JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

The Impact of Artificial Intelligence (Chatbots and 3D Printing) in Prompting Economic Growth and Investments

A case of the real estate sector in the UAE

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Abstract: The study explores the impact of Artificial Intelligence (AI) technologies in the real estate sector. Highlighting the role of real estate in economic growth and development in the UAE, the research examines how the integration of AI technologies influences economic growth and investments. A purposive sampling was employed to distribute surveys to 220 real estate investors and agents. With a 90% response rate, the analysis of 200 surveys revealed that perceived compatibility and relative advantage of AI chatbots influence investors to have confidence. Moreover, the perceived complexity of AI chatbots and 3D printing influences investors' decision-making with reliance on peer opinions. On the contrary, the results suggested no direct link between the integration of AI technologies and economic growth in the real estate industry. The findings are useful for professionals in the real estate sector aiming to capture investors' attention through the integration of cutting-edge technologies like AI chatbots and 3D printing.

Index Terms **– real estate growth, investments, AI in real estate, AI chatbots, 3D printing in real estate, UAE real estate**

I. INTRODUCTION

The concept of Artificial Intelligence (AI) was first put forward by John McCarthy in 1955, he believed that every instance of the development of intelligence can be replicated by machines [1]. However, Dick [2] argued that the origin of the concept of AI roots back to the 1940s referring to the novel Runaround by Isaac Asimov in 1942. The story revolves around a robot who faces the dilemma of deciding whether to fulfil the orders of retrieving selenium or not because it introduces a situation where he would be violating one of the laws either the Second or Third laws of robotics mentioned in the novel. Owing to the confusion, the robot falls into a feedback loop and oscillates around a point where compulsions of follow-order law and avoid-danger laws become stronger making him run in circles around the selenium pool [3]. Although the novel may have made fictional references to the use of robotics, the conceptualization of AI is not explicitly mentioned. It was later when McCarthy's [4] project became popular that AI gained attention for its benefits in increasing the accuracy and efficiency of business operations.

AI comes in two varieties: weak AI and strong AI [5]. An AI is considered weak when it is used merely as a tool to examine and replicate human intelligence. In opposition to this, strong AI is when the machine is capable of learning and enhancing cognitive processes. Through the appropriate software or computing, computers may comprehend and tailor their conduct based on prior behaviour and experience [6]. Automatic networking between machines is a feature of strong AI that has a significant scaling effect [7]. Machine learning, automated processes, dematerialization, the sharing economy, and self-driving cars are some of the most significant economic applications of strong AI [8]. The evolution of advanced technologies like AI is evident in the international market as businesses across the globe have transformed. AI has become a vital tool in the way businesses interact with clients and consumers in various sectors including health, education, construction, manufacturing, and real estate [9, 10]. AI technologies are researched because of their benefits in business such as enhanced customer services, efficient operations, and the potential to increase economic growth along with investments [11]. The present study is especially interested in two AI technologies such as AI chatbots and 3D printing technology. AI chatbots incorporate the processing of natural languages to produce a conversational discourse that sounds human. The model of language can give answers to queries and create a variety of written content, such as blog posts, social media updates, essays, software, and emails [12].

OpenAI, a well-known San Francisco-based AI study and implementation business that was established in December 2015, is the owner and developer of ChatGPT [13]. GPTs, like ChatGPT and Google Chat, can do a variety of activities, including solving economic models, designing tests, helping with research, developing concepts, and improving writing. Large amounts of unstructured data, such as online postings, customer evaluations, and survey responses are analysed using AI chatbots like ChatGPT [14]. Whereas, 3D printing is creating a physical item out of a three-dimensional in-nature digital model, usually by applying successively many tiny coatings of a material. Employing a computer-generated layout, 3D printing, sometimes referred to as additive manufacturing (AM), is a technique for building three-dimensional objects step by step [15]

The potential of AI technologies is relevant to the real estate sector in the United Arab Emirates (UAE) as well. the real estate sector is one such area that has seen a major impact, chatbots and 3D printing are only two of the many ways that can be used to boost the economy and investments in real estate. UAE's effort to diversify its economy is supported in large part by the real estate sector. To lessen the nation's reliance on oil and gas-related income, the UAE government is concentrating on growing the economy. Approximately 5.5% of the UAE's total gross domestic product (GDP) is produced by real estate operations [16]. In recent years, Dubai's economy has grown significantly with the help of the real estate activities industry. Many of the processes, products, business models, and operations in the UAE real estate industry are projected to change quickly because of the swift scale-up and implementation of AI such as virtual assistance, chatbots and other emerging applications. 10% of the total economic output in the emirate of Dubai is accounted for by the real estate sector [17]. Thus, the incorporation of AI technologies, such as chatbots and 3D modelling, has been critical in recent years in fostering economic expansion as well as investment in a variety of areas [18]. However, Lee et al. [19] argued that economic growth resulting from AI technology adoption is likely to occur when there is a robust strategy in place for research development.

Nevertheless, realizing the potential applications of AI in terms of chatbots and 3D modelling, the researchers are interested in exploring how the real estate sector in UAE is benefitting from these AI technologies. The necessity of real estate efficiency in contributing to UAE's economic growth and development is stressed, considering the impact of AI technologies in prompting economic growth and investments in UAE real estate is assessed in the present study.

II. Literature Review

A. Theoretical Framework

The present study is interesting in understanding the impact of AI technologies such as AI chatbots and 3D printing in boosting economic growth and investments. The important theories that informed the development of the present study included diffusion of innovation and the theory of planned behaviour. Rogers introduced the diffusion of innovation theory [20] and it is now commonly used in organisational studies, business, and management studies among others to examine the adoption of emerging technologies. The theory suggests that the technology adoption process is mainly influenced by five characteristics such as relative advantage, complexity, comparability, trialability and observability. The relative advantage is the perceived benefit of AI chatbots and 3D printing as compared to traditional methods [20]. Compatibility is the ease of use and alignment of the AI technologies with the existing processes in the real estate sector [20]. Trialability is the option available related to the technology to be adopted and used before full-scale adoption is implemented. Complexity refers to the perceived complicatedness while implementing and managing AI technologies [20]. These are used to understand the adoption level of AI technologies in the real estate sector in Dubai. The aim is to assess the rate of adoption of AI chatbots and 3D printing to understand its link to economic growth and investments in the sector.

On the other hand, the theoretical underpinning for the examination of the investment behaviour for the study is informed by the theory of planned behaviour. Ajzen [21] introduced the theory of planned behaviour which argues that a person's behaviour depends on their attitudes, subjective norms, and perceived behaviour control. Attitudes refer to the evaluation of one's behaviour and the result of it, subjective norms involve the opinion, beliefs and influence of significant others that influence individual behaviour; while perceived behaviour control refers to a person's perception of their capabilities to exhibit a behaviour [21]. The investment activities are assessed in terms of the attitudes of investors, subjective norms, and perceived behavioural control of investors. The aim is to assess the investment-related decision-making process and investment behaviour related to AI chatbots and 3D printing adoption in the real estate sector.

B. AI Technologies and Economic Growth

Previous studies [22, 23, 24] have indicated a link between AI technologies and economic development such as AI chatbots and 3D printing being specifically relevant to the real estate sector. The basic function of AI chatbots is to produce text-box responses that are like what real people would write. As a result, it is appropriate for dialogue delivery to customers in terms of AI systems, and digital assistants [25]. AI chatbots driven by machine learning along with additional models of language can be used by real estate organisations to analyse reviews, ratings, and other unorganised information. For instance, Rousseau [26] highlighted that the processing of natural language is used by Chat GPT, an AI chatbot, to produce conversational discourse that sounds human. The model of language can give answers to queries and create a variety of written content, such as blog posts, social media updates, essays, codes, and emails. The use of AI chatbots like Chat GPT offers insightful information on customer preferences, problems, and other crucial elements.

With relevance to the link between 3D modelling and economic growth in the real estate sector, there are some indications of a positive link. Without having to physically visit the properties, 3D modelling enables potential buyers as well as investors to have fully immersive and in-depth insights into the real estate properties. Realistic representations of properties can be created using AI-driven 3D modelling software, allowing potential purchasers to examine the layout, style, and facilities in a virtual setting [27]. For foreign buyers who might not have the opportunity to personally view the properties, the use of technology has proven to be quite helpful. 3D printing moves beyond modelling and has the potential to impact the real estate sector in terms of automation, price changes, customer demands, enhancing operations, and boosting sales. For instance, Jandyal et al. [28] highlighted that in the real estate industry, 3D printing offers enormous advantages like cost-effectiveness, off-site building, quicker processing, greater quality, and much less time. The prevailing belief was that additive manufacturing would significantly reduce trade between nations since it allows economies to make items domestically. Researchers Rouf et al. [29] stated that most 3D-printed homes have curved, free-form designs composed of a cement mixture. As per the authors, such projects range from livable beta models for research to cheap housing that is ready for occupancy and even premium luxury residences. The advantages of a 3D-printed house primarily include the potential for novel designs, lower prices, and fewer building mistakes. Overall, this increases the efficiency of the real estate sector in terms of buying and selling. A climate favourable for economic development would require individualised support and an immersive real estate experience using AI technologies, effectively [30]. While studies in the past, as above, have examined the advantages of AI technologies such as 3D printing and AI chatbots, the impact of using these two in the context of real estate is not empirically investigated. To fill this knowledge gap, the following hypotheses are developed.

H1: There is a significant relationship between AI adoption (AI chatbots and 3D printing) and economic growth.

H2: There is a significant interaction effect of AI technologies (AI chatbots and 3D printing) on economic growth.

C. AI TECHNOLOGIES AND INVESTMENTS

Even though AI has been extensively studied for decades [31], it remains one of the most enigmatic topics in computer science since the field is so broad and ambiguous. It is thought that AI encompasses anything from intelligent machines to the search algorithms utilised in games for children. It is implied that AI has implications in almost every way that people utilise computers in society. AI is sometimes employed in more covert ways, for as by looking at customer histories and influencing marketing choices [32]. Although earlier robotics efforts were more focused on mechanical design than smart control, robots have long been associated with the public's idea of intelligent computing. Robots have become increasingly potent test subjects for ideas regarding intelligent behaviour around the globe thanks to AI, though. It has been asserted that AI encompasses more than only robots, though. Using computers as test subjects can help us better grasp the essence of intelligent cognition and action [33]. As described by Ray [34] by offering suggestions that can be utilised as input in different image-generation structures, AI chatbots can assist you in creating AI images. It can easily produce intricate and nuanced cues thanks to its processing of natural language abilities. According to Beerbaum [35], a rise in economic productivity might occur much faster than in previous technology revolutions, AI chatbots replaced cognitive work rather than physical chores that call for expenditure in equipment and facilities. Gao et al. [36] stated that real estate market information, like as property prices, trends in the market, and demand-supply factors, can be analysed using AI chatbots. By analysing enormous volumes of data, AI chatbots can produce insightful forecasts that help stakeholders as well as investors make wise decisions about real estate investments, pricing strategies, and market entrance points. Thereby, due to the variety of benefits generated by the adoption of AI, the present study directs attention towards attaining investments with the adoption of AI. Accurate representations enable investors to make well-informed decisions, boosting their confidence in the UAE real estate market [37]. For instance, Manrai and Gupta [38] examined the perceptions of investors towards investing in services that are driven by AI-powered robotics. The study analysed responses collected from 252 responses and found a positive association between investments and AI technology adoption [38]. AI technology integration has not only enhanced UAE real estate but also drawn foreign investors, to the simplicity of carrying out transactions. A 3D item is produced by the additive method of 3D printing, which involves building up layers of material. In impoverished nations, 3D printing provides an additional benefit in attracting investments and boosting the economy. It is simpler for business owners and investors to monitor and optimise the various processes of production since additive manufacturing is digital [39]. The production of high-value components, such as those used in the aviation and medical technology sectors, or low-volume substitutes will benefit from the usage of 3D printing technologies in remote production the most. There will be a wider range of substances available for additive manufacturing. Building parts including walls, facades, and foundations can be created utilising 3D printing and compulsive manufacturing methods [40]. This technology enables a quicker and more accurate manufacturing process, less material waste, and greater design customization options. Technologies like 3D printing can improve the viability of real estate developments and draw investment to the UAE by reducing building costs and schedules.

To the best of the researcher's knowledge, the interaction effect of AI technologies such as AI chatbots and 3D printing has not been examined. Based on the opportunity to produce beneficial results with the utilisation of multiple but right kinds of technologies, the following hypotheses are tested.

H3: There is a significant relationship between AI adoption (AI chatbots and 3D printing) and investment activities.

H4: There is a significant interaction effect of AI technologies (AI chatbots and 3D printing) on investment activities.

III. MATERIALS AND METHODS

A positivist philosophy supports objectivity and focuses on factual data siding with the concept of fixed realities [41]. Thus, the researcher employed a quantitative research methodology. Primary data was collected and analysed using statistical analysis to understand the impact of AI technologies in prompting economic growth and investments in the real estate sector.

A. SAMPLING SIZE AND TECHNIQUE

The sample size was determined using purposive sampling which is a type of non-probability sampling technique [42]. About 220 investors and real estate agents in Dubai's real estate industry were invited to the research. The approach to answering the research questions required access to experts in UAE real estate specifically real estate agents and investors were included. Owing to the need for an appropriate sampling technique that could allow the recruitment of suitable candidates, purposive sampling was employed [43]. However, it is necessary to understand the importance of setting clearly defined inclusion and exclusion criteria for the participants. The inclusion and exclusion criteria were set based on the factors of experience, knowledge, exposure to real estate projects in terms of either development or investment, geographics and diversity [43, 44]. Table 1 is provided below which mentions the details regarding factors for the inclusion of the potential respondents. In addition to that, the specific participants who were excluded are also stated.

Table 1: Recruitment of participants

Factors	Inclusion	Exclusion
Experience	Respondents having 3+ years of experience in the real estate sector were prioritised and included	Respondents having less than 3 years of experience were excluded
Knowledge	Respondents knowing AI and 3D printing technologies were prioritised and included	Respondents having an indirect connection to real estate investment or development were excluded
Diversity	Respondents having knowledge or experience of different backgrounds such as residential, industrial, and commercial real estate were included	Participants who invested only outside the UAE real estate industry were excluded
Exposure to real estate development/investment projects	Participants who have had either or exposure to both were prioritised	People who did not have any kind of exposure to real estate development and investment were excluded.
Geographics	People from the UAE real estate sector were considered	People who are outside the UAE were excluded

Following the inclusion and exclusion criteria, the population sample only included real estate developers and investors who had the relevant experience, knowledge, exposure, and background of participating in the UAE real estate sector.

IV. Data Collection

A total of 220 survey questionnaires were distributed to the respondents who met the above-mentioned criteria. With a 90% response rate, 200 survey questionnaires were received. The survey questionnaire comprised a total of 24 items, 5 were used to collect demographic details. The adoption of AI technology was assessed with statements developed using three aspects of the diffusion of innovation theory such as relative advantage, compatibility, and complexity for both AI chatbot adoption (CBA) and 3D printing adoption (3D) items separately making a total of 6 items. Other studies [45, 46] also developed survey items drawn from a diffusion of innovation theory in its entirety Moreover, 3 items related to expert's opinions regarding economic growth (EG) were used. The remaining 6 items were of investment activities (IA) assessed using the theory of planned behaviour, 2 items for each aspect such as attitudes (AA1 and AA2), subjective norms (SN), and perceived behaviour control (PB1 and PB2) were developed. Previous studies [47, 48] have used the theory of planned behaviour to develop survey items to assess investment behaviour, this supports the use of validated items. All the responses were recorded using a 5-point Likert scale starting from 1 to 5 indicating strongly disagree to strongly agree, respectively. The data was analysed using different statistical analysis techniques including descriptive, correlational and regression analysis (specifically multivariate analysis). Statistical Package for the Social Sciences (SPSS) version 21 was used for data analysis.

V. Data Analysis

A. Respondents Profile

Table 2 shows the respondent's profile in terms of age, gender, and nationality. The distribution of age is shown that shows that 26% of people lie in the age range 25-34, 23% in the 35-44 age range, 28% lie in the 45-55 age range, and 23% of respondents are ages 55 and above. In terms of gender, 66% of participants were male whereas 34% of participants were female. Most of the participants were emirate, 53% whereas the remaining were non-emirate such as 47%.

Table 1: Respondent's Profile

Demographics	Category	Frequency	Percentage
Age	25-34	53	26%
	35-44	47	23%
	45-54	55	28%
	55+	45	23%
Gender	Male	133	66%
	Female	67	34%
Nationality	Emirati	95	53%
	Non-Emirati	105	47%

Figure 1 is shown below illustrating the distribution of experience of participants along with exposure to diverse projects of real estate, the experience is shown in years. The experience varies across the participants and the exposure to diverse projects of real estate as well.

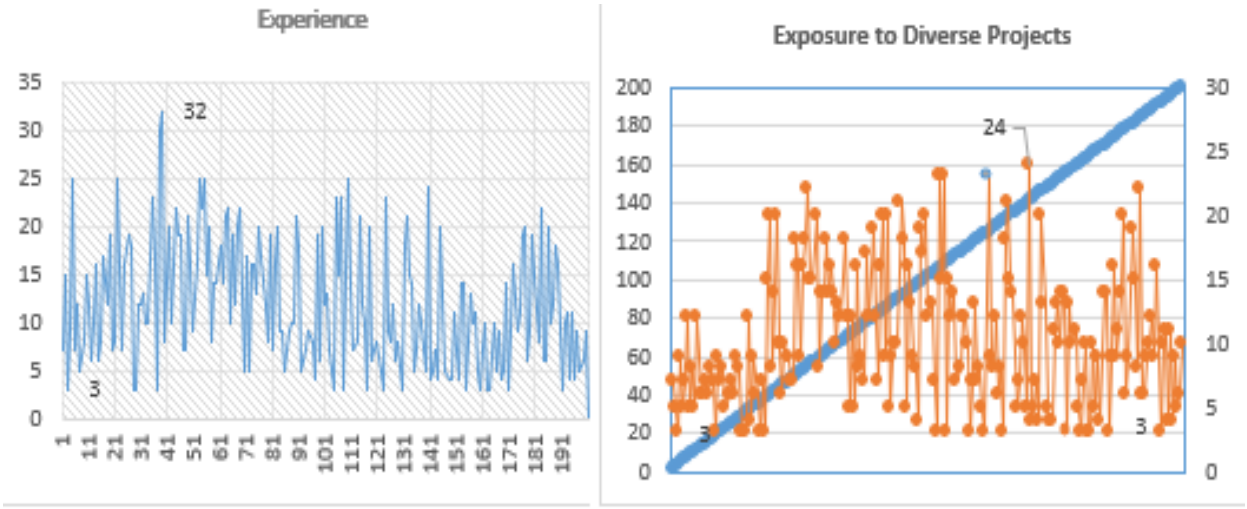

Figure 1: Experience and Exposure to real estate projects

B. DESCRIPTIVE ANALYSIS

The collected data was analysed using descriptive analysis, correlation analysis and regression analysis. The results of the descriptive analysis are presented in Table 3 which shows that the minimum age in the sample was 25 and the maximum age was 65, all the respondents were between this age group range, and N is the total number of samples. Furthermore, the experience of the respondents was analysed, the respondents had at least 3 years of exposure to real estate projects and maximum exposure is 32 years. The maximum years of experience for all respondents is 32 whereas all participants had at least 3 years of experience. The data is highly varied and positively skewed in terms of age, the gender and nationality are negatively skewed.

Table 2: Descriptive Analysis

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Skewness**	
	Statistic	*Statistic*	*Statistic*	*Statistic*	*Statistic*	*Statistic*	*Std. Error*
Age	200	25	65	43.78	11.732	0.109	0.172
Experience	200	3	32	11.86	6.46	0.55	0.172
Gender	200	0	1	0.67	0.473	-0.704	0.172
Nationality	200	0	1	0.66	0.475	-0.681	0.172
Exposure to real estate projects	200	3	24	10.22	5.298	0.607	0.172

C. Correlation Analysis

In the first step, the variables were analysed using correlational analysis, the results are shown in Table 4. Independent variables (IV) and dependent variables (DV) are shown in the table such as AI technologies such as AI chatbots (CBA) and 3D printing (3D), the economic growth variables (EG) and investment activities based on attitudes (AA), subjective norms (SN) and perceived behaviour control (PB) related to investment activities. This was conducted to determine the correlation between IV and DVs, the outcome of this step informed the next step.

Table 3: Correlation Analysis Results

Pearson Correlation		EG1	EG2	EG3	AA1	AA2	SN1	SN2	PB1	PB2
CBA1	*Sig. (2-tailed)*	0.84	0.57	0.13	0.76	0.13	0.04	0.93	0.52	0.19
CBA2	*Sig. (2-tailed)*	0.68	0.51	0.33	0.09	0.16	0.30	0.07	0.41	0.50
CBA3	*Sig. (2-tailed)*	1.00	0.39	0.08	0.38	0.31	0.44	0.48	0.10	0.98
3D1	*Sig. (2-tailed)*	0.68	0.89	0.51	0.19	0.12	0.98	0.89	0.01	0.82
3D2	*Sig. (2-tailed)*	0.35	0.05	0.90	0.30	0.35	0.95	0.47	0.16	0.63
3D3	*Sig. (2-tailed)*	0.99	0.92	0.10	0.62	0.54	0.40	0.57	0.55	0.73

As shown in Table 4, CBA1 is highly correlated to EG1 and SN2 with values close to 1 such as 0.84 and 0.93 respectively whereas CBA1 is moderately correlated to EG2, AA4, and PB1 with values 0.57, 0.76, and 0.52, respectively. CBA2 shows moderate to weak correlation with EG1, EG2 and PB2. Similarly, CBA3 shows mostly weak correlations except for a high correlation with EG1 and PB2. All items of 3D printing show moderate to high correlation with EG and items of investment activities. The correlation showed that 3D printing adoption showed a high correlation with economic growth and investment activities.

D. Regression Analysis

The regression analysis was performed to examine the link between the adoption of AI technologies such as AI chatbots adoption and 3D printing adoption and economic growth and investment activities in Dubai's real estate sector. To analyse the link between multiple IVs and DVs, a multivariate regression model was assessed using SPSSv21, Table 5 shows the results of this analysis without the interaction effects. None of the 3D printing (3D) or Chatbot adoption (CBA) items showed a significant effect on any of the economic globalisation (EG) and investment activities (IA) items (AA1, AA2, SN1, SN2, PB1, PB2) which were developed using TBP.

Table 4: Multivariate Tests, All variables

Effect	Value	F	Hypothesis df	Error df	Sig.
3D1	0.837	1.166	27	500.05	0.259
3D2	0.932	.686c	18	342	0.826
3D3	0.888	0.767	27	500.05	0.796
CBA1	0.809	1.041	36	642.553	0.406
CBA2	0.824	0.948	36	642.553	0.558
CBA3	0.836	0.876	36	642.553	0.678

However, a good-fitted model was obtained using only the variables that showed a high correlation in the previous step. Based on the high correlation between the variables 3D printing and CBA, a multivariate analysis was conducted to assess the causal link and as well as interaction effect. The multivariate statistics test such as Wilk's lambda was taken into consideration. Table 6 shows the multivariate analysis results that show significant value for the interaction effect of CBA1 and 3D2 such as $p<0.05$. The value of Wilk's lambda is 0.76 and the F value is different from 0, $F(24,415.34) = 1.67$. Overall, the model is found significant, but there is a need to look at the test of between-subject effects to understand the simple and interaction effects extensively.

Table 5: Multivariate Tests, Highly Correlated Variables

Effect Multivariate Statistic: Wilks' Lambda	Value	F	df	Error df	Sig.
3D2	0.93	1.75	6	286	0.10
3D1	0.96	0.60	9	348.17	0.79
CBA1	0.92	1.01	12	378.63	0.43
3D2*3D1	0.88	0.95	18	404.95	0.50
3D2*CBA1	0.76	1.67	24	415.34	0.02
3D1*CBA1	0.86	0.61	36	423.23	0.96

Table 7 shows the results of the test of between-subject effects, there is a simple effect of 3D printing adoption technology and investment activities with p=0.05 which is considered significant. Moreover, there is an interaction effect of AI chatbot adoption and 3D printing adoption on the investment activities with p = 0.01 which is less than 0.05 and F (8,2.68) = 2.60. Apart from this, other items of 3D printing adoption are not significantly linked to any other items of economic growth and investment activities.

Table 6: Between-Subjects Effects

Tests of Between-Subjects Effects						
Source	**Dependent Variable**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Model	**SN1**	2564.382a	55.00	46.63	39.17	0.00
	EG2	2737.523b	55.00	49.77	45.26	0.00
	PB1	2490.729c	55.00	45.29	43.99	0.00
3D1	**SN1**	2.16	2.00	1.08	0.91	0.41
	EG2	3.19	2.00	1.59	1.45	0.24
	PB1	6.16	2.00	3.08	2.99	0.05
3D2	**SN1**	1.34	3.00	0.45	0.38	0.77
	EG2	2.08	3.00	0.69	0.63	0.60
	PB1	2.30	3.00	0.77	0.74	0.53
CBA1	**SN1**	5.36	4.00	1.34	1.13	0.35
	EG2	0.34	4.00	0.09	0.08	0.99
	PB1	8.48	4.00	2.12	2.06	0.09
3D2 * 3D1	**SN1**	2.74	6.00	0.46	0.38	0.89
	EG2	6.12	6.00	1.02	0.93	0.48
	PB4	10.04	6.00	1.67	1.63	0.14
3D2 * CBA1	**SN1**	8.80	8.00	1.10	0.92	0.50
	EG2	12.64	8.00	1.58	1.44	0.19
	PB1	21.41	8.00	2.68	2.60	0.01
3D1 * CBA1	**SN1**	10.62	12.00	0.89	0.74	0.71
	EG2	4.75	12.00	0.40	0.36	0.98
	PB1	9.74	12.00	0.81	0.79	0.66

R Squared = .937, Adjusted R Squared = .913

The R squared value is .93 which is acceptable and indicates that the model predicts 93% variation caused by IV on DV. The adjusted R squared value is reliable when multiple variables are involved which is .91%. This means that the model predicts 91% variation caused by the simple effect of 3D2 on PB1 and the interaction effect of 3D2 and CBA1 on PB1.

A simple effect test was conducted to understand the interaction effect observed in the multivariate analysis. Table 8 shows the results of the simple effects tests which indicates that at least one of the IV effects significantly the DV. It is revealed that the CBA1 is significantly linked to PB1 with p = 0.01 (< 0.05) and F (4, 3.26) = 3.18 when the partial Eta Squared value is 0.064. Furthermore, the interaction effect between 3D2 *CBA1 is also significant with p = 0.02 (<0.05) with F (8, 2.33) = 2.27. Whereas, 3D2 is not significantly related to PB1 which explains the simple effects rooted in the interaction effect.

Table 7: Main Effects

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	28.401a	14	2.029	1.98	0.021	0.13
Intercept	1540.165	1	1540.165	1503.442	0	0.89
3D2	3.886	2	1.943	1.897	0.153	0.02
CBA1	13.057	4	3.264	3.186	0.015	0.064
3D2 * CBA1	18.664	8	2.333	2.277	0.024	0.09
Error	189.519	185	1.024			

R Squared = .130 (Adjusted R Squared = .065)

The R-squared value is .130 which indicates that the model predicts 13% variation caused by the IV on DV. The adjusted R squared indicates that a 6.5% variation is caused by the simple effect of CBA1 and the interaction effect of CBA1*3D2 on PB1. The hypotheses summary is presented in the next section.

E. Hypothesis Testing and Summary

The first hypothesis "There is a significant relationship between AI adoption (AI chatbots and 3D printing) and economic growth (H1)" is rejected because none of the 3D printing adoption items or CBA adoption items showed any significant relation with the dependent variables (see Table REF). Similarly, the second hypothesis "There is a significant interaction effect of AI technologies (AI chatbots and 3D printing) on economic growth (H2)" is also rejected because the interaction effects did not show any significant relation to any of the EG items as shown in Table 9. Most of the 3- and 4-way interaction effects showed constant values that are insignificant which are omitted in the table.

Table 8: Interaction Effects on Economic Growth

Interaction Effect	Value	F	Hypothesis df	Error df	Sig.
CBA1 * CBA2	0.623	1.102	48	307.142	0.309
CBA1 * CBA3	0.57	1.332	48	307.142	0.081
CBA2 * CBA3	0.72	0.797	45	306.767	0.82
CBA1 * CBA2 * CBA3	0.472	0.84	105	309.346	0.853
3D1 * 3D2	0.925	0.69	18	441.72	0.822
3D1 * 3D3	0.818	1.202	27	456.243	0.224
3D2 * 3D3	0.901	0.925	18	441.72	0.549
3D1 * 3D2 * 3D3	0.81	0.948	36	461.647	0.558
CBA1 * 3D1	0.535	0.982	30	123.954	0.502
CBA2 * 3D1	0.607	1.097	21	121.151	0.36
CBA3 * 3D1	0.438	1.341	30	123.954	0.135
CBA1 * 3D2	0.828	1.096	24	392.142	0.345
CBA2 * 3D2	0.822	1.142	24	392.142	0.294
CBA3 * 3D2	0.735	1.217	18	189.99	0.251
CBA1 * 3D3	0.57	0.873	30	123.954	0.657
CBA2 * 3D3	0.619	0.815	27	123.304	0.725
CBA3 * 3D3	0.505	0.902	36	124.821	0.63
CBA1 * CBA2 * 3D2	0.691	0.889	60	403.601	0.707
CBA1 * CBA2 * 3D3	0.527	0.963	87	350.961	0.575

The third hypothesis such as "There is a significant relationship between AI adoption (AI chatbots and 3D printing) and investment activities (H3)" is rejected because none of the CBA and 3D printing adoption items shows a significant effect on the dependent variables related to investment activities. However, the fourth hypothesis such as "There is a significant interaction effect of AI technologies (AI chatbots and 3D printing) on investment activities (H4)" is partially accepted. The table shows multivariate test results for the interaction effect of CBA and 3D on investment activities. Specifically, the interaction effect of 3D1 and 3D3 is significant on the dependent variables with p= 0.02 (<0.05). The interaction effect of 3D2 and 3D3 is significant on the dependent variables with p= 0.04 (<0.05). Moreover, the interaction effect of 3D1 and CBA1 is significant on the dependent variables with p= 0.03 (<0.05).

Table 9: Multivariate Analysis, Interaction Effects on Investment Activities

Effect	Value	F	Hypothesis df	Error df	Sig.
CBA1 * CBA2	0.346	1.231	96	573.369	0.08
CBA1 * CBA3	0.445	0.916	96	573.369	0.698
CBA2 * CBA3	0.449	0.966	90	568.974	0.57
CBA1 * CBA2 * CBA3	1.51	1.009	210	630	0.462
3D1 * 3D2	0.803	0.962	36	674.631	0.534
3D1 * 3D3	0.616	1.45	54	784.744	0.021
3D2 * 3D3	0.722	1.443	36	674.631	0.047
3D1 * 3D2 * 3D3	0.664	0.909	72	838.214	0.688

3D1 * CBA1	0.168	1.417	60	209.389	0.038
3D1 * CBA2	0.297	1.312	42	186.378	0.114
3D1 * CBA3	0.253	1.047	60	209.389	0.398
CBA1 * 3D2	0.407	1.33	48	318.969	0.081
CBA2 * 3D2	0.622	0.9	36	283.805	0.637
CBA3 * 3D2	0.494	1.372	36	283.805	0.084
CBA1 * 3D3	0.29	0.93	60	209.389	0.621
CBA2 * 3D3	0.468	0.604	54	203.456	0.985
CBA3 * 3D3	0.193	1.07	72	217.987	0.349

Table 11 shows further tests of assessing the between-subject effects, CBA1 has a significant link to SN1 with p = 0.01 (<0.05), F (4, 2.87) = 3.31. Moreover, the interaction between CBA1 and CBA2 has a significant link to PB2 with p = 0.05 (<=0.05), F (15, 1.79) = 1.89. CBA1 has a significant link to SN1 with p = 0.01 (<0.05), F (4, 2.87) = 3.31. All the F values of significant relationships are significantly different from 0 which provides evidence to partially accept hypotheses. The hypothesis is partially accepted because all interaction effects of CBA adoption and 3D printing are not significantly linked to investment activity items such as attitudes (AA1 and AA2), perceived behaviour control (PB1 and PB2) and subjective norms (SN1 and SN2).

Table 10:Between-Subjects Interaction Effects

Tests of Between-Subjects Effects						
Source	**Dependent Variable**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
CBA1	**AA4**	1.201	4	0.3	0.205	0.934
	AA2	1.395	4	0.349	0.27	0.896
	SN1	11.49	4	2.872	3.311	0.019
	SN2	1.44	4	0.36	0.254	0.906
	PB1	4.229	4	1.057	0.807	0.528
	PB2	1.903	4	0.476	0.502	0.734
CBA2	**AA4**	1.035	4	0.259	0.177	0.949
	AA2	7.673	4	1.918	1.485	0.223
	SN1	1.907	4	0.477	0.549	0.7
	SN2	9.746	4	2.437	1.72	0.163
	PB1	0.75	4	0.188	0.143	0.965
	PB2	5.284	4	1.321	1.395	0.251
CBA3	**AA4**	2.539	4	0.635	0.433	0.784
	AA2	2.037	4	0.509	0.394	0.812
	SN1	8.506	4	2.126	2.451	0.06
	SN2	2.959	4	0.74	0.522	0.72
	PB1	0.533	4	0.133	0.102	0.981
	PB2	1.958	4	0.489	0.517	0.724
3D3	**AA4**	1.59	3	0.53	0.362	0.781
	AA2	1.543	3	0.514	0.398	0.755
	SN1	6.154	3	2.051	2.365	0.084
	SN2	4.27	3	1.423	1.005	0.4
	PB1	2.367	3	0.789	0.602	0.617
	PB2	3.68	3	1.227	1.295	0.288
CBA1 * CBA2	**AA4**	16.914	15	1.128	0.769	0.702
	AA2	26.145	15	1.743	1.349	0.215
	SN1	10.91	15	0.727	0.839	0.632
	SN2	27.162	15	1.811	1.278	0.256
	PB1	19.684	15	1.312	1.001	0.471

	PB2	26.888	15	1.793	1.893	0.051
CBA1 * CBA3	**AA4**	18.397	14	1.314	0.896	0.568
	AA2	12.712	14	0.908	0.703	0.759
	SN1	15.548	14	1.111	1.28	0.258
	SN2	24.977	14	1.784	1.259	0.27
	PB1	10.01	14	0.715	0.546	0.891
	PB2	9.4	14	0.671	0.709	0.754
CBA1 * 3D3	**AA4**	20.582	10	2.058	1.404	0.21
	AA2	4.938	10	0.494	0.382	0.948
	SN1	10.197	10	1.02	1.176	0.333
	SN2	12.478	10	1.248	0.881	0.558
	PB1	7.359	10	0.736	0.562	0.836
	PB2	9.083	10	0.908	0.959	0.491
CBA2 * CBA3	**AA4**	17.977	14	1.284	0.876	0.588
	AA2	14.169	14	1.012	0.784	0.681
	SN1	17.739	14	1.267	1.461	0.167
	SN2	13.417	14	0.958	0.676	0.784
	PB1	11.927	14	0.852	0.65	0.808
	PB2	18.8	14	1.343	1.418	0.185
CBA2 * 3D3	**AA4**	11.45	9	1.272	0.868	0.56
	AA2	6.517	9	0.724	0.561	0.821
	SN1	5.204	9	0.578	0.667	0.734
	SN2	4.936	9	0.548	0.387	0.935
	PB1	9.008	9	1.001	0.764	0.65
	PB2	5.351	9	0.595	0.628	0.767
CBA3 * 3D3	**AA4**	11.854	12	0.988	0.674	0.767
	AA2	10.399	12	0.867	0.671	0.769
	SN1	20.549	12	1.712	1.974	0.051
	SN2	17.599	12	1.467	1.035	0.435
	PB1	11.61	12	0.967	0.738	0.707
	PB2	15.67	12	1.306	1.379	0.212
CBA1 * CBA2 * CBA3	**AA4**	12.384	6	2.064	1.408	0.233
	AA2	5.235	6	0.872	0.675	0.67
	SN1	6.541	6	1.09	1.257	0.297
	SN2	7.142	6	1.19	0.84	0.546
	PB1	8.204	6	1.367	1.043	0.411
	PB2	11.237	6	1.873	1.978	0.089
CBA1 * CBA3 * 3D3	**AA4**	1.524	1	1.524	1.039	0.314
	AA2	2.381	1	2.381	1.843	0.181
	SN1	0.024	1	0.024	0.027	0.869
	SN2	0.857	1	0.857	0.605	0.441
	PB1	0.095	1	0.095	0.073	0.789
	PB2	3.429	1	3.429	3.621	0.064

a R Squared = .976 (Adjusted R Squared = .892)
b R Squared = .980 (Adjusted R Squared = .911)
c R Squared = .986 (Adjusted R Squared = .937)
d R Squared = .978 (Adjusted R Squared = .899)
e R Squared = .978 (Adjusted R Squared = .901)
f R Squared = .985 (Adjusted R Squared = .930)

All the R squared and adjusted R squared values are above .89 which indicates a good fitness of the model. Overall, the main finding of the study is that the fourth hypothesis is partially accepted, the interaction effect of chatbot adoption and 3D printing adoption in real estate agencies partially affects investment behaviour.

VI. Discussion

The first main finding is that the interaction effect between CBA1 (perceived relative advantage) and CB2 (perceived compatibility) is significant to PB2 (confidence regarding investments in real estate projects), this indicates that professionals in the real estate sector who perceive AI chatbots advantageous and prefer using its over traditional methods, given that they align with existing processes, are more like to attract investors. Thus, a positive perception of the use of AI chatbots can lead to increased investment activities and demonstrate the strengths of this AI technology for real estate business. Manrai and Gupta [38] have also found similar implications for investment activities but have not particularly examined the case of the real estate industry.

The above finding not only reveals the advantages of AI technologies over traditional methods of customer service but also the importance of aligning it with the existing processing for full integration. In other words, a well-integrated AI technology is more likely to boost investments and increase the confidence of investors in real estate projects [38, 22].

The second main finding is that the interaction effect between CBA3 (perceived complexity of AI chatbots) and 3D3 (perceived complexity of the 3D printing technology) is significant to SN1 (perceptions' influence on investment decisions). This indicates that when the adoption of AI technologies, AI chatbots and 3D printings, is perceived as complex, individuals are more likely to take second opinion of industry experts and peers to make investment decisions. The above findings imply the significance of external party validation and collective decision-making of stakeholders when complex technologies like AI are being navigated in the real estate sector.

Apart from the interaction effects, one of the main effects is pivotal, the effect of CBA1 (perceived relative advantage of AI chatbots) on SN1 (perceptions' influence on investment decisions). This finding implies that real estate investors' perceptions of investing in projects are influenced by the perceived relative advantage of AI chatbot adoption over traditional customer service techniques or methods. As opposed to previous studies [23, 24] finding a significant impact of AI technology adoption on economic growth in other domains, the present study found a non-significant relationship between AI chatbots and 3D printing technology within the real estate context. A logical explanation of this is found in Lee et al. [19] study which claims that AI adoption at low levels is not significantly associated with economic growth but the economic growth is likely to increase as the adoption level of AI intensifies with a strong research and development strategy.

Altogether, these findings suggest a multifaceted nature of AI technology adoption in the real estate industry. The study highlights the important role of AI technologies in enhancing the growth and development of the real estate sector while revealing the complexities of its implementation. Additionally, the influence of industry experts and peers on the decision-making process of investors is also a pivotal finding. The comprehensive insights serve as a valuable guide for experts and professionals in real estate to gain investors with the help of integrating advanced technologies like AI chatbots and 3D printing.

VII. Conclusion

The study aimed to analyse the impact of AI technologies such as AI chatbots and 3D printing adoption on the economic growth and investments in Dubai's real estate sector. The findings illuminate the complex and multifaceted nature of AI technology adoption and its influence on investment decisions. While the study did not find any significant impact on AI technologies such as AI chatbots and 3D printing on economic growth, findings are pivotal to understanding the impact on investments. The social influences and expert opinions are highlighted in terms of shaping the decision-making process of investors in the real estate sector. The positive perceptions of AI chatbots and increased compatibility with the existing processes significantly improve investment activities as the investors are more likely to have confidence in such projects. This stresses the need for understanding the relative advantage of AI technologies over outdated methods of customer service in the real estate sector. Importantly, the study stresses the need to understand the perceived complexity of AI technology adoption. When perceptions of complexity are high, individuals are likely to rely on social influence and seek help from industry experts to make investment decisions in real estate projects. The study holds essential implications for the real estate industry in Dubai and beyond. It provides useful and practical solutions to benefit from integrating AI technologies in a way that boosts investments. By understanding the complex nature of AI technology adoption, stakeholders would be able to make informed decisions and beneficially integrate technologies. The study has limitations as it focuses on the context of Dubai real estate which may not generalise the findings to other sectors or other regions. Nevertheless, the study contributes to the research on the integration of AI technologies and develops a path to achieve sustainable, innovative and effective growth in the real estate sector.

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