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Stevan Dedijer
1911-2004

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ABSTRACT The purpose of this study is to investigate the interrelation of the main variables affecting technology intelligence management to design an appropriate model of high technologies intelligence management at national level organisations. Based on a literature review, a conceptual model was developed. It includes 11 main variables classified into three levels: the operational, managerial, and environmental levels. Participants in the present research included 160 experts in technology intelligence from Iranian universities and industry, 137 of whom completed the research questionnaire. Research information and hypotheses were analysed and tested using structural equation modeling, SPSS, and LISREL software. The findings show that to properly manage a technology intelligence system in high technologies at national level organisations, attention to the managerial and operational levels is more important than environmental factors. It also shows that to establish technology intelligence in organisations, managers should pay more attention to these factors to gain confidence in the effectiveness of the implementation of this system.

KEYWORDS High technologies, innovation management, technology intelligence, technology intelligence management, technology intelligence processes

1. INTRODUCTION

Due to the continuous increase of competition limits caused by globalisation and flourishing, dynamic markets, technology intelligence has become an important factor in strategic and business intelligence (Schuh et al. 2015). Therefore, technology forecasting and technology intelligence at the corporate level are becoming increasingly important to create a positive impact that complements interventions at the political level (Farrukh & Holgado 2020). The growth of competition in the business environment makes technology-based organisations more dependent on the constant flow of information from the organisation's environment. In order to gather information from all available information sources, ranging from the internet to multivariate and heterogeneous data from the company's internal databases and information, organisations need intelligent systems (Wu et al. 2018).

In technology-intensive sectors, technology intelligence activities should be aimed at collecting and providing relevant and timely information on technological information relevant to new or emerging technologies (Kerr & Phaal 2018). However, the gathered information is usually saved in organisational repositories and distributed database systems, but is not efficiently used.

Proper provision and use of the collected information requires systematic and innovative solutions that monitor technological changes, and in accordance with these changes, help the organisation's management to make intelligent decisions. Predicting trends and changes in technology development is an important quality necessary for survival and growth in today's competitive environment. One of the systematic solutions to monitor changes is to design and implement technology intelligence in an organisation. Organisations should pay special attention to the concept of technology intelligence and its applications, considering the technology-oriented nature and also the turbulent atmosphere of the competitive environment of today (Hataminejad et al. 2017).

Technology intelligence refers to an activity that supports decision-making at many levels (Loh & Mortara 2017). In other words, technology intelligence, with an impact on activities like strategic planning, use of resources, technology change management, absorption capacity, research and development, learning, construction and production, product and process development, marketing, and dynamic capabilities (identified as technological innovation capabilities), plays a key role in supporting decisions (Teza et al. 2016). Therefore, it can be said that supporting technological decisions has become possible through technology intelligence.

Research has been conducted in different industries to establish technological intelligence structures and processes in advanced countries and at transnational levels (Lichtenthaler 2003, 2004a & 2004b; Wu 2018; Thavorn 2020). However, despite the importance of technology intelligence systems in technological decision-making, a comprehensive model of technology intelligence in technology-oriented organisations has not yet been introduced. Therefore, the present study provides an opportunity to design and evaluate a model to create robust technology intelligence systems for technology decision-makers in the field of high technology at national level organisations.

The purpose of the present study is the conceptual design of an appropriate technology intelligence management model and the investigation of how to properly combine the main dimensions of technology intelligence (including technology intelligence processes management, technology intelligence missions and goals, technology intelligence coordination structures, technology intelligence tools and infrastructure of the organisation, and technology intelligence cycles) in the field of high technologies at national level organisations.

2. THEORETICAL FOUNDATIONS AND LITERATURE REVIEW

2.1 Technology intelligence definitions

From the perspective of different researchers, and in chronological order, different definitions of technological intelligence are examined and the definition employed in this research is presented thereafter.

Ashton (1997) identifies technology intelligence as sensitive business information about foreign or technological threats, opportunities, or scientific developments that have the potential to influence a company's competitive position. According to another definition, technological intelligence is a part of competitive intelligence that supports decision-making about scientific and strategic investments and helps decision-makers to calculate and evaluate the relative strategic ability of other organisations (Hohhoff 1997). According to Coburn (1999), technology intelligence is an analytical process that transforms competing distributed technology data into usable and relevant technological knowledge about competitors' positions, the extent of effort, and trends.

Lichtenthaler (2003) defines technology intelligence as one of the main tasks of technology management, which is independent of the implementation method. According to Lichtenthaler, the purpose of technology intelligence is to take advantage of the potential opportunities and to defend the organisation against potential threats by providing information related to technological trends in a competitive environment. In the study conducted by Taghva and Majidfar (2014), technology intelligence is defined as a group of activities related to supporting the decision-making concerning the general and strategic management of an organisation.

According to Nasullaev and Manzini (2020), technology intelligence is a strategic development process combined with creativity to improve performance by identifying potential options and new strategies, and reducing the likelihood of failure in the event of strategic discontinuities. Gonçalves and de Almeida (2019) consider technology intelligence to be one of the various methods of using competitive intelligence. According to these researchers, technology intelligence, like competitive intelligence, strives to find and process weak signals in order to identify opportunities and threats and provide practical information. In the study by Thavorn et al. (2020), technology intelligence is defined as a tool for predicting trends and adjusting the needs of future communities with knowledge and technology provision.

In the definitions provided by different researchers, two key concepts are common to most of them. The first is the use of technology intelligence as a decision-making support activity, and the second is its use in an organisation's strategic decision-making. The definition of technological intelligence considered standard in this research is the one provided by Savioz (2004). Savioz defines technology intelligence as decision-making support activities in general and technology management with recourse to providing timely information related to the facts and technological trends of the organisation's environment through collection, analysis, and dissemination.

Technology intelligence equips an organisation with the ability to store and present information to foster an awareness of the threats and opportunities of technology (Kerr et al. 2006). Moreover, technology intelligence offers mechanisms for benefiting from business and technology opportunities and getting prepared to confront threats through the effective presentation of information related to the organisation (Lichtenthaler 2003). Technology intelligence can guide research and development and offer the possibility for the timely utilisation of emerging technologies. The results gained from the implementation of technology intelligence can upgrade innovative and sustainable routes, increase competitiveness and bring social benefits (Thavorn et al. 2020). In addition, technology intelligence serves as an effective way of adopting a strategy to develop production and technology (Naruse & Kosaka 2011). Intelligence, in an important field like technology, can also improve the conditions of organisations in terms of technological innovation capabilities and competitiveness (Bonyadi Naeini et al. 2016).

2.2 Technology intelligence cycles

The effectiveness of technology management depends primarily on the quality of the technology intelligence process, i.e., the acquisition and evaluation of information about technological trends. Various cycles for technology intelligent processes have been presented, and here we follow the three cycles presented by Herring, Kerr, and Savioz.

The Herring Cycle (1997) consists of 5 steps: planning and direction, collection and reporting, processing and storage, analysis, and dissemination. In the first step, the key information needs of decision-makers, including strategic needs, early warnings, and key players, are identified. In the second step, the data is collected from a wide variety of sources using various techniques and tools. In this regard, the internet serves as a significant source for gathering the information needed for intelligence. The third step involves modifying and storing information using methods such as detection, language translation, data reduction, and text analysis in such a way that it is available to analysts. After preparing the information resources during the previous steps, in the fourth step the information is analyzed based on a systematic approach and in accordance with the information needs and the set goals of intelligence. Finally, in the fifth step, information and communication are disseminated by adopting a structured method.

The Kerr cycle (2006) consists of six phases: coordination, searching, filtering, analysis, documentation, and dissemination. The first phase of this model coordinates the technology intelligence efforts needed to fill specific technology know-how gaps after receiving input (needs or requests) from intelligence applicants. After the search phase and in the filter phase, the information is checked for relevance and, in case of irrelevance, is returned to the search phase. In the analysis phase, the information is interpreted, the report on its relevance is submitted to the specific context of the organisation, and intelligence requests are made. After completing the analysis, documentation is done. This includes creating the necessary reports, structuring the content of intelligence information, storing information, and managing knowledge within the organisational memory. Finally, the last phase is completed to inform intelligence customers of the new and updated intelligence.

Savioz's (2004) technology intelligence model is presented with a focus on knowledge creation. The main or direct activities of creating value in Savioz's model are characterised as being the same technology intelligence processes (i.e., formulation of needs and collection, analysis, distribution, and use of relevant information). Value manifests itself in the improvements made in decision-making, meaning that when the quality of information (in terms of content and timing) improves, uncertainty decreases (Savioz 2004). Indirect or supporting factors empower key activities (technology intelligence cycle). In a technology intelligence system, these supporting factors include general processes of technology intelligence management, technology intelligence goals and missions, technology intelligence structures, and technology intelligence tools.

2.3 Technology intelligence in practice

Technology intelligence goals and missions determine the goal and output of a technology intelligence system. The mission of technology intelligence must always be related to the mission and strategy of the business (Talaoui & Kohtamäki 2020). Lack of knowledge or incongruity in senior executives' and researchers' perceptions of the mission and goals of technology intelligence can lead to the failure of intelligence activities. Therefore, intelligence activities should always be founded on intelligence mission and goals, which are themselves related to the business mission and strategy.

Technology intelligence structures describe how intelligence activities are delegated to different units and individuals, and how they are organised. There are three general structures for coordinating technology intelligence activities: formal, project-oriented, and informal. In the formal structure, affairs are coordinated through a hierarchy of positions and divisions (Lichtenthler 2000, 2003 & 2004b). The project-oriented structure is used to coordinate intelligence activities in temporary projects (Abbass & Mehmood 2020). Finally, in the informal structure, intra-organisational communication intensifies freely. This structure is highly dependent on organisational culture and intra-organisational communication channels. The informal structure of technology intelligence seeks to direct spontaneous behaviours to collect information.

Technology intelligence tools can be classified into two categories: technology intelligence methods and technical infrastructure. The application of each method depends on various criteria, including strategy, environmental complexity and industry uncertainty, time, and complexity of the method itself. The most important methods of technology intelligence are process extrapolation, proprietary analysis, bibliographics, scenario building, cross-impact analysis, orientation, Delphi, relational trees (Lichtenthaler 2000), patent analysis (An et al. 2018), technology opportunity discovery (Yoon et al. 2015) and technology life cycle analysis (Greitemann et al. 2017). Another technology intelligence tool is the technical infrastructure which is crucial to the successful implementation of competitive information systems and facilitates the systematic collection and distribution of intelligence information. This tool is used in most stages of the intelligence process (collection, analysis, and distribution).

2.4 Managerial aspects of technology intelligence

Technology intelligence is one of the central processes in technology management because it examines and evaluates innovative trends. Four management factors, namely strategic management, knowledge management, innovation management, and technology management, form the basis of technology intelligence. Strategic management is the art and science of the formulation, implementation, and evaluation of multiple-task decisions that enable an organisation to achieve its strategic goals. According to Wheelen et al. (2018), strategic management is a set of managerial decisions and actions that determine the long-term performance of a company. In this research, strategic management includes four stages of environmental review: strategy formulation, implementation, control, and evaluation. The first stage, the environmental review, includes examining the external environment. This includes, for example, industry, the national environment, the transnational environment, and examining the internal environment of the organisation, which includes the structure, culture, and resources of the organisation. In the strategy formulation stage, the mission of the organisation is first formulated, and after determining the operational goals and aspirations, strategies are formulated. The last step in determining the strategies is to determine the policies of the organisation,since policies are the link between development and implementation. In the implementation phase, the organisation determines the plans, budgets, and procedures, and finally, it controls and evaluates these strategies.

Knowledge management is the systematic process of discovering, selecting, organising, summarising, and presenting information in a

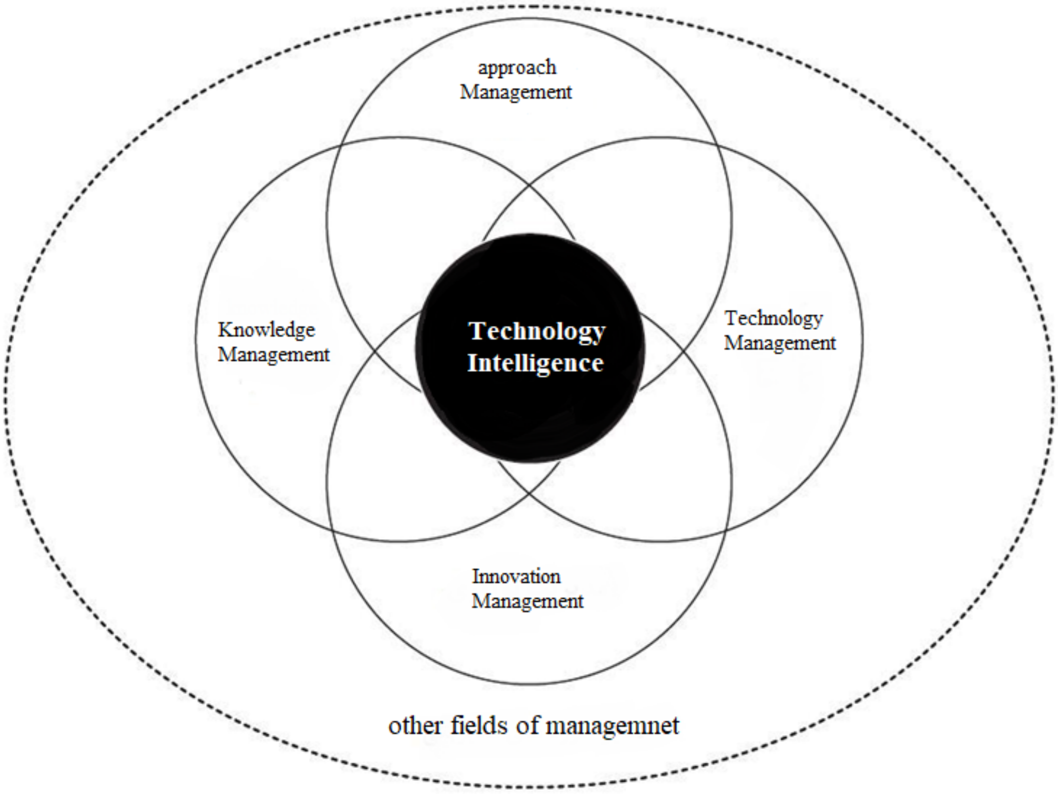

Figure 1 The position of technology intelligence among other areas of management (Savioz 2004).

way that improves people's knowledge in their area of interest. Knowledge management helps the organisation to gain knowledge and insight from its experiences and focus its activities on acquiring, storing, and using knowledge so that it can use this knowledge in problem-solving, dynamic training, strategic planning, and decision-making. Knowledge management not only prevents the deterioration of the organisation's intellectual assets, but also continuously adds to these assets. Knowledge management can also include all the methods through which an organisation manages its knowledge assets, including how to collect, store, transfer, apply, update, and create knowledge (Lubitz & Wickramasinghe 2007).

Innovation management contributes to the organisations' competitiveness, economic performance, and environmental sustainability (Chen et al. 2019). The research literature shows different perspectives on the circumstances and stages of the innovation process. What these views have in common is that at the beginning of the process, there is something similar to the idea, and at the end, a kind of realisation or commercialisation of the idea occurs. Technology intelligence is used in the early stages of this process because it can create an idea or act as an entryway to inspire it (Savioz 2004).

Technology intelligence processes are the basic actions for managing a system that designs, directs, and develops it. Design, here, means creating a theoretical model that represents what needs to be created in reality, and is a process that is predominately creative (Ulrich & Probst 1988). Directing is an online process that constantly guides the technology intelligence system to accomplish its goals and mission. Finally, system development involves conscious changes to cope with social and strategic changes. Figure 1 shows the position of technology intelligence among the aforementioned management factors.

2.5 Environmental factors affecting technological intelligence

Internal factors, external factors, and human resources are the three constructs that can be placed among the environmental conditions affecting technological intelligence. The reason for labeling these factors "environmental" is that they include internal and external environment factors of the organisation. These factors have a significant impact on technology intelligence management, as described below.

Nosella et al. (2008), in their research, point to four factors: an organisation's business model, type of industry, culture, and resources dedicated to research and development. In the study conducted by Peyrot et al. (2002), the amount of an organisation’s capital, the cost of the technology intelligence system from the perspective of managers, the ease of the use of the technology intelligence system from the perspective of managers and employees, and the applicability and necessity of the technology intelligence system from the perspective of managers and employees, are considered to be internal organisational factors. Tao and Prescott (2000) examined the size of the intelligence unit (the number of people working in the technology intelligence unit). Lichtenthaler (2004) also considers the innovation-based organisational culture as an internal organisational factor. In addition to these factors, two other factors, the organisation's emphasis on technological leadership and the marketing of existing goods and services, were added according to research experts.

External organisational factors were also extracted from previous research and are as follows: use of open innovations in organisations (Veugelers et al. 2010), formation of social networks within the organisations in order to support technology intelligence activities, and formation of social networks outside the organisations, e.g. specialist networks (Mortara 2009), paying attention to the results of technology foresight at national level, and paying attention to specific policies in various fields of science and technology at the national level on the part of organisation managers (Calof & Smith 2010). Government support for creating technology intelligence processes in the organisations was also added, following expert consultation.

Researchers have identified different roles for individuals in a technology intelligence system (Savioz 2004). Individuals can initiate various activities, including gathering, analysis, evaluation, and spread of information in the organisation (Safdari Ranjbar et al. 2017). Such roles require different skills. Typically, in large companies, each role is fulfilled by one or more individuals. However, it is difficult to find individuals who have all the necessary skills. Various studies have been conducted on the importance of human resources and the actors in the technology intelligence system. Various topics, including observers, users, and mediators of technology intelligence, technology ambassadors, listening posts, external experts, and technology intelligence specialists, have been studied.

Table1 Examples of technology intelligence implementation in Iran and in the world.

Implementation Example	**Author(s) and Year of Publication**	**Derived Benefit or the Result**
Fuel cell technology	Karshenas & Malaek 2013	Designing a technology-intelligent system at the national level and identifying functions affecting its sustainability
Fifty-five companies active in the pharmaceutical industry	Bonyadi Naieni et al. 2016	Increasing technological innovation capabilities and competitiveness
Pharmaceutical companies present at the Iran Pharma exhibition	Amini 2017	Upgrading competitive advantage
Companies operating in Pardis technology park	Samadi et al. 2018	Increasing the level of strategic innovation
Research institute of Petroleum industry	Khodayari et al. 2020	Monitoring technology changes
Mapna Tose'e 1Power Plant Construction and Development Company	Khamse et al. 2019	Reinforcing technology intelligence in power plant industries and other companies of the Mapna Group
United States Patent and Trademark Office Database	Yoon et al. 2015	Building a performance-based knowledge base for technology intelligence, including information about products and technologies and the relationship between them
Oil Turbo Compressor Company	Ranjbar & Cho 2016	Implementing technology intelligence in designing and building a gas turbine production system
Cambridge University Technology Management Center	Loh & Mortara 2017	Designing a performance measurement framework for technology intelligence that helps structure future measurements and evaluate strategies
Petrochemical industry	Gonçalves & de Almeida 2019	Increasing organisations’ willingness to carry out complex projects with outsourcing because there was no need for deep work

Table 2 The relationships among research variables proposed by this research (abbreviated as proposed) and other sources in the scientific literature. H = Hypothesis. Op. = operational; Man. = Managerial; Env. = Environmental.

Source of scientific literature	Dependent Variable	Independent Variable	H	Level
Lang 1998; Kerr 2018; Majidfar 2013	Technology intelligence cycles	Mission and goals of technology intelligence	H1	Op.
Lichtenthaler 2007; Majidfar 2013	Technology intelligence cycles	Coordination structures of technology intelligence activities	H2	
Savioz 2004	Technology intelligence cycles	Technology intelligence infrastructure and tools	H3	
Proposed	Technology Intelligence infrastructure and tools	Mission and goals of technology intelligence	H4	
Savioz 2004	Coordination structures of technology intelligence activities	Mission and goals of technology intelligence	H5	
McDonald & Richardson 1997	Mission and goals of technology intelligence	Technology intelligence process management	H6	Man.
Savioz 2004	Technology intelligence infrastructure and tools	Technology intelligence process management	H7	
Lichtenthaler 2007	Coordination structures of technology intelligence activities	Technology intelligence process management	H8	
Savioz 2004	Technology intelligence process management	Knowledge management of the organisation	H9	
Proposed	Mission and goals of technology intelligence	Knowledge management of the organisation	H10	
Yoon 2015	Technology intelligence cycles	Knowledge management of the organisation	H11	
Proposed	Technology intelligence process management	Strategic management of the organisation	H12	
Jennings & Lumpkin 1992	Mission and goals of technology intelligence	Strategic management of the organisation	H13	
Proposed	Technology intelligence cycles	Strategic management of the organisation	H14	
Savioz 2004	Technology intelligence process management	Innovation management of the organisation	H15	
Proposed	Mission and goals of technology intelligence	Innovation Management of the organisation	H16	
Proposed	Technology intelligence cycles	Innovation Management of the organisation	H17	
Lichtenthaler 2004a, 2004b	Technology intelligence process management	Intra-organisational factors	H18	Env.
Veugelers et al. 2010	Technology intelligence process management	Extra-organisational factors	H19	
Tao 2000; Majidfar 2013	Technology intelligence process management	Technology intelligence human resources	H20	
Proposed	Mission and goals of technology intelligence	Intra-organisational factors	H21	
Proposed	Mission and goals of technology intelligence	Extra-organisational factors	H22	
Krystek,1993; Majidfar 2013	Mission and goals of technology intelligence	Technology intelligence human resources	H23	
Lichtenthaler 2004	Technology intelligence cycles	Intra-organisational factors	H24	
Veugelers et al. 2010	Technology intelligence cycles	Extra-organisational factors	H25	
Lichtenthaler 2000	Technology Intelligence Cycles	Technology intelligence human resources	H26	

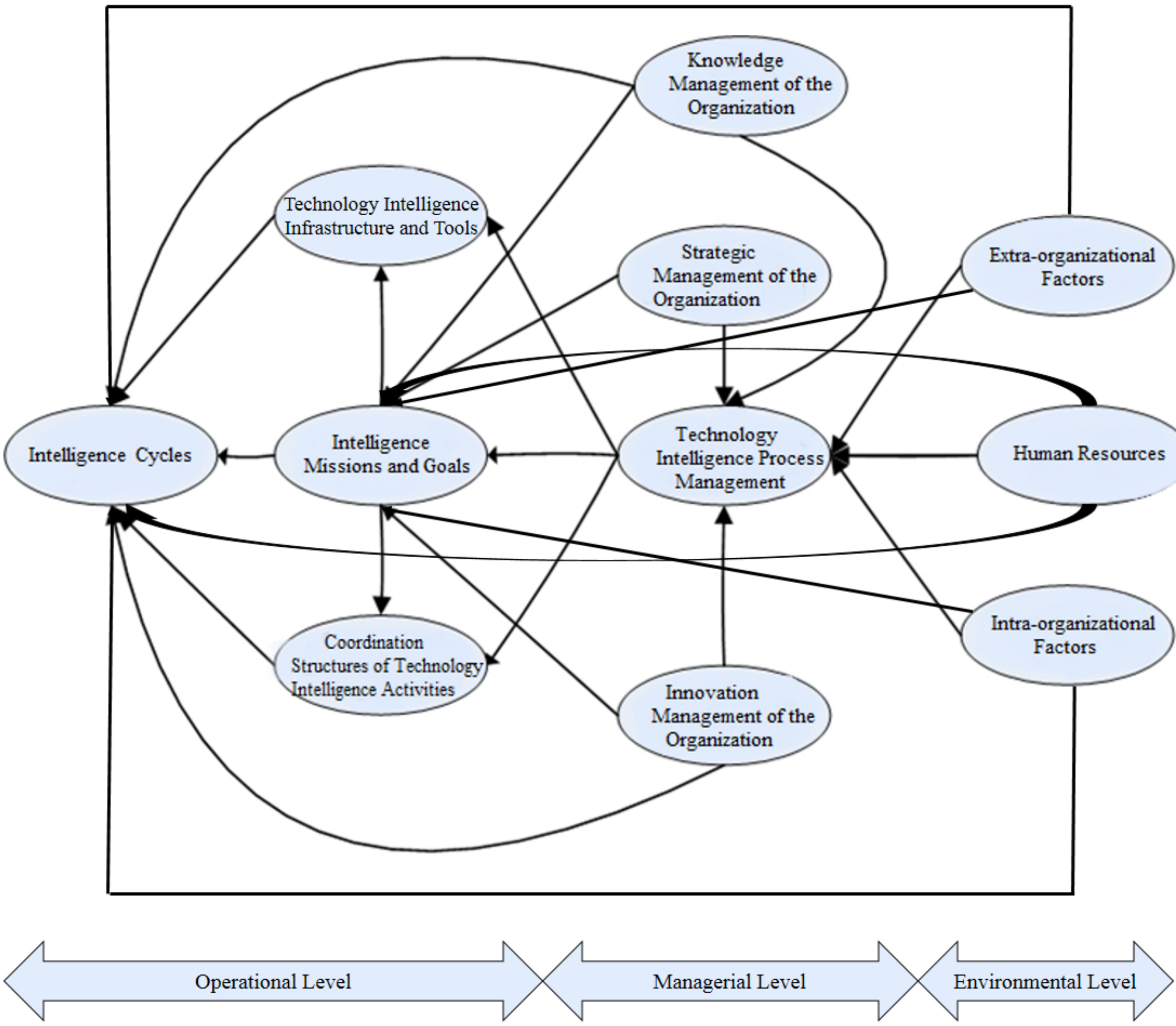

Figure 2 Conceptual model of the research.

2.6 Research literature

Over the past few years, several businesses have been established in Iran and throughout the world that provide technology intelligence services. For an organisation or industry to be able to use technology intelligence, certain conditions are required: 1) the organisation operates within the environment of dynamic technological industries, a place where the rate of change is high, and the possibility for the latest technologies to get introduced is strong; 2) the organisation owns highly technological products, in a place where technology is a distinctive factor, introduction rate is high, and timing to enter the market is of importance; 3) a large portion of the organisation's activities are dedicated to research and development; and 4) the organisation expects a great deal of its business revenue growth to come from new products (Karshenas & Malaek 2013).

In general, it can be said that the implementation of technology intelligence often increases the level of innovation and competitiveness of businesses and industries. However, many of these businesses failed to sell their services and gain profit from them (Sadraie 2009). Establishing a technology intelligence system can vary depending on the technological needs and trends of each country. Therefore, a comprehensive study of these environmental conditions and technological trends can play a central role in preventing the failure of these businesses. Table 1 shows some examples of technology intelligence implementation at national and international levels.

2.7 Hypotheses and conceptual framework

According to previous studies, in order to properly manage technology intelligence systems in the field of high technologies at national level organisations in the desired situation, the main variables of technology intelligence can be classified into three levels or layers. These are the operational level (including four dependent variables: technology intelligence tools and infrastructure, structures coordinating technology intelligence activities, mission and goals of intelligence, and finally, technology intelligence cycles), the managerial level (including three independent variables: strategic management of the organisation, knowledge management of the organisation, and innovation management of the organisation, and a dependent variable: technology intelligence system management), and the environmental level (including three dependent variables: extra-organisational factors, intra-organisational factors, and human resources). Table 2 shows the relationships among these variables proposed in this study and by other sources in the scientific literature, and Figure 2 shows the proposed conceptual model with respect to the relationships among these variables.

3. METHODOLOGY

The present study presents applied research in terms of its purpose and cross-sectional research in terms of time. The approach in this study is the use of a quantitative method along with the data collected through a questionnaire, in the form of survey research. The statistical population of this study included 160 Iranian experts, to whom questionnaires were sent electronically. Of these, 137 responses were received. Given this, it can be said that the study had an acceptable response rate.

Following the use of the structural equation modeling (SEM) method to analyze the results, the appropriate sample size can be obtained based on the number of relationships between variables in the model. To validate the structural equation analysis for each relation in the model, between five and ten samples must be collected (Hooman 2009; Qasemi 2009). In this study, there were 20 relationships between variables in the model, meaning that at least 100 questionnaires were needed.

The questionnaire contained 74 questions. For each question, a five-point Likert scale was used, the answer options of which were as follows: very high frequency, high frequency, moderate frequency, low frequency, and very low frequency. When the purpose is exploring the attitudes of the participants in research, a Likert scale functions well (Nardi 2003; Rea & Parker 2005). The questionnaire included 11 sets of questions categorised based on the intended components of the research. A summary of the demographic information of the participants in this study is available in Table 3.

The data obtained from the questionnaire were analyzed using inferential statistics and through structural equation modeling (analysis of covariance structure) and with the help of SPSS and LISREL software. Structural equation modeling is a very general and powerful multivariate analysis technique in the multivariate regression family that can test a set of regression equations simultaneously. This method is a comprehensive approach that uses confirmatory factor analysis and econometric models to analyze the hypothetical relationships between latent variables (invisible or theoretical) measured by explicit variables (observable or experimental). Structural equation modeling is sometimes called structural analysis, causal modeling, and sometimes LISREL (Hooman 2009).

Table3 Frequency and percentage of the study participant demographics and general information.

Demographic or General Information	Group	Frequency	Frequency (Percentage)
Education	Ph.D.	24	17.5
	Ph.D. Candidate	22	16.1
	Master's Degree	78	56.9
	Bachelor's Degree	13	9.5
Position	Top-level manager	4	4.4
	Middle-level manager	16	11.7
	Researcher or Faculty member	43	31.4
	Expert or Consultant	72	52.6
Organisation Type	Industries and companies	36	26.3
	Research and academic centers	45	32.8
	Mediating and supporting organisations or institutions	56	40.9

Table4 Factor loading and reliability coefficients of the research variables.

Construct	Questions	Cronbach's Alpha	Result
Technology intelligence process management	1-9	0.754	Acceptable
Technology intelligence tools and infrastructure of the organisation	10-12	0.709	Acceptable
Intra-organisational factors related to technology intelligence	13-24	0.695	Relatively acceptable
Coordination structures of technology intelligence activities	25-27	0.721	Acceptable
Technology intelligence human resources	28-33	0.745	Acceptable
Technology intelligence mission and goals	34-37	0.727	Acceptable
Strategic management of the organisation	38-48	0826	Acceptable
Environmental factors of the organisation	49-54	0.684	Relatively acceptable
Technology intelligence cycles	55-60	0.794	Acceptable
Knowledge management of the organisation	61-67	0.797	Acceptable
Innovation management of the organisation	68-74	0.779	Acceptable

The constructs explored in this study, including technology intelligence cycles, technology intelligence tools and infrastructure of the organisation, technology intelligence coordination structures of activities, technology intelligence mission and goals, technology intelligence process management, knowledge management of the organisation, innovation management of the organisation strategic management of the organisation, human resources, intra-organisational factors, and extra-organisational factors, were analyzed in separate measurement models. To validate each of these measurement models, questions with a factor loading of less than 0.5 had to be eliminated. However, none of the research questions had such conditions. Therefore, all questions remained for analysis.

3.1 Reliability assessment

When Likert scale questions are employed in questionnaires, Cronbach's alpha is suitable to determine reliability (Gay et al. 2009; Trochim & Donnelly 2008). Therefore, the reliability of the variables in this study was assessed using Cronbach's alpha. As shown in Table 4, the calculated Cronbach's alphas for all constructs, except the two constructs: internal factors and environmental factors of the organisation, were higher than 0.7. This indicates a high reliability of the research tool. These two constructs also have a relatively acceptable reliability because they are close to 0.7. Moreover, Cronbach's alpha calculated for the whole questionnaire is 0.876, which indicates a very high reliability for the research tool.

3.2 Validity assessment

In order to assess the validity of the research, content validity and face validity methods were used. Face validity is a part of content validity (Danaiefard et al. 2004). Content validity refers to the extent to which a construct contains enough relevant information (Ghauri, Gronhaug & Strange 2020). In the present study, two methods were used to prove the validity. The first method referred to expert agreement in the field. In this study, the opinions of university professors and industry experts were used. The second method is to use standard scholarly questionnaires in relevant articles and books. It is also worth mentioning that the entire factor loading of the questions in each construct was more than 0.5, hence approving the convergent validity (Table 2).

4. RESEARCH FINDINGS

After collecting and analyzing the data and considering the distinct effect of the variables in each of the three layers, the structural equation model was used to test the research hypotheses in each layer separately. Hypotheses could be analyzed at the operational level (H1-H5) and managerial level of the model in four categories: i.e., technology intelligence management (H6-H8), technological knowledge management of the organisation (H9-H11), strategic management of the organisation (H12-H14), and innovation

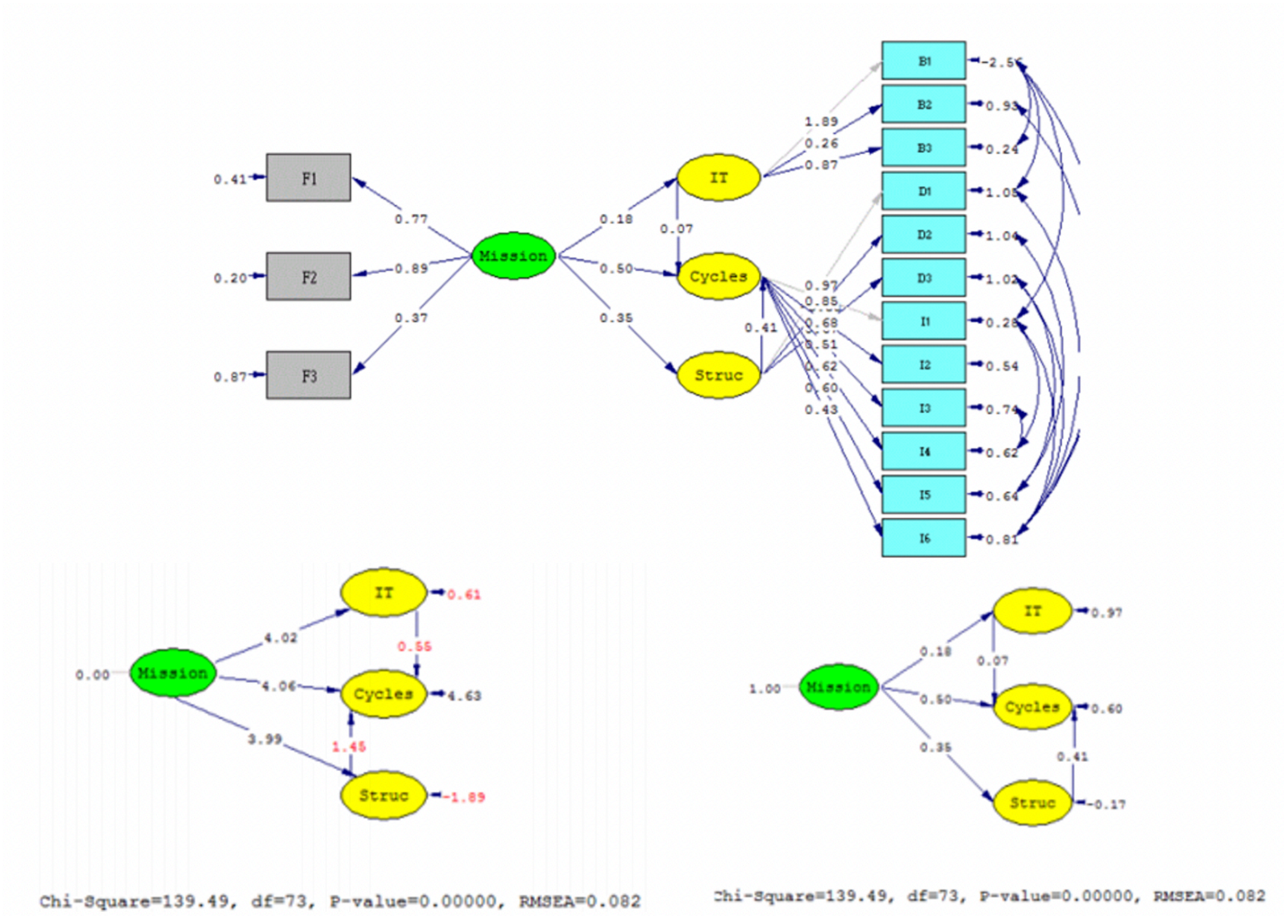

Figure 3 Structural equation model for hypotheses related to the operational level.

management of the organisation (H15-H17), and sub-hypotheses of the environmental level of the model in three categories: i.e., the effects of intra-organisational factors, extra-organisational factors, and human resources on the management of technology intelligence processes (H18- H20), goals and mission of technology intelligence (H21- H23), and technology intelligence cycles of the organisation (H24- H26). The research hypotheses were separately examined at all three levels and the results were presented in standard estimation mode.

The structural equation modeling developed for H1-H5 is observable in standard and meaningful modes in Figure 3. As demonstrated in Figure 3, only the relation of constructs pertaining to H1, H4, and H5 were significant and these hypotheses were confirmed. Moreover, the relationship between constructs related to H2 and H3 was not meaningful. Therefore, these hypotheses were rejected.

After examining the operational level, the hypotheses related to the managerial level were assessed according to the same four categories. As can be seen in Figure 4, in the technology intelligence process management category, the relationship between constructs pertaining to H6, H7, and H8 were significant and these hypotheses were confirmed. Fit indices indicate the proper fit of the model.

As shown in Figure 5, in the category of technology intelligence knowledge management, the relationships among constructs pertaining to hypotheses H9, H10, and H11 were meaningful and these hypotheses were confirmed based on the initial structural equation model.

As shown in Figure 6, in the technology intelligence strategic management category, only the relationship of constructs pertaining to H12 and H13 was meaningful and these hypotheses were confirmed based on the initial conceptual model. The relationship between constructs related to hypothesis H14 was not meaningful. Therefore, this hypothesis was rejected.

According to Figure 7, in the technological innovation management category, only the relationships of constructs pertaining to hypotheses H15 and H17 were meaningful and these hypotheses were confirmed based on the initial structural equation model. Moreover, the relationships between the constructs

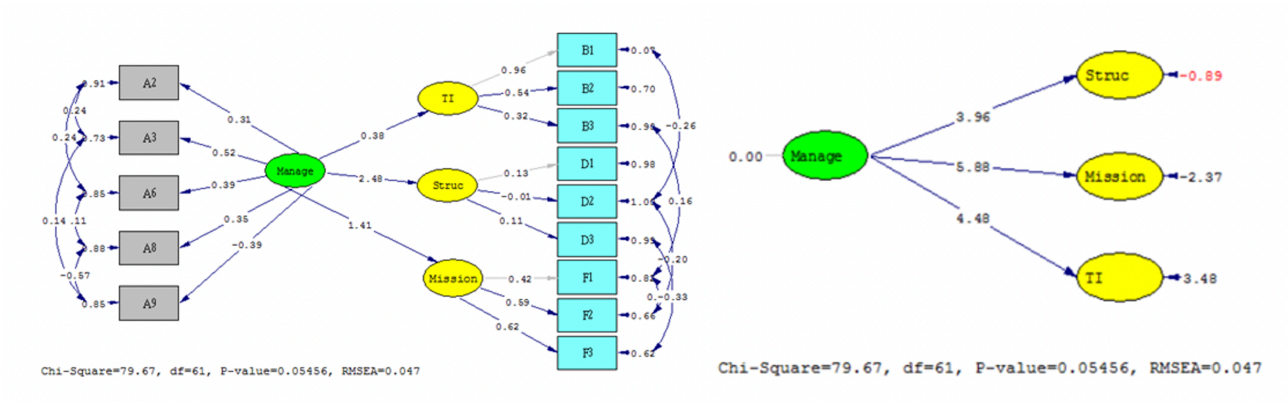

Figure 4 Structural equation model for hypotheses related to the category of technology intelligence process management.

related to H16 weren't significant and, as a result, this hypothesis was rejected.

Finally, the hypotheses related to the environmental level (including the three structures of intra-organisational, extra-organisational, and human resources) and their impacts on the three categories of technology intelligence processes management, technology intelligence mission and goals, and technology intelligence cycles were examined. As demonstrated in Figure 8, based on the initial structural equation model, H18, H19, and H20 (of technology intelligence processes management) were rejected.

As shown in Figure 9, based on the initial structural equation model and in meaningful mode, H21 and H22 were rejected, but H23 was confirmed.

Similarly, it can be observed in Figure 10 that, based on the initial structural equation model and in meaningful mode, H24 and H26 were rejected, but H25 was confirmed. In addition, a summary of research findings related to the research hypotheses is given in Table 5.

According to the results in Table 5, the study's hypotheses were statistically significant and all but 11 hypotheses were confirmed. Following this, the fitness of the research model was evaluated. The purpose of evaluating the fitness of the model was to determine whether or not the theoretical relationships between the variables, considered by the researchers when formulating the theoretical framework, were confirmed by the data gathered from the research. In other words, this test determines the degree to which the model conformed to the empirical data.

In the estimation process in the LISREL software, a matrix called "implicit covariance matrix" (an estimated covariance matrix of the statistical population) is obtained. The model has a better fit, to the extent that this matrix gets closer to the covariance matrix of the sample population. Values obtained from the set of fit indices revealed that the research model had a good and appropriate fit, and the results of the fit indices indicated the fit of the conceptual research model. Consequently, there was no need to adjust the adequacy of the model fit.

Finally, according to the rejected and confirmed hypotheses based on a survey carried out on experts, the final model was developed, as presented in Figure 11.

The values of t in Table 5 show that all the conceptual components of the corrected final model are significant. The values of λ also show the importance of each relationship in the model, which can be used as a guide for future applied research or in practice.

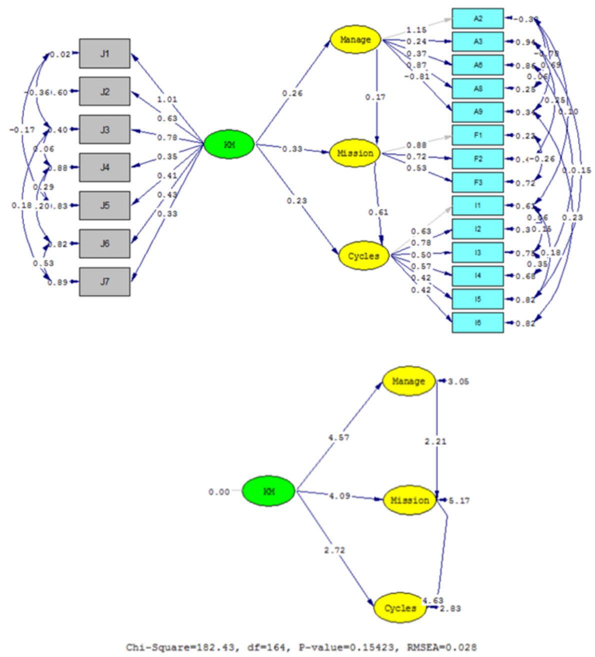

Figure 5 Structural equation modeling for hypotheses related to the technological knowledge management of the organisation category.

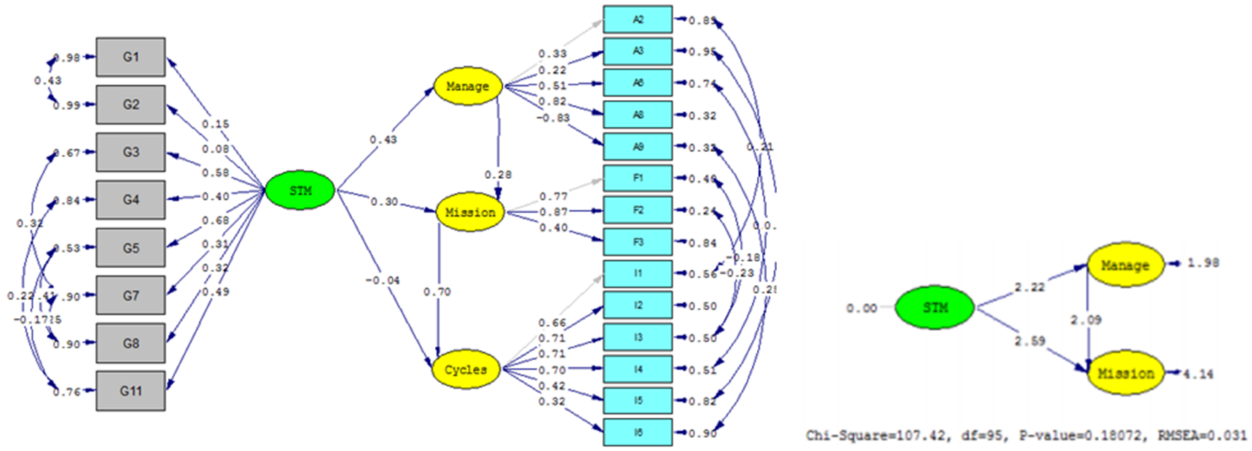

Figure 6 Structural equation modeling for hypotheses related to the organisational strategic management category.

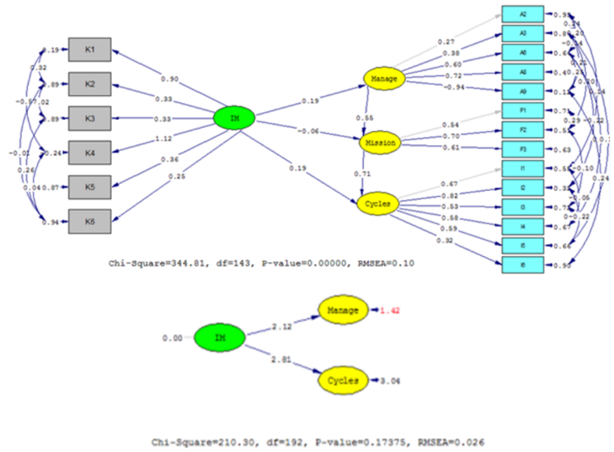

Figure 7 Structural equation modeling for hypotheses related to the organisational innovation management category.

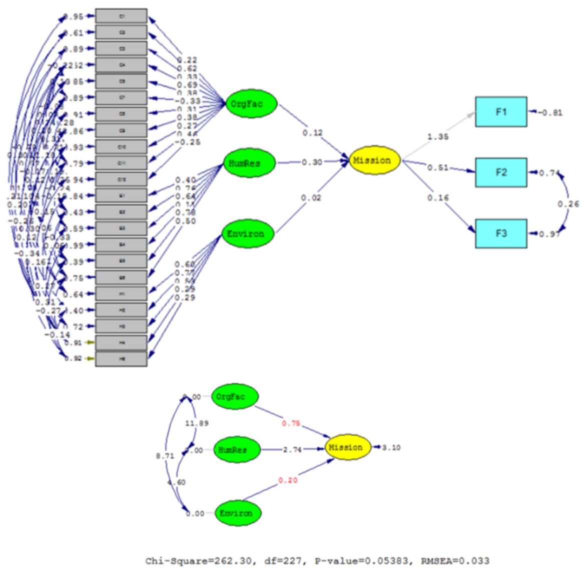

Figure 9 Structural equation modeling for hypotheses related to the impact of the environmental level of the conceptual model on technology intelligence goals and missions.

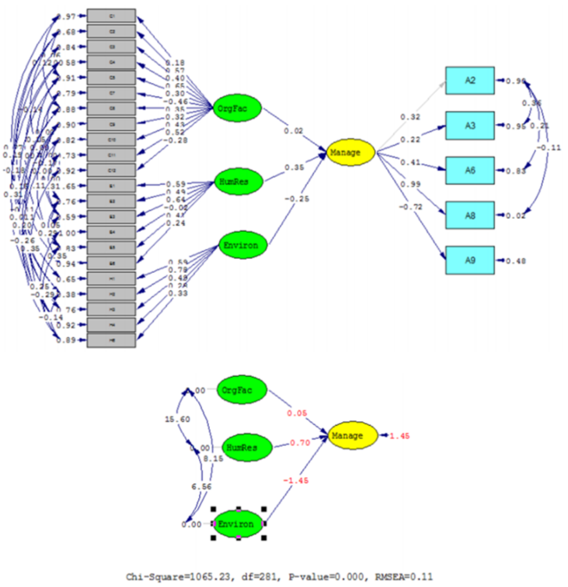

Figure 8 Structural equation modeling for hypotheses related to the impact of the environmental level of the conceptual model on technology intelligent process management.

5. DISCUSSION AND CONCLUSION

In this research, based on the theoretical structure of the primary constructs, the measurement model was the reflective type and the primary constructs defined the indices. As a result, structural equation modeling was used to analyze the general model and the research hypotheses. In the factor analysis of the model, a confirmatory factor analysis was first used to evaluate the construct validity of the research tools and the fit of the measurement model. The confirmatory factor analysis indicated that the proposed factor models are suitable according to the measurement model in standard estimation mode and significance mode, as well as fit indices.

Structural equation modeling was then used to measure the relationships between the

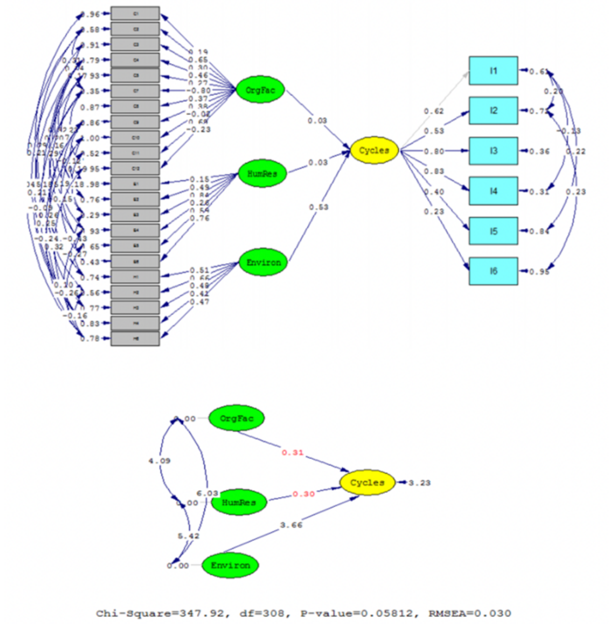

Figure 10 Structural equation modeling for hypotheses related to the impact of the environmental level of the conceptual model on cycles.

hidden variables. In this model, based on the data, the relationships between the components of the conceptual model were investigated by calculating the path coefficients and the values of factor loading in three layers in the form of research hypotheses. To investigate the research hypotheses, eight structural equation models were formed and the impacts of the variables on each other were analyzed. Accordingly, the relationships between some of the research variables were not confirmed and fifteen hypotheses out of the twenty-six hypotheses were confirmed.

According to the results obtained from research hypotheses testing, it appeared that the mission and goals of technology intelligence have a positive effect on technology intelligence cycles, technology intelligence infrastructure of the organisation, technology intelligence tools, and coordination structures of technology intelligence activities.

Table 5 Factor loading and t-statistics.

Level	Hypotheses	Factor loading	T-statistics	Status
Operational	H1	0.67	6.99	confirmed
	H2	-	-	rejected
	H3	-	-	rejected
	H4	0.22	4.24	confirmed
	H5	0.33	3.78	confirmed
Managerial	H6	1.41	5.88	confirmed
	H7	0.38	4.48	confirmed
	H8	2.48	3.96	confirmed
	H9	0.26	4.57	confirmed
	H10	0.33	4.09	confirmed
	H11	0.23	2.72	confirmed
	H12	0.38	2.22	confirmed
	H13	0.30	2.69	confirmed
	H14	-	-	rejected
	H15	0.31	2.12	confirmed
	H16	-	-	rejected
	H17	0.31	2.01	confirmed
Environmental	H18	-	-	rejected
	H19	-	-	rejected
	H20	-	-	rejected
	H21	-	-	rejected
	H22	-	-	rejected
	H23	0.30	2.74	confirmed
	H24	-	-	rejected
	H25	0.53	3.66	confirmed
	H26	-	-	rejected

Therefore, the first, fourth, and fifth hypotheses of the study were confirmed. In this regard, it can be claimed that technology intelligence missions and goals play a central role at the operational level. The deeper the insight into the goals and missions of technology intelligence reveals itself in the members of organisations, especially managers, the faster and more effective cycles of technology intelligence, and effective design

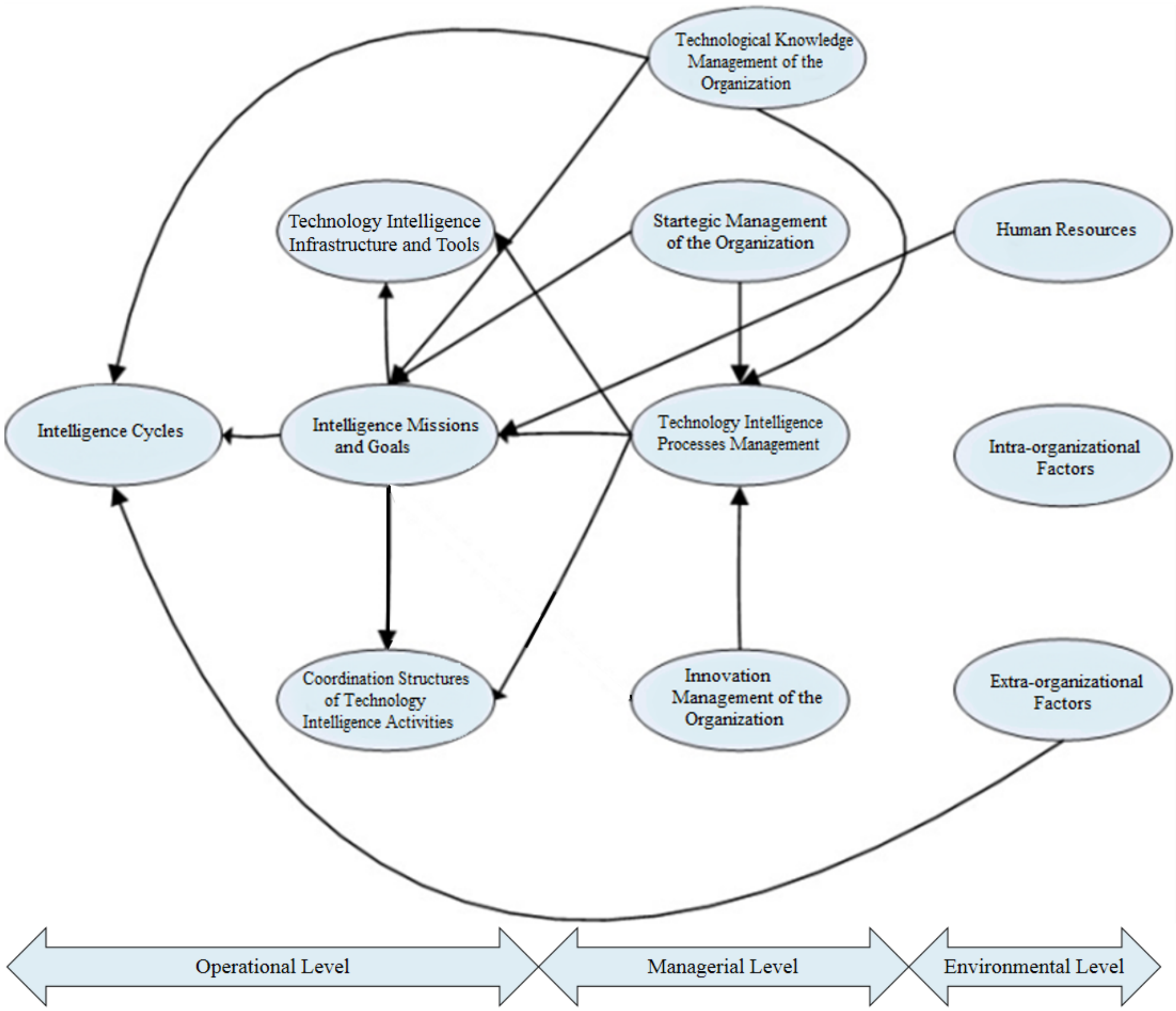

Figure 11 The appropriate model of intelligence management of high technologies in organisations at a national level (based on the confirmed hypotheses).

and selection of the type of technology intelligence coordination structure, would be. This insight can also facilitate the provision of appropriate technology intelligence infrastructure and technology intelligence tools for organisations.

In addition, the results showed that the strategic management of the organisation does not have a direct impact on technology intelligence cycles. This leads to the rejection of the fourteenth hypothesis of the research. Also, innovation management of the organisation does not affect the goals and missions of technology intelligence, so the sixteenth hypothesis was rejected as well. In general, technology intelligence process management and knowledge management, considering the confirmation of all relevant hypotheses, play a more important role than strategic management and innovation management at the managerial level. They have a direct and more significant impact on missions and goals, coordination structures, tools and infrastructure, and the technology intelligence cycle.

At the environmental level, these three factors (intra-organisational, extra-organisational, and human resources) had no impact on the technology intelligence process management. Therefore, the eighteenth, nineteenth and twentieth hypotheses were rejected. Furthermore, except for human resources, these factors did not affect the mission and goals of technology intelligence. Given the positive impact of human resources on the mission and goals of technology intelligence, the acceptance of technology intelligence as a decision-making approach by people in organisations can help to better understand the mission and goals of technology intelligence. This acceptance primarily depends on the culture dominating the organisation and the support of senior management.

Considering the rejection of the twenty-fifth hypothesis, the only factors influencing the cycles of technology intelligence at the environmental level are the external factors such as the use of open innovations and the formation of social networks. Intra-organisational factors and human resources have little impact on this construct. Therefore, focusing on external factors can facilitate technological intelligence cycles in the organisation.

In summary, the research findings show that most of the confirmed hypotheses are related first to the management level of the model (10 confirmed hypotheses out of 12 hypotheses) and then to the operational level of the model (3 out of 5 hypotheses). The lowest number of confirmed hypotheses is related to the environmental level (2 out of 9 hypotheses).

Although these findings generally support the initial conceptual model, several outcomes were relatively unpredictable. Some results need to be understood by further research. Thus, in general, these results support the conceptual model at operational and managerial levels. This indicates that in the opinion of experts, for proper management of a technology intelligence system in high technologies at national level organisations, it is more important to pay attention to managerial and operational levels. At these levels, three variables have the most impact on the other variables and play a key role in this model: technology intelligence missions and goals, process management, and technological knowledge management of the organisation.

The practical conclusions of this research are the following:

Due to the complexity of the relationships of variables in a technology intelligence system, designing an evolutionary process for the establishment of technology intelligence in organisations that are not officially and perfectly familiar with technology intelligence and its formal processes and structures is recommended.

Operational and managerial levels are the most critical components of a technology intelligence system. Hence, teaching the concepts and methods of technology intelligence by experts to the managers and employees of the organisation who are setting up the technology intelligence system is a necessity.

Since technology intelligence missions and goals, and process management have the most impact on the model, need analysis of the information required by managers and experts in the field of high technologies to plan the future technology intelligence system is critical.

Strengthening the organisation's IT infrastructure, including internal network, internet, hardware, and software requirements of technology intelligence, is also recommended.

The managerial level has the most confirmed hypotheses in the model. Therefore, the integration of knowledge management, innovation management, strategic management systems, and technology intelligence systems of organisations will improve and make this system more efficient.

Additionally, in future research, appropriate models for the specific applications of technology intelligence could be investigated in the form of case studies in other organisations and industries, such as biotechnology or nanotechnology. It is also possible to study the impact of variables like organisational culture and organisational environment on the interactions in technology intelligence activities. Technology intelligence is not limited to large companies; nevertheless, due to financial, technical, skill-related, and time limitations, the majority of small and medium-sized companies are neglected. Consequently, scholars could analyze models for technology intelligence processes in small and medium-sized organisations as well.

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