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Explaining the effects of innovation and learning on dimensions of project sustainability in the Iranian Construction Industry

Alireza Siyavashpour, Hani Arbabi*

Faculty of Arts, Tarbiat Modares University, Tehran, Iran

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Abstract

A great volume of financial resources, human resources, and production materials of countries are utilized in construction projects in developing countries. Construction processes have become a threat to the survival of future generations and business quality of active organizations in this field due to their detrimental effects on the environment, economy, and human societies such as excessive consumption of natural resources, increasing pollution, loss of human dignity, and lack of sufficient motivation among project staff. Sustainability has been considered a challenging option to overcome today's threats with the ultimate goal of balancing the economic, social, and environmental conditions of projects without compromising the necessary resources for future generations. Furthermore, many studies have proven the effects of innovation and learning components on improving sustainability in different countries. The present study aimed to investigate the effects of innovation and learning components on dimensions of sustainability in Iranian construction industry projects. A questionnaire was designed based on the conceptual model of the research and 85 valid samples were collected. Data analysis was performed using SPSS22 and Smart PLS3. According to the results, learning and innovation had positive and significant effects on the social, economic, and environmental dimensions of projects.

Keywords: construction projects, sustainability, innovation, learning
2020 MSC: 60J20

1 Introduction

A large volume of many construction projects can be seen in cities. Projects, which were once considered the causes of economic development and the progress of human business, have become a threat to the environment, social life, and the survival of their business. The priority of project stakeholders has been on issues such as time, cost, and quality of the project, while the traditional management of projects has had devastating effects on the environment and stakeholders, such as excessive consumption of natural resources, increasing environmental pollution, and reducing economic resources to finance projects. Therefore, the continuation of the current trend has led to human extinction. Sustainability has been considered an important challenge of our time [31]. Global demand for sustainable development has put a lot of pressure on the construction industry to improve sustainable capacities [23]. Sustainability is about the balance and coordination between the economic, social, and environmental goals of projects. It means the improvement of the quality of human life according to humanistic views, maintenance of the viability

*Corresponding author
Email address: Arbabi@modares.ac.ir (Hani Arbabi)

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and diversity of the earth according to the naturalistic view, and providing the business benefits according to the profit-oriented view [26]. Increasing knowledge about sustainability has also emerged in recent years [29].

Furthermore, projects as a tool for change in organizations play important roles in the realization of sustainable business processes and practices [30], for example, construction projects. Construction projects have a significant impact on quality of life. Their output and results change the nature, function, and appearance of cities and villages where people live and work. The construction, use, repair, maintenance, and destruction of these projects generate a large volume of resources, energy, and biodegradable waste [20]. Even though the attention to sustainability in projects has been a choice to increase attention to the projects, it seems that reducing financial resources and destructive social effects of projects should be considered as a requirement in projects in near future due to resource constraints, increasing environmental pollution, and endangering the earth [29].

According to studies, the construction industry has low levels of sustainability in developing countries [4]. Given that achieving sustainability requires the use of sustainable methods throughout the product life cycle from the stages of ideas and concepts to the end of the product life, sustainability has been taken into consideration as an important issue in the construction industry by various researchers over the past two decades [14].

For the survival of an organization through its projects as a social system, it must be able to interact and coordinate with its environment. Organizations need innovation and continuous learning to achieve sustainable goals. They can respond to environmental changes by focusing on the knowledge gained from projects. Innovation facilitates the creation of new knowledge from existing knowledge. Organizations can facilitate sustainability by sharing knowledge and completing the learning cycle [33]. The construction industry needs sustainable changes, and organizations need to figure out how to manage those changes. To cope with such changes, they need continuous learning which leads to the manifestation of competitive advantages. Therefore, the concept of learning improves organizational performance to increase its level of sustainability [23]. As one of the three dimensions of sustainability about issues related to project teams, intra-organizational social relations of project teams with their colleagues outside the project, motivation, etc. can increase the ability to learn and transfer knowledge from the project to the organization, and it causes sustainable measures in the organization [5].

Furthermore, sustainable innovation, which leads to competitive advantages, requires a systematic and effective management approach based on knowledge and learning [6]. Sustainable development requires innovation that can be achieved through effective knowledge management in projects [33]. Improving the level of sustainability to prevent negative effects on the environment and society, and preventing the loss of economic resources are urgent and necessary for companies. The challenge for companies is to develop knowledge for a long-term understanding of sustainability that can be supported by innovation and learning within their organization [17].
Organizations also need two things for sustainability: knowledge for learning, and the learning capacity of the organizations to respond to environmental changes. Therefore, learning is an essential factor for sustainability [33]. The ability of construction organizations to cope with environmental changes requires organizational learning, which in turn leads to the potential to improve organizational performance to increase the level of sustainability [23].

Since comprehensive research has not been conducted in the field of Iranian construction industry projects to explain the effects of learning and innovation components on the dimensions of sustainability by the researcher, an important objective of the present study was to determine the status of sustainability in Iranian construction industry projects and explain the effect that learning and innovation could have on all three dimensions of project sustainability.

In the second section, the conceptual model of the research is presented while referring to the theoretical bases and research background. The method of this study is then described. The fourth section presents the research results, and finally, the conclusion of the research findings and comparison of these findings with previous research are presented.

2 Theoretical bases and research background

Sustainability is defined as the process of creating an image of a society that respects the prudent use of natural resources so that the current generations achieve high levels of economic security and it facilitates the ability to achieve democracy and popular participation in controlling their society while maintaining the integrity of environmental and life systems [19]. According to this definition, sustainability is a balanced development in which three categories of factors are independent and somehow combined.

The problems of developing countries such as Iran are as follows: rapid urbanization, deep poverty, social inequality, low levels of skills, the inability of institutions and poor governance, unstable economic environment, and environmental degradation that causes a challenging environment [7]. Sustainable buildings are naturally different from conventional buildings. They need special materials, different construction methods, as well as management commitment to sustainability to minimize risks and increase the chance of project delivery [13]. New construction systems have emerged to meet the needs of sustainability in the construction industry in most countries (e.g. industrial production, prefabrication, optimal use of construction materials, energy savings in the construction industry, the possibility of proper recycling of construction materials, and finally, economizing the construction sector) [9]. The results of research by Zarghami and Azemati indicate that the level of sustainability in Iran is very lower than international standards [35]. Despite having a rich history in architecture responsive to climate and environmental and climatic conditions, these factors have been largely ignored in the creation of modern buildings in Iran because constructions have changed from infrastructure to industry-based practices [18]. Banihashemi et al [3] found that commitment to high-quality work and having stakeholders in favor of sustainable delivery are important for the success of projects [3]. There are models for sustainability in the literature, one of the most widely used of which is the 3P model, and the three main components of this model are People (referring to the social dimension of sustainability), Planet (considering the environmental dimension of sustainability), and Profit (considering the economic dimension of sustainability) [32] and this model was used in most previous models and research because it has a good comprehensiveness in covering the components of sustainability; hence, it was also used in the present study.

Learning and innovation are effective factors of sustainability, and they are investigated in terms of effects on dimensions of sustainability in the following several studies, and then the conceptual model of research derived from such studies is presented below.

Learning is utilized to describe certain types of activities or processes that may occur at multiple levels of change. In other words, learning which occurs on a smaller scale leads to macro-learning [11]. Learning can affect sustainability and it is important to note that the organizations must interact and adapt to the environment to survive as a live social system [33].

As one of the three dimensions of sustainability about issues related to project teams, social relations of project teams with their colleagues outside the project, motivation, etc., social capital can help increase the ability to learn and transfer knowledge from the project to the organization. Learning leads to the strengthening of social capital in organizations [5]. Individuals exert their influence through local networks and can create lasting effects, especially in participatory leadership styles. Learning and change empower organizations through improving the competence and training of personnel [27]. More companies' progress toward sustainable social goals may be achieved through better persuasive and participatory approaches that are obtained from learning. Companies contribute to their learning processes by participating with companies that have shown reliability and commitment to social issues [21].

Therefore, the first research hypothesis can be presented as follows:

Hypothesis 1: The project team members' learning has a positive and significant effect on the social dimension of sustainability in these projects.

Interdisciplinary collaboration between different individuals leads to sustainable learning processes that can be useful for solving economic challenges and problems [27]. Uncertainties in environmental economic systems can be to some extent addressed through technological advances that are achieved through learning processes [21]. Therefore, the second hypothesis of the research can be presented as follows.

Hypothesis 2: The project team members' learning has a positive and significant effect on the economic dimension of sustainability in these projects.

Key environmental standards can be applied under routine oversight and control, and further improvements can be made by adapting to environmental changes. Uncertainties in ecological systems can be to some extent addressed through technological advances that are achieved through learning processes [21]. The ability to recycle and use environmentally friendly materials has been considered a key requirement for new product development through learning [27]; hence, the third research hypothesis can be presented as follows:

Hypothesis 3: The project team members' learning has a positive and significant effect on the environmental dimension of sustainability in these projects.

Innovation has become the pillar of organizations in the present rapidly changing world. Innovation has increased with the growth of knowledge in organizations so that sparks of innovation are formed by providing a knowledge base in which new efforts to develop a new product are meaningful [8]. Innovation is a means for survival, not just growth. The ability to absorb and integrate acquired knowledge with existing knowledge leads to the creation of new knowledge and is the key to sustainable development and innovation [6]. Innovation and sustainable development are constructs that are intricately intertwined. Given that organizations are exposed to environmental complexity and uncertainty, the ability to adapt to these conditions is essential. The more compatible organizations, the greater their competitive advantage over competitors. Knowledge and innovation are solutions to achieve this competitive advantage [25].

Creating sustainability requires new products and processes. Innovation increases sustainability and reduces social inequalities by transforming business processes and practices and improving systematic control. Therefore, innovation supports the social aspect of sustainability [17]. Innovation leads to the strengthening of social capital [5]; and it is, in fact, the core of creating a sustainable human society [10]. More companies' progress towards sustainable social goals may be achieved through better persuasive and participatory approaches that are obtained from innovation. Companies contribute to their innovation process by partnering with companies that demonstrate their reliability and commitment to social issues [21]. Sustainable innovation is presented in response to the management of requirements related to social, economic, and ecological aspects [15]. Innovation affects the social performance of sustainability [16]. Therefore, the fourth research hypothesis can be presented as follows:

Hypothesis 4: The project team members' innovation has a positive and significant effect on the social dimension of sustainability in these projects.

Considering the effect of innovation on sustainability, it can be pointed out that innovation is necessary for firms and sustainable businesses and leads to the necessary development to produce new products or improve previous products that take care of the economic aspects of sustainability [17]. Deliberate changes in the company's products or processes create economic value [1]. Innovation affects the economic performance of sustainability [16]. Therefore, the fifth research hypothesis can be presented as follows:

Hypothesis 5: The project team members' innovation has a positive and significant effect on the economic dimension of sustainability in these projects.

Innovation affects the environmental performance of sustainability [16]. In addition to the effective role in the use of resources, innovation reduces the negative effect on the environment and supports environmental aspects of sustainability by making changes in previous processes and business practices [17]. The implementation of an environmental management system is under the ISO 14000 standard which is an example of organizational innovation for environmental sustainability [34]. Sustainable innovation aims to reduce tensions between the environment, social status, and financial goals of companies [2]; hence, the sixth research hypothesis can be presented as follows:

Hypothesis 6: The project team members' innovation has a positive and significant effect on the environmental dimension of sustainability in these projects.

Figure 1 shows the conceptual model of the present study that is taken from previous studies.

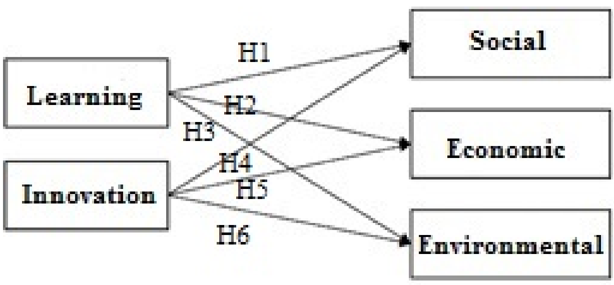

Figure 1: Conceptual model of research

3 Methodology

The present study was quantitative in terms of the method type and examined construction projects in Iran. The research steps are as follows.

3.1 Preparing the questions of the questionnaire and performing its validity

The questionnaire was researcher-made and consisted of a combination of several standard questionnaires [22] for innovation items [12] for learning items, and [28] for sustainability items that were adapted for the research purposes after translation into Persian and with some changes. The learning variable had four items, the innovation variable had five items, the social variable had eight items, the economic variable had four items, and the environmental variable had eight items. One of the changes made to the items was that they were adapted to the context of the projects because projects were the analysis units.

Formal validity was utilized to validate the questions. The initial version of the questionnaire was given to two university professors and two industry experts who were working in the construction industry, and the shortcomings and ambiguities of the questionnaires were removed and they were reviewed after making suggestions. In this review, some shortcomings were eliminated in the translation of standard questionnaires and some items were clarified. Regarding various scales in the questionnaire, the five-point Likert scale was used (1=very low, 2=low, 3=moderate, 4= high, and 5=very high)

3.2 Data collection

The online version of the questionnaire was created using Porsline software and was distributed online by sending its link to projects of project-based organizations.

The statistical population of the research consisted of Iranian construction industry projects that were active in Tehran province and Tehran city so that the researcher can access them to collect data. Due to a large number of projects, the following criteria were considered in the selection of projects:

A) During the data collection period, they must be in the construction phase of the project or their construction must be recently completed to be a good indicator of the recent status of the Iranian construction industry.
B) They must include small, medium, and large-size projects to involve projects of different sizes in research.
C) They must include various types of projects, including administrative, residential, commercial, and cultural.

Research samples included several projects with the aforementioned characteristics in the statistical population in which the respondents, who participated in the research on behalf of their organizations or companies, have characteristics that could well describe the status of their projects. Features were as follows:

1) Familiarity with the project management literature,
2) Knowledge about the project implementation process,
3) A member of the project planning and control department or decision-maker of each project.

To determine the number of samples, 85 valid samples were collected with the follow-up because the statistical population included an unknown (infinite) number. In studies with infinite communities, a good number of samples are collected by achieving saturation in the results of the collected data. In the present study, the software output was obtained with 60 first samples, 70 first samples, and finally, 85 samples, and the results of the first 60 samples and 70 samples were different (although not in rejecting or confirming the hypotheses and only in amounts of path coefficients) but the results of 70 samples and 85 samples had very small differences in amounts of their path coefficients, indicating that the sample size was relatively appropriate. The researcher used the random sampling method to collect samples and collected a large amount of data by attending the "Sustainable Construction" conference which was held specifically on the nature of sustainability in projects. The contact numbers, Emails, and addresses of many of the companies were also obtained from them at the same conference, and they were invited to participate in the research via SMS, and a web version of the questionnaire was sent to them after their confirmation that they could cooperate. Since most of the organizations or companies at the Sustainable Construction Conference had good ranks, some questionnaires were also distributed among members working on smaller projects or with medium or poor executive status (suspended projects, projects facing budget shortfalls, etc.) to prevent bias in results, and the characteristics of the projects and their representative respondents were identified through the snowball technique.

Table 1 presents the demographic characteristics of the respondents to the questionnaire, such as age, gender, education level, and type of project in which they were working.

The most important point is that most respondents (about 40%) had less than five years of experience in the Iranian construction industry, and it was probably a research limitation. According to Table 1, the two positions, management (41.2%) and administrative/expert (36.6%) constituted the highest frequency of respondents with a large difference.

3.3 Data analysis

SPSS22 was used to extract descriptive statistics of research variables. In the inferential statistics phase of the research variables, structural equation modeling and SmartPLS3 tools were utilized to analyze the questionnaire data. The software was used for data analysis due to the following reasons.

- The sample size of the research was relatively small (85 valid samples)

Table 1: Demographic statistics of the respondents to the questionnaire

Demographic characteristics	**Index**	**Number (out of 85)**	**Frequency percentage**
Age	20-25 years	5	5.7%
	25-35 years	33	37.9%
	35-45 years	39	44.8%
	Above 45 years	10	11.5%
Gender	Female	21	24.1%
	Male	66	75.9%
Education level	Associate degree	3	4%
	Bachelor	21	24%
	Master	51	59%
	Ph.D.	12	13%
Job position	Management	35	41.2%
	Counseling	6	7.1%
	Administrative/expert	31	36.6%
	Executive	10	11.8%
	Other	3	3.5%
Type of project	Residential	50	59.2%
	Commercial/ Administrative	24	29.4%
	Medical/ Service	14	17.6%

- The conceptual model of the research had a researcher-made type.
- The conceptual model of the research had a relatively moderate complexity (considering the number and relationships between variables).
- It was possible to explain the relationships between variables with this tool.

3.4 Validation of findings

Validation of the research conceptual model and its variables was measured using confirmatory factor analysis (CFS) and its defined indices (e.g. convergent and divergent validity) as discussed in detail in the fourth section. For the validation of the findings, they were compared with the existing literature on the status of sustainability in Iran and showed a good overlap to a large extent. It was then given to two university professors and two industry experts who had good practical experience in this field and were somehow familiar with the challenges of implementing sustainability. The findings were validated to a large extent with a final consensus between them.

3.5 Nonlinear Structural Equation Model

The traditional linear structural equation model is typically made up of two parts: the measurement model describing the relationships between the observed and latent variables and the structural model describing the relationships between the latent variables. Given a vector of p observed variables $\mathbf{Z}_i$ for the ith individual in a sample of size n and a vector of q latent variables f_i, the linear structural equation model system can be written:

$$\mathbf{Z}_i = \mu + \Lambda f_i + \varepsilon_i, \tag{3.1}$$

$$b_0 + \mathbf{B}_0 f_i = \delta_{0i}, \tag{3.2}$$

where in the measurement model, the matrices $\mu(p \times 1)$ and $\Lambda(p \times q)$ contain fixed or unknown scalars describing the linear relation between the observations $\mathbf{Z}_i$ and the common latent factors f_i, and ε_i represents the $(p \times 1)$ vector of random measurement error independent of f_i such that $E(\varepsilon_i) = 0$ and $Var(\varepsilon_i) = \Psi$ with fixed and unknown scalars in Ψ; and in the structural model, the matrices $\mathbf{b}_0(d \times 1)$ and $\mathbf{B}_0(d \times q)$ contain fixed or unknown scalars defining d different additive linear simultaneous structural equations relating the factors to one anther plus the $(d \times 1)$ vector of random equation error δ_{0i}, where $E(\delta_{0i}) = 0$ and $Var(\delta_{0i}) = \Delta_0$ with fixed and unknown scalars in Δ_0.
The simultaneous linear structural model as written in (3.2) is very general. For many practical research questions which can be addressed by simultaneous structural models, itis useful to model specific variables in terms of the rest of the variables, i.e., it is useful to consider some of the latent variables as endogenous and others as exogenous, where endogenous variables are those that are functions of otherendogenous and exogenous variables. Let $f_i = (\eta_i', \xi_i')'$ where

η_i are the d endogenous latent variables and $_i$ are the $q-d$ exogenous latent variables. Then a commonly used form for the structural model (3.2) becomes:

$$\eta_i = \mathbf{b} + \mathbf{B}\eta_i + \Gamma\xi_i + \delta_i, \tag{3.3}$$

where it is assumed the equation errors δ_i have $E(\delta_i) = 0$, $Var(\delta_i) = \Delta$ and are independent of the ξ_i as well as independent of ε_i in (3.1), and the matrices $b(d \times 1), \mathbf{B}(d \times d), \gamma(d \times (q-d))$, and $\Delta(d \times d)$ are fixed or unknown scalars. The structural model (3.3) is said to be in implicit form, implicit because it has endogenous variables on both sides of the equations, i.e., it is not " solved" for the endogenous variables. it is assumed that thediagonal of $\mathbf{B}$ is zero so that no element of η_i is a function of it self. A sufficient condition for solving (3.3) is that $(I-B)$ is invertible, then (3.3) can be solved for the endogenous variables and written as

$$\eta_i = \mathbf{b}^* + \Gamma^*\xi_i + \delta_i^*, \tag{3.4}$$

where $b^* = (I-B)^{-1}b, \gamma^* = (I-B)^{-1}\gamma$, and $Var(\delta_i^*) = (I-B)^{-1}\delta(I-B)^{-1'}$. The structural model (3.4) is said to be in reduced form as the η_i now appears only on the left-hand side of the equation. It is important to note the assumption that the equation errors δ_i where additive and independent of the ξ_i in the implicit form (3.3) results in the equation errors δ_i^* in the reduced form (3.4) also being additive and independent of the η_i.

Given p, q and d, additional restrictions must be placed on $\boldsymbol{\mu}, \boldsymbol{\Lambda}, \boldsymbol{\Psi}, \boldsymbol{b}_0, \boldsymbol{B}_0$, and $\boldsymbol{\Delta_0}$ in (3.1)-(3.2) in order to make all the unknown parameters identifiable. The assumption that (3.2) can be written in reduced form (3.4) is the typical restriction placed on the structural model.
Additionally, a common restriction placed on the measurement model (3.1) is the errors-in-variables parameterization where q of the observed variables are each fixed to be equal to one of the q different latent variables plus measurement error. For a thorough discussion of identifiability in linear structural equation models see, e.g.. Finally, it should be noted that there is no inherent distributional assumptions needed for $\boldsymbol{\varepsilon}_i, \boldsymbol{\delta}_{0i}$, nor $\boldsymbol{f}_i$ at this point of model specification although distributional assumptions may be added eventually to perform estimation.

A mixture SEMs for a $p \times 1$ random vector $\boldsymbol{y}_i$ is defined as follows:

$$f(y_i) = \sum_{k=1}^{K} \pi_k f_k(y_i|\mu_k, \sum_k), \qquad i = 1, \cdots, n, \tag{3.5}$$

where $\boldsymbol{K}$ is the number of components which can be unknown, π_k's are component probabilities which are nonnegative and sum to 1.0, $f_k(\boldsymbol{y}|\boldsymbol{\mu_k}, \sum_{\boldsymbol{k}})$ is a multivariate normal density function with an unknown mean vector $\boldsymbol{\mu_k}$ and a covariance matrix $\sum_{\boldsymbol{k}}$. Conditional on the kth component, suppose that y satisfies the following measurement model:

$$y = \mu_k + \Lambda_k\omega_k + \varepsilon_k, \tag{3.6}$$

where $\boldsymbol{\mu_k}$ is an $\boldsymbol{p \times 1}$ intercept vector, $\boldsymbol{Y_k}$ is a $p \times q$ factor loading matrix, $\boldsymbol{\omega_k}$ is a $q \times \mathbf{1}$ random vector of latent variables, and $\boldsymbol{\varepsilon_k}$ is a $p \times \mathbf{1}$ random vector of error measurements with distribution $\boldsymbol{N(0, \Psi_k)}$, which is independent of $\boldsymbol{\omega_k}$, and $\boldsymbol{\Psi_k}$ is a diagonal matrix. Let $\boldsymbol{\omega_k}$ be partitioned into $(\eta_n^T, \xi_k^T)^T$, where $\boldsymbol{\eta_k}$ is a $q1 \times 1$ vector, $\boldsymbol{\xi_k}$ is a $q2 \times 1$ vector, and $q1 + q2 = q$. The structural equation is defined as

$$\eta_k = B_k\eta_k + \Gamma_k\xi_k + \delta_k, \tag{3.7}$$

where $\boldsymbol{B_k}$ and $\boldsymbol{Y_k}$ are $q1 \times q1$ and $q1 \times q2$ matrices of unknown parameters; and random vectors $\boldsymbol{\xi_k\lambda_k}$ are independently distributed as $N\boldsymbol{(0, \Phi_k)}$ and $N(0, \boldsymbol{\Phi_{\lambda k}})$, respectively; and $\boldsymbol{\Phi_k}$ is a diagonal matrix.
We assume that $\boldsymbol{B}_{0k} = (\boldsymbol{I}_{q1} - \boldsymbol{B_k})$ is nonsingular and $(\boldsymbol{I}_{q1}$ is independent of any elements in $\boldsymbol{B_k}$. One specific form of $\boldsymbol{B_k}$ that satisfies this assumption is the lower or upper triangular matrix. As the mixture model defined in (3.5) is invariant with respect to permutation of labels $k = 1, \cdots, K$, adoption of an unique labeling for identifiability is important. Roeder and Wasserman (1997), and Zhu and Lee (2001) proposed to impose the ordering $\mu_{1,1} < \cdots < \mu_{k,1}$ for eliminating the label switching (jumping between the various labeling subspace), where $\mu_{k,1}$ is the first element of the mean vector $\boldsymbol{\mu}_k$. This method works fineif $\mu_{1,1}, \cdots, \mu_{k,1}$ are well separated.

However, if $\mu_{1,1}, \cdots, \mu_{k,1}$ are close to each other, it may not be able to eliminate the label switching, and may introduce incorrect results. Hence, it is necessary to find a sensible identifiability constraint. In this chapter, the random permutation sampler developed by Frühwirth-Schnatter (2001) will be applied for finding the suitable identifiability constraints. See the following sections for more details.

Moreover, for each $k = 1, \cdots, K$, structural parameters in the covariance matrix $\sum_k$ corresponding to the model defined by (3.6) and (3.7) are not identified. A common method in structural equation modeling for identifying the model is to fix appropriate elements in $\boldsymbol{A}_k, \boldsymbol{B}_k$, and /or $\boldsymbol{Y}_k$ at preassigned values. The positions of thepreassigned values of the fixed elements in these matrices of regression coefficients can be chosen on a problem-by-problem basis, as long as each $\sum_k$ is identified. In practice, most manifest variables are usually clear indicators of their corresponding latent variables are usually clear indicators of their corresponding latent variables. This give rather clear prior information to specify the zero values to appropriate elements in these parameter matrices. See the illustrative example in section 5 for a more concrete example. For clear discussion of the proposed method, we let $\boldsymbol{\Pi} = (\Pi_1, \cdots, \Pi_k)$, and $\boldsymbol{\theta}$ be the vector which contains all unknown parameters in the covariance matrices that defines an identified model.

4 Results

4.1 Sustainability of projects

Table 2 presents the descriptive indicators of the three dimensions of sustainability in 85 research samples.

Table 2: Descriptive indices of sustainability variables

Variable	Number of items	Mean	Sd	Variance	Minimum	Maximum
Economic	4	2.82	0.80	0.64	1	5
Environmental	8	1.84	0.77	0.60	1	5
Social	8	3.45	0.72	0.52	1	5
Sustainability	20	2.73	0.63	0.40	1	5

When talking to the participants in the research about the purpose of the questionnaire, important points were obtained, which are stated below in the explanation of Table 2. Regarding the social dimension, it can be pointed out that there are laws by upstream organizations in the field of human resources, stakeholders, and social capital that indicated the need to follow these laws and put the situation of this dimension of sustainability in relatively better conditions such as labor law, banking law, and laws of the Department of Finance. The laws and regulations in this field at the national level have inadvertently caused the pillars of the projects to follow them. For example, the minimum salary and benefits defined by the labor law for different jobs have made it impossible for employers and project managers to override lower-level pay responsibilities. In the field of Health, Safety, and Environment (HSE) issues, the executive agents of projects, laws, regulations, and standards have been defined which are mostly observed by institutions such as municipalities and banks, but no acceptable measure is taken in terms of training forces in the field of safety. When the executive pillars of the projects are covered to a greater extent by insurance companies, a greater degree of safety is used in the project environment. It should be noted that despite all these regulations, they are sometimes ignored due to the poor performance of regulatory agencies, whether in the field of safety, wages, or other issues. Furthermore, the workers' wages are much lower than project revenues, and defined bureaucracies and the complexity of pursuing receivables lead to a lack of motivation for the demanders.

In the economic dimension, construction companies are subconsciously observing the attention to the long-term economic benefits of the projects as an important component of sustainable economics due to the conditions governing the national economy, such as high inflation. This is especially true for long-term projects that have a long construction time. An interviewee acknowledged that "due to the negative ratio of interest rate of bank loans to inflation in the long term, the economic evaluation of the projects was based on a balanced view of short-term and long-term benefits to the project's economic criteria (e.g. return on investment (ROI) and NPV)". It acted as a double-edged sword, and for example, the tendency to depot materials decreased the incentive to manage them effectively, but with the interactions that all these factors had together, they obtained an average of 2.82 for the economic dimension. In the field of environmental dimension, there is an unfavorable status in the construction industry of Iran. The prevailing view and tendency of the main actors of the projects are towards the economic and sometimes social issues of the projects, and the environmental dimension has been neglected. Despite inexpensive energy prices, lack of supervision, the gap in environmental laws, and lack of incentives in the construction industry, there will be no incentive to reduce energy consumption, use green energy, reduce waste and pollutants, and effectively manage natural resources.

To examine the status of sustainability, it was hypothesized that "the status of sustainability is below average in Iranian construction industry projects". Therefore, the One-Sample T-test was used (considering that 85 samples were collected in the study and were higher than 25 samples, there was no need to check the data normality to use this test). Table 3 presents the output of SPSS22, indicating the status of this test for the sustainability variable.

The following two hypotheses are presented in this test:

Null Hypothesis: The average sustainability is equal to the assumed average (assumed average ≤ 3).

Table 3: One-sample t-test related to the sustainability variable

One-Sample Test				
	Test Value =3			
	T	Df (n-1)	Sig. (2-tailed)	Mean Difference
Sustainability of the project	7.521	84	.000	0.52157

First Hypothesis: The average sustainability is not equal to the assumed average.

The null hypothesis was rejected and the first hypothesis was confirmed since the significance level was 0.00 for the sustainability variable and less than 0.05. Therefore, the mean status of sustainability was not equal to the assumed average and was lower than the average.

4.2 Explaining the effects of innovation and learning on dimensions of project sustainability

Figure 2 shows the conceptual model of research in the standardized state of factor loadings.

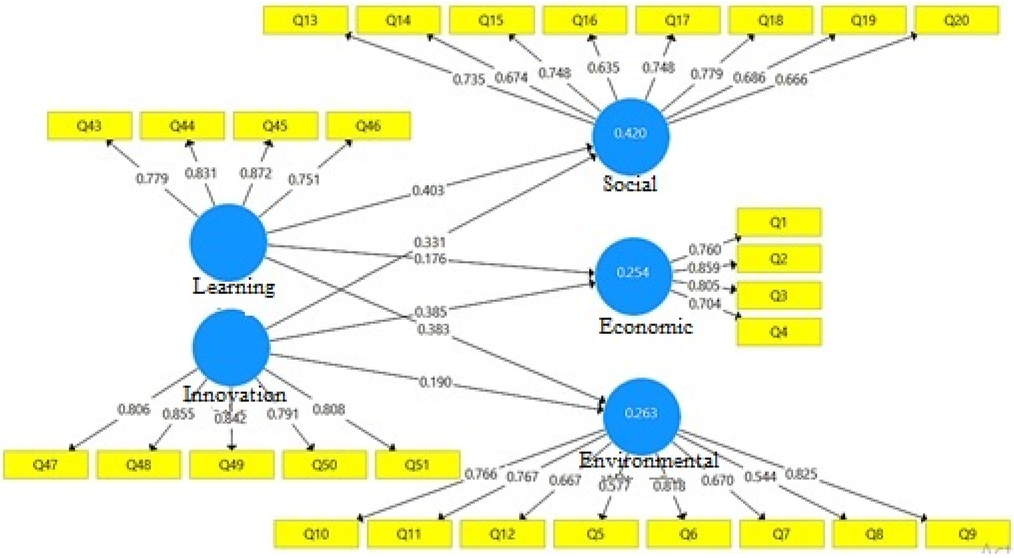

Figure 2: Conceptual model of research with standardized factor loading coefficients

Figure 3 also shows the standardized coefficients of t-values related to the items and variables of the research conceptual model.

As shown in Figure 3, the t-values and the standardized factor loadings between the questions and their latent variables were greater than 1.96 and 0.4 respectively in all cases. Therefore, appropriate questions were included in the research and there was no need to delete or change the questions. Table 4 presents the values of Cronbach's alpha coefficient, composite reliability coefficient, and convergent validity.

Table 4: Cronbach's alpha and composite reliability coefficients of research variables

Variable	**Cronbach's alpha coefficient** (alpha>0.7)	**Composite reliability coefficient (CR>0.7)**	**Convergent validity** (AVE>0.5)	**Result**
Innovation	0.879	0.911	0.674	Desired
Economic	0.796	0.868	0.615	Desired
Environmental	0.858	0.891	0.506	Desired
Social	0.859	0.890	0.505	Desired
Learning	0.826	0.884	0.655	Desired

According to Table 5, the divergent validity of the model was appropriate.

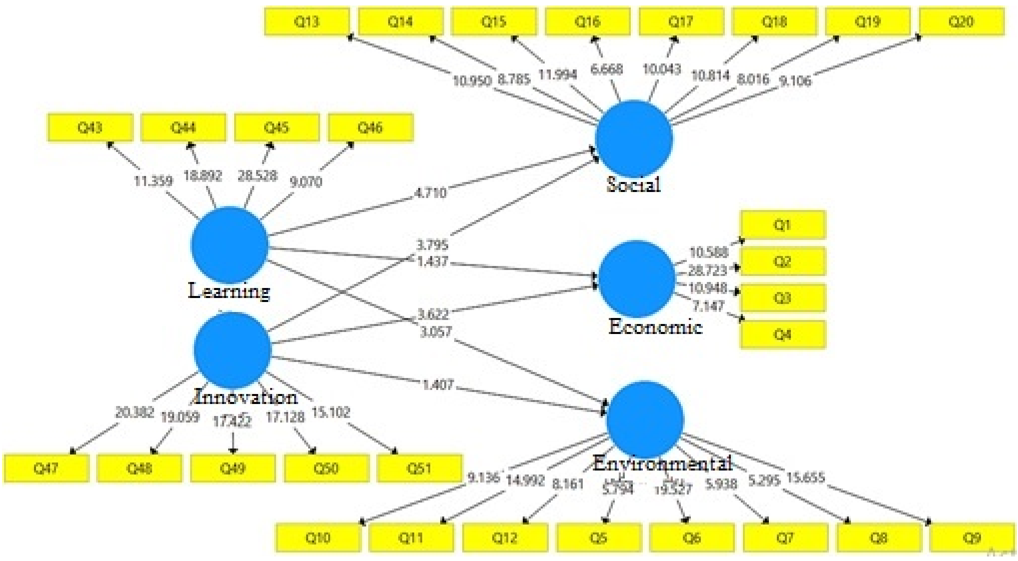

Figure 3: Conceptual model of research with standardized coefficients of t-values

Table 5: Results of divergent validity study by Fornell and Larcker method

Learning	**Innovation**	**Environmental**	**Economic**	**Social**	**Variables**
Social	0.711				
Economic	0.553	0.784			
Environmental	0.561	0.523	0.711		
Innovation	0.554	0.482	0.401	0.821	
Learning	0.586	0.389	0.784	0.553	0.810

Table 6 presents the intensity of the effects of independent variables on dependent variables.

Table 6: Intensity of the effects of independent variables on dependent variables

Path: independent variable →dependent variable	$\mathbf{f^2}$	**Result**
Innovation → Social	0.11	Desired
Learning → Social	0.195	Desired
Innovation → Economic	0.138	Desired
Learning → Economic	0.029	Medium
Innovation → Environmental	0.034	Medium
Learning → Environmental	0.138	Desired

Table 7 presents the predictive correlation index and the adjusted coefficient of determination of the dependent variables.

Table 7: R^2 and Q^2 coefficients of dependent variables

Dependent variable	**Predictive correlation index ($\mathbf{Q^2}$)**	**Result**	**Adjusted coefficient of determination ($\mathbf{R^2}$)**	**Result**
Social	0.145	Weak	0.406	Strong
Economic	0.125	Weak	0.236	Medium
Environmental	0.128	Weak	0.263	Medium

Table 8 presents the results of confirmation or rejection of each research hypothesis.

According to Table 8, hypotheses two and six are rejected and the other four hypotheses are confirmed. Among the

Table 8: Results of estimation of significant coefficients of t-value and standardized path coefficient

Independent variable	Dependent variable	B	T-value	Significance level	Result
Learning	Social	0.403	4.710	0.04	Confirmed
Learning	Economic	0.176	1.437	0.00	Rejected
Learning	Environmental	0.383	3.057	0.098	Confirmed
Innovation	Social	0.331	3.795	0.282	Confirmed
Innovation	Economic	0.385	3.622	0.00	Confirmed
Innovation	Environmental	0.190	1.407	0.00	Rejected

confirmed hypotheses, the effect of learning on the social dimension showed a higher value probably because of paying more attention to humanities in recent years. Paying attention to knowledge management issues and establishing knowledge management units in organizations for maintaining and developing knowledge in projects might be other reasons.

The existence of rejected hypotheses is more important than the confirmed hypotheses. Regarding the impact of learning on the economic dimension, which is not confirmed, it is worth noting that many projects still use traditional mechanisms and do not address technological issues and the emerging technologies to receive, record, create and analyze data. Issues related to the acceptance of emerging technologies and resistance to changes are reflected among project staff. This issue becomes more prominent, especially in older employees with more work experience. The results of the present study are obtained if about 72% of the respondents had a master's or doctoral degree, and perhaps with the participation of people with a lower education level and older, the status will be even worse.

In terms of the impact of innovation on the environmental dimension, which is not confirmed, despite paying more attention to sustainability issues in recent years and the existence of more scientific conferences and meetings in Iran, they are seldom noticed at the industrial level so that the production of products and services in line with green construction is proceeding at a very low speed, and there is a big gap with green standards both in the production of construction materials and principles and methods of implementation. Most of the production materials are old and non-renewable and a lot of waste is sent to the environment during their implementation and use. Construction methods are also very old and sometimes heavy materials are used in construction, and there is a need to produce more of these materials some of which are obtained from natural sources.

5 Discussion and conclusion

The present study, which aimed to explain the effects of innovation and learning components on the sustainability dimensions of projects in the Iranian construction industry, examined the mean of all three dimensions of sustainability (social, economic, and environmental) as well as the mean of all sustainability variables resulting from the three components, and the that mean lower than average was obtained. The result was consistent with the results of a study by Zarghami et al [35] who concluded that the level of sustainability was very low in Iran compared to international standards. Malek and Grierson [18] also argued that despite a rich history in architecture responsive to climate, and environmental and climatic status, the factors were largely ignored in the creation of modern buildings in Iran [18], [3] also pointed out that problems, which prevented the integration of sustainability in project management practices in construction projects, were identified [3].

Four out of six research hypotheses (learning on social factors, learning on environmental factors, innovation on social factors, innovation on economic factors) were confirmed and two hypotheses (learning on economic factors, and innovation on environmental factors) were rejected, and the results were somewhat consistent (in terms of confirmed hypotheses) with the results of previous research presented in the section of the theoretical basis of the research. The research context in Iran was probably not ineffective in achieving the results of not confirming the above two hypotheses.

Even though the respondents acknowledged that learning and innovation could lead to competitive advantages for organizations, and creating a competitive advantage could help improve their performance and ultimately improve their sustainability, the status of sustainability variables, which were below the defined average level, indicated that we need to move towards improving these components in organizations. Sometimes the environmental dimension is a prevailing view of the concept of sustainability among those involved in the construction industry, while organizations are subconsciously involved in economic and social issues. The problem is the lack of proper management of these dimensions, indicating an inappropriate orientation towards sustainability goals. It seems necessary to inform people about the basic nature of sustainability. Creating training programs and holding more conferences and gatherings about sustainability are some measures that can be effective.

Another issue is the attitude that some people toward investing in relatively new topics such as sustainability because new concepts always bring uncertainties that make their use questionable and with doubt. Such doubts are probably about the implementation of these concepts and incurring additional costs for organizations or about the individuals' reluctance to believe in these issues. To create an open and receptive culture of ideation, the organizations must provide an open and supportive environment for changes, and acceptance of mistakes and failures, as learning opportunities for individuals to freely and creatively express their creative and innovative ideas without fear of failure or being penalized.

Based on the results of the present research and according to the conditions of projects and subsequently different organizations, it is suggested to consider the effects of learning on dimensions of sustainability of projects and create procedures for documenting knowledge and experience of employees, use motivational tools and appropriate training programs to create a culture of knowledge sharing among employees, and use a database to record, store and retrieve useful knowledge of employees, thereby leading to effective use of organizational knowledge obtained through project knowledge, and improving the organizational performance. If organizations provide opportunities to encourage employees to share latent knowledge, there will be a path for creative employees to share their experiences and tacit knowledge according to project goals.

As a conclusion of the present study, it is worth noting that as long as organizations do not want a change in the paths of learning and innovation, they cannot make appropriate investments with good feedback to achieve sustainability goals. The rotten view of the Iranian buildings needs a little revision in new subjects such as sustainability.

Some applications of the present study for Iranian construction project stakeholders are that organizations, which are beginning to use sustainability in their projects, can use the results of this study, take a useful step in this way, and consider the scores of components to know which components have the most limitations and shortcomings, and pay more attention to them to implement sustainability with more confidence. If national planning is further developed in this field, organizations will be more inclined toward this concept, and the results of the present research will be more applicable.

In terms of research and scientific context, the present findings can be a valuable starting point for researchers who intend to work in the field of sustainability and its determinants. Researchers can use the research results and the knowledge, which gain about the status of sustainability in construction projects in Iran, to conduct research for improving the current status.

Since numerous construction projects with different residential, commercial, administrative, health, etc. applications are being designed and implemented in Iran, the researcher faced with an infinite number of projects in determining the number of samples, which included 85 valid samples, and perhaps a relatively small number of 85 samples was a limitation of the present study. The research, which examined the Iranian construction industry projects, had two limitations in terms of generalization of results as follows. First, it particularly examined the Iranian construction industry, and second, it was more applicable to the project analysis unit. Therefore, conducting similar research in other industries such as oil and gas, and comparing the results can provide valuable findings. Future researchers can also define aspects of sustainability and examine their interaction in organizations in separate studies. The results of the present study can only be generalized to the construction industry projects in Iran and specifically, Tehran province, and the construction status can be different in other provinces and countries with different economic, social, and environmental conditions; hence, the present study may produce different results in those countries.

Given the findings of the present study and its limitations, the researcher suggests conducting new studies some of the most important of which are as follows:

- Investigating the success factors of Iranian construction projects that are implemented with a sustainable approach
- Investigating the motivating factors in project-based organizations to implement sustainability in projects
- Evaluating the performance of similar construction projects of the organization before and after the introduction of sustainability guidelines defined for the organization
- Factors for promoting innovation and learning in project-based organizations.

References

[1] R. Adams, S. Jeanrenaud, J. Bessant, D. Denyer and P. Overy, *Sustainability-oriented innovation: A systematic review*, Int. J. Manag. Rev. **18** (2016), no. 2, 180–205.

[2] D.B. Authority and L. Allé, *The future of eco-innovation: The role of business models in green transformation*, OECD/European Commission/Nordic Innovation Joint Workshop: Copenhagen, Denmark, 2012.

[3] S. Banihashemi, M.R. Hosseini, H. Golizadeh and S. Sankaran, *Critical success factors (CSFs) for integration of sustainability into construction project management practices in developing countries*, Int. J. Project Manag. **35** (2017), no. 6, 1103–1119.

[4] N. Baron and D. Donath, *Learning from Ethiopia–A discussion on sustainable building*, Proc. of SBE16 Hamburg Int. Conf. Sustain. Built Envir. Strategies–Stakeholders–Success Factors, Held from 7th to 11th March in Hamburg, Germany, 2016.

[5] V. Bartsch, M. Ebers and I. Maurer, *Learning in project-based organizations: The role of project teams' social capital for overcoming barriers to learning*, Int. J. Project Manag. **31** (2013), no. 2, 239–251.

[6] M. Dasgupta and R. Gupta, *Innovation in organizations: A review of the role of organizational learning and knowledge management*, Glob. Bus. Rev. **10** (2009), no. 2, 203–224.

[7] C. Du Plessis, *A strategic framework for sustainable construction in developing countries*, Construct. Manag. Econ. **25** (2007), no. 1, 67–76.

[8] M. Du Plessis, *The role of knowledge management in innovation*, J. Knowledge Manag. **11** (2007), no. 4, 20–29.

[9] M.H. Fallah, *Construction industry and sustainable development*, Sofeh **15** (2005), no. 40.

[10] M.M. Gobble, *Innovation and sustainability*, Res. Technol. Manag. **55** (2012), no. 5, 64–67.

[11] S.L. Hoe, *Organizational learning: conceptual links to individual learning, learning organization, and knowledge management*, J. Inf. Knowledge Manag. **6** (2007), no. 3, 211–217.

[12] G.T.M. Hult, R.F. Hurley, L.C. Giunipero and E.L. Nichols, *Organizational learning in global purchasing: a model and test of internal users and corporate buyers*, Decision Sci. **31** (2000), no. 2, 293–325.

[13] N.K.M. Isa, Z.A. Samad and A. Alias, *A review on sustainability principles of building: Formulation of a theoretical framework*, J. Survey. Construct. Property **5** (2014), no. 1, 1–16.

[14] S.A. Khan, M. Koc and S.G. Al-Ghamdi, *Sustainability assessment, potentials and challenges of 3D printed concrete structures: A systematic review for built environmental applications*, J. Cleaner Product. **303** (2021), 127027.

[15] J. Klewitz and E.G. Hansen, *Sustainability-oriented innovation of SMEs: a systematic review*, J. Cleaner Product. **65** (2014), 57–75.

[16] E. Kuzma, L.S. Padilh, S. Sehnem, D.J. Julkovski and D.J. Roman, *The relationship between innovation and sustainability: A meta-analytic study*, J. Cleaner Product. **259** (2020), 120745.

[17] G.C. López-Torres, J.A. Garza-Reyes, G. Maldonado-Guzmán, V. Kumar, L. Rocha-Lona and A. Cherrafi, *Knowledge management for sustainability in operations*, Product. Plann. Control **30** (2019), no. (10-12), 813–826.

[18] S. Malek and D. Grierson, *A contextual framework for the development of a building sustainability assessment method for Iran*, Open House Int. **41** (2016), no. 2, 64–75.

[19] M.L. Martens and M.M. Carvalho, *Key factors of sustainability in project management context: A survey exploring the project managers' perspective*, Int. J. of Project Management **35** (2017), no. 6, 1084-1102.

[20] J.I. Messner, *An architecture for knowledge management in the AEC industry*, Construction Research Congress: Wind of Change: Integration and Innovation, 2003.

[21] M. Müller and B. Siebenhüner, *Policy instruments for sustainability-oriented organizational learning*, Bus. Strategy Envir. **16** (2007), no. 3, 232–245.

[22] B.Y. Obeidat, M.M. Al-Suradi and A. Tarhini, *The impact of knowledge management on innovation: An empirical study on Jordanian consultancy firms*, Manag. Res. Rev. **39** (2016), no. 10, 1214–1238.

[23] A. Opoku and C. Fortune, *Organizational learning and sustainability in the construction industry*, Built Human Envir. Rev. **4** (2011), no. 1, 98–107.

[24] A. Opoku and C. Fortune, *Implementation of sustainable practices in UK construction organizations: Drivers and challenges*, Int. J. Sustain. Policy Practice **8** (2013), 121–132.

[25] M. Peris-Ortiz, J.J. Ferreira and J.M.M. Lindahl, *Knowledge, innovation, and sustainable development in organizations: A dynamic capability perspective: An overview*, In Knowledge, Innovation and Sustainable Development in Organizations, 2019, 1–10.

[26] M.H. Pulaski, M.J. Horman and D.R. Riley, *Constructability practices to manage sustainable building knowledge*, J. Architect. Engin. **12** (2006), no. 2, 83–92.

[27] B. Siebenhüner and M. Arnold, *Organizational learning to manage sustainable development*, Bus. Strategy Envir. **16** (2007), no. 5, 339–353.

[28] A. G. Silvius and R. Schipper, *A maturity model for integrating sustainability in projects and project management*, 24th World Cong. Int. Project Manag. Assoc. (IPMA) Istanbul, Turkey, 2010.

[29] A.G. Silvius and R. Schipper, *A conceptual model for exploring the relationship between sustainability and project success*, Procedia Comput. Sci. **64** (2015), 334–342.

[30] A.G. Silvius and R.P. Schipper, *Sustainability in project management competencies: analyzing the competence gap of project managers*, J. Human Resource Sustain. Stud. **2014** (2014).

[31] G. Silvius, *Sustainability as a new school of thought in project management*, J. Cleaner Product. **166** (2017), 1479–1493.

[32] M.A. Köhler, M.G. Silvius, M.J. van den Brink, M.R. Schipper and M.J. Planko, *Sustainability in project management*, Gower Publishing, Ltd., 2012.

[33] D.M. Wong, *Knowledge management catalyst for sustainable development*, Int. Symp. Inf. Technol., 2010.

[34] H.H. Wu, A.H. Lee and T.P. Tsai, *A two-level replenishment frequency model for TOC supply chain replenishment systems under capacity constraint*, Comput. Ind. Engin. **72** (2014), 152–159.

[35] E. Zarghami, H. Azemati, D. Fatourehchi and M. Karamloo, *Customizing well-known sustainability assessment tools for Iranian residential buildings using the fuzzy analytic hierarchy process*, Build. Envir. **128** (2018), 107–128.