Identifying Customer-Related Barriers to Widespread 5G Adoption in Qatar Using Correlation Analysis

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*Abstract –*5G provides much high data rates, lower latency, and better quality of service compared to its predecessor 4G. Nevertheless, the rate at which customers in Qatar are switching from their existing 4G data plans to the new 5G plans is not as fast as would have been anticipated. This study identifies the customer-related factors that are hindering the widespread adoption of 5G in Qatar. To this end, a questionnaire was conducted to collect data on customers' mobile data usage and preferences based on a set of factors that could be correlated with customers' willingness to switch to 5G. The data is analyzed using Spearman's Rank Correlation and other statistical tests to identify the degree of correlation between the willingness to use 5G and the different independent factors. Hence, the most important hindrances slowing the switching from 4G to 5G in Qatar are identified and ranked. It is found that price represents the greatest obstacle slowing the transition from 4G to 5G. Therefore, several recommendations are proposed to overcome this challenge to increase 5G usage. Encouraging the transition to 5G networks in Qatar will reflect in boosting many uprising technologies such as smart homes, smart cars, smart cities, Internet of Things, and other emerging technologies.

Keywords – IoT, 5G, 4G, Spearman's Rank Correlation, Data rate, latency, Statistical Analysis.

I. INTRODUCTION

In the past decade, communication technologies have witnessed many revolutions that resulted in radical changes in how the world is connected. One of these technologies is the development of 5G broadband cellular networks. 5G is the fifth-generation technology for broadband cellular networks which began worldwide deployment in 2019 [1]. 5G promises to meet the rapidly increasing worldwide demand on high-speed, low-latency, and high-quality connectivity. 5G is on pace to improve many aspects of current generation mobile networks including data rate, latency, bandwidth efficiency, and power consumption [1]. It is expected that 5G can deliver data rates of up to 20 Gbps and expand new spectrums like mmWave [2], [3]. Moreover, 5G networks will boost Internet of Things (IoT)

services and lead the transformation of next-generation industries [3]. 5G technology was introduced when NASA launched machine-to-machine intelligence in 2008, marking the Internet of Things development [3- 5]. In the same year, South Korea (credited as the pioneer of 5G) developed a 5G research and development program [6]. In collaboration with King's College London, Ericsson, and Vodafone UK conducted an isolated pre-standard 5G test in December 2017 [5]. The field experiment was conducted in central London at 35 GHz frequency with a prototype device, making it the first live 5G test in the UK [5]. 5G has already been deployed in many countries worldwide. Fig. 1 illustrates the top ten cities worldwide that currently have the fastest 5G networks. However, full deployment of 5G networks is still in its early stages in most countries
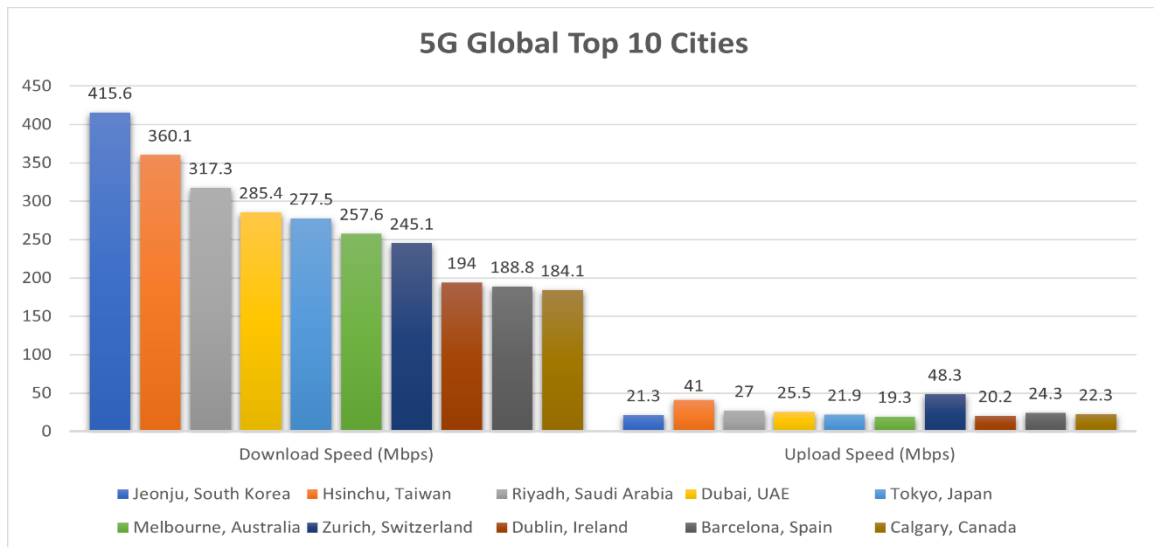
Fig. 1 Top ten cities worldwide with fastest 5G networks [7].

as is the case in Qatar, where there are many challenges facing its widespread adoption due to both technological hurdles and customer-related barriers.

As the world is deploying 5G, it is becoming increasingly vital to understand how customers feel about their current mobile broadband services, as well as how they perceive this next generation of wireless technology. There are some existing case studies discussing the customer-related barriers to 5G adoption in several countries, however, there are nearly no such studies conducted in Qatar that can be found in the literature.

II. MATERIALS AND METHOD

A. Aim of the Study

This case study aims to identify the most critical customer-related hindrances that slow down switching from current 4G cellular networks to the new 5G networks available in Qatar. By identifying these hindrances, the service providers in Qatar can address the specific customer-related problems to promote 5G adoption in Qatar. The importance of this case study is two-fold. Firstly, by identifying the customer problems facing 5G usage, companies can work to resolve these problems and hence boost their share in the market achieving increased business benefits by attracting more customers to use their 5G data plans. Secondly, customers will benefit from the improved features and unique advantages of 5G once their concerns are identified and addressed. Furthermore, it is anticipated that by conducting this study and its associated questionnaire, the level of awareness about 5G technology, features, usage, and challenges in Qatar will be enhanced both for the public and relevant companies to smooth and encourage the transition to 5G networks which will reflect in boosting many uprising technologies such as smart homes, smart cities, IoT, and electric vehicles.

Following data collection from the questionnaire, appropriate statistical analysis techniques, namely, Spearman correlation and χ^2-test will be applied to identify the relations (correlations/ associations) between customers' willingness to use 5G and the different independent variables considered. Subsequently, the results will be analyzed to reach the research conclusion and provide several recommendations to enhance 5G spread in Qatar.

B. Considerations About 5G Adoption

Studies have been conducted regarding the adoption of 5G in terms of benefits, challenges, and requirements. In Qatar, the cost of installation, prices, compliance, and regulations are among the challenges that hinder the adoption of 5G technology which are in line with the challenges highlighted in [8]. The cost of launching 5G technology, corresponding bandwidth acquisition, and hardware installations require massive investments [9]. Operators recoup these costs from their customers, making them pay huge sums for 5G connectivity, and therefore, customers become more resistant to 5G adoption [9]. Thus, although 5G technology provides many benefits to customers, many barriers hinder it from being widely adopted in Qatar.

In [10], a study on the adoption factors of 5G for smart learning in China was conducted. To learn about customers' desire to embrace 5G technology for smart learning, the study employed a novel model by combining the technology adoption model (TAM) as the basic theoretical model with social practice theory elements (SPT). Based on data analysis of a survey with a sample size of 375 university students in China using structural equation modeling (SEM), it was discovered that the cumulative effect of material, meanings, and competency access elements influence the student's adoption of 5G in smart learning. The authors reported some limitations in the study because it was conducted in only a few universities in China. Besides, universities in different territories may have diverse psychological, educational, and demographic features.

Another study on the customer adoption of 5G services was conducted but focused on the effect of environmental awareness, knowledge, and health consciousness on the customer's purchasing intentions for 5G [11]. Using the SEM technique and the integrated value adaptation model (VAM), data from 423 respondents was collected via an online survey. The survey considered both 4G and 5G and requested demographic data such as the location, gender, age, and education level. The other part of the survey contains a series of measurement items designed to capture the construction of their research model. High-quality data were ensured by using the cross-sectional survey method. The conclusion drawn from the survey is that users are more likely to use 5G services if they find these services useful. Moreover, the research findings confirm that the user's attitude toward accepting 5G is heavily influenced by the user's environmental awareness and knowledge.

The study in [12] assessed customer desire for 5G services and consumer behavior regarding purchase delay. The study was conducted using discrete choice models based on random utility theory. The mixed logit model is used in the first phase of the study to calculate consumer preference, marginal willingness to pay, and the relative value of 5G services. Whereas the second phase of the study employed an ordered logit model to examine the delay factors impacting the consumer willingness to purchase 5G services. Since individual customers' 5G service purchase timing is predicted to vary depending on the type of 5G service, the study adopted an ordered logit model that groups the purchase time of 5G services as ordinal data. The attributes included in the survey were chosen from 5G mobile services and 5G application services to encompass representative 5G characteristics. The "data transmission rate" and "monthly data offer" were identified as key characteristics of 5G mobile services. "Connected automobiles" and "IoT for family usage" are examples of 5G application services that exhibit ultra-low latency and hyper-connectivity, respectively. These application services are found to have an influence on the customer's decision to use 5G. The last considered attribute under the author's 5G subscription model was the additional monthly payment amount the consumer should pay for 5G services compared to 4G. The research concluded that customers are postponing 5G services adoption mostly owing to cost and a lack of demand. Consumer acceptance of 5G services is expected to reduce by more than half as a result of buyer purchase delays of more than a year. This is because it is difficult to infer that a purchasing delay of more than a year corresponds to an actual purchase. Moreover, consumers perceived 5G technology as a constant innovation that just builds on the preceding generation's technical capabilities. Practitioners, on the other hand, have always argued that 5G technology is a discontinuous breakthrough that will transform consumer user behavior and industry paradigms. This disparity between consumer and producer perceptions of 5G is not desirable for enabling diffusion and activating customer demand in the 5G market. Therefore, it was suggested that businesses and governments should focus on changing public views of 5G technology and promoting innovative features of 5G services and applications.

C. Methodology

The main question that this case study aims to answer is: "what are the most important factors that discourage customers from switching to 5G networks?" This is answered by identifying the factors that could be potentially correlated with customers' willingness to switch to 5G. Then, conducting a questionnaire to collect relevant data and applying appropriate statistical techniques to identify the correlation between each factor and the willingness to use 5G. Then finally, ranking the factors based on the strength of their correlation. Addressing the correlated factors would likely

increase 5G usage by customers. To that end, we designed a questionnaire to understand the relationship between customer adoption of 5G services and several factors. Some of these factors are based on the previous studies reported earlier in this paper. Table I illustrates the factors considered in this study as well as their data type based on the design of the questionnaire.

Data rate was picked among the factors since fast and stable connections with lower latency and no internet buffering are becoming essential to users, especially as more people are working and studying remotely. However, the price paid for increasing the data rate may not justify the upgrade to 5G for many customers. This is because the prices of 5G data plan packages in Qatar are considerably more expensive than the corresponding prices of 4G packages. The average monthly price of the unlimited amount of local data in Qatar is QR 450 for 5G speeds and around QR 150 for 4G speeds [13]. In other words, a typical 5G subscription could cost as much as three times the cost of a 4G subscription for the same amount of data. Besides data rate and price, users' internet applications also influence their decision to upgrade to a 5G plan. For instance, the need for lower latencies and no buffering is considerably higher for gamers and video streamers than for people who just use their phones for texting and calling. Furthermore, low population areas may not have 5G coverage, which could be a factor in preventing widespread 5G adoption. Regarding 5G coverage in Qatar, it is noted that while 4G nearly covers all inhibited areas in Qatar, 5G only covers Qatar's capital (Doha) and its nearby areas as well as a few other cities in Qatar [14], [15]. Fig. 2 shows the coverage map of 5G and 4G networks in Qatar. 5G adoption might also be delayed because many customers still do not own a 5G capable phone. Therefore, 5G mobile phone support is also considered among the factors. Other factors such as gender and age group may also be associated with 5G adoption. To summarize, Fig. 3 illustrates our research model and framework.

Table 1. The factors considered in the study.

Variable Type	Variable	Data Type
Dependent	Willingness to use 5G	Interval
Independent	Mobile phone 5G support	Nominal
	Awareness	
	Data rate	Interval
	Price	
	Latency	
Stratification	Gender	Nominal
	Residence	
	Age	Interval

Fig. 2 Qatar's 5G (left) and 4G (right) coverage map [14], [15].

III. ANALYSIS AND RESULTS

After the distribution of the questionnaire, a total of 230 responses were collected. No outliers were detected at the 5% significance level for all responses to all the questions. Therefore, all 230 responses were considered in the analysis. The normality test showed that the data does not follow the normal distribution. Hence, non-parametric tests were used to examine the associations and the correlations of the factors with 5G adoption. Fig. 4 illustrates the demographics of the respondents. It was found that only 41% of the respondents were current 5G subscribers, even though 63% of them had 5G supporting phones.
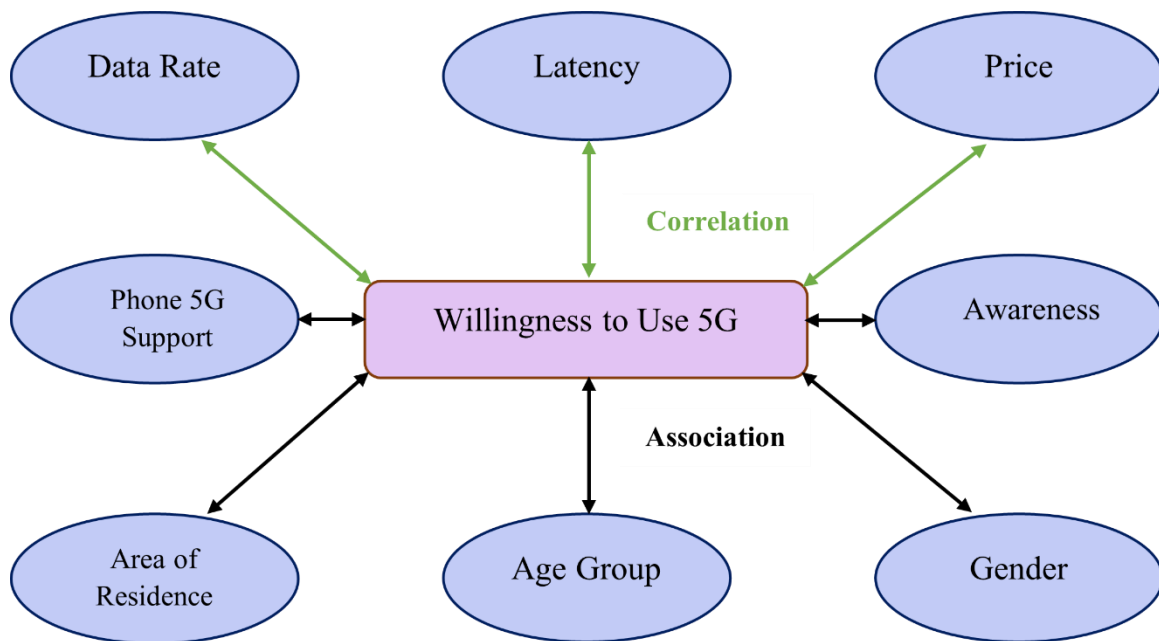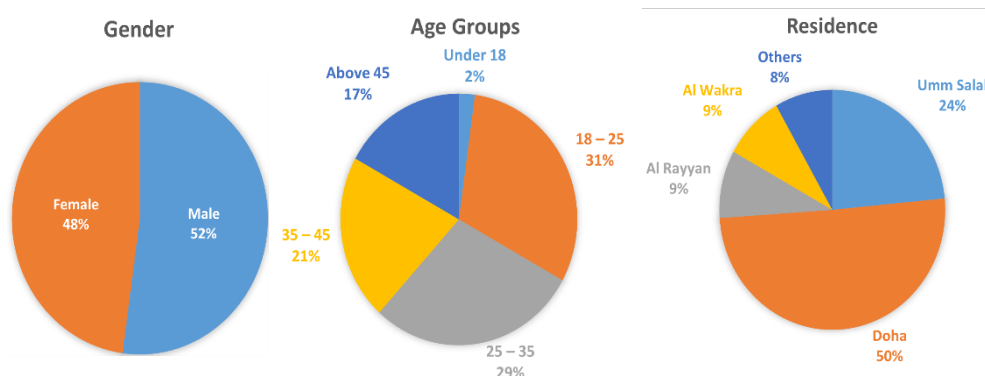
Fig. 3 Research model and framework.

Fig. 4 Respondents' demographics.

Moreover, while 50% of male respondents were current 5G users, only 32% of females were current 5G users. The χ^2-test at a 1% significance level showed a significant association between gender and subscription to 5G packages. It was also found that Doha, Umm Salal, Al Rayyan, and Al Wakra had comparable ratios of 5G users and non-users. Given that these locations have appreciably different levels of 5G network coverage, as seen from Fig. 2, a customer's choice to subscribe to a 5G data plan may not be highly influenced by their area of residence. This may be due to the lack of awareness about the coverage of 5G networks in Qatar as was reflected from the conducted questionnaire which showed that 34% of respondents were not aware that 5G networks do not yet cover all major areas in Qatar.

Regarding the influence of the independent factors on the willingness to use 5G, Table II summarizes the main findings. The Spearman correlation coefficients were calculated to assess the degree of correlation between customers' willingness to use 5G and their data rate needs, latency requirements, and price. The Spearmen test was conducted at the 95% confidence level. It can be seen from the Table that there is a "moderate" negative correlation between the willingness to use 5G and the price the customer has to pay. In other words, customers who are not willing to pay a high price on their data plans are more unwilling to use 5G. Moreover, there is also a "moderate" positive correlation between data rate and willingness to adopt 5G. Hence, the higher the data rate that the customer requires for his internet applications, the more willing they are towards switching to 5G. On

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the other hand, it can be seen that there is a "low" negative correlation between latency and willingness towards 5G, possibly indicating that latency has little impact on customers' willingness to switch from 4G to 5G data plans.

To further verify our findings, the χ^2-test at 5% significance level was conducted to verify that there is indeed an association between the three factors considered in the correlation analysis and the customer being a current 5G user. Table II shows the results of the calculated χ^2 values and the p-values. It was found that there is a significant association between each of the three factors and 5G adoption. In order to provide further validity to the results of our statistical analysis, the questionnaire had a question that directly asked the respondents about the most important factor that influences their decision when choosing to subscribe to a given data plan, whether 4G or 5G. The data from this question revealed that 61.3% of respondents considered the price of the data plan to be the most influential factor on their decision. Nearly equal number of respondents, around 17%, reported that data rate and coverage of 5G across all major cities in Qatar was the most important factor they take into consideration. On the other hand, only 4.3% of respondents considered latency to be the most important factor. These results are in perfect consistency with our statistical results from correlation and association tests. They verify that price is the most highly correlated factor with 5G usage followed by data rate and then latency.

Table II also shows that there is a significant association between 5G usage and phone 5G support, as expected. This is highlighted from the calculated χ^2 value which is much greater than the table value at 1 degree of freedom, since 5G phone support is nominal data. Moreover, there is a significant association between awareness about 5G features and limitations and 5G usage as reflected from the χ^2-test.

IV. DISCUSSION

The results of the statistical analysis prove the existence of a correlation between 5G usage and price, data rate, and latency. The negative correlation between price and willingness towards 5G implies that the higher the price of the 5G data plan, the more unwilling are customers to use 5G.

Table 2. Correlation/ Association Between The Willingness To Use 5g And The Independent Factors.

Factor	Spearman Correlation Coefficient	p-Value	χ^2-Value	p-Value
Price	-0.546	<0.000	13.855	<0.008
Data Rate	0.418	<0.000	10.988	<0.027
Latency	-0.342	<0.000	9.557	<0.044
Phone 5G Support	-	-	16.155	<0.000
Awareness	-	-	5.403	<0.020

The other correlation coefficients can be interpreted similarly, yet price has the strongest correlation with customers' willingness to adopt 5G.

Although low latency is one of the most important features of 5G as it opens new possibilities for services that require instant responses such as telemedicine, autonomous vehicles, drone communications, and game streaming, the conducted survey revealed that latency has the lowest correlation with the willingness of 5G adoption. Possible reasons could be consumers' unawareness of the opportunities low latency could bring. Besides, low-latency applications are not yet widespread among Qatari general consumers. This also explains why price is the leading factor affecting consumer decision, since the added features of 5G data plans in terms of higher data rates and lower latencies may not justify the extra cost of upgrading to 5G as many customers do not need very high data rate or very low latencies for their daily internet applications.

We propose few research-based recommendations that can increase the spread of 5G usage among customers in Qatar based on the results obtained from this study. Increasing 5G adoption in Qatar is beneficial for both network providers and users since it is an essential component of smart and sustainable cities. Price is the main factor that prevents customers in Qatar from adopting 5G data plans and services. Therefore, we recommend that network providers lower their prices for 5G data packages in the following manner. The network providers may consider creating a basic 5G package which is a partial 5G data plan, allowing users to access 5G speeds and services comparatively far better than 4G but not at par with premium 5G packages. This solution will potentially attract many customers to upgrade their existing 4G plans to 5G. Moreover, since network providers in Qatar

currently offer 5G plans, by giving users a specific amount of local data balance in Gigabytes, at a much more expensive rate compared to 4G plans. They can develop a new 5G plan which features both 4G and 5G connectivity and local data balances. The 5G local data balance will be the primary source of connectivity. However, when the 5G local data balance is consumed, the 4G data balance will be activated automatically, charging less than 5G. Through this switch, users can get a significant compromise on the speed with the price based on their individual needs. Customers will pay a relatively smaller extra amount compared to their regular 4G plans to get this 5G-4G mixed plan based on their customized needs. They will be able to choose to switch between 4G and 5G networks as they wish depending on network coverage and applications which will justify the extra cost for many customers. In the future, this can encourage customers to purchase more 5G data balance as they get more accustomed to high-speed connectivity, resulting in a smooth transition to full 5G plans.

V. CONCLUSION

This case study has identified the most important obstacles slowing down customers' transition to 5G networks in Qatar. Data collected from 230 respondents revealed that 59% of the respondents are not using 5G networks even though 63% of them have 5G capable phones. Spearmen correlation coefficients showed that price is the most highly correlated (negatively) factor with 5G adoption. Based on the analysis of the relations between price, data rate, latency, 5G coverage, and respondents' awareness of 5G features and limitations, it is concluded that the main factor limiting widespread adoption of 5G in Qatar is the considerably high prices of 5G data plans compared to 4G plans such that the new features provided by 5G do not justify the significant price increase especially that most customers do not require very low latencies or very high data rates for their most common internet applications. Therefore, it is recommended that service providers in Qatar establish some basic 5G packages, that have lower data rates than current premium 5G packages, in a way that allows customers to gain some of the new features of 5G networks yet not all the features of a full 5G subscription since such features are not needed by many customers. This allows service providers to

increase their 5G network usage by customizing 5G data plans that meet the demands of many Qatari customers without affecting their current 5G users. This shall encourage and smooth the transition to 5G in Qatar which will reflect in improving many future technologies from smart cars to IoT connectivity to smart cities.

REFERENCES

[1] E. Korzeniewska and A. Krawczyk, "5G Technology as the Succesive Stage in the History of Wireless Telecommunication," *2019 IEEE International Conference on Modern Electrical and Energy Systems (MEES)*, 2019, pp. 470-473.

[2] D. Wang, D. Chen, B. Song, N. Guizani, X. Yu and X. Du, "From IoT to 5G I-IoT: The Next Generation IoT-Based Intelligent Algorithms and 5G Technologies," in *IEEE Communications Magazine*, vol. 56, no. 10, pp. 114-120, October 2018.

[3] G. Liu, Y. Huang, Z. Chen, L. Liu, Q. Wang and N. Li, "5G Deployment: Standalone vs. Non-Standalone from the Operator Perspective," in *IEEE Communications Magazine*, vol. 58, no. 11, pp. 83-89, November 2020.

[4] J. Rischke, P. Sossalla, S. Itting, F. H. P. Fitzek and M. Reisslein, "5G Campus Networks: A First Measurement Study," in *IEEE Access*, vol. 9, pp. 121786-121803, 2021.

[5] M. Pätzold, "5G Is Going Live in Country After Country [Mobile Radio]," in *IEEE Vehicular Technology Magazine*, vol. 14, no. 4, pp. 4-10, December 2019.

[6] Gillipsie and Clara, "South Korea's 5G ambitions," *Korea Economic Institute of America,* 2020.

[7] "Distribution of 5G in cities and countries worldwide," [Online]. Available: https://www.faistgroup.com/news/distribution-5g-worldwide/. [Accessed 17-April-2022].

[8] Gupta, Akhil and R. K. Jha, "A survey of 5G network," *Architecture and emerging technologies,* vol. III, no. 3, pp. 1206-1232, 2015.

[9] Aslam, Nida, S. U. Rehman , I. U. Khan and M. A. Khan, "Exploring the Development and Progression of 5G," *A Bibliometric Analysis of Scholarly Production,* vol. 1, no. 1, pp. 1-17, 2020.

[10] S. K. Shah, Z. Tang, S. M. Sharif, and A. Tanveer, "An empirical study of Chinese students' behavioral intentions to adopt 5G for smart-learning in covid-19," *Smart Learning Environments*, vol. 8, no. 1, 2021.

[11] S. K. Shah, T. Zhongjun, A. Sattar, and Z. XinHao, "Consumer's intention to purchase 5G: Do environmental awareness, environmental knowledge and health

consciousness attitude matter," *Technol. Soc.*, vol. 65, p. 101563, May 2021.

[12]   K. Maeng, J. Kim, and J. Shin, "Demand forecasting for the 5G service market considering consumer preference and purchase delay behavior," *Telemat. Inform.*, vol. 47, p. 101327, Apr. 2020.

[13]   "Internet on postpaid," Vodafone Qatar. [Online]. Available: https://www.vodafone.qa/en/services/data-plans/internet-on-postpaid. [Accessed: 17-April-2022].

[14]   "Vodafone Qatar Coverage," Opensignal, 17-Jun-2021.   [Online].   Available: https://www.opensignal.com/networks/qatar/vodafone-coverage. [Accessed: 17-April-2022].

[15]   "Ooredoo Qatar Coverage," Opensignal, 17-Jun-2021.   [Online].   Available: https://www.opensignal.com/networks/qatar/ooredoo-coverage. [Accessed: 17-April-2022].