SC Statistic	Number of Regimes
Economic Development	*-785.36*	*23.96*	*29.52*	2
				3

Based on the estimated results for determining the best regime, the two-regime case consistently shows the highest maximum likelihood function and the lowest Akaike and Schwarz criteria.

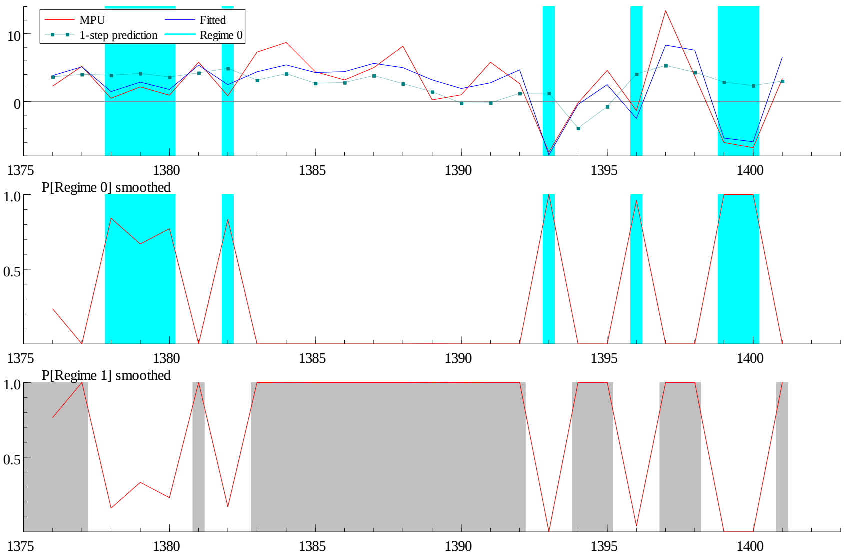
In Markov-Switching models, all variables must be stationary, and necessary tests, such as the LR test, are used to assess the suitability of the non-linear model. After determining the optimal lags and regimes based on the Schwarz criterion (for optimal lag) and the regime determination test, and given the high number of endogenous variables (which increases the estimated parameters in the model) and the limited data, a two-regime model is deemed more appropriate. Therefore, in this study, the model is estimated with two regimes (2MS), and the necessary tests are reported and interpreted.

After conducting the necessary tests for estimating the model, different models are estimated to examine the relationship between green finance, fintech, and economic development in Iran. Based on the results, the probability of remaining in the first regime is 75%, the probability of staying in the second regime is 80%, the probability of transitioning from the first regime to the second is 25%, and vice versa is 20%.

Moreover, based on the results, the years that fall under the first regime include 1999–2001, 2003, 2013, 2017, and 2021–2022. The years under the second regime include 1996–1997, 2002, 2004–2012, 2015–2016, and 2018–2019.

Generally, the second regime corresponds to periods of greater recession in the Iranian economy.

Figure 1. Probability of each year falling into one of the two regimes extracted for the model



The results of the Markov model estimation show that most coefficients are statistically significant at the 95% confidence level. The intercept coefficient for the model in the first regime is 0.11, while in the second regime, it is -0.82. A negative intercept indicates a recession regime, while a positive intercept indicates a boom regime (Hamilton, 1989). It is important to note that the intercept represents the average impact of other variables not explicitly included in the model but influencing economic development (the dependent variable). Since economic development is lower in recession periods than in boom periods, a negative intercept indicates a recession regime. Conversely, a positive intercept represents a boom regime. Additionally, the variance of the error terms in the first regime (boom) is 0.08, while in the second regime (recession), it is 0.74. These numbers indicate that the first regime (boom) has less volatility compared to the second regime (recession) in this study.

Table 3. Markov-Switching Model Estimation Results

Variable	Coefficient	Standard Deviation	t-Statistic	Probability
c1	0.116408	0.023637	4.924808	0.0001
c2	-0.822679	0.047883	-17.18086	0.0000
σ1	0.089278	0.027937	3.195642	0.0015
σ2	0.742134	0.193535	3.834616	0.0001
SD (-1)	0.029212	0.010482	2.786775	0.0055
GREENgdp (1)	0.210418	0.095113	2.212287	0.0274
GREENgdp (2)	0.077424	0.013421	5.769035	0.0000
Fintech (1)	0.072578	0.030158	2.406622	0.0164
Fintech (2)	0.026711	0.012321	2.167938	0.0306
Labor (1)	0.173019	0.072536	2.385275	0.0174
Labor (2)	0.053752	0.022425	2.396934	0.0165
EDU (1)	0.197885	0.085146	2.324058	0.0201
EDU (2)	0.077384	0.010161	7.615773	0.0000
CAP (1)	0.144886	0.021574	6.715828	0.0000
CAP (2)	0.107799	0.020271	5.317791	0.0000

The results of the model estimation indicate that green finance (GREENgdp), fintech, employment (Labor), education (EDU), and capital (CAP) contribute to greater economic development during boom periods compared to recession periods. Specifically, for every unit increase in green finance, fintech, employment, education, and capital, economic development increases by 21, 7, 17, 19, and 14 units, respectively. Green finance, through various factors such as the faster adoption of advanced technology from developed countries, increased benefits from research and development programs, achieving larger economies of scale, reducing price deviations and fluctuations, and thus more efficient use of domestic resources between sectors, and faster supply of new goods and services, can impact the economic development index. Increased economic development, accompanied by a rise in GDP, will lead to increased production and exports, which, along with the need for increased green finance, will affect economic development. Therefore, maintaining economic stability should be a priority for officials and government authorities.

As mentioned in the model introduction section, the residuals of the Markov-Switching model should be normally distributed and free of autocorrelation and heteroscedasticity. The results of the related tests are provided below.

Table 4. Results of Diagnostic Tests for the Model

Test Type	Test Statistic	Test Statistic Value	Probability Value
Lack of Autocorrelation (Ljung-Box Test)	X2X^2X2 (4)	2.3287	0.6325
Normality Test (Jarque-Bera Test)	X2X^2X2 (2)	2.2174	0.6325
Homoscedasticity Test (ARCH Test)	F (12,1)	0.4789	0.4785

Based on the results of the autocorrelation, normality, and homoscedasticity tests, the error terms do not exhibit autocorrelation, non-normality, or heteroscedasticity, and the Markov model results are validated.

Discussion and Conclusion

The results of this study provide important insights into the relationship between green finance, fintech, and economic development in Iran, highlighting the role these factors play in driving sustainable economic growth. Using the Principal Component Analysis (PCA) model to calculate the green finance index and the Markov-Switching (MS) regime change model to assess the impact of green finance and fintech on economic development from 1996 to 2022, this study demonstrates a significant and positive relationship between these variables. Specifically, the study shows that during periods of economic boom, a unit increase in green finance leads to a 21-unit increase in economic development, while fintech, employment, education, and capital contribute to economic development increases of 7, 17, 19, and 14 units, respectively.

These findings align with existing literature that emphasizes the importance of green finance and fintech in promoting sustainable development. For instance, Bayram et al. (2022) note that fintech can enhance the effectiveness of green finance by improving access to capital for environmentally sustainable projects, reducing transaction costs, and facilitating transparency. Similarly, Farahani et al. (2022) highlight the potential of fintech to accelerate the adoption of renewable energy technologies, which is consistent with this study's finding that renewable energy had the most significant impact on the composite green finance index. The emphasis on renewable energy as a key driver of green finance supports the broader literature that stresses the role of clean energy in achieving sustainable development goals (Du et al., 2022; Jiang, 2024).

Furthermore, the study's results regarding the contribution of fintech to economic development are consistent with research by Chen et al. (2021), who found that fintech innovations enhance financial inclusion and efficiency, particularly in underserved regions. The positive impact of fintech on economic development in this study reflects similar conclusions from Dahi (2024), who discusses how fintech enables SMEs to access credit, thereby boosting entrepreneurship and productivity. This is particularly relevant in the Iranian context, where access to traditional financial services has been limited due to economic sanctions and banking restrictions. By providing alternative financing mechanisms, fintech is playing a crucial role in driving economic growth, particularly in sectors that have historically struggled to access capital (Aziz, 2024).

The study also highlights the importance of education, employment, and capital in fostering economic development, which resonates with existing research that links human capital development to economic growth. As Chatterjee (2023) points out, fintech not only facilitates access to financial services but also promotes financial literacy and education, which are essential for sustainable economic development. The finding that education significantly contributes to economic development supports the argument that investments in human capital are critical for achieving long-term growth, as emphasized by Nuryitmawan (2023). Employment, too, plays a key role in driving economic growth, and this study's results align with research by Dahi (2024) and Guo et al. (2023), who note that fintech platforms create new job opportunities and improve labor market efficiency by facilitating entrepreneurship and innovation.

Moreover, the role of capital in promoting economic development is well-established in the literature. This study's finding that capital investment has a significant positive impact on economic growth is consistent with research by Chen et al. (2022), who argue that fintech-driven financial innovations can reduce the cost of capital and increase the efficiency of investments in sustainable projects. The use of fintech to streamline capital flows into green finance initiatives is particularly important for emerging economies like Iran, where traditional financial systems may lack the capacity to fund large-scale sustainable projects. As Li et al. (2022) note, the integration of fintech into green finance systems can help bridge the gap between investors and sustainable projects, facilitating the flow of capital into sectors that are critical for long-term economic growth.

The study's results also underscore the importance of green finance in driving sustainable economic development, particularly through its impact on renewable energy, energy efficiency, and real GDP per capita. These findings align with research by Jiang et al. (2020) and Liu et al. (2023), who highlight the role of green finance in reducing carbon emissions, promoting energy efficiency, and supporting the transition to a low-carbon economy. The positive relationship between green finance and economic development observed in this study supports the broader literature that argues for the integration of environmental sustainability into economic growth models (Li, 2024). As this study demonstrates, green finance not only contributes to environmental sustainability but also plays a key role in promoting economic resilience and stability, particularly in the context of developing economies like Iran.

Despite the valuable insights provided by this study, there are several limitations that should be acknowledged. First, the study is based on data from Iran over a specific period (1996–2022), and while this allows for an in-depth analysis of the relationship between green finance, fintech, and economic development in this context, the findings may not be fully generalizable to other countries or regions with different economic structures, regulatory environments, or levels of technological development. For instance, countries with more advanced fintech ecosystems or more developed green finance sectors may experience different dynamics. As a result, caution should be exercised when extrapolating these findings to other contexts, particularly in regions with varying levels of economic development or regulatory frameworks (Guo et al., 2023).

Second, the use of the Markov-Switching model, while appropriate for capturing regime shifts between periods of economic boom and recession, may not fully account for other external factors that could influence the relationship between green finance, fintech, and economic development. Factors such as geopolitical risks, global financial crises, and technological disruptions could significantly affect these relationships and should be considered in future studies. Additionally, the study relies on secondary data, which may limit the accuracy of the findings. While efforts were made to ensure the reliability of the data, there is always the potential for measurement errors or inconsistencies in the data sources used (Chen et al., 2024).

Lastly, the study focuses primarily on quantitative measures of green finance, fintech, and economic development, which may overlook some of the qualitative aspects of these relationships. For example, the study does not consider the social and cultural factors that may influence the adoption of fintech or the success of green finance initiatives in different regions. These factors could play a critical role in shaping the effectiveness of these systems and should be explored in future research.

Building on the findings and limitations of this study, several avenues for future research are suggested. First, future studies should explore the relationship between green finance, fintech, and economic development in different regional contexts, particularly in developing economies outside of Iran. Comparative studies that examine how these relationships vary across countries with different levels of technological development, regulatory environments, and economic structures could provide valuable insights into the factors that influence the success of green finance and fintech initiatives (Guo et al., 2023). Additionally, exploring the role of global regulatory frameworks, such as international climate agreements or fintech regulations, in shaping these relationships would be a valuable area of investigation.

Second, future research should consider the role of external factors, such as geopolitical risks or technological disruptions, in influencing the relationship between green finance, fintech, and economic development. For example, examining how global financial crises or changes in global energy prices impact the effectiveness of green finance and fintech systems could provide a more comprehensive understanding of these dynamics. Moreover, future studies could use more sophisticated econometric models that account for these external factors and provide a more nuanced analysis of the relationships between these variables (Liu et al., 2021).

Third, future research should incorporate qualitative measures to better understand the social and cultural factors that influence the adoption of fintech and the success of green finance initiatives. For example, investigating how consumer attitudes toward technology, trust in financial institutions, or cultural preferences for certain types of investments impact the effectiveness of these systems could provide valuable insights into the factors that drive or hinder their adoption. Additionally, future studies could explore the role of financial literacy and education in shaping the success of fintech and green finance initiatives, particularly in developing economies where these factors may be critical for achieving long-term economic development (Atikah, 2023; Aziz, 2024).

The findings of this study have important implications for policymakers, financial institutions, and businesses seeking to promote sustainable economic development through green finance and fintech. First, policymakers should focus on creating a regulatory environment that supports the growth of fintech and green finance sectors. This includes developing policies that encourage innovation in fintech, such as providing incentives for the development of digital financial services and ensuring that regulations do not stifle innovation (Maknickienė, 2024). Additionally, policymakers should focus on creating a stable and predictable regulatory framework for green finance, ensuring that financial institutions are incentivized to invest in sustainable projects.

Second, financial institutions should leverage fintech innovations to improve access to capital for green projects, particularly in sectors such as renewable energy and energy efficiency. By using fintech platforms to reduce transaction costs, improve transparency, and facilitate the flow of capital, financial institutions can help bridge the gap between investors and sustainable projects. This is particularly important in developing economies like Iran, where traditional financial systems may lack the capacity to fund large-scale sustainable projects (Chen et al., 2022).

Lastly, businesses should focus on integrating fintech and green finance into their operations to promote sustainable growth. This includes investing in renewable energy technologies, improving energy efficiency, and adopting sustainable business practices. By leveraging fintech to access capital for these projects, businesses can not only reduce their environmental impact but also improve their long-term profitability and competitiveness in a rapidly evolving global economy (Wang et al., 2022). Moreover, businesses should focus on enhancing financial literacy and education among their employees and customers to ensure that they can fully participate in and benefit from the growth of the green economy (Chatterjee, 2023).

In conclusion, this study highlights the significant role that green finance and fintech play in promoting sustainable economic development in Iran. The findings provide important insights for policymakers, financial institutions, and businesses seeking to leverage these tools to drive economic growth and environmental sustainability. However, future research is needed to further explore the dynamics between these variables in different regional contexts and to account for the external factors that may influence their success.

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