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IMPACT OF ECONOMIC POLICY UNCERTAINTY, GOVERNANCE QUALITY AND BANK VARIABILITY ON FINTECH IN PAKISTAN: A QUANTILE REGRESSION APPROACH

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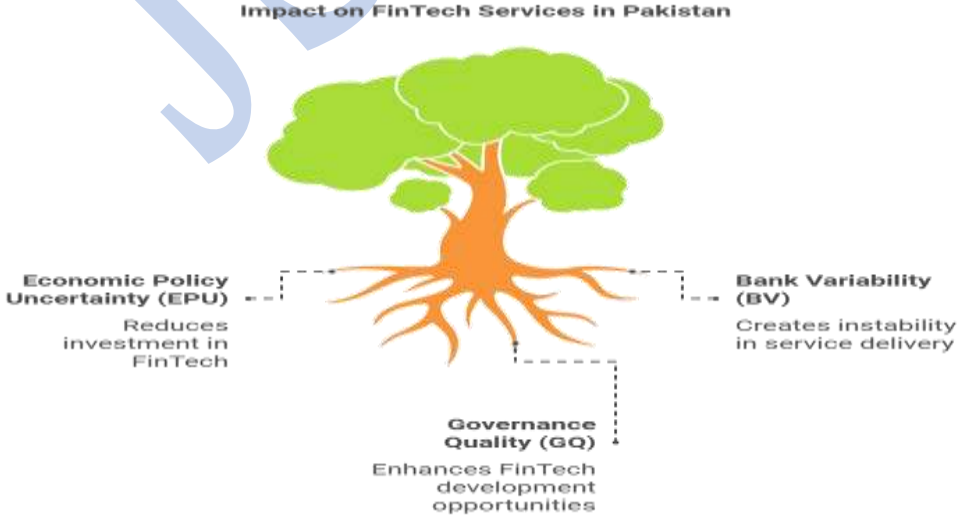
ABSTRACT
Motivated by the high levels of recent economic policy uncertainty, bank variability, and governance quality conditions in Pakistan, this paper investigates the impact of these factors on FinTech in Pakistani commercial banks. Using the economic policy uncertainty (EPU) index, world governance indicators (WGI), bank variability, and FinTech services in 19 Pakistani commercial banks during 2014-2020. Quantile Regression (QR) has been employed to address the nonlinear data's tail dependence issue and examine the impact on different quantiles. Quantile regression is a more effective method to separate the connection under various market conditions. The findings show that EPU and BV negatively affect FinTech services, while GQ strengthens FinTech. This empirical research has policy implications for government agencies, bankers, regulatory authorities, investors, and the State Bank of Pakistan. Our research provides insight to policymakers with several critical and noteworthy consequences and recommendations.

Keywords: *FinTech, economic policy uncertainty, bank variability, governance quality, quantile regression, Pakistani commercial banks*

Graphical Presentation of Abstract



Introduction

FinTech revolution is transforming the worldwide financial landscape, and Pakistan is no exception. The dynamic environment in which Pakistani commercial banks operate is impacted by the unpredictability of economic policy, the caliber of governance, and the intrinsic unpredictability of the banking industry. These factors significantly influence the adoption and growth of FinTech at these institutions. Uncertainty in economic policy brought on by shifting laws, tax laws, and government programs may make it difficult for FinTech businesses to attract investors. Wen et al., (2022) argued that the impact of economic policy uncertainty on investment choices and economic growth, especially in developing nations, is examined in (Economic policy uncertainty and growth nexus in Pakistan: fresh evidence using NARDL model, 2021). Fostering confidence and stability, drawing in FinTech investment, and guaranteeing fair competition all depend on the quality of governance, which includes accountability, transparency, and the rule of law, highlighting the importance of bank stability and regulatory oversight (Aastveit et al., 2018).

In addition to this, inter-bank differences that include variance in risk appetite, strategic priorities and technological infrastructure allow for a wide variety of FinTech to be used in Pakistan's commercial banks environment. Some of the banks would be willing to take risks and innovate, while other banks will be very conservative. Your current document mentions varying levels of FinTech adoption among Pakistani banks, supporting this point (Hidayat & Hossain, 2024). This study seeks to focuses on the relationship of economic policy uncertainty, governance quality and bank variability in order to find out how these factors interact in regard to the FinTech landscape in Pakistani commercial banks. Understanding these issues is crucial for all stakeholders in the country so that financial risks, challenges and opportunities which come with the genetics of the FinTech revolution can be addressed and fully met, thus enhancing the financial sector of Pakistan in a more effective and inclusive manner. (Sajid et al., 2023).

In Pakistan, the role of economic policy uncertainty (EPU), governance quality, and bank stability on FinTech development in commercial banks has been investigated by examining the interaction between these factors and the use, growth and impact of banks' FinTech. There is a considerable focus on these elements: Effect of EPU on FinTech Endorsement Due to the possibility of unpredictable shifts in the regulatory or economic landscape, banks in these areas are believed to be resistant to adopting a more integrated financial technology such as FinTech (Zhang et al., 2023). For instance, unstable taxation or legal frameworks for banking may make financial institutions take a wait and see method hence defer their involvement with FinTech growth. Although banks with FinTech seek liquidity and management of risks in turbulent periods, it may have been the case that EPU could have compelled banks to cut down on investments in advanced or ground changing ventures (Idrees & Ullah, 2024). A high EPU may influence consumers' banking reasoning, who at times, may seek new banking substitutes that are based on FinTech due to perceived security and regulatory safeguard worries or vice versa.

In addition, good governance also generally supports the advancement of FinTech. Transparency, stability and accountability are the underlying factors of good governance. Governance is likely to improve relationships between banks

and their customers and thereby improve the confidence it brings, which in turn increases innovation and investment in Fintech services (Li et al., 2023). Good governance would enhance investors, stakeholders, consumers trust and thus the investment boosted in Fintech. Apart from providing scope for open banking, a sound and transparent governance may foster collaborations with Fintech service providers (Mansoor et al., 2024).

While ensuring security, this also means that the capacity to integrate Fintech solutions into existing business lines depends on strong risk management processes which in turn relate to the effectiveness of the governance framework. This could assist in alleviating issues of cybersecurity and operational risks which are key challenges with the adoption of Fintech (Zhang et al., 2023). Be that as it may, where banks are more profitable and have bigger capital cushions they are more likely to invest in Fintech. Such banks would be well placed to fund the adoption of a more aggressive approach to define corporate strategy and develop new products, technologies or partnerships with Fintech firms. In addition, asset quality and risk composition: New technology in particular makes operation more expensive and complex and so banks with low asset quality and low non-performing assets and stable risk profile may be more willing to implement Fintech innovations.

In the context of competitive nature of financial institutions, banks' interpersonal dynamic is yet another factor of variability. More advanced and market-driven banks can deploy FinTech solutions as a means to enhance experience with customers, reduce costs, and differentiate themselves.

In Pakistan's banking sector, better governance and reduced EPU index, by decreasing uncertainties and encouraging investment in FinTech, can potentially facilitate a smoother digital evolution. However, high EPU may delay this evolution due to risk-averse behavior. While the customer's confidence, which is a determinant of the general use of FinTech services, is based on soundness of governance. Consequently, consumers are more likely to adopt FinTech products issued by well-governed and regulated banks. Pakistani banking institutions can apply FinTech in broadening the reach of formal banking services especially to the unbanked and under-banked populations by reducing the level of risks and adhering governance standards. In a market with great demand for financial services that are affordable to the general public, FinTech can provide quick, simple and cost-effective options (Nawazish & Afza, 2024).

In Pakistan, various digital banking services have expanded over the last few years due to advancements in technology, growing ownership of smartphones, and a need for better and quicker access to banking services. Now, let us examine the current environment of digital banking services in Pakistan, including the nature of services administered, who provides services, emerging issues, and the strengths and weaknesses of the sector. Pakistani commercial banks provide the following services: Mobile Banking Apps: Almost every central bank in Pakistan now has a mobile banking app, which allows customers to perform transactions, check balances, pay bills, and transfer funds. Examples include apps from HBL, UBL, Meezan Bank, and Bank Alfalah. Internet Banking: Internet banking services enable users to manage their accounts online via a web browser, offering services similar to those on mobile banking apps, such as bill payments, fund transfers, and balance inquiries. Digital Wallets: Pakistan's FinTech companies and telecom

operators offer digital wallet services like JazzCash and Easypaisa. These wallets provide mobile top-ups, bill payments, money transfers, and merchant payments. QR Code Payments: QR code-based payments have become more popular, especially among small retailers. Many banks and digital wallets now support QR code payments, which simplify transactions by allowing customers to scan and pay directly from their accounts or wallets. Person-to-Person (P2P) Transfers: Real-time P2P transfer services have increased in popularity, allowing customers to send money easily within and across banks using mobile apps, internet banking, or digital wallets. Branchless Banking: Pakistan has adopted branchless banking services in collaboration with telecom companies, such as UBL Omni and HBL Konnect, enabling people to access basic banking services through agents in remote areas. The recent trends in FinTech in Pakistan are: Adoption of Raast: Raast, developed by the State Bank of Pakistan, is an instant payment system aimed at making digital payments accessible and affordable for everyone, including small businesses. This system facilitates instant and low-cost transactions between banks and digital wallets. Increased Financial Inclusion: Digital banking has been crucial in promoting financial inclusion in Pakistan, particularly in rural areas where branchless banking agents help customer's access financial services without traditional bank branches. Rise of Digital-Only Banks: Digital-only or neobanks are emerging as a new trend in Pakistan, providing fully digital banking services without needing physical branches. Examples include banks like TAG and Sadapay, which focus on offering straightforward, mobile-first banking solutions. Enhanced Security and Authentication: With an increased focus on cybersecurity, banks, and digital wallet providers have implemented more robust security protocols, such as two-factor authentication (2FA), biometric authentication, and transaction alerts, to safeguard customer data and transactions. While there are specific challenges faced by Digital FinTech in Pakistan like, Limited Digital Literacy: While mobile penetration is high, digital literacy remains low, particularly in rural areas. Educating the population about digital banking services and how to use them securely is essential for widespread adoption. Infrastructure Limitations: Unreliable internet connectivity and electricity shortages, especially in remote areas, can hinder the effectiveness of digital banking services. Cybersecurity Risks: The rise of digital banking has also increased cybersecurity threats. A critical challenge is ensuring that robust security measures are in place to protect sensitive financial data. Regulatory Compliance and Oversight: The regulatory environment is evolving, and FinTech faces regulatory challenges as they work to align with policies set by the SBP and other financial authorities. While FinTech in Pakistani commercial banks have much attraction to Gex Z as smartphone and internet penetration continue to increase, digital banking in Pakistan is expected to proliferate. With supportive government policies, continued development of the digital payments infrastructure, and efforts to increase financial literacy, digital banking can transform the financial landscape, enhance customer experiences, and drive economic growth.

The existing has explored the impact of economic policy uncertainty on investment and growth in Pakistan. However, research on how policy uncertainty affects FinTech adoption in commercial banks is limited. Further research is needed to understand how specific policy uncertainties, such as regulatory changes, tax fluctuations, and government support for FinTech initiatives,

influence commercial banks' investment decisions and strategic direction regarding FinTech adoption. Moreover, the research examines the institutional determinants of financial development in South Asian countries, including Pakistan (Aman et al., 2024). But the other side of the matter is, the particular influence of the quality of governance on the adoption of FinTech in commercial banks is to require more research. This research looks in details on how aspects of governance, such as law, order, accountability and transparency affect the users and the banks' willingness and confidence in the adoption of FinTech applications. The influence of law regulation on the stability and safety of the Fintech landscape also deserves more scrutiny. Your document shows the difference of the use of FinTech services across the banks' clientele in Pakistan (Zahid et al., 2024). However, the actual factors that accounts for this unevenness are to be investigated more. This research examines how the scale of the bank, technological capabilities, willingness to take risks, and strategic focuses affect the uptake of different types of FinTech applications. Proper understanding of the internal relations in commercial banks is essential in determining the constraints and facilitators to the use of FinTech. These variables have all been examined, but the literature on how economic policymaking uncertainty, quality of governance and differences across banks affect the use of FinTech tools among Pakistani commercial banks is sparse. This paper gives full attention to how these factors are interrelated and how they affect one another. For example, how does the governance quality chase the policy uncertainty and the FinTech investment? How does the variance of banks affect the effectiveness of state policies concerning the promotion of FinTech usage? By addressing these questions, we will also be able to comprehend the determinants of FinTech use in the Pakistani commercial banks while designing appropriate measures to assist the successful establishment of FinTech services.

Literature Review

Researchers are drawn to FinTech services in banks by the literature that is currently available because of the rise in technological advances and reforms. As financial intermediaries, traditional banks offer depositors and borrowers a platform for financial transactions, which are now transformed into FinTech services to obtain digital banking services. Three key factors—economic policy uncertainty (EPU), bank variability (BV), and governance quality (GQ)—have been studied and developed about the popularity of FinTech services. While governance quality benefits banking services like FinTech, two factors—economic policy uncertainty and bank variability—have a negative impact. Evidence from developed nations shows that higher service fees shorten banks' FinTech services during periods of severe economic policy uncertainty because the banks increase the risk premium through service charges to preserve financial stability under high EPU.

Drobetz et al. (2018) examined 21 developed nations between 1989 and 2012. They discovered that while banking services rely on efficient governance, EPU affects the risk premium of bank investments and the cost of capital. According to Ozili (2021), banking services decline when global economic policy is unclear. The central bank also enforces stringent cash holding requirements, raising banks' service fees. Bank overdraft facilities are one way that banks' services respond to economic policy uncertainty by reducing credit availability and loan repricing. As FinTech advanced and commercial banks partnered with FinTech firms to help

consumers and track certain elements that impact FinTech services, the discussion heated up.

According to a recent study by Nguyen (2020), which looks at the connection between EPU and financial stability, EPU has a big impact on financial stability in 900 commercial banks in eight major European countries. However, laws provide a buffer for financial stability during economic policy uncertainty. According to Bernal et al. (2016), the government deficit, cash volatility, and output loss all act as moderators in the relationship between EPU and bank activities. Unfavorable economic conditions worsen the underlying economic conditions, impacting banking services and increasing non-performing loans and credit default. Francis et al. (2024) support the previously described findings. According to the report, uncertainty around economic policy also makes it more difficult to make investments and lowers bank profits. As institutional investors, banks are hesitant to make new, long-term investment decisions that impact FinTech services due to a pessimistic business climate caused by legislative uncertainty. Increasing EPU has a macroeconomic impact by decreasing employment, innovations, collective investment, and productivity improvement, according to Chi and Li's (2017) study. In this case, macroeconomic variables need to be addressed.

As a result, there is less demand for loans, which lowers bank profitability and causes a contraction in FinTech services. As a result of these effects, there is less demand for bank loans overall, which drives down lending rates. A small body of research suggests that low-interest rate spreads occasionally because low banking profitability. The substantial risk associated with the unpredictable nature of economic policy that affects FinTech is the cause of the low interest rate spread. A different argument from the one above is put out by Ashraf and Shen (2019), who contend that economic policy uncertainty lowers interest rates. They concluded that to cover the additional costs associated with the risk of loan default, banks hike lending rates during periods of policy uncertainty. According to the previously described idea, banks increase lending fees to mitigate credit risk and lower profits associated with the risk of uncertain economic policy (Boumparis et al., 2019). Further research highlights the significance of information asymmetry and banking riskiness in addition to the previously listed studies. Previous studies have demonstrated that information asymmetry brought on by economic policy uncertainty impacts the relationship between banks and borrowers (Yaseen & Rao, 2019). Market players act more like a herd when there is uncertainty regarding the accuracy of information because of policy uncertainty, according to information asymmetry, which characterizes herding behaviour. According to Ng et al. (2020), banks might not always be able to evaluate the companies' performance accurately because of a lack of information. Because of this, they rely on the estimates of their peer banks when making lending choices, which can occasionally lead to loan defaults. At the same time, digitalizing financial services helps lessen information asymmetry. Additionally, like other bank services, FinTech services encompass any digital transactions that lower costs and boost bank profitability; nonetheless, bank profitability is impacted by the state of the economy.

Banks imposed interest rates on FinTech services to offset default and credit risk, according to a cross-country analysis that used the GMM model and included 23 industrialized and developing nations. FinTech services also positively correlated

with economic growth (Le & Ngo, 2020). Economic policy has exhibited a complex and ambiguous trend toward banking services in recent years, particularly during the COVID-19 epidemic and other general economic downturns. Using stepwise regression and the VAR technique, an even study investigates how the US EPU affects banking services. Pre-event, event, and post-event periods were separated, and it was discovered that EPU had a significant impact on banking services. In contrast, the pandemic was contagious and caused slums worldwide (Chowdhury et al., 2022).

Individuals and banks found it challenging to make accurate predictions about the government's future economic policy decisions due to the heightened economic policy uncertainty. On a sample of 1058 banks from 23 countries, the link has also been examined using the system GMM model and two-step sequential estimation of the linear panel data model. According to the findings, EPU affects financial stability by lowering banking services; however, when bank and nation-specific characteristics are taken into account, a good governance quality lessens the impact of loss. Increases in unemployment, decreased investment in technology, decreased household and business spending, a decline in economic activity, a decline in consumer behavior, and the failure of the financial or economic recovery process all occurred during the EPU. Theoretically, banking services and EPU are adversely correlated, but the relationship is mediated by governance quality, and excellent governance has a beneficial impact and boosts economic growth. (Ali and others, 2023).

The literature currently in publication examines the impact of economic policy uncertainty (EPU) in developed nations on several topics, including bank corporate investment (Chen et al., 2021), employment (Zhu, 2021), the stock market (Ma et al., 2022), business cycle effects (Adjei, 2022), the equity premium (Dos, 2021), monetary policy (Aastveit et al., 2018), credit default swap (CDS) spreads (Wisniewski & Lambe, 2015), bank profitability (Ozili & Arun, 2022), non-performing loans, and capital ratio (Karadima, & Louri, 2021). This relationship sheds light on the ongoing discussion in developed nations about the effects of EPU on banking services, financial stability (Phan et al., 2021), loan loss provisions (Tran & Houston, 2021), debt holding policy (Athari & Bahreini, 2023), profitability (Ozili & Arun, 2022; Wang et al., 2022; Orden et al., 2023), and loan loss provisions. EPU also affects banking services, credit risk, non-performing loans and loan loss provisions, liquidity creation, loan pricing, earning opacity, and risk-taking in Asian nations like Pakistan.

Additionally, market shares, interest rates, and currency rate sensitivity all have an impact on the services provided by banks (Adubi and Okunmadewa 1999, Elyasiani, Mansur et al. 2007, Akel & Torun, 2017). First, the evaluation of markets, banking institutions' interest rate sensitivity, and exchange rate risk. Risk, accounting variables, and financial ratio measurements based on an evaluation of the strength of the market relationship comprise the second set of components. Observe that the bank market sample reacts well to the services provided by banks (Abiola and Olusegun 2017). Another study employs a vector auto-regression model to assess the characteristics of Nigeria's banking industry in connection to variability from 1980 to 1994. Using a Markov-switching model, it finds a negative link. Using GARCH-in-Mean mode foreign currency rates for publicly listed

Australian investment banks, Yunos et al. (2008) explain how Australian banks are affected by bank variability and some additional risk variables in 1990.
However, small banks employ monetarily determined interest rates and exchange rates to protect themselves against larger banks because they are more susceptible to changes in interest rates and bank variability. Since net interest income and traditional bank returns are the main sources of historical profit, this analysis mainly shows how banks prioritize interest rate exposure (Cushman, 2008). As a result, the findings discuss the disparity in bank book sizes and yield distinct outcomes for large and small banks. On the other hand, BV and bank services have an asymmetrical relationship with a negative association. Banking services and stock market volatility were found to be significantly correlated by the extreme ends at the 25th and 75th quantiles. Additionally, the correlation and contagion effect of economic recession on bank volatility have been examined using the DCC-GARCH model (Batten et al., 2023).
Nonetheless, Huo and Ahmed (2017) found no appreciable trade-off between the volatility return of stock and bank shares and the time changes in the observation of stock return volatility. By using the GARCH-in-Mean model, which accounts for both short- and long-term variability, research also examines the various European economies, including US and Japanese banks, interest rate and exchange rate sensitivity, and bank variability in 16 countries. The results show that there is occasionally a meaningfully negative or mixed relationship between bank variability and banks' services (Tai, 2000). According to Bekaert and Harvey (2000) and Mohsin et al. (2020), a robust banking system promotes economic growth, whereas a developing banking system is susceptible to bank variability. Although India has a sophisticated financial system and is one of the most developed emerging economies (Bartram & Wang, 2015), banking services are susceptible to macroeconomic factors and bank variability.

As institutional investors, banks are, therefore, forced to take on risks and bank variability. Banks would successfully accept and manage a variety of financial market volatility in order to reduce losses and prevent the detrimental effects of bank variability effectively and systematically (Hassan & Aliyu, 2018; Zainur, 2021). Limiting susceptibility and risk concentration, minimizing losses from various uncontrollable events, and informing regulators of such variability are the goals of implementing bank variability management. Banks invest in less risky portfolios to avoid suffering large stock market losses. Due to the market's complexity, size, structure, and current state, no single risk management approach is effective for all banks. As a result, banks need to create a framework for managing bank variability in order to attain sustainable business growth. However, the connection between FinTech and bank variability in Pakistani commercial banks is still unclear given the financial market's crucial role in asset pricing and price discovery.
To deal with interest rates, inflation, and exchange rates that lead to bank volatility, banks raise service fees for all services, including FinTech. This is known as the banks' risk premium, which protects them from downside risk when stock market volatility is strong. To the best of our knowledge, however, no substantial research has been done on the influence of BV on FinTech services in the context of Pakistani commercial banks.

The highlighted legislative changes produced favorable external conditions that East Asian nations shared. However, because of their unstable financial markets and regulatory quality, banks in low-income nations are impacted by economic shocks. The East Asian banking industry's CAMEL ratios have undergone a stress test (Pomerleano, 2009). Furthermore, the quality of governance and economic freedom in 12 Middle Eastern and North African nations improves bank services, both online and offline, which in turn accelerates economic growth. To investigate the link between 2005 and 2020, the study used the GMM model (Djebali, 2024). Strict regulations, on the other hand, reduce the stability and efficiency of bank profits. Based on a sample of over 3000 banks from 130 countries over five years from 2013 to 2018, the findings showed a negative relationship between bank services, the regulatory framework, and governance quality. When measures aimed at banks are separated from measures aimed at borrowers, the analysis further shows that this finding remains valid (Gaganis et al., 2021).

The study thoroughly investigates the intricate connections between legislation, governance quality, and bank services using panel data from 2210 banks spread over 47 European nations between 2000 and 2016. The CAMELS method is used to rate the quantile regressions. Strong regulation positively correlates with bank services, whereas inadequate governance, deposit insurance, and more rigid rules appear to degrade bank services. In 2019, Shaddady and Moore. From 1994 to 2014, the effects of macroeconomic variables on 16 Islamic banks and economic expansion were studied in MENA and non-MENA oil-importing and exporting economies. The relationship between macroeconomic variables and Islamic banks' activities is not linear. According to Mensi et al. (2020), a dynamic panel quantile model was used to examine an asymmetric link and discovered that macroeconomic factors and economic growth had an asymmetric association on various quantiles. As digital banking, FinTech services are more susceptible to macroeconomic fluctuations and governance quality, much like other financial services. Inflation is another factor that is getting worse. Bank FinTech, like other banking services, has been shown to be influenced by macroeconomic factors through the use of fixed and random effects models as well as the Arellano, Froot, and Roger's methods in 17 developing countries between 2011 and 2020 (Arzova, & Sahin, 2024). Applying the ARDL model after ECM to the banking industry in Turkey between 1960 and 2015 produced some similar findings and discovered a long-term correlation between banking services and economic growth (Katırcıoglu et al., 2020). In light of these research, this study uses inflation and economic growth as control variables in order to find reliable results related to banking services.

In particular, size, age, capital adequacy, economic growth, liquidity ratio, and profitability are among the internal and external factors—that is, macroeconomic and bank-specific factors—that determine bank services like FinTech in 14 Ethiopian banks between 2008 and 2019 using the GMM model for penal data (Isayas, 2022). The causal relationships among financial systems, government efficacy, regulatory quality, and economic growth in African nations are explained by another study. The selected African nations displayed patterns of impulsive responses and causality. Uncertainty and risk are reduced by good governance, mainly through rules and efficient administration. The asymmetric and symmetric causal links between financial system, regulatory quality, and economic

performance in a few African nations over 23 years are also examined in this study. The impulse response between the financial system, regulatory quality, and economic performance was also evaluated. Although causality and impulse response patterns differ among the chosen nations, a symmetric causal relationship between the financial system and governance quality and an asymmetry association between the financial system and economic performance have been identified.

Lee (2021). Using certain controlled variables, this discussion identifies governance quality as crucial when discussing banks' FinTech services in developed and developing nations. Still, not enough is known about this link to Pakistani commercial banks. The foundation of the financial industry, banks, are sensitive to EPU, which has a significant impact on FinTech and other banking services. EPU has a more negative impact on banks in developing nations, which lowers service volume. The relationship between bank FinTech and EPU must be investigated in a study conducted in emerging nations. Furthermore, GQ is a significant determinant of bank services in Asian nations. However, the quality of governance and the financial infrastructure are lower in underdeveloped countries than in developed ones. The literature does not sufficiently support the association between GQ and bank services, but research on banks' FinTech services in Pakistan is still lacking in this field. Additionally, a wealth of literature explores the variables influencing bank services in Asian nations. However, because FinTech is still in its infancy and in its flowering stage, there is a dearth of study on this topic in emerging nations. The State Bank of Pakistan and the Security and Exchange Commission of Pakistan govern the FinTech services offered by Pakistani commercial banks, another example of developing nations. Although Pakistani commercial banks also provide FinTech services regulated by the State Bank of Pakistan and the Security and Exchange Commission of Pakistan, as far as we know, no such evidence examines the factors that determine the expansion of FinTech services in Pakistan. Like other banking services, FinTech in Pakistan is influenced by several factors that have not yet been thoroughly examined (Rashid & Jabeen, 2016). According to existing research, Pakistani banks reveal less about the factors affecting their services, especially FinTech companies like BV. The literature indicates an asymmetric relationship between EPU and BV but a symmetric relationship between governance quality and bank services. In order to close the research gap, this paper examines the variables that influence bank FinTech services in Pakistan.

Data and Methodology

Economic policy uncertainty (EPU) data from the State Bank of Pakistan, World Development Indicators (FinTech proxy), World Governance Indicators (government efficacy and regulatory quality), and monthly financial statements of the corresponding banks from websites from January 1, 2014, to December 31, 2020, were the sources of the data. Chaudhary et al. (2020) established the EPU index, which has been used in previous studies. The author calculated the bank variability data.

Koenker and Bassett (1978) suggested the quantile regression methodology as the main empirical tool for methodological selection. There are two benefits to this methodology. We employ an estimation technique that enables us to assess the influence of EPU, BV, and GQ on FinTech services in Pakistani commercial banks

by the study's motivation. Because of data asymmetries, we can use the quantile regression (QR) technique to determine the association with low, middle, and high degrees. This approach is pertinent in explaining the current values of the dependent variable, according to current development research (Koenker & Hallock, 2001; Billger & Goel, 2009; Okada & Samreth, 2012; Asongu & Nwachukwu, 2017; Asongu et al., 2018). Even if mean effects are still significant, we have employed the quantile regression (QR) estimation strategy, contributing to the literature by using an estimating approach considering the dependent variable's initial values. The method's justification for its policy significance comes from the realization that average values provide broad policy suggestions that may not work unless modified for nations with low, middle, and high levels of initial FinTech development. Furthermore, estimating techniques based on mean values, like ordinary least squares (OLS), are predicated on the assumption that they are regularly distributed. This assumption of normally distributed error terms is unnecessary for the QR technique (Tchamyou & Asongu, 2016). The optimization problem in Eq. (1) is presented without subscripts for simplicity and clarity. This makes it possible to build the θth quantile estimate of FinTech as a dependent variable, where θ is between 0 and 1. Unlike OLS, which minimizes the sum of squared residuals, QR minimizes the weighted sum of absolute deviations. With θ=0.10 or 0.90, the residuals can be generally weighted to the 10th or 90th quantiles. The conditional quantile of yi given xi is thus obtained, and different slope parameters are calculated for each θth specific quantile. When parameters are only assessed at the conditional distribution mean of FinTech development in the OLS slope, this formula is analogous to E(y/x) = xi'β.

Koenker and Bassett (1978) described the quantile regression of yi given xi as follows:

$$qy_i(\tau \mid x) = \alpha(\tau) + x_i\beta(\tau) \quad (1)$$

The regression quantile for $0 < \tau < 1$ is represented by the notation $(\alpha\tau, \boldsymbol{\beta}T\ \tau\ )T$. Given independent and identically distributed (i.i.d.) data $(yi, \boldsymbol{x}i)$, with $i = 1,\ldots,n$, we examine the linear model. Yi's τth conditional quantile is represented by equation (1) as qyi(τ|x) and 0 <τ< 1. The unobserved effect is represented by α (τ), whereas the estimate from the quantile regression model is represented by β (τ). The predictor variable vector is denoted by x. This allows for the following calculation of the β (τ):

$$y_i = \alpha_\tau + \boldsymbol{x}^T{}_i\, \boldsymbol{\beta}_\tau + \varepsilon_i \quad (2)$$

Where $P(\varepsilon i > 0) = 1 - \tau$ is satisfied by the error term εi, which is independent of $\boldsymbol{x}i$ and has density $f\varepsilon(\cdot)$, then $yi = \alpha\tau + \boldsymbol{x}T\ i\ \boldsymbol{\beta}\tau\boldsymbol{\upsilon}$ (2). Testing the hypothesis is the aim of this study.

In contrast to

$$H1 : \boldsymbol{\beta}\tau \neq \boldsymbol{\beta}\tau,0,\ H0 : \boldsymbol{\beta}\tau = \boldsymbol{\beta}\tau,0 \quad (3)$$

The specified k-dimensional vector in this instance is $\boldsymbol{\beta}\tau,0$, and dimension p may be significantly more than or even equal to the sample size n in a high-dimensional environment. The statistical demonstration of model significance in conditional quantile is provided by the fact that we can put $\boldsymbol{\beta}\tau,0 = 0$ without losing generality. In general, when p is much smaller than n for a given $\tau \in (0,1)$, the estimator for $(\alpha\tau,\ \boldsymbol{\beta}\tau)$ in the model (1) is generated by minimizing the loss function. $\triangleq \arg\min\ \alpha,\beta\ \sum\ L\tau(\alpha,\boldsymbol{\beta}) \triangleq \arg\min\ \alpha,\beta\ \sum ni{=}1\ \rho\tau\ (yi - \alpha - \boldsymbol{x}T\ i\ \boldsymbol{\beta})$ (3)

whose indicator functions, $\rho\tau(u) = u\ (\tau - I\{u < 0\})$ and $I\{x \in A\}$, have values of 0 otherwise and 1 if $x \in A$. The nonparametric density estimation involved in the asymptotic distribution of regression quantiles complicates the theoretical study and real-world application of Wald-type test statistics. Therefore, when dimension p is low, the regression rank-score test is proposed to solve the inference problems. The rank-score test statistic is defined using the quantile score function, $\phi(t) = \tau - I\{t < \tau\}$. In order to simulate the score function evaluated at $\boldsymbol{x}T\ i\hat{}\boldsymbol{\beta}\tau$, a rank-based test for quantile regression has been created using *bni* (Koenker and Machado, 1999; Wang et al., 2009).

$$(\alpha\tau, \hat{}\boldsymbol{\beta}_\tau) = \arg\min_{\alpha,\beta} \sum L_\tau(\alpha,\boldsymbol{\beta}) \triangleq \arg\min_{\alpha,\beta} \sum_{i=1}^{n} \rho_\tau\ (y_i - \alpha - \boldsymbol{x}^T{}_i\ \boldsymbol{\beta}) \quad (4)$$

However, in high-dimensional environments, where dimension p is almost equal to or greater than sample size n, the inverse of the sample covariance matrix may not exist or deviate substantially from its true value. The rank score test may become impractical in these circumstances, requiring the development of a new test statistic suitable for high-dimensional scenarios.

$$T^{RS}{}_n = \Omega^T{}_n S^{-1}{}_n\ \Omega_n / (\tau(1-\tau) \quad (5)$$

The sample covariance matrix of $\boldsymbol{x}$ is denoted as Sn, and $\Omega n = n-1/2\ \sum n\ i=1(\boldsymbol{x}i - \bar{\boldsymbol{x}})\hat{}\ bni$

$$\hat{}bni = \begin{cases} \tau & \text{if } yi > \boldsymbol{x}T\ i\hat{}\boldsymbol{\beta}\tau, \\ \in (\tau - 1, \tau) & \text{if } yi = \boldsymbol{x}T\ i\hat{}\boldsymbol{\beta}\tau, \\ \tau - 1 & \text{if } yi < \boldsymbol{x}T\ i\hat{}\boldsymbol{\beta}\tau. \end{cases} \quad (6)$$

The quantile regression technique is a helpful tool for capturing such discrepancies because it looks at FinTech's reaction throughout the conditional distribution. This technique may, therefore, access the structure and degree of reliance between FinTech and EPU, GQ, and BV under both typical and atypical market conditions, such as uncertainties (Baur, 2013). Additionally, quantile regression works better than basic least square regression, especially when the error component in the underlying data has a non-normal distribution. The quantile regression approach is a trustworthy econometric method when considering skewness, heteroskedasticity, and outliers (Koenker and Hallock, 2001).

Results and Discussion

The results of the descriptive statistics on the research data are shown in Table 1. According to statistical statistics, the sample's FinTech services from Pakistani commercial banks had an average value of -7.83E-08 with a deviation of 1.8787, showing a notable variability in banking systems across the study period. Numerous high values and data variability are revealed by the high average EPU values with a standard deviation of 42.989. Low SD denotes less variance around the FinTech mean, per Berger et al. (2022). However, the data on Pakistani economic policy uncertainty may contain outliers due to its irregular distribution, as indicated by the results of skewness and kurtosis. Bank variability and governance quality data show leptokurtic data with high values, whereas Fintech

and bank-specific control factors are platykurtic with low values in the data and may be outliers. However, statistics on inflation and economic growth are fundamentally released regularly. Additionally, 25% of the data have low or negative values, whereas the upper quartile shows an upward tendency. Fintech services are expanding quickly in Pakistan. However, the data is influenced by other factors, and the economic growth is skewed negatively.

Table 1. Descriptive Statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max	Skew.	Kurt.	Q1	Q3
FinTech	84	-7.83E-08	1.8787	-2.6536	3.4547	0.1982	1.7113	-1.9665	1.534
EPU	84	100.227	42.989	33.21	254.48	1.032	4.053	68.195	119.465
BV	84	1.20E-07	2.816	-3.996	16.391	2.637	15.161	1.6122	1.0465
GQ	84	-2.57E-08	1.2332	-4.3623	1.514	-1.6303	5.832	-0.6966	-0.2888
BSC	84	-7.54E-07	6.731	-11.765	13.005	0.061	1.907	-5.5638	5.1519
INF	84	7.907	6.155	0.102	20.704	0.868	2.713	4.0065	8.9355

Note: Table 1 consists of the values of mean, standard deviation, minimum, maximum values, median, skewness, kurtosis, lower and upper quartile.

Table 2 demonstrates that we cannot rule out the null of a unit root for any variable at any level, with the exception of FinTech services, economic policy uncertainty, bank variability, and governance quality. We may reject the null of I(I) for these indices at their first differences, implying that other variables are subject to an I(I) process.

Table 2.Phillips-Perron and ADF test for Unit Root

Variables	ADF		PP	
	I(0)	I(I)	I(0)	I(I)
FinTech	2.150	-6.099	1.472	-6.207
	0.999	0.000**	0.997	0.000**
EPU	4.482	-3.534	-4.449	-3.534
	0.000**	0.000**	0.000**	0.000**
BV	6.110	-3.534	-6.115	-3.534
	0.000**	0.000**	0.000**	0.000**
GQ	7.502	-2.506	3.932	-2.655
	1.000	0.114	1.000	0.255
BSC	1.644	-5.487	1.051	-5.564
	0.998	0.000**	0.995	0.000**
INF	-0.909	-5.279	-1.361	-5.177
	0.785	0.000**	0.601	0.000**
EG	3.646	-5.465	2.284	-5.529
	1.000	0.000	0.999	0.000

*The values with ** shows the level of significance.*

Table.3 Quantile Regression

Quantiles										
Mean	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8		0.9
	-0.35	-0.07	0.06	0.01	0.16	1.75	1.80	0.63		
EPU	0.729	0.941	0.949	0.994	0.870	0.085	0.075	0.532	-0.01	0.990
	-0.81	-1.12	-1.07	-0.48	-0.25	-0.89	-1.10	-0.95		
BV	0.419	0.266	0.289	0.632	0.802	0.378	0.274	0.343	-0.19	0.847
	6.95	4.29	2.84	2.43	2.83	3.51	4.96	5.34	5.25	
GQ	0.000	0.000	0.006	0.018	0.006	0.001	0.000	0.000		0.000
	32.35	21.50	19.93	19.46	18.20	19.21	42.85	67.44		54.39
BSC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
	-10.23	-9.39	-9.11	-6.93	-7.05	-6.27	-4.41	-2.46		
INF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	-1.68	0.096
	-7.78	-4.20	-2.82	-2.84	-3.03	-2.81	-4.14	-5.33		
EG	0.000	0.000	0.006	0.006	0.003	0.006	0.000	0.000	-7.44	0.000
	7.02	6.76	4.55	3.25	3.47	2.64	4.80	6.37		
Cons	0.000	0.000	0.000	0.002	0.001	0.010	0.000	0.000	9.08	0.000
R sq	0.9287	0.9282	0.9317	0.9335	0.9303	0.9270	0.9255	0.9291		0.9338

Uncertainty in economic policy hurts FinTech services. The uncertainty surrounding economic policy considerably impacts all quantiles (10th, 20th, and 90th) except the 0.9 quantiles. This implies that FinTech services appear to decline when uncertainty rises, consistent with Kang and Ratti's (2013, 2015) findings. To better predict FinTech services in Pakistani commercial banks, it is essential to consider the effects of economic policy uncertainty under different market conditions. It is also crucial to remember that the influence is not continuous due to the great heterogeneity of the projected coefficients for this measure. Moreover, we may conclude that FinTech services at all quantiles are negatively impacted by bank variability, inflation, and economic growth. Conversely, for all quantiles, bank-specific control factors and governance quality have a beneficial impact. Therefore, the conclusion indicates little heterogeneity in the effects of bank variety, governance quality, and economic policy uncertainty on FinTech services, even when the marginal impacts differ among conditional distributions of FinTech services.

Conclusion and Recommendations

This paper examines the significance test for high-dimensional quantile regression, and we propose a test approach based on the quantile score function. We obtain the asymptotic distributions of the test statistics for the null and alternative hypotheses. As a helpful theory extension, asymptotic distributions are considered when the design matrix follows an elliptical distribution. Comparing our proposed test to several existing methods, simulations have shown that it has greater power for non-Gaussian heavy-tailed data. The empirical research highlights the significance of quantile regression as a tool in econometrics and finance. Based on monthly data from January 2014 to December 2020, the findings suggest how governance quality, bank variability, and economic policy uncertainty affect FinTech services in Pakistani commercial banks. It is evident from the sample

period that FinTech services are negatively impacted by economic policy uncertainty. Except for the 0.9 quantiles, all (10th, 20th, and 90th) are significantly impacted by economic policy uncertainty. This suggests that when uncertainty increases, FinTech services seem to decrease. Furthermore, we can conclude that bank variability, inflation, and economic growth hurt FinTech services at all quantiles.

On the other hand, favorable impacts for governance quality and control characteristics unique to banks are seen at all quantiles. Therefore, although the marginal impacts vary among conditional distributions of FinTech services, the conclusion shows no evidence of heterogeneity in the effects of bank variety, governance quality, and economic policy uncertainty on FinTech services. The results of the study are in line with earlier research that indicates Fintech has a negative relationship with inflation (Andreou & Anyfantaki, 2021), bank variability (Shaik et al., 2023), uncertainty about economic policy (Bahtiar et al., 2023; Anwer et al., 2024; Shao et al., 2024), governance quality (Ansari et al., 2024; Patra & Sethi, 2024), and economic growth (Murrar et al., 2024). These results are consistent with earlier. Strong governance quality strengthens FinTech services, while the findings give bank management insight into investing operations during periods of significant economic policy uncertainty and bank variability. Additionally, the government and regulatory bodies have a significant role in directing the State Bank of Pakistan to introduce appealing schemes to citizens and monitor Pakistani investment. Future political instability in Pakistan and geopolitical risk can be further examined concerning this link.

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