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Examination of Relationship between Effective Components on Technological Innovation System and their Application in Biomass Resources

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Abstract

The present research examines designing of a model for biomass resources (livestock waste) application in the rural areas in Tehran province with emphasis on use of technological innovation system. Considering the nature of investigation, it is a type of quantitative and practical study with correlational measures. A survey was used to collect the required data. The population consists of all cattle owners in Tehran province that according to the Agricultural Jihad organization, they are 4677 subjects in 11 cities. Of these, 355 owners were selected via the Cochran's formula through stratified random sampling method. The SPSS software was a means to analyze the data. The main result of the current study is that socio-cultural functions of innovation, transmission, distribution, promotion, and training of technological innovative knowledge and formation of technology markets hold a direct and meaningful association with application of biomass resources. Moreover, the multivariate regression analysis results indicate that functions related to constraints an obstacles cannot explain application biomass changes. Functions of technological innovative system are able to explain changes of using biomass resources. In addition, the independent variables are able to explain changes in formation of technology market, improvement of innovative entrepreneurship activities as well as the function of development and increase of innovative human resources.

Keywords: Biomass resources, technological innovative system.

Introduction

Energy has always been considered as a fundamental need for continuation of economic development, and providing welfare. Since global rate of energy consumption in 2011 was 114 billion tons crude oil per year, it is estimated that up to 2020 this rate increases to 123 billion tons[1]. The extent of using fossil fuels in the next century will be so massive. Also, some scholars believe that the crisis of providing energy is very tangible in a way that in addition to affecting quality of social life, it will endanger global economic development[2].

Accordingly, finding other sources of energy seems necessary. Because, in one hand perishable fossil fuels, diversifying energy sources, sustainable development and energy security, and environmental problems resulting from the consumption of fossil fuels and on the other hand, clean and renewable features of new energy sources like sun, wind, biomass and so forth, have seriously attracted the world's attentions to development and use of renewable energies and increasing the share of these resources in the global energy markets[3]. To do this, in the recent years through using simple and easily accessible technologies for all, a new fuel has been introduced that in addition to providing the required energy and being inexpensive, it has caused to maintenance of natural resources and protect from environmental pollution. This new energy source is biogas resulted from using one of the most frequent biomass resources naming livestock waste. It has been produced in many rural areas such as China, India and in European countries and America and has brought about many significant soci-economic and environmental effects[4].

Production of renewable energies locally can offer a good alternative. The renewable energies are capable to facilitate socio-economic development in communities in condition projects are to be designed intelligently and are programmed according to local inputs and corporations[5]. Currently, the portion biomass has in supplying basic energy sources for the industrialized countries are less than three percent. unlike fossil fuels can be found in form of condensed layers , biomass is more diluted and costs of collecting them in mass volumes for economic use of energy due to dispersed materials, low energy density and often being wet are considerable[6]. Predictions on use of biomass consumption on the basis international advanced policies scenario indicate that this sort of energy has the highest rate of consumption in present and future[7]. Accordingly, the present research aims to design the model of biomass resources consumption (livestock waste) in rural areas in Tehran province with emphasis on TIS.

Literature Review: The biomass resources through undertaking different biochemical and thermo chemical processes are capable to produce energy in three forms of electricity, heat and fossil fuels and have been used in different domestic, industrial, and transportation fields[8]. Studies indicate that in case of using biogas in transportation amount of CO_2 pollutions cause greenhouse gases to increase will be reduced up to approximately 65 to 85 percent[9]. It should be mentioned that from selling per kWh of electricity from biogas, 6 cents will be received. Also, injection of biogas to the gas network is established[10]. Of the resulted biogas can use in production of heat, warm water and electricity much cheaper than other fuels like natural gas and oil. Moreover, methane production from anaerobic digesters causes rural electricity production cooperatives[11]. The obtained energy from biogas in addition to production of a clean fuel for rural areas as the main purpose possesses some subsidiary advantages like enriched fertilizer for agriculture, increase of public health and maintenance of the environment[12].

However, in Iran a scarcity of different investigation on technologies in general and biogas technology produced by livestock waste in specific in an organized manner is evident. Moreover, considering this subject, no purposeful labor division has been planned among public and private sectors. In order to perform a research, developing and creating knowledge in field of biogas technology in Iran's villages, management of this issue must be taken into consideration[13].

Theoretical framework: In following definition of some technical terms are provided. Innovation consists all practical, technological, commercial and financial steps for successful development and application of biomass resources (livestock waste) in the rural areas[14]. Innovation and development of technology are the results of a complex series of relations among active elements in a system called innovation system[15]. In the current research technological innovative system (TIS) include a series of seven major functions (Innovative policy making, Establishment of facilitating and support infrastructures of technological innovation system, Investigation, development and creation of knowledge, Transmission, distribution and promotion of TI knowledge, Development and improvement of innovative human resources, Improvement of innovative entrepreneurship activities, and formation of technology markets)[16].

Biomass contains all substances found in the nature. Materials were alive in the immediate past, created from living beings or their waste. Biomass is discussed versus fossil fuels such as oil, gas and coal. The source of fossil fuels is like biomass, but the difference is that the fossil sources are made of biomass resources were alive in far past and are shaped under certain temperature and pressure conditions[17]. In general, biomass resources refer to all biodegradable components of products, wastewater and agricultural waste (including vegetable and animal substances), forestry industries and other related industries, and biodegradable municipal and industrial waste[18].

Research background: Visakhamoorthy has compared experimental measurements from a converted indirect injection diesel Kubota D905 engine fueled with a simulated biomass derived gas with simulation results using a multi-zone homogeneous charge compression ignition (HCCI) engine model[19]. Garay in his article review the current situation and the potential in Hungary for the production and use of biomass, biogas and biofuel[20]. Chen did write China is rich in biomass resources, with favorable conditions for the development and utilization of biomass energy. Currently, the main secondary forms of biomass energy utilized in China include biogas, biomass power, bioethanol, biodiesel[21]. Okello in his paper presents a review of the efforts and progress made by different organizations in promoting improved bioenergy technologies in Uganda. The study was based on an extensive review of available literature on improved bioenergy technologies introduced in the country[22]. Monlau research on conversion of sunflower oil cake (SOC) into methane by mesophilic anaerobic digestion was the object of this study. The effect of a combined dilute acid-thermal pretreatment (acid concentration and temperature) on solubilisation and methane potential was investigated using a central composite design (CCD)[23]. Namuli calculates the size and mode of operation of a biomass waste to energy conversion system that would result in maximum revenue for a given herd size. A Taboo Search optimization technique is used. A number of equally good solutions are generated[24]. Suvisanna proposes mixtures of substrates for biogas production for various livelihood zones of Cambodia. The occurrence of biomass suitable for biomethanation is most favorable in electrified rural areas, except for fishing villages[25].

Methodology

The current research is a type of quantitative and practical investigation since it aims to develop practical knowledge in a specific field whose results are applicable for herders, farmers, experts, researchers, planners and policy makers in agricultural issues and optimizing fuel and energy consumption. Moreover, this research is a sort of descriptive–correlational one with survey.

Scope of research: The time scope of research is in years 2011-2012. The subject scope is in field of designing a model for application of biomass resources (livestock waste) in the rural areas of Tehran province with emphasis on TIS. The geographical domain places in the rural areas of Tehran. The reason to select this scope is the potential of producing biogas resulted from livestock waste in the rural areas in all Iranian provinces with a capacity of 177659820 m^2 per day that the highest produced volume belongs to Tehran province with total capacity of 44092348 m^2 per day[7].

Validity and reliability: To specify the instrument validity, content and face validity were used. That is, first the questionnaire was given to some experts then their comments were received. Also, in pre-test stage the content validity was measured. In the current research also, the Cronbach's alpha was a means for assessment of the instrument. In a pilot study the questionnaire whose reliability was tested with the panel method was also tested in the similar region. Since the Cronbach's alpha for each index is larger than 0.70, thus the reliability is accepted, which is an indication of internal correlation among the variables.

Sample size and sampling method: To estimate the sample size, Cochran formula was used. The population size includes 4677 participants with (t = 1.96), level of confidence 95% and (d = 0.05). The variance for studied variable is the dependent variable. Accordingly, 355 subjects were selected via proportionate stratified random sampling method.

$$n_{cochran} = \frac{\frac{P(1-p)Z^2_{1-a/2}}{d^2}}{1+1/N(\frac{P(1-p)Z^2_{1-a/2}}{d^2}-1)} = \frac{\frac{0.5*0.5*(1.96)^2}{(0.05)^2}}{1+1/4677(\frac{0.5*0.5*(1.96)^2}{(0.05)^2}-1)} = \frac{384.16}{1.0819}355.07 \cong$$

Equation-1
Cochran Formula

Data collection and analysis: In the current paper, to achieve theoretical and field data, different methods like reviewing national and international Articles, books, searching web sites and interviewing with experts of the new energies organization (SANA) and Animal Deputy of Agricultural Jihad Organization of Tehran province was performed. In addition to the methods were used for reviewing previous studies and experts opinions, a question in form of a field study was applied in order to collect the required data from the rural areas.

After collecting and classifying the data, two descriptive and inferential statistics methods were utilized for the data analysis via SPSS18. In the inferential statistics the one-sample Kolmogorov - Smirnov test, Pearson's correlation test, multivariate regression, path analysis and exploratory factor analysis were used.

The Hypotheses: Considering the nature of study and theoretical framework, the research hypotheses are developed as follows, in the participant's viewpoint: i. The function of innovation policy making in the TIS model has effects on application of biomass resources (livestock waste) in the rural areas of Tehran province. ii. The function of establishment of facilitation and support from the technological innovations in the TIS model has effects on application of biomass resources (livestock waste). iii. The function of research, development and creation of knowledge in the TIS model has effects on application of biomass resources (livestock waste) in the rural areas of Tehran province. iv. The socio-cultural function of innovation in the TIS model has effects on application of biomass resources (livestock waste). v. The function of transmission, promotion, distribution and training of technological innovation knowledge in the TIS model has effects on application of biomass resources (livestock waste) in the rural areas of Tehran province. vi. The function of development and promotion of innovative human resources in the TIS model has effects on application of biomass resources (livestock waste). vii. The function of promotion of technological entrepreneurship activities in the TIS model has effects on application of biomass resources (livestock waste). viii. The function of formation of technology markets in the TIS model has effects on application of biomass resources (livestock waste).

The conceptual model: The present research is a type of practical research. Thus, the conceptual model is designed in terms of eight functions of TIS (the independent variables), and biomass resources in the rural areas in Tehran province (the dependent variable) (figure-1).

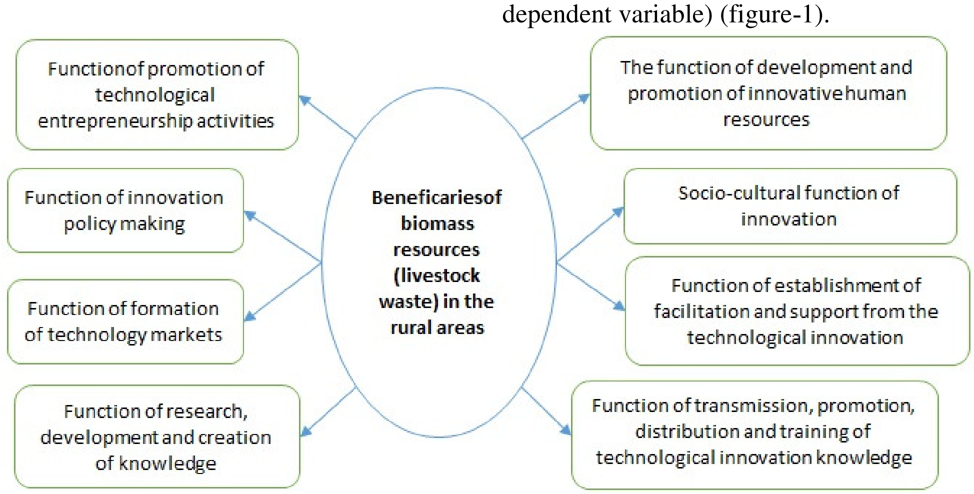

Figure-1
The conceptual model

Results and Discussion

Descriptive statistics: Descriptive findings examine distribution of properties ad and the sample characteristics in relation to a specific subject. These section consists of three parts (because of numerous tables and diagrams there were excluded): i. Examination of individual characteristics of the respondents, ii. Examination of the respondent's viewpoint on functions of innovation system, iii. Examination of the respondents' viewpoint on effective factors on the above components and prioritizing them.

Test of the hypotheses: To test the research hypotheses, the parametric tests (Pearson's correlation and multivariate regression) were utilized. First, normal distribution of the data was assessed.

The Kolmogorov – Smirnov test: In order to examine the normal distribution of data, the Kolmogorov – Smirnov test was used (Table 1).

Table-1
The Kolmogorov – Smirnov test results

Variable	Z	Sig.
Function of innovation policy making	0.982	0.290
Function of establishment of facilitation and support	1.750	0.070
Research, development and creation of knowledge	1.720	0.071
Socio-cultural function of innovation	2.441	0.053
Transmission, promotion, distribution and training of technological innovation knowledge	0.938	0.345
Function of development and promotion of innovative human resources	1.994	0.065
The function of promotion of innovative entrepreneurship activities	1.578	0.068
Function of formation of technology markets	1.357	0.079

Level of significance for all research hypotheses is greater than 0.05, therefore the data are normally distributed.

Pearson's correlation test: For determining coefficients of the variables related to functions of innovation system and components associated to application of biomass resources, the Pearson's correlation test was used (table 2).

Multivariate regression: In order to identify the effect of relevant components to constraints and obstacles before application of biomass resources (livestock waste) in the rural areas, multivariate regression was used (table 3).

Table-2
Function of TIS model dimensions on the basis of biomass resources

TIS model	Correlation coefficient	Result
Innovation policy making	0.092	No meaningful relation
Establishment of facilitation and support from TI	-0.041	No meaningful relation
Research, development and creation of knowledge of innovation	-0.033	No meaningful relation
Socio-cultural of innovation	0.130*	Hypothesis confirmation and a direct and meaningful relation
Transmission, promotion, distribution and training of technological innovation knowledge	0.120*	Hypothesis confirmation and a direct and meaningful relation
Development and promotion of innovative human resources	0.055	No meaningful relation
Promotion of innovative entrepreneurship activities	0.079	No meaningful relation
Formation of technology markets	0.180**	Hypothesis confirmation and a direct and meaningful relation

** Sig= 0.01(Two-tailed test) * Sig= 0.05 (Two-tailed test)

Considering (F= 1.049) in (Sig= 0.399), since it is larger than 0.05 thus it can be concluded that components related to obstacles and constrains are unable to explain changes in application of biomass resources. Considering (F= 2.055) in (Sig= 0.033), since it is smaller than 0.05 so, it can be concluded that components functions of TIS are able to explain changes in application of biomass resources. Regarding (F= 3.388) in (Sig= 0.001), since it is smaller than 0.05 thus it can be reasoned that the independent variables are able to explain changes in function of formation of technology market. With regard to (F= 8.704) in (Sig= 0.001), because it is smaller than 0.05, it can be concluded that the independent variables are able to explain changes in the promotion of technological entrepreneurship activities function. Considering (F= 6.244) in (Sig= 0.001) that is smaller than 0.05, it can be stated that the independent variables are able to explain changes in function of developing and promotion of innovative human resources.

Table-3
Results of regression analysis

Statistic index / patterns	R	R^2	Adjusted R^2	F	Sig.
The independent variables on biomass resources					
Components related to obstacles and limitations	0.154	0.024	0.001	1.049	0.399
Functions of TIS	0.226	0.051	0.026	2.055	0.033
Function of TIS on function of formation of technology markets					
Function of formation of technology markets	0.270	0.073	0.0513	3.388	0.001
The independent variables on function of promotion of innovative entrepreneurship activities					
Promotion of innovative entrepreneurship activities	0.386	0.149	0.132	8.704	0.001
The independent variables on promotion of innovative human resources					
Promotion of innovative human resources	0.334	0.112	0.094	6.244	0.001

Identification and prioritization relevant components to each factor: In this stage, first indexes of each factor analysis models will be confirmed and in following, the meaningfulness of relationship of each item with studied factors via the LISREL diagrams will be considered either meaningfulness or being standard.

Socio-cultural function of innovation: According to the LISREL output in table 4, the value of x2/df is (1.79). Presence of x2/df smaller than 3 indicates the model is appropriately fitted. Also, root mean square error of approximation (RMSEA) must be lower than 0.08 that in the provided model it is equal 0.065. The rate of GFI, AGFI, CFI, and NFI must be larger than 0.9 that in the model these values are equal to 0.93, 0.91, 0.92, and 0.94 respectively. Moreover, value of RMR must be smaller than 0.05 that its value in the model is 0.049. Considering the LISREL indexes and outputs, it can be concluded that the selected indexes for measurement o socio-cultural function of innovation has the required validity and they can properly assess socio-cultural function of innovation. Table 4 presents five indexes of factor analysis. Figure 2 shows the estimated model and figure 3 represents T-value model relevant to socio-cultural function of innovation. The following table indicates the extracted indexes from the model.

Table-4
Indexes of factor analysis related to socio-cultural function of innovation

Statistic	Value
Chi-Square	7.18
Df	4
Chi-Square/ Df	1.79
RMSEA	0.065
GFI	0.93
AGFI	0.91
CFI	0.92
NFI	0.94
RMR	0.049

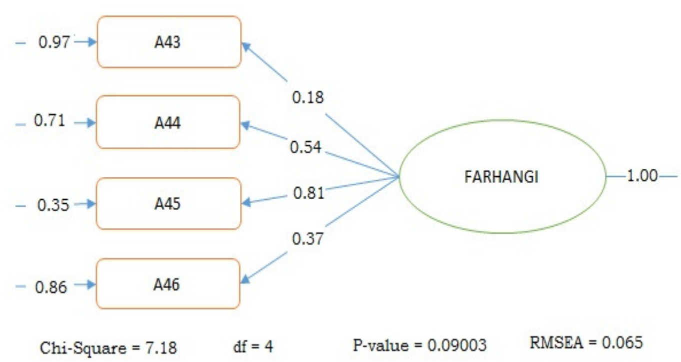

Figure-2
The estimated model related to socio-cultural function of innovation

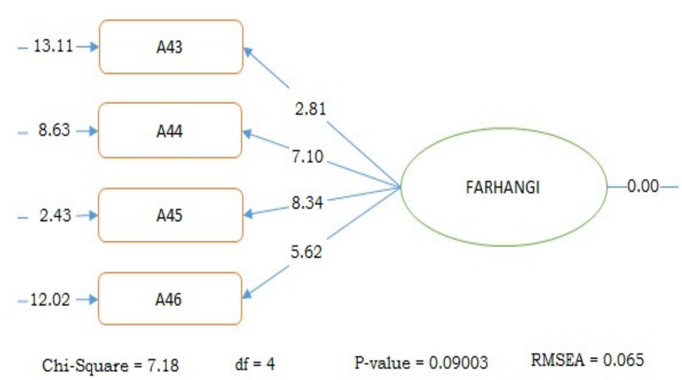

Figure-3
The T-value model for socio-cultural function of innovation

To determine rate of effectiveness of each items measuring socio-cultural function of innovation, the factor coefficients or loads were used. Table 5 indicates the effective variables on socio-cultural function of innovation were rated according to their factor loads.

Table-5
Rating of the effective variables on socio-cultural function of innovation

latent variable	Manifest variables	Factor load	Rank
Socio-cultural function of innovation	Supporting formation of business groups especially the private sector in field of biogas	0.81	1
	Short-time support from consuming biogas technology for correlation of consumption in the rural areas	0.54	2
	Establishment of competitive environments for this technology	0.37	3
	Introduction of advantages of biogas technology products	0.18	4

Transmission, distribution, promotion and training of TI knowledge function: Considering the LISREL output in table 5, the value of x^2/df is 1.40. Presence of x2/df smaller than 3 indicates the model is appropriately fitted. Also, root mean square error of approximation (RMSEA) must be lower than 0.08 that in the provided model it is equal 0.036. The rate of GFI, AGFI, CFI, and NFI must be larger than 0.9 that in the model these values are equal to 0.92, 0.90, 0.91, and 0.91 respectively. Moreover, value of RMR must be smaller than 0.05 that its value in the model is 0.043. considering the LISREL indexes and outputs, it can be concluded that the selected indexes for measurement of transmission, distribution, promotion and training of TI knowledge function of innovation has the required credit and they can properly assess transmission, distribution, promotion and training of TI knowledge function. Table 6 presents seven indexes of factor analysis. Figure 4 shows the estimated model and figure 5 represents T-value model relevant to transmission, distribution, promotion and training of TI knowledge function. The following table indicates the extracted indexes from the model.

Table-6
Factor analysis indexes related to transmission, distribution, promotion and training of TI knowledge function

Statistic	Value
Chi-Square	126.02
Df	90
Chi-Square/ Df	1.40
RMSEA	0.036
GFI	0.92
AGFI	0.90
CFI	0.91
NFI	0.91
RMR	0.043

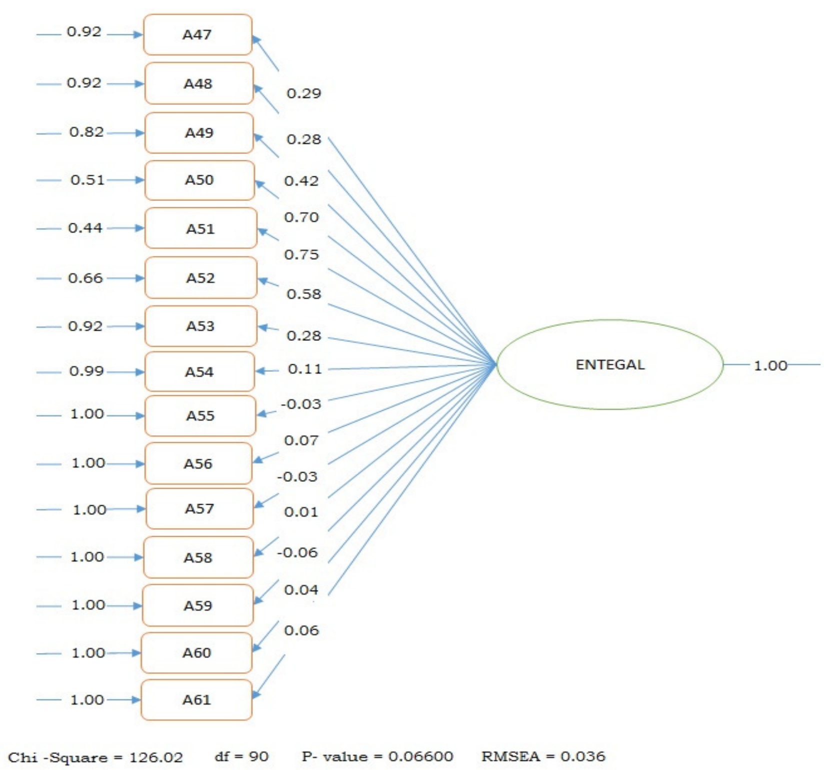

Figure-4
The estimated model related to Transmission, distribution, promotion and training of TI knowledge function

To determine rate of effectiveness of each items measuring, transmission, distribution, promotion and training of TI knowledge function the factor coefficients or loads were used. Table 7 indicates the effective variables on transmission, distribution, promotion and training of TI knowledge function were rated according to their factor loads.

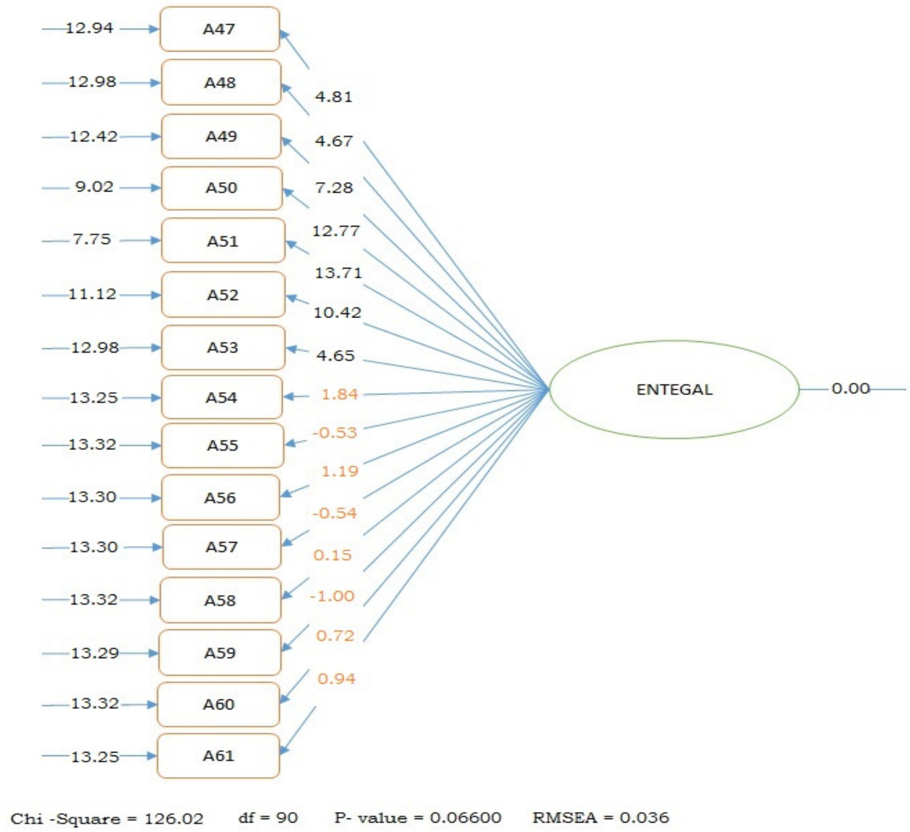

Figure-5
The T-value model for transmission, distribution, promotion and training of TI knowledge function

Table-7
Rating of the effective variables on transmission, distribution, promotion and training of TI knowledge function

Latent variable	Manifest variables	Factor load	Rank
Transmission, distribution, promotion and training of TI knowledge function:	Printing and distribution of promotional literature - training (such as magazines, news bulletins)	0.75	1
	Classes and workshops in the field of biogas technology	0.70	2
	Public meetings with the rural (group discussions and contacts)	0.58	3
	transferring relevant technology	0.42	4
	Transferred informally by companies that are active in this field	0.29	5
	Transfer of biogas technology facilities	0.28	6
	Face to face meetings with every farmer	0.28	7
	Villagers' visit from standard biogas unit	0.11	8
	Virtual exhibitions through the information network in the field of biogas technology	0.07	9
	Giving required information services in the field of biogas technology	-0.06	10
	Villagers' continuing education to enhance their skills and experience in the field of biogas technology	0.06	11
	Villagers' continuing education to enhance their knowledge in the field of biogas technology	0.04	12
	Using training slides and video on biogas technology	-0.03	13
	Holding seminars and trade fairs in the field of biogas technology	-0.03	14
	use of mass media such as radio and television	0.01	15

Function of formation of technology markets: Considering the LISREL output in Table 8, the value of x2/df is 2.67. Presence of x2/df smaller than 3 indicates the model is appropriately fitted. Also, root mean square error of approximation (RMSEA) must be lower than 0.08 that in the provided model it is equal 0.069. The rate of GFI ,AGFI, CFI , and NFI must be larger than 0.9 that in the model these values are equal to 0.94, 0.92, 0.95, and 0.94 respectively. Moreover, value of RMR must be smaller than 0.05 that its value in the model is 0.026. Considering the LISREL indexes and outputs, it can be concluded that the selected indexes for measurement of function of formation of technology markets has the required credit and they can properly assess function of formation of technology markets. Table 8 presents indexes of factor analysis. Figure 6 shows the estimated model and figure 7 represents T-value model relevant to function of formation of technology markets.

Table-8
Factor analysis indexes related to formation of technology markets

Statistic	Value
Chi-Square	24.08
Df	9
Chi-Square/ Df	2.67
RMSEA	0.069
GFI	0.94
AGFI	0.92
CFI	0.95
NFI	0.94
RMR	0.026

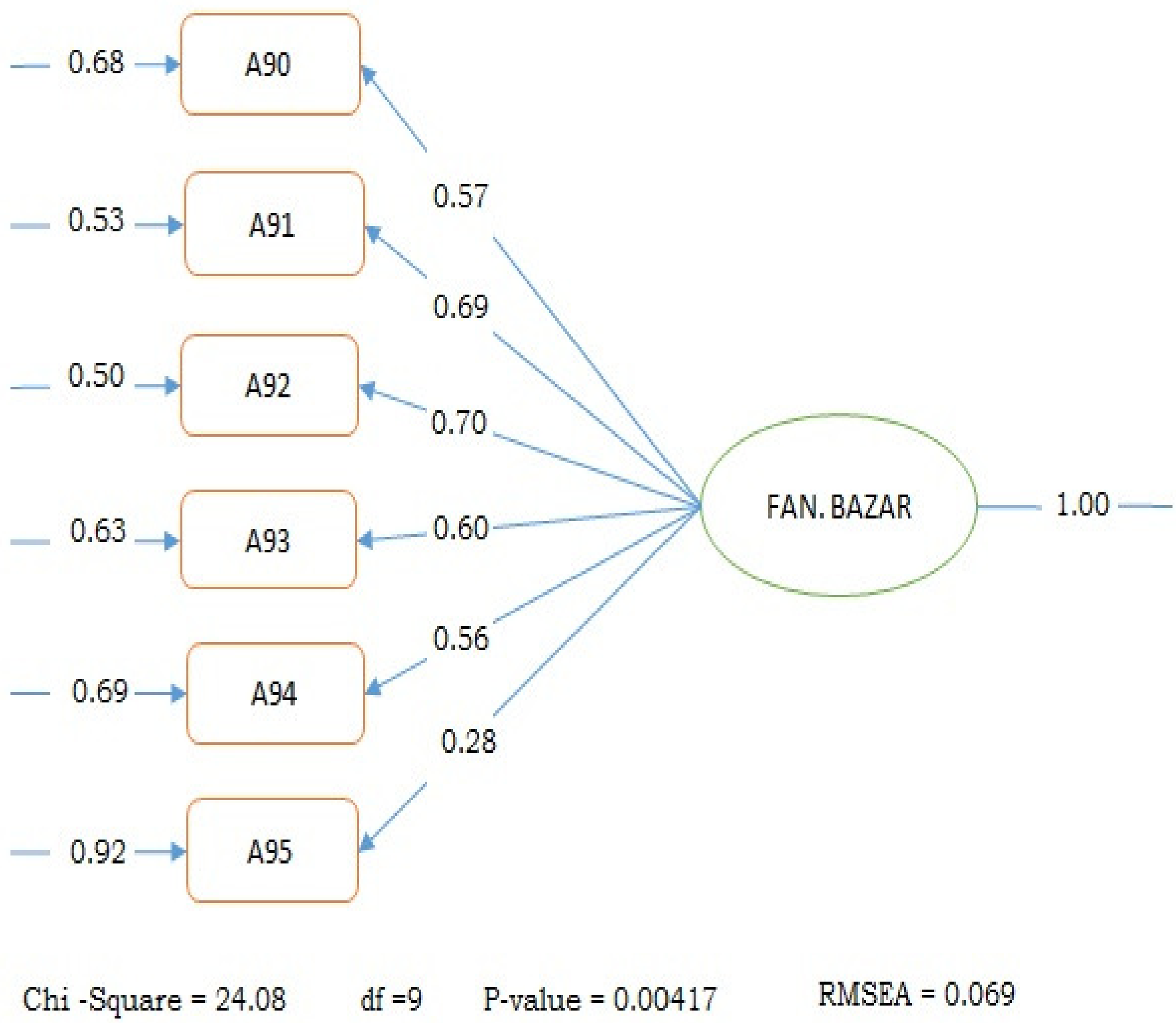

Figure-6
The estimated model for function of formation of technology markets

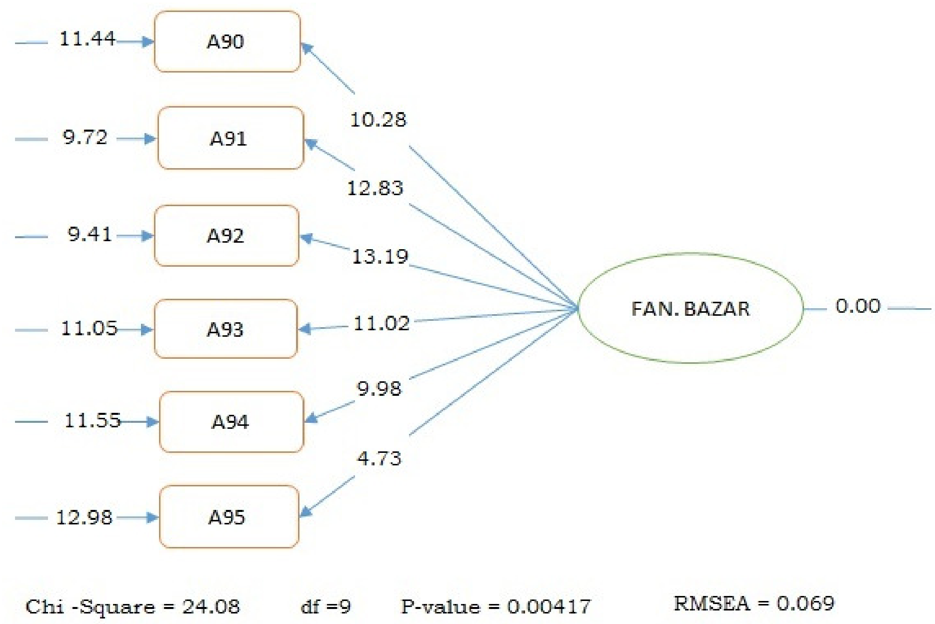

Figure-7
T-Value model related to function of formation of technology markets

For determination of the rate of effectiveness of each items measuring, function of formation of technology markets, the factor coefficients or loads were used. Table 9 indicates the effective variables on function of formation of technology markets were rated according to their factor loads.

Table-9
Rating the effective variables on formation of technology markets

Latent variable	Manifest variables	Factor load	Rank
Function of technology market formation	Providing financial services	0.70	1
	creation of centers providing data in the field of biogas technology	0.69	2
	Providing biogas technology assessment services	0.60	3
	Through the introduction of technology directly between buyer and seller	0.57	4
	Presenting technical services	0.28	5
	Presenting franchise service	0.28	6

Conclusion

Since in Iran more than half of populations are living in villages, this requires meeting their energy needs. Because the problem of providing needed energy and fuel fails due to some different problems like scattered villages, deficient communication ways, and particular cultural, social and economic structures and as such the consequences of this problem will be spread in the natural resources. The reasons for conducting the current research, thus, are as follows: i. A complete understanding of existence of such conditions and standards like amount of produced livestock waste, rate of energy consumption per family and existence of good climate in the rural areas of Tehran province. ii. Since few studies have been conducted on application of biomass resources especially livestock waste in the rural areas, the present research can be seen as a reliable document for gaining more insight about these resources in the areas. iii. Considering the results obtained by previous studies, the current investigation is in accordance with the Management and Planning Organization, Nour Alahi, Ghasemi and Eduardo et al[12,26-28].

The main result of the present research in participant's viewpoint is that socio-cultural functions of innovation, transmission, distribution, promotion and training of TI knowledge function, and formation of technology markets function hold a direct and meaningful relationship with usage of biomass resources. Moreover, the results obtained by multivariate regression analysis indicate that i. Functions related to constrains and obstacles are unable to explain changes in using biomass resources. ii. Functions of TIS are able to explain application of biomass resources. iii. The independent variables are able to explain changes in function of formation of technology markets. iv. The independent variables are capable enough to explain changes in promotion of technological entrepreneurship activities. v. The independent variables are able to explain the changes in function of development and promotion of innovative human resources. vi. Furthermore, the effective variables on usage of biomass resources were rated via the LISREL software. Tables 5, 7, and 9 showed the results.

Recommendations: Socio-culture function of innovation: i. Supporting formation of business groups especially expansion of the private sector in the biogas technology. ii. Creation of a competitive environment related to this technology in the country, and introduction of advantages of biogas technology products. iii. Concerning short-term support from biogas technology consumption due to modification of consumption culture in the rural areas.

Function of transmission, distribution, promotion and training of technological innovative knowledge: i. In-person meetings with the rural in their houses and farms. Ii. Public meetings with the rural (using group discussions and stay in touch with them). iii. Holding training classes and workshops on biogas technology. iv. Holding commercial seminars and fairs in biogas technology. v. Holding on line exhibition through an integrated information network in field of biogas technology. vi. Using the mass media like radio and TV programs, the rural are constantly trained in order to increase their competence and experience in field of biogas technology.

Function of formation of technology markets: i. Giving financial services to persons have created some business in biogas. ii. Establishment of centers for presenting data on biogas technology. iii. Providing assessment services for biogas technology. iv. Providing technological services to the rural. v. Presenting the franchises services.

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