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Original Article

A framework of examining the factors affecting public acceptance of nuclear power plant: Case study in Saudi Arabia

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ABSTRACT

The Saudi National Atomic Energy project aims to adopt peaceful nuclear technologies and be part of the country's energy mix. As emerging nuclear energy, it is essential to understand public concerns and acceptability of nuclear energy, as well as the factors influencing acceptance to develop nuclear energy policy and implement nuclear energy programs. The purpose of this study is to analyze the public attitudes and acceptance of nuclear energy among Saudi Arabian citizens by utilizing protection motivation theory and theory of planned behavior. A total of 1,404 participants answered a questionnaire which was distribute by convenience sampling approach. A Structural Equation Modeling framework was constructed and analyzed to understand public behavior toward building the country's first Nuclear Power Plant (NPP). Before analyzing the data, the model was validated. The research concluded that the benefits of nuclear power plants were essential in determining people's acceptance of NPPs. Surprisingly, the effect of the perceived benefits was found higher than the effect of the perceived risks to the acceptance. Furthermore, the public's participation in this study revealed that the NPPs location has a significant impact on their acceptance. Based on the finding, several policy implementations were suggested. Finally, the study's model results would benefit scholars, government agencies, and the business sector in Saudi Arabia and worldwide.

1. Introduction

The economic growth of Saudi Arabia has increased drastically over the last three decades, mainly because of the abundance of oil and natural gas reservoirs. According to the General Authority for Statistics (GASTAT) of Saudi Arabia, real Gross Domestic Product (GDP) recorded an increase of (12.2%) during the second quarter of 2022 compared to the same period last year 2021. This growth is mainly due to the high increase in oil activities, Non-oil activities, and Government activities. Saudi Arabia is also a member of the G20 forum as one of the world's largest economies, and its economic growth is heavily dependent on non-renewables, and there is an urgent need for the country to explore alternative sources of energy such as nuclear, solar, or wind energy [1,2]. Many countries have committed to using renewable and nuclear energy to reduce petroleum consumption and limit their greenhouse gas emissions [3].

In April 2016, Saudi Arabia adopted its vision for 2030, which aims to establish and develop renewable and sustainable energy projects [4]. One of the projects under this vision is the Saudi National Atomic Energy Project which will allow harmless nuclear energy in the country. The project will contribute to the existing national energy and will be done in agreement with the local requirements and international commitments to nuclear energy. In addition, nuclear energy will play an essential part in reducing the high consumption of the nation's fossil fuels and diversifying the country's economy [5].

The previous nuclear accidents and incidents such as Chernobyl, Three Mile Island, and Fukushima have caused serious concerns about the safety of nuclear energy in the communities. The level of trust toward nuclear energy among public members has decreased recently, especially when there are cleaner and renewable energy sources like photovoltaics and wind-driven generators [6]. Recently, there is also opposition to the usage and development of nuclear energy after the Fukushima nuclear explosion [7]. For instance, an anti-nuclear protest in Guangdong province, China, in July 2013 concerned with the Jiangmen nuclear power plant project. In Germany, more than 80% of Germans were against the usage

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Nomenclature

GCC	Gulf Cooperation Council
NPP	Nuclear Power Plant
NRRC	Saudi Nuclear and Radiological Regulatory Commission
AVE	Average Variance Extracted
CFA	Confirmatory Factor Analysis
CR	Composite Reliability
PLS	Partial Least Square
PMT	Protection Motivation Theory
SEM	Structural Equation Model
SFL	Standardized Factor Loading
TPB	Theory of Planned Behavior
AN	Acceptance of Nuclear Power Plant
NK	Nuclear Knowledge
P	Proximity
PB	Perceived Benefits
PR	Perceived Risk
SI	Social Influence
TR	Trust in Regulations
M	Mean
S	Population size
SD	Standard Deviation
e	Level of precision
f^2	Effect size
n	Sample size
p	Probability of obtaining the observed results

and development of nuclear energy after the Fukushima nuclear explosion accident. In comparison, the opposition was as high as 90% in Austria after a similar nuclear accident [8].

Rogers developed Protection Motivation Theory (PMT) and broadened the model of health-related beliefs in both the social psychology and health fields. PMT was created to better explain fear appeals by drawing on the expectancy-value and cognitive processing theories. As a result, one of the most effective explanatory hypotheses for anticipating a person's desire to take preventive action is PMT. PMT has been extensively used in research related to natural disasters. The protection motivation theory claims that a person's conduct changes in response to a life-threatening or coping evaluation [9]. In 1991, Ajzen introduced the Theory of Planned Behavior (TPB). It claims that attitude, arbitrary rules, and perceived behavioral control all impact a person's conduct. TPB is one of the most effective persuasion theories and has been applied extensively in various fields [10]. Integrating the PMT with the extended TPB has been made in some studies. Kurata et al. [11] integrated the PMT and extended TPB to assess the factors affecting the perceived effectiveness of the 2020 typhoon Vamco (Ulysses) flood disaster response among Filipinos. Likewise, Ong et al. [12] integrated PMT and extended TPB in evaluating the factors influencing Filipinos' preparation intention for The Big One earthquake by utilizing Structural Equation Modeling (SEM). In addition, Prasetyo et al. [13] analyzed factors of perceived effectiveness of COVID-19 prevention measures among Filipinos, by integrating PMT and extended TPB by using SEM.

No study investigated the factors affecting public acceptance of nuclear power plants in Arab Gulf countries, specifically Saudi Arabia. Especially there is no difference in the culture between these counties. The current study aims to examine and understand the public acceptance of nuclear energy and investigate the factors that affect public acceptance in Saudi Arabia. This study also helps policymakers to understand public perceptions about nuclear power plants.

2. Literature review and research hypotheses

2.1. Literature review

For the purpose of the present study, "public acceptance of nuclear programs" will be defined as the ability and willingness of the people to accept the usage and development of nuclear power reactors for electricity generation and other secondary applications of nuclear technologies, as determined by the concerned community [10]. The public perceptions and acceptance of nuclear energy are crucial to promoting the development of nuclear energy in local communities [14]. Many studies indicated that insufficient knowledge limits the creation or development of nuclear energy programs since knowledge is an important psychological factor and significant influence on public acceptance [15]. Nuclear energy is regarded as a controversial energy source, and the research on public engagement in the context of this energy is very limited. Public engagement is assumed to be helpful to make best socially and morally right decisions that will provide the correct information about the nuclear energy. The sufficient knowledge will improve public satisfaction, support and acceptance of the usage and development of nuclear energy [16]. The researchers consider individual factors and complex social, cultural, and historical factors when determining public acceptance of nuclear power [17]. For instance, Kim et al. [7] mentioned that most people who live far from nuclear facilities support nuclear power conditionally, based on social benefits and its effect on the country's welfare. These people have never considered the individual negative impact of nuclear energy. This conditional support has been referred to as reluctant acceptance. Therefore, public engagement about nuclear power deserves serious attention and will be considered in the present research work. The current research aims to understand the effects of public knowledge about nuclear energy, trust in local regulations, social influence, proximity, perceived benefit, and perceived risk of nuclear energy.

Nuclear knowledge is the most important step toward positively influencing the accep-tance of nuclear energy in any country with a nuclear program. The knowledge about the principle of nuclear power will make people have fewer worries about the negative influence since they will have a clearer blueprint of nuclear power advantages and utilizations [18]. Sun and Zhu [19] argued that more knowledge of nuclear energy could improve public acceptance. Stoutenborough et al. [20] suggested that people with a higher level of nuclear energy knowledge have a high chance of having a positive attitude towards promoting energy. Moreover, the study of Owens and Driffil [21] proved that the prevalence of information deficiencies has seriously affected the public acceptance of nuclear energy. Therefore, the provision of local-based knowledge about nuclear energy can improve their social acceptance and facilitate the rapid implementation of nuclear energy. Similarly, trust in regulations was found to have an impact on decreasing and increasing the acceptance of nuclear power. Moreover, the degree of trust depends heavily on the belief of people overr certain objects. Oh and Hong [22] found that public projects can be hindered by a prevailing lack of trust in the government. For example, in Korea, Mah et al. [23] suggested that the Hong Kong government must build trust in the local community, which must be given prominent attention in nuclear decision-making. It should also assume a key role in enhancing such trust. Siegrist et al. [24] pointed out that when the public has more confidence in the government's nuclear energy information and policies, they will support the government's control over the development of nuclear energy. Finally, people will accept such developments. The government can increase the acceptance of nuclear energy by disclosing transparent and relevant information and holding public hearings and discussions [25]. Helgeson et al. [26] stated that interpersonal relationships link social actors that share beliefs and influence one another regarding attitude behavior. Many scholars acknowledge that social media influences friends, family members, or co-workers, and such an influence process can shape the right attitude towards risky issues such as nuclear energy [27]. Therefore, social influence is considered one of the essential factors in increasing acceptance of nuclear energy in a non-Western cultural context like Saudi Arabia.

In the present study, proximity means the distance from a nuclear energy source, and we will want to establish the relationship between proximity and nuclear energy acceptance. Most researchers have found positive effects on the behavior of the public who resides near nuclear facilities [28]. The study by Greenberg showed that the residents living close to nuclear power plants prefer nuclear power as compared to the general population [29,30]. Their preference is caused by their familiarity with local nuclear power plants, economic perceptions, and social benefits. A number of research works [31,32] have established that proximity is usually associated with a lower level of concern and higher acceptance among the local community. Other researchers have suggested that the participation of nuclear facilities in supporting the local economy will result in the communities that are their potential source of harm [33].

Perceived risk refers to an individual's perceptions of the possible negative consequences of a specific event or conduct [34], determined by the probability of the risk occurring together with its prospect loss [35]. The risk associated with nuclear energy is brought by perception from the general public, who disagree with experts' assessments. Some people have changed their attitude towards nuclear power and perceived more risks after Chernobyl, Three Mile Island, and Fukushima nuclear disasters. Moreover, there is a change in people's perception of social benefits and the acceptance of nuclear power [34]. Park and Ohm [36] found that the perceived risk negatively affected public intention to use nuclear energy after the Fukushima nuclear explosion. Yaqoot et al. [37] established that the perceived risk negatively affects public acceptance of renewable energy. Some communities are concerned about the negative effect of nuclear radiation exposure, which could cause serious irreversible damage to large neighboring geographical areas [38,39].

In the present research, the perceived benefit is defined as the positive result that in-dividual assume that themselves or their community will benefit from the development and utilization of nuclear energy. A perceived benefit is an intellectual emotion that positively affects an individual's behavior [40,41]. Orbell et al. [42] stated that the perceived benefit refers to the estimated likelihood that a recommended course of action is usually needed for a positive outcome. In most cases, the perceived benefit is negatively associated with the perceived risk. Finucane et al. [43] suggested that the nuclear-induced effects are the most important determining factors of both perceived benefits and perceived risks. Therefore, Ardvin et al. [8] found that perceived benefits relatively outweighed the perceived risk of the reopening of the Bataan Nuclear Power Plant (BNPP). Eiser and Joop [44] found that perceived benefit (safe energy supply) was the most important factor in the acceptance of nuclear power plants, and the economic benefits of nuclear energy were the main driving force behind the development of the technology.

2.2. Research framework

The integration of Protection Motivation Theory PMT and Theory of Planned Behavior TPB as frameworks might be used to explore the perception of citizens, which is supported by prior studies in many countries. Using PMT and TPB, one might analyze behavior holistically and identify variables influencing the acceptance of people [8,45].

Nuclear knowledge, trust in local regulations, social influence, proximity, perceived benefit, and perceived risk significantly affect the acceptance of nuclear power plants. When the public perceives the benefits of a nuclear power plant, especially in Saudi Arabia, they will change their attitude and accept nuclear power plants. On the other hand, if the public perceives the risks of nuclear energy, they will reject the idea of nuclear energy in the country. To evaluate the significant effect of the factors on the acceptance of nuclear energy, we, therefore, propose the following hypotheses:

H1. Perceived risk has a significant effect on acceptance of nuclear power plant.

H2. Perceived benefit has a significant effect on acceptance of nuclear power plant.

H3. Knowledge about nuclear energy has a significant impact on the perceived risk.

H4. Knowledge about nuclear energy has a significant impact on the perceived benefit.

H5. Trust in regulations has a significant impact on the perceived risk.

H6. Trust in regulations has a significant impact on the perceived benefit.

H7. Social influence has a significant impact on the perceived risk.

H8. Social influence has a significant impact on the perceived benefit.

H9. Proximity of a nuclear power plant has a significant impact on the perceived risk.

H10. Proximity of a nuclear power plant has a significant impact on the perceived benefit.

Model of the acceptance of nuclear power plant is constructed. The model and the latent variables adopted from PMT and TPB are shown in Fig. 1.

3. Research methodology

3.1. Sample

This study looked into the societal acceptance of building a nuclear power reactor in Saudi Arabia. The population size will be every adult who is living in Saudi Arabia. In order to find a suitable sample size, we used this formal with 95% confidence [46]:

$$n = \frac{S}{1 + S(e)^2} \quad (1)$$

where n is the sample size, S is the population size, and e is the level of precision. G. Isreal [47] concluded that the population size would not affect the sample size if it is more than 100, 000. As our population size is more than 100, 000 and for 3% level of precision, a 1, 111 sample size will be sufficient.

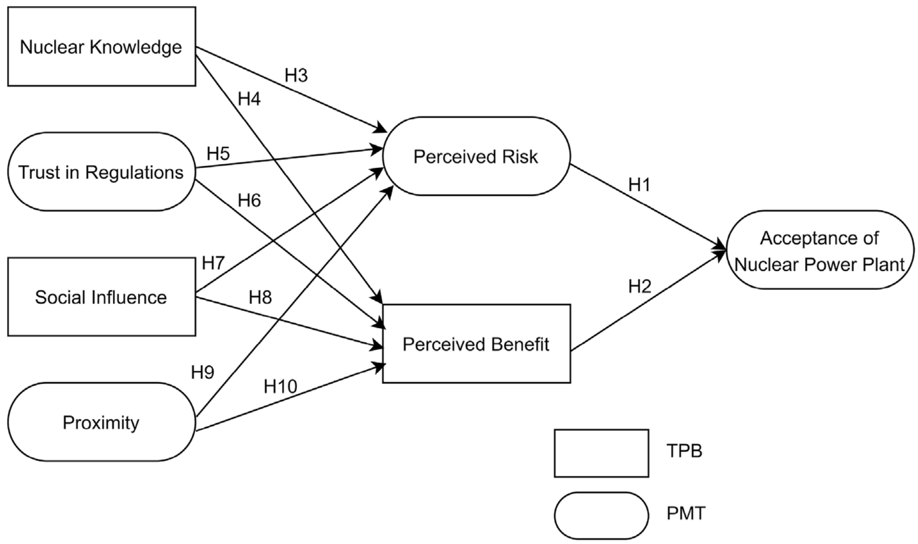

Fig. 1. Research model of public acceptance of nuclear power plant.

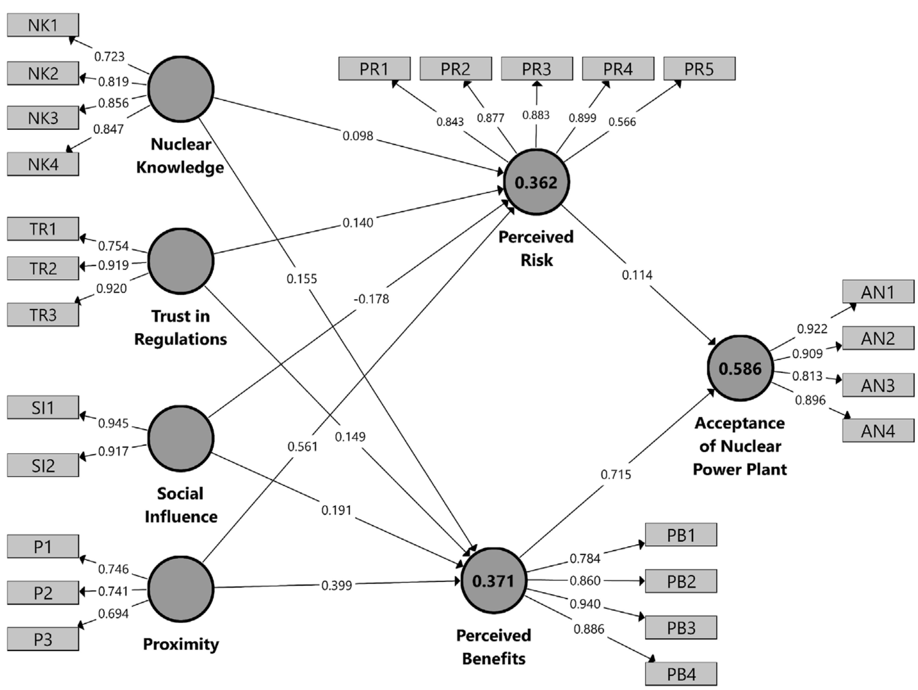

Fig. 2. The SEM measurement model with path coefficients.

A total of 1404 Saudis voluntarily and fully agreed to participate in this study, while it has been distributed to more than 4, 200 persons by using convenience sampling approach. Table 3 shows the descriptive statistics of the responses. It could be seen that 61.5% were males while 38.5% were female, most of whom were within 26–35 years of age (26.5%). The majority (58.4%) have a bachelor's degree in a different field, followed by 19.4% in high school, 15.1% are graduate education, and 7.1% of respondents hold a diploma. The data shows the majority are highly educated and this reflect the current statistics in Saudi Arabia. Based on the Organisation for Economic Co-operation and Development (OECD) report states that 98% (the global average is 76%) of Saudis at age 18 are in different type of educations, the highest rate of all countries. In addition, Saudi Arabia has one of the highest percentages of adults entering tertiary education for the first time, at 73% (the global average is 66%) [48].

When it comes to the region, the majority of respondents (37.9%) come from the west, while 25.9% come from the center, 20.8% come from the East region, and the rest come from the south and north region, with 8.8% and 6.6%, respectively.

3.2. Data collection and procedure

The data was gathered using a questionnaire survey approach. The survey approach was chosen for two reasons. First, it enables researchers to gather a wide range of random samples within a low time and cost. The second reason, reduce the pressure on respondents to react quickly and provide them with a sense of anonymity [49–51].

The questionnaire survey was performed online because of the benefits of an online surveying, such as saving time and money on the survey, reducing data input errors, and providing easy access to groups and individuals who would be difficult to contact through traditional channels [52,53]. After uploading the questionnaire, an online questionnaire was created with a URL (Uniform Resource Locator) link for responders to access. The URL link was then shared with responders, allowing them to complete the questionnaire. The poll was performed from beginning-February to mid-March 2022, and the respondents were Saudis citizens. To encourage respondents to participate in the survey and increase the response rate, the questionnaire filling instructions stated that their replies would be treated with absolute anonymity and confidentiality.

3.3. Measures

A questionnaire survey was used to gather data for this study to examine the hypotheses. The questionnaire is divided into four sections. The first section has been used to describe the survey's research aim, provide instructions for filling out the questionnaire, and thank respondents for participating. The second section has collected respondents' basic demographic information (e.g., gender, age, educational level, and residence location). The third section introduces the idea of nuclear energy, nuclear energy policy, social impact, and geographic location influence. Finally, the impact of perceived risk and perceived benefit have been measured in the last section. Respondents should expect to spend 5 to 7 min on average to complete the survey. Moreover, two experts in the field have reviewed and validated the questions.

The current study's hypotheses were assessed using several measurement items because they were latent variables [8,54–58]. Five measures were used to assess perceived risks: “I will worry that my family may be harmed by nuclear radiation during the normal operation,” “I will worry about nuclear accidents occurring at the local power plant.”, “If a nuclear accident occurred, it would have a negative impact on the local environment.” “If a nuclear accident occurred, it would have a negative impact on my health.” and, “I think the probability of nuclear leakage in nuclear power plants is high.” Four items have been used to assess perceived benefit: “nuclear power plant can help to reduce the price of electricity.”, “nuclear power plants create jobs for people in the region.”, “nuclear energy contributes to improve Saudi's economic development” and “the development of nuclear energy will increase Saudi's overall international power.”. Four measuring questions have used to assess respondent's nuclear energy knowledge: “I understand the basic scientific principles behind nuclear power generation.”, “I understand the risk of nuclear radiation.”, “I understand uranium is currently the most important nuclear fuel.” and “I understand nuclear power is generated by fission.” Trust in regulations was composed of three items, and they have expressed as: “I know the responsibilities of NRRC.”, “Even if a nuclear accident occurs, the NRRC has the ability to cope with its negative impact.” and “I trust the NRRC's nuclear safety supervision”.

Two items have assessed the social influence of respondents: “My friends and colleagues support using nuclear energy.” and “The social media supports using nuclear energy”. Three measuring questions have been used to assess the proximity impact in this study: “I do not want a nuclear power plant built near my working or living area.”, “I don't mind having a nuclear power plant in Saudi Arabia as long as it is outside of city limit.” and “If there is a nuclear power plant in my place of residence, I will consider moving to other areas.”. Respondents' acceptance of nuclear power plant was measured by four items: “I am in favor of nuclear power generation.”, “I support Saudi's development in nuclear power,” “The advantages of Nuclear power outweigh the disadvantages.” and “I support the Saud's investment in research and development of Nuclear energy through vision 2030”. Table 1 shows the construct and measurement items.

3.4. Content validity

The content validity was evaluated by two experts in the field of nuclear energy and legislation. In addition, the questionnaire was sampled from 21 undergraduate students.

Based on the feedback, the researchers in this study had to eliminate one variable and four constructs in three variables.

3.5. Structural equation modeling

The structural equation model (SEM) approach is a standard tool for investigating the correlations between hypotheses and the assigned indicators [59,60]. The SEM technique has been used to test research hypotheses in this study. SEM can appropriately show outcomes of all the exogenous and endogenous latent variables [61]. This approach will concurrently determine the compatibility of the developing data outputs. SEM is a confirmatory factor analysis (CFA) technique used to determine whether a particular model is valid to find a suitable one. The hypothesis has been expressed as a model, and confirmatory factor analysis has been used to measure the patterns and determine if the latent variables can adequately describe the observable variables. The potential causal relationship between variables was then investigated by comparing the estimated matrices representing the model's variable relationships to the actual matrices. The relation between the hypotheses in this study was determined using the variance-based partial least squares (PLS) approach. PLS is ideally suited for this study since the major goal is to investigate the interaction effects of attitudes and normative aspects [49,62]. SmartPLS 3.2.6 has been used as statistical software to analyze the collected survey data and test hypotheses.

4. Data analysis and results

This section aimed to analyze the data and evaluate the study's hypothesis. This section has three subsections: descriptive statistics, confirmatory factor analysis, and hypothesis evaluation. Before the analysis, the data were checked for missing values and outliers. The missing values were filled by extrapolating the previous cell's values.

4.1. Descriptive statistics

Table 2 presents the mean (M), standard deviation (SD), and correlation among all the research constructs. The mean reflects the participants' responses to each construct and shows the level of agreement among them. Table 2 shows that the highest mean was on the perceived benefits (mean = 4.01). The acceptance of nuclear power plants (mean = 3.88), nuclear knowledge (mean = 3.62), and trust in regulations (mean = 3.42) were at the moderate level, while social influence was nearly the midpoint level (mean = 3.06). The proximity (mean = 2.15) and perceived risk (mean = 2.02) were below the midpoint level. The correlations among the constructs show that there are high correlations between the perceived benefits and acceptance of nuclear power plants (0.635) and perceived risk and proximity (0.523).

Since the latent variable “acceptance of the nuclear power plant” has several observed variables whose data were collected using a 5-Point Likert scale, the average of these observed variables were calculated, and their values rounded to the nearest whole number. This gave the overall variable ‘acceptance of nuclear power plant’ which was used for analysis and conducting cross-tabulation

Table 1
The construct and measurement items.

Variable	Code	Constructs
Nuclear Knowledge	NK-1	I understand the basic scientific principles behind nuclear power generation.
	NK-2	I understand the risk of nuclear radiation.
	NK-3	I understand uranium is currently the most important nuclear fuel.
	NK-4	I understand nuclear power is generated by fission
Trust in Regulations	TR-1	I know the responsibilities of NRRC.
	TR-2	Even if a nuclear accident occurs, the NRRC has the ability to cope with its negative impact.
	TR-3	I trust the NRRC's nuclear safety supervision.
Social Influence	SI-1	My friends and colleagues support using nuclear energy
	SI-2	The social media supports using nuclear energy.
Proximity	16–1	I do not want a nuclear power plant built near my working or living area
	16–2	I don't mind having a nuclear power plant in Saudi Arabia as long as it is outside of city limit
	16–3	If there is a nuclear power plant in my place of residence, I will consider moving to other areas.
Perceived Risks	PR-1	I will worry that my family may be harmed by Nuclear radiation during the normal operation
	PR-2	I will worry about Nuclear accidents occurring at the local power plant.
	PR-3	If a Nuclear accident occurred, it would have a negative impact on the local environment.
	PR-4	If a Nuclear accident occurred, it would have a negative impact on my health.
	PR-5	I think the probability of nuclear leakage in nuclear power plants is high
Perceived Benefits	PB-1	Nuclear Power Plant can help to reduce the price of electricity.
	PB-2	Nuclear power plants create jobs for people in the region.
	PB-3	Nuclear Energy contributes to improve Saudi's Economic Development
	PB-4	The development of nuclear energy will increase Saudi's overall international power.
Acceptance of Nuclear Power Plant	AN-1	I am in favor of nuclear power generation.
	AN-2	I support Saudi's development in nuclear power
	AN-3	The advantages of Nuclear power outweigh the disadvantages.
	AN-4	I support the Saud's investment in research and development of Nuclear energy through vision 2030

Table 2
Means (M), Standard Deviation (SD) and Correlations of the constructs.

Construct	M	SD	NK	TR	SI	P	PR	PB	AN
NK	3.62	1	1						
TR	3.42	1.04	0.34*	1					
SI	3.06	1.05	0.38*	0.38*	1				
P	2.15	0.87	−0.21*	−0.09*	−0.14*	1			
PR	2.02	0.86	−0.17*	−0.16*	−0.03	0.52*	1		
PB	4.01	0.88	0.37*	0.32*	0.37*	−0.45*	−0.32*	1	
AN	3.88	1.02	0.29*	0.27*	0.31*	−0.43*	−0.43*	0.63*	1

N = 1,404, *p < .05.

incorporating a Chi-square tests of the demographic variables of the study.

Chi-square test was conducted to see that if gender, age, education and region is associated or independent of Acceptance of nuclear power plants. Table 4 shows the Chi-square results for all variables; the p-values were less than 0.05. It can be concluded that there is a statistically significant association between gender, age, education and region and acceptance of nuclear power plant.

Table 3
Demographic profile of respondents.

Variable	Categories	Frequency	Percent
Gender	Male	864	61.5
	Female	540	38.5
Age	20 or younger	228	16.2
	21–25	224	16
	26–35	372	26.5
	36–45	292	20.8
	46 or older	288	20.5
Education	High School or less	272	19.4
	Diploma	100	7.1
	Bachelor	820	58.4
	Graduate Education	212	15.1
Region	Center	364	25.9
	East	292	20.8
	North	92	6.6
	South	124	8.8
	West	532	37.9

N = 1,404.

Table 5 shows the cross tabulation of gender, age, education, and region to the acceptance of the nuclear power plant. While majority of the male strongly agreed with the acceptance of nuclear power plant, majority of female agreed with acceptance of nuclear power plant. In addition, most of the younger people seemed to "agree" with the acceptance of nuclear power plant while the aged respondent 'strongly agreed' on the acceptance of nuclear power plant. The statistics seemed to suggest that as the age increased, there was increased acceptance of nuclear power plant. For all levels of education, the majority respondents either 'agreed' of 'strongly agreed' on the acceptance of nuclear power plant.

4.2. *Confirmatory factor analysis*

The second analysis of the research was confirmatory factor analysis (CFA). The goal of CFA analysis was to determine the reliability and validity of the study constructs and evaluate the fitness of the study model. An evaluation was needed to test the model fitness and the validity and reliability of the constructs. This was accomplished using statistics such as standardized factor loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE).

The results of the CFA geared towards testing the convergent validity, discriminant validity, and composite reliability are presented in Table 6 and Fig. 3. The convergent validity was tested

Table 4
Chi-Square test of gender, age, education, and region to the acceptance of the nuclear power plant.

		Gender	Age	Education	Region
Pearson Chi-Square	value	64.06	66.56	63.43	95.48
	df	4	16	12	16
	Asymptotic Significance(2-sided)	0	0	0	0
Likelihood Ratio	Value	67.2	72.01	69.28	103.9
	df	4	16	12	16
	Asymptotic Significance(2-sided)	0	0	0	0

Table 5
Cross tabulation of gender, age, education, and region to the acceptance of the nuclear power plant.

		Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly** Agree
Gender	**Male**	2%	3%	13%	38%	44%
	Female	3%	9%	20%	41%	27%
Age	**20 or younger**	4%	7%	18%	42%	30%
	21–25	0%	4%	9%	43%	45%
	26–35	1%	2%	19%	42%	35%
	36–45	3%	4%	21%	33%	40%
	46 or older	4%	10%	11%	36%	39%
Education	**High school or less**	4%	12%	12%	41%	31%
	Diploma	0%	8%	16%	32%	44%
	Bachelor	2%	4%	17%	40%	37%
	Graduate Level	2%	0%	17%	34%	47%
Region	**Center**	2%	3%	15%	35%	44%
	East	3%	3%	14%	40%	41%
	North	0%	4%	9%	74%	13%
	South	0%	0%	23%	42%	35%
	West	3%	9%	17%	35%	36%

N = 1404.

using standardized factor loadings and average variance extracted (AVE). The required threshold for factor loadings, according to Chin et al. [59] and Hair et al. [63].

I. Ghozali [64], is greater than or equal to 0.5. For AVE, the required threshold is also greater than or equal to 0.5 [64]. The results from this analysis as seen in Table 6 indicated that standardized factor loadings ranged from 0.566 to 0.945 while that of AVE ranged from 0.529 to 0.867. The results indicated that the required threshold was satisfied, hence confirming the validity of the constructs. The reliability of the constructs was evaluated using Cronbach's alpha and composite reliability (CR). The recommended threshold for CR should be equal to or above 0.70 [64,65]. The results of the analysis showed that CR ranged from 0.771 to 0.936, which confirms the reliability of the constructs.

Table 6
Results of measurements model – convergent validity.

Latent Variables	Variables	SFL	CA	rho A	CR	AVE
Nuclear Knowledge(NK)	NK1	0.723	0.833	0.87	0.886	0.661
	NK2	0.819				
	NK3	0.856				
	NK4	0.847				
Trust in Regulations(TR)	TR1	0.754	0.833	0.851	0.901	0.754
	TR2	0.919				
	TR3	0.92				
Social Influence (SI)	SI1	0.945	0.847	0.87	0.929	0.867
	SI2	0.917				
Proximity (P)	P1	0.746	0.74	0.79	0.771	0.529
	P2	0.741				
	P3	0.694				
Perceived Risk (PR)	PR1	0.843	0.882	0.935	0.911	0.678
	PR2	0.877				
	PR3	0.883				
	PR4	0.899				
	PR5	0.566				
Perceived Benefits (PB)	PB1	0.784	0.891	0.901	0.925	0.755
	PB2	0.86				
	PB3	0.94				
	PB4	0.886				
Acceptance of Nuclear Power Plant(AN)	AN1	0.922	0.908	0.914	0.936	0.785
	AN2	0.909				
	AN3	0.813				
	AN4	0.896				

SFL: Standardized Factor Loading, CA: Cronbach's Alpha CR: Composite Reliability, AVE: Average Variance Extracted.

Table 7
Discriminant validity-cross loading.

	NK	TR	SI	P	PB	PR	AN
NK1	**0.723**	0.213	0.343	0.063	0.255	−0.009	0.245
NK2	**0.819**	0.308	0.213	0.283	0.345	0.266	0.343
NK3	**0.856**	0.176	0.314	0.177	0.272	0.188	0.304
NK4	**0.847**	0.325	0.358	0.122	0.274	0.123	0.313
TR1	0.423	**0.754**	0.339	0.037	0.272	0.089	0.283
TR2	0.214	**0.919**	0.3	0.155	0.298	0.198	0.289
TR3	0.225	**0.92**	0.334	0.153	0.275	0.176	0.26
SI1	0.404	0.357	**0.945**	0.155	0.382	0.003	0.379
SI2	0.254	0.331	**0.917**	0.201	0.314	0.027	0.313
P1	0.107	−0.012	0.042	**0.746**	0.271	0.43	0.197
P2	0.292	0.249	0.323	**0.741**	0.554	0.342	0.608
P3	0.051	0.027	0.003	**0.694**	0.195	0.487	0.167
PB1	0.305	0.269	0.424	0.309	**0.784**	0.171	0.56
PB2	0.291	0.267	0.297	0.433	**0.86**	0.305	0.611
PB3	0.324	0.298	0.334	0.421	**0.94**	0.352	0.685
PB4	0.328	0.291	0.276	0.517	**0.886**	0.447	0.757
PR1	0.063	0.126	−0.052	0.464	0.232	**0.843**	0.208
PR2	0.085	0.103	−0.032	0.479	0.238	**0.877**	0.239
PR3	0.306	0.22	0.089	0.521	0.445	**0.883**	0.477
PR4	0.249	0.188	0.028	0.542	0.395	**0.899**	0.418
PR5	−0.059	0.032	−0.031	0.231	0.072	**0.566**	0.018
AN1	0.34	0.296	0.341	0.407	0.69	0.312	**0.922**
AN2	0.341	0.269	0.273	0.44	0.697	0.384	**0.909**
AN3	0.292	0.251	0.421	0.338	0.61	0.189	**0.813**
AN4	0.36	0.308	0.309	0.485	0.687	0.453	**0.896**

In addition, the research carried out showed that the discriminant validity was calculated. Chin et al. [59] explained that we should expect to see each item's loadings to be higher than the cross-loadings and that items that a construct shows more correlated with another construct mean that they have a high possibility of sharing the same type of measurements. The cross-loading as seen in Table 7 shows the relationship between each construct and the others. All the constructs in this study belong to the type of measurements in our framework, which confirms the discriminant validity of the constructs. Another method to see the discriminant validity was assessed by comparing the square root of each AVE in the diagonal with the correlation coefficients (off-diagonal) for each construct in the relevant rows and columns [66]. The discriminant validity as seen in Table 8 was confirmed by comparing the square roots of AVE vs the correlations between constructs. When the square roots of AVE were higher than the correlations between constructs, it indicated that there is discriminant validity.

4.3. Evaluation of hypothesis

This section was geared toward the evaluation proposed hypothesis of the study. The hypothesis was evaluated by running the partial least square structural equation modeling (PLS-SEM). The significance of the relationship between p-values and path coefficients was evaluated with a 95% confidence level. The results as seen in Table 9 and Fig. 2 indicated that the path coefficient between nuclear knowledge and perceived risk was positive and significant ($\beta = 0.098$, $p<0.05$), which confirmed hypothesis three (H3) that nuclear knowledge has a significant impact on the perceived risk. The path coefficient between nuclear knowledge and perceived benefits was positive and significant ($\beta = 0.155$, $p<0.05$), which confirmed hypothesis four (H4) that nuclear knowledge has a significant impact on the perceived benefit. The path coefficient between trust in regulation and perceived risk was positive and significant ($\beta = 0.14$, $p<0.05$), which confirmed hypothesis five (H5) that trust in regulation has a significant impact on the perceived risk. The path coefficient between trust in regulation and perceived benefits was positive and significant ($\beta = 0.149$, $p<0.05$), which confirmed hypothesis six (H6) that trust in regulations has a significant impact on the perceived benefit.

The path coefficient between social influence and perceived risk was negative and significant ($\beta = -0.178$, $p<0.05$), which confirmed hypothesis seven (H7) that social influence has a significant (but negative) impact on the perceived risk. The path coefficient between social influence and perceived benefits is positive and significant ($\beta = 0.191$, $p<0.05$), which confirmed hypothesis eight (H8) that social influence has a significant impact on the perceived

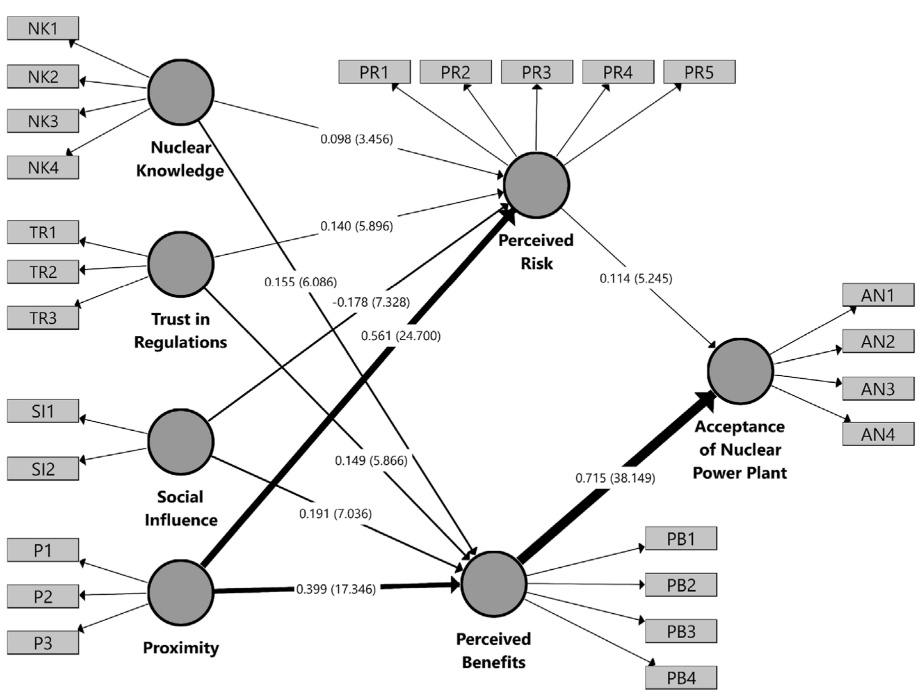

Fig. 3. A final SEM model with path coefficients.

Table 8
Discriminant validity - latent variable correlations.

	NK	TR	SI	P	PR	PB	AN
Nuclear Knowledge(NK)	**0.813**						
Trust in Regulations(TR)	0.32	**0.868**					
Social Influence(SI)	0.36	0.371	**0.931**				
Proximity(P)	0.22	0.137	0.189	**0.727**			
Perceived Risk(PR)	0.202	0.183	0.015	0.568	**0.82**		
Perceived Benefits(PB)	0.359	0.324	0.377	0.489	0.38	**0.87**	
Acceptance of Nuclear Power Plant(AN)	0.378	0.318	0.375	0.474	0.38	0.76	**0.886**

Table 9
Path coefficient of the research hypotheses.

Hypothesis	Relationship	Mean (M)	Std. Dev	T-Stat	P-Val	Decision
H1	PR → AN	0.114	0.022	5.317	0	Supported
H2	PB → AN	0.714	0.019	37.581	0	Supported
H3	NK → PR	0.097	0.027	3.614	0	Supported
H4	NK → PB	0.156	0.026	5.986	0	Supported
H5	TR → PR	0.138	0.023	6.083	0	Supported
H6	TR → PB	0.149	0.024	6.195	0	Supported
H7	SI → PR	−0.178	0.024	7.497	0	Supported
H8	SI → PB	0.189	0.027	7.156	0	Supported
H9	P → PR	0.563	0.022	25.904	0	Supported
H10	P → PB	0.4	0.022	18.483	0	Supported

Table 10
The effect size of the exogenous constructs.

Hypothesis	Relationship	f^2	Effect
H1	PR → AN	0.027	Small
H2	PB → AN	1.061	Large
H3	NK → PR	0.012	No effect
H4	NK → PB	0.031	Small
H5	TR → PR	0.025	Small
H6	TR → PB	0.039	Small
H7	SI → PR	0.039	Small
H8	SI → PB	0.046	Small
H9	P → PR	0.462	Large
H10	P → PB	0.237	Medium

benefits. The path coefficient between proximity and perceived risk is positive and significant ($\beta = 0.561$, $p<0.05$), which confirmed hypothesis nine (H9) that the proximity of a nuclear power plant has a significant impact on the perceived risk. The path coefficient between proximity and perceived benefits is positive and significant ($\beta = 0.399$, $p<0.05$), which confirmed hypothesis ten (H10) that the proximity of a nuclear power plant has a significant impact on the perceived benefits.

The path coefficient between perceived risk and acceptance of a nuclear power plant is positive and significant ($\beta = 0.114$, $p<0.05$), which confirmed hypothesis 1 (H1) that perceived risk has a significant effect on the acceptance of a nuclear power plant. The path coefficient between perceived benefits and acceptance of a nuclear power plant is positive and significant ($\beta = 0.715$, $p<0.05$), which confirmed hypothesis two (H2) that perceived benefits have a significant effect on acceptance of a nuclear power plant. Overall, all the hypotheses of the study were supported by the findings of this research, since all the path coefficients were significant (p-values < 0.05). While nine path coefficients were positive, one of them (social influence to perceived risk) was negative, implying a negative effect of social influence on perceived risk.

The effect size (f^2) of each hypothesis was studied. It indicates the relative effect of a particular exogenous latent variable on endogenous latent variables using changes in the *R* squared. Chin et al. [59] calculated the effect size as the increase in *R* squared of the latent variable to which the path is connected, relative to the latent variable's proportion of unexplained variance. Table 10 shows the effect size of the exogenous constructs. Hypothesis two and nine are showing that there is a large effect, and hypothesis ten is showing a medium effect. Hypotheses one, and four through eight are showing a small effect, while there is no effect on hypothesis three.

5. Discussion

This research study is on the public's acceptance of nuclear power plants in Saudi Arabia. It sees the relationship and the effect of nuclear knowledge, trust in regulations, social influence, proximity, perceived risk, and perceived benefits on acceptance of having the first nuclear power plants in the country. The present findings show a positive attitude toward having a nuclear power plant. One main effect on this was the perceived benefits. The current price of electricity for residents is approximately five cents per kWh [67]. As the main source of electricity in Saudi Arabia is from fossil fuels, having other sources of energy can reduce the price of electricity [68].

The public agrees with this statement, they believe that the benefit of producing power from nuclear power plants can reduce the price of electricity. Another way that nuclear power plants may be accepted is by directly affecting the public with the creation of jobs. On the other hand, the public in this research believe that having a nuclear power plant can benefit Saudi's economy and increase its international power. Another main part that affects the acceptance of the nuclear power plant is the proximity. The public in this research have shown that the location of the plant has a great effect on its acceptance. They do not want a nuclear power plant to be built near their homes; some of them intend to move out of their current city if there is a nuclear power plant near them. The proximity has a great effect on the perceived risk. However, even with the high level of perceived risk associated with the proximity, the benefits outweigh it and the public will support and accept the building of a nuclear power plant.

The research finds that there is a relationship between social influence and the acceptance of nuclear power plants. In this study, “social influence” was focused on friends and social media. The results show that the friends' participants support using nuclear energy. In addition, social media feeds in the country, according to the results, also support using nuclear energy. From that, we can see that the social influence positively affects the perceived benefits, which in turn affect the acceptance of building a nuclear power plant. Moreover, the public showed that they trust the regulatory body. They believe the regulator's safety standards are high and that the power plant will be built with these standards in mind. Finally, the public's basic knowledge of nuclear science plays a factor in the acceptance of nuclear power plants. It shows that people who know the science behind nuclear energy perceive that a nuclear power plant has reduced risk and increased benefits compared to others. From the results, we observed the male intend to strongly agree to accept NPPs more than female. Also, we found older and high educated people strongly agree than young and less educated, and this is due to the education plays a significant role to minimize the perceived risk and thus accept NPPs.

This research aimed to explain the public attitude toward nuclear power plants in Saudi Arabia using the Structural Equation Modeling (SEM) framework. The measures in this study aimed to investigate perceived risk and perceived benefits through hypotheses affected by the factors of social identity, regulations, location, and signaling knowledge and how they can impact people's acceptance. The study contributes to the theory by establishing a new research model and framework. This model explains the public attitude towards adopting and constructing nuclear power plants in Saudi Arabia by examining the hypotheses that will aid in understanding public acceptance and awareness.

6. Conclusion and policy implication

Nuclear power plants (NPPs) are now widely regarded as one of the most reliable sources of energy. However, nuclear energy has long been viewed as a debatable energy source for reducing carbon emissions, mitigating global warming, and facilitating the transition to a low-carbon society.

Saudi Arabia plans to introduce nuclear energy to their energy mix as part of Vision 2030. As an emerging nuclear country, it is critical to understand the public behavior toward having Saudi's first nuclear power plant.

This study evaluates the public acceptance of nuclear power plants by studying the public behavior toward the nuclear perceived risk and benefits and see the factors that affect their acceptance, such as their knowledge about nuclear, trust in regulations, social influence and the location of the power plants.

The public of Saudi Arabia understand the perceived risk and benefits from building NPP, however, they overweight the perceived benefit. In addition, the location of building the first NPP is critical as the public have some concerned about having it inside a city limit. To implement the policy of building a nuclear power plant, the location will be critical. As the study shows, the relationship between the proximity of the power plant to people's homes and the perceived risk is significant. It would be best to build a nuclear power plant outside of the city limit, but also close enough to the city that the public believes the nuclear power plant can create more direct and indirect jobs. This balance should be considered to maximize potential benefits and approval.

As the study shows, a national awareness program is critical for the importance of social influence and trust in regulations as well as the acceptance of the nuclear power plant. This can be started by learning what the public knows about nuclear power and seeing what the perceived risk is. From that, a national action awareness program should be adopted with the cooperation of different government sectors to build up a nation that knows about nuclear power plants and their associated benefits.

According to the latest Saudi population statistics, 40% of Saudis are less than 24 years old [2]. Soon, those young people will lead the county. Investing in those people and giving them the knowledge that will help them in the future is important. One of the most important things we can teach them is nuclear science. Therefore, schools and universities would be wise to add nuclear science and engineering subjects to their curriculums.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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