The impact of information technology and communication systems on the agility of supply chain management systems

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Abstract

Purpose – The impact of information technology (IT) on the agility of supply chain management (SCM) systems is very noticeable in the business world nowadays. Competition and constant changes, including product/technological innovations, decreasing product lifestyles and product proliferation, create pressure that affects the business environment. Organizations are required for answering the changes in the market to gain a competitive advantage and business success. The organizations are able to answer to unexpected market changes through supply chain market, and these changes are converted to business opportunities. Using IT to achieve the agility of SCM is one of the important factors to help the organizations. Therefore, the adoption of IT and its efficient implementation can improve the cooperation between supply chain agility through the rapid transfer, the distribution of accurate information and the use of information. This paper aims to investigate the impact of IT on the agility of SCM.

Design/methodology/approach – A total of 120 employees of the Golasal firm are involved in collecting data using a questionnaire. Measurements were performed in all questionnaires using a five-point Likert scale. The causal model is evaluated by structural equationmodeling technique, which is used to examine the reliability and validity of the model.

Findings – The results have shown that IT has positive influences on the agility of SCM systems. In addition, the obtained results have shown that four variables, namely, IT skills and knowledge, IT-based systems integration, IT infrastructure and design of global position system and geographic information systems, affect the agility of SCM systems.

Originality/value – In this paper, the agility of SCM systems is pointed out and the approach to resolve the problem is applied into a practical example. The presented model provides a complete framework to examine the impact of IT on the agility of SCM systems.

Keywords Information systems, Agility, Supply chain management

Paper type Research paper

1. Introduction

Information technology (IT) in many organizations supports the sustainability and growth of their businesses (Van Grembergen and De Haes, 2017). IT is the basis for organizations to improve the process of supply chain management (SCM) systems. Previous studies have shown that the investment in IT guarantees organizational performance (Tarafdar and Qrunfleh, 2016). IT in an organization can be available to its employees, often contained in the organization's mission and vision, business objectives, operating procedures and so on

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(Dewett and Jones, 2001). The technology element in information systems is called IT. It refers to a set of the computing systems in an organization (Soltani and Navimipour, 2016). The organizations can search new modes of structuring their workforce using IT (Nohria and Berkley, 1994).

On the other hand, the concept of SCM that has been introduced by Oliver and Webber (1982) is accepted in the industrial and academic press. Then, it is time to introduce many definitions of the SCM. Stevens (1989) has proposed an idea of moving from internal to external optimization. Orienting toward customer satisfaction was proposed by Cooper *et al.* (1997). The flows of product, services, finances and information and stressing the importance of relationships and networks are in the center of Harland's (1996) attention. Separating SCM from logistics and providing different perspectives on SCM vs logistics were presented by Cooper *et al.* (1997) and Larson *et al.* (2007) and Stentoft *et al.* (2016), respectively. The uncertainty of the marketplace is due to the global orientation and increased performance-based competition. The rapid change intechnology and economic conditions affect the uncertainty of the marketplace (Mentzer *et al.*, 2001; Swanson *et al.*, 2018).

Venkatraman (1990) has proposed agility as customer responsiveness and mastering market turbulence. Yusuf *et al.* (1999) have believed agility functions as one of the main factors for improving competitiveness. In Lee (2004), agility was considered as one of the most salient issues of contemporary SCM. Swafford *et al.* (2006) have believed that organizations are able to react quickly and more effectively to marketplace volatility and other uncertainties through the supply chain agility. A focal firm requires supply chain agility to produce products according to the variable needs of customers. The companies respond quickly to volatile demand and short product life-cycles through supply chain agility (Museli and Jafari Navimipour, 2018). Using supply chain agility is required to produce new products according to the needs of customers (Tarafdar and Qrunfleh, 2016). Supply chain agility is used by companies to attain competitive advantage (Wu *et al.*, 2016).

In practice, it is very difficult to manage the combination of multiple organizations. A number of tools are provided by IT to facilitate, streamline and increase the reliability of communications. The information between organizations is exchanged through IT (de Barros *et al.*, 2015). The performance of the supply chain is improved by adopting IT. Organizations in a supply chain often adopt IT because of the institutional pressure exerted by their supply chain partners (Lai *et al.*, 2006; Martinez-Sanchez and Lahoz-Leo, 2018). Proposing a model to study the impact of IT on the agility of SCM systems is the main aim of this paper. In this regard, the employees of the Golasal firm of East Azerbaijan in Iran have been studied. The main goals of the paper are:

- investigating the effect of IT and knowledge skills on the agility of SCM;
- investigating the impact of IT infrastructure on the agility of SCM;
- investigating the impact of geographic information systems (GISs) and global positioning system (GPS) on the agility of SCM; and
- investigating the impact of IT-based integration on the agility of SCM.

The following classification shows the contents of this paper. The related literature is reviewed in Section 2. The research methodology by describing the data collection, presenting the research model and defining the measurement of variables is discussed in Section 3. Sections 4 and 5 include the analysis of results, conclusions, limitations and the suggestions for future research.

2. Literature review

Companies have reacted to the apparent opportunities and threats of globalization through various production practices that have increased the agility of SCM systems. One of these methods was the use of information technology to increase the agility of supply chain management systems. The agility of SCM systems is aimed at boosting supply chains and achieving superior performance (Wiengarten *et al.*, 2016). Organizations always have some problems such as unpredictable demand, uncertainty in supply, nonexistent and/or damaged infrastructure, inadequate logistics resources and insufficient information. The organizations adopt their operations to the requirements of the environment to answer to this uncertainty and/or changing situations. The ability of agility to develop and maintain operational responsiveness and flexibility has been proposed by L'Hermitte *et al.* (2016). It manages sudden and short-term logistics, risks and uncertainties. Organizations can survive a turbulent and volatile environment using agility. IT in the supply chain performs better than focal firm and the partners by providing timely, accurate and reliable information (Jin, 2006). It has an important role in improving SCM (Li *et al.*, 2009). IT has an advantage for producers to improve supply chain agility, reduce cycle time, achieve higher efficiency and deliver products to customers in a timely manner (Radjou, 2003).

Lambert and Cooper (2000) have examined the important issues in the SCM. The supply chain network structure, the management components and the supply chain business processes are the interrelated elements of managing the supply chain. The results have shown that superior competitiveness and profitability are created through the structure of activities/processes within and between companies. The main factors of supply chain and integrating business processes are necessary to have successful SCM. A prerequisite for successful SCM is to coordinate activities within the firm. The efficiency and effectiveness of a process for the entire supply chain are increased by combining supply chain process integration and re-engineering. It is critical that the derived benefits are equitably distributed.

Also, in another research, Christopher (2000) has investigated the agile supply chain for competing in volatile markets. Cross-functional integration and marketing investigation are required to have a successful SCM. A framework is provided for SCM. Also, the questions are provided to investigate the way of its performance. Case studies were conducted at several companies. The results have shown that agility is the key to survive in these changed conditions. The creation of responsive supply chains is another way of surviving. To have a rapid response to the needs of the market requirement, a high level of agility is required. The importance of logistics and SCM in the marketplace is not considered by marketing management. However, the importance of agility in a business environment is very noticeable. Volatility and unpredictable demand become standard in this condition.

Furthermove, Sambamurthy *et al.* (2003) have examined shaping agility through digital options. They have defined agility as an important factor in innovation and competitive performance of firms in current business environments. The companies improve agility through information technologies, including process, knowledge and communication technologies. Agility, digital options and entrepreneurial alertness are the three important organizational capabilities that affect the performance of companies through IT investments and capabilities. Also, the performance of firms is influenced by strategic processes, including capability building, entrepreneurial action and coevolutionary adaptation. The companies can launch many and varied competitive actions through the impact of dynamic capabilities and strategic processes. These competitive actions are the main factors to have firm performance.

Wu *et al.* (2006) have examined the impact of IT on supply chain capabilities and the performance of the organization. The IT-related resource is transformed into a higher value for a firm through the supply chain abilities. By embedding IT into a supply chain system, an organization is able to improve channel-specific assets via effective information exchange and better coordination with supply chain partners. One of the information advantages against competitors is the capabilities of the supply chain in companies through access to knowledge and resource integration. The response of companies to market changes is faster than competitors because of the improvement in IT-based supply chain abilities. Protecting the company against the imitation of other organizations is because of these abilities, which over time will develop the agility of SCM.

Also, Braunscheidel and Suresh (2009) have examined the organizational antecedents of a supply chain agility for risk mitigation and response. A firm's supply chain agility is the inner ability of the firm to connect key suppliers and customers. It aims to respond promptly to market changes to help the wider supply chain. The results have shown that market orientation has an impact on both internal and external supply chain integration. Also, it affects two elements of external flexibility. The level of internal integration is affected directly by learning orientation. Firms with high levels of external integration have high levels of internal integration, and this is consistent with past research. The levels of external flexibility present are not related to internal and external integration.

Finally, Papadopoulos *et al.* (2016) have examined supply chain improvement in the construction industry. Construction is a productive process in their point of view. There are various and complex interfaces between participants and problems originated from the lack of coordination of these participants. The results have shown that the SCM provides several principles to reduce the lack of coordination. Greater certainty of out-turn costs, delivery of better underlying value to the client, on-time delivery, more repeat business with key clients, productivity improvement, value creation, competitive advantages and better relationships between parties are the main advantages of using SCM principles by construction organizations.

3. Research model and hypothesis

Providing a model to study the impact of IT on the agility of the SCM is the main goal of this section. Figure 1 presents the proposed research model. The investigated variables in this

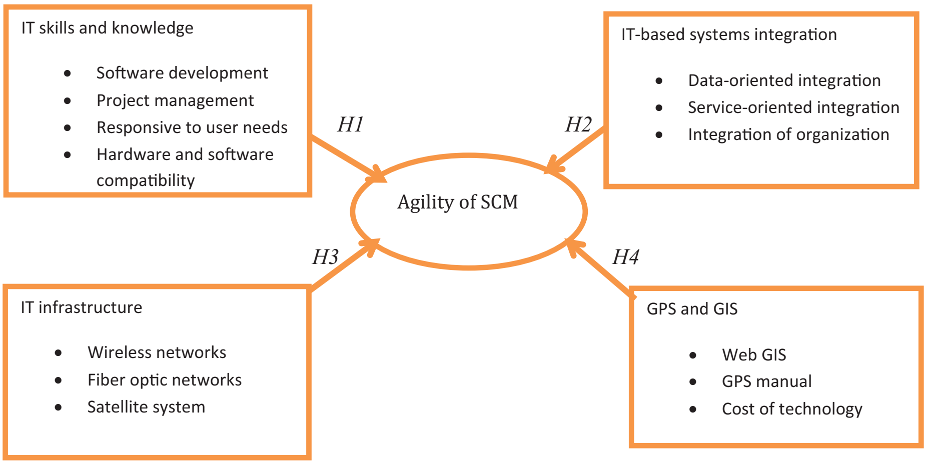

Figure 1. Proposed research model

study are IT skills and knowledge, IT-based systems integration, IT infrastructure, GPS and GIS. Four variables within 13 dimensions are presented and discussed. Four hypotheses are presented in this section to test the relationship between the components of the framework. The following sections discuss the hypotheses and its supporting literature in detail. The most important state of the art research studies is discussed in the rest of this section to study the impact of IT on the agility of the SCM systems. The previous studies are the basis to discuss 13 dimensions within four variables in the rest of this section.

3.1 Information technology skills and knowledge

Knowledge and the skills of IT are necessary to use IT systems (Smirnov and Chandra, 2001). The operation of organizations is affected by advances in computer-based technology for more than 30 years (Paganetto, 2017). The emphasis of organizations has shifted from working with materials to working with knowledge (Holsapple and Whinston, 1987). The use of IT has resulted in a widespread transformation in the administrative and information systems, allowing for the electronic transmission of data, documents and communications through computer and telecommunication lines (Dutta *et al.*, 2015). A relationship between investment in IT and the productivity of enterprises and human resource productivity is positive (Ray *et al.*, 2005). IT also increases the ability of organizations to increase product diversity and improve quality and customer satisfaction and agility of SCM systems (Vangala *et al.*, 2017). IT and knowledge skills include software development, project management, being responsive to user needs andhardware and software compatibility, which will be discussed in the next section. Therefore, IT skills and knowledge are adopted in the research model of this study to evaluate the effectiveness of the agility of SCM systems. Thus, the hypothesis related to IT skills and knowledge is:

H1. The effectiveness of the agility of SCM systems is affected by IT skills and knowledge.

3.1.1 Software development. With every passing year, software has become an increasingly essential and vital constituent of the society (Fuggetta and Di Nitto, 2014). The software is a weapon for competition and success (Lesser and Ban, 2016). Many organizations are looking for skilled resources with lower costs for software development (Herbsleb and Moitra, 2001). The competitiveness of companies is achieved through effective software development from ideation to delivery (Lesser and Ban, 2016). A gap is created in the design of electronic systems by rapid growth of system complexity (Ecker *et al.*, 2009). Software development is the fulfillment of the needs of users or customers in the form of a software product. The development of software from the design phase of a conceptual solution to the problem (feasibility) starts after receiving the demands, and the system analysis is performed. Eventually, this design with the help of implementation tools becomes a real system (Barrett *et al.*, 2006). By developing software in organizations and synchronizing it with enterprise applications, the agility of the SCM system is enhanced.

3.1.2 Project management. IT projects, complex activities, and various industrial, commercial and managerial changes, are planned, coordinated and controlled by project management (Gray, 2008). Project management is the practice of initiating, planning, executing, controlling, and closing the work of a team to achieve specific goals and meet specific success criteria at the specified time (Cha *et al.*, 2018; Guide *et al.*, 2003). The complexity of the supply chain increases by increasing the type of product. Therefore, as demand increases, the tasks and outsourcing processes increase (Chen *et al.*, 2006). Many nonstandard and nonrepetitive activities should be managed and coordinated because of the similarity of supply chains to large-scale projects. In one sense, the SCM is converted into project management (Gaudenzi and Christopher, 2016). Recently, researchers have shown that the efficiency of organizations has increased using project management (Mir and Pinnington, 2014). The correct management of the project will aggravate the SCM systems.

3.1.3 Responsive to user needs. Providing tool kits for user innovation is a way to meet the needs of users. This method allows users to customize products for themselves (Franke and Von Hippel, 2003). There should always be ongoing efforts to ensure that the IT used in organizations meets the needs of different users (Vakili and Navimipour, 2017). Providing services to users with timely and accurate responses will aggravate SCM systems (Venkatesh *et al.*, 2003).

3.1.4 Hardware and software compatibility. The companies should be flexible to adopt and respond to market changes owing to the rapid change and dynamic global business environment (Dao *et al.*, 2011). The competition in the business market, in investments and in the application of IT since mid-1990s has been very impressive (McAfee and Brynjolfsson, 2008). The most common tools were email, office productivity tools, Web browsers, the library catalog, database searching tools and printers (Maceli and Burke, 2016). So, IT is ubiquitously integrated into products and services to provide innovation (Del Giudice and Straub, 2011; Leonhardt *et al.*, 2016). Software can control the work of a computer and applications such as word spreading – spreadsheets that perform tasks for computer users (Fried *et al.*, 2010). In the event of hardware and software compatibility in system organizations, the agility of SCM systems will have a positive effect.

3.2 Information technology-based systems integration

Today, each organization, depending on its type of activity, chooses a system and model for integrating the information system; therefore, it cannot be a unique way for all organizations. Generally, organizations can use data-oriented and service-oriented integration and the integration of organization depending on their context (Gunasekaran and Ngai, 2004). To produce a product in competition with other suppliers, high-technology components, subsystems, software, knowledge, engineers, leaders and technicians should be combined through the systems integration (Hobday *et al.*, 2005). The systems integration is often required to achieve business integration (Ettlie *et al.*, 2017; Markus, 2000). Today, the rapid change of market needs require unprecedented levels of interoperability to integrate various information systems to share knowledge and collaborate with organizations (Shen *et al.*, 2007). The integration of Web services and software agents to select efficient services and the integration of inter-organizational business processes are necessary to provide a computing paradigm (Prencipe *et al.*, 2003). IT-based systems integration includes data-oriented integration, service-oriented integration and integration of organization, which will be discussed in the following sections. Therefore, this study's research model adopts IT-based systems integration acceptance as a dependent variable comprising data-oriented integration, service-oriented integration and integration of organization to evaluate the direct and indirect effects on the agility of SCM systems. Therefore, the hypothesis related to IT-based systems integration is:

H2. IT-based systems integration has a positive impact on the agility of SCM systems.

3.2.1 Data-oriented integration. Some organizations believe that data integration should take place in the data area and it is created in the organization's database. If the organization is visited by somebody, the degree is submitted to its different units (Koponen *et al.*, 2007). One of the steps that can be taken in this way is to transfer data between two or more databases, i.e. the system and infrastructure, such as software, through which all databases are stored in a system, and the organizational units that need this information should have access to this integrated information bank (Czajkowski *et al.*, 2016). In the meantime, some organizations have a large number of integrated databases design infrastructure, and this integrated system has the information of all databases (Papotti *et al.*, 2014). Data-centric integration with the provision of information banks can have an impact on the agility of SCM systems.

3.2.2 Service-oriented integration. Over time, supply chain processes move toward IT-based business processes in relation to service-oriented integration. This is done to increase the flexibility of IT-based applications in enterprise networks (Mohammadi *et al.*, 2018). Today, the needs and opportunities that are changing rapidly in the global marketplace require collaboration to integrate diverse systems. In this case, knowledge is shared and collaborated with organizations (Shen *et al.*, 2007). Reducing cost, improving responsiveness to changes and increasing service level making are the results of using service-oriented integration (Papazoglou, 2003). Such systems must ensure that service requests are correctly routed and directed and answered to the right time, and these services communicate clearly and accurately based on the relationship policies (Roelich *et al.*, 2015).

3.2.3 Integration of organization. With the advancement of human societies and the transformation of small businesses into large organizations that require more extensive and complex human resources tasks, the coordination between the components and processes of such organizations has become a challenging issue (Museli and Jafari Navimipour, 2018). Today, the coordination of the components of an organization is the only factor survival and development in global competition (Paine, 1994). Ethical lapses by employees can put organizations at a substantial risk. This risk can be limited through the improved compliance procedures, and a culture of organizational integrity is built by successful efforts (Kayes *et al.*, 2007).

3.3 Information technology infrastructure

The impact of IT infrastructure on the firm's ability to use IT competitively is very noticeable in the recent years (Field *et al.*, 2015). The present and the future IT applications are built on IT infrastructure as developed on the technological foundation (Chung *et al.*, 2003). The supply chain agility is defined as a firm's ability; therefore, the firm performance is affected by IT infrastructure through enabling higher-order business capabilities (Andrade and Doolin, 2016). The purpose of IT infrastructure is to create and expand networks and telecommunication services, transmission, acquisition and supply networks, multimedia communications, data storage, portable prototyping, cryptographic and security technologies and more (Luo and Bu, 2016). The firms exchange knowledge, align processes and achieve operation flexibilities through a platform provided by IT infrastructure (Gunasekaran *et al.*, 2016). IT affects the efficiency and effectiveness of business processes and the agility of SCM systems within and across organizational boundaries through embedding applications into business processes (Braunscheidel and Suresh, 2009). IT infrastructure includes wireless networks, fiber optic networks and a satellite system, which will be discussed in the following sections. To evaluate the direct and indirect effects on the effectiveness of the agility of SCM systems, the research model in this study adopts IT infrastructure acceptance as a dependent variable comprising mobile wireless networks, satellite system and fiber optic networks. Thus, the hypothesis related to IT infrastructure acceptance is:

H3. The IT infrastructure will positively influence the effectiveness of the agility of SCM systems.

3.3.1 Wireless networks. The SCM is one of the universal efforts in the multinational businesses. The global expansion of digital communications and e-commerce has caused the agility of the supply chain. Therefore, the development of e-commerce and the future trends should be understood (Murillo, 2001). Wireless communications cover a wide range of technologies. Satellite communications, television broadcasting, local wireless networks known as Wi-Fi, Bluetooth, wireless mouse and keyboard and cellular telecommunications are examples of wireless technologies (Tarr *et al.*, 2001). The organizations improve their performance by the rapid growth of IT and networks in SCM. IT and networks can support the operations of companies, unite distant links of the supply chain and increasingly interconnect companies with its customers (de Barros *et al.*, 2015).

3.3.2 Fiber optic networks. In 1976, the first fiber optic telephone network was installed in Chicago. Since then, fiber has become commonplace in the communications infrastructure (Wu *et al.*, 2014). All high bandwidth and/or long-distance communications are able to choose fiber optics (Lecoy, 2008). The development of telecommunication and the convenience of data transmission via fiber optic communication and telecommunication systems is one of the most important issues in today's world. Accuracy and ease of speed are the most important features of fiber optic communication. One of the most important uses of fiber optic communication is the transmission of digital signals that can be split in the time domain (Essiambre *et al.*, 2008). Fiber optic is one of the fastest data transferring environments. Today, fiber optics are used in many different ways, such as urban and intercontinental telephone networks, computer networks and the internet (Loeffelholz and Badar, 2017). This network is a key enabler and can achieve a breakthrough in the area of supply chain design, configuration and planning. The need is to deploy IT-enabled networks to promote collaboration, flexibility and accuracy on the agility of SCM (Wu and Chiu, 2018).

3.3.3 Satellite system. Satellites can be used in all aspects of everyday life, such as the provision of telecommunication, radio and television services. Also, satellites can be used for meteorological and atmospheric phenomena, weather, ground transportation, geology, mapping and other peaceful purposes (Lechner and Baumann, 2000). Given that mobile systems suffer from some limitations such as the impossibility of providing services in remote areas, satellites can be used as complementary systems for mobile, land-based and fixed-line systems in remote areas of use (Jeffers *et al.*, 1991). Meanwhile, one of the most important applications of space for telecommunication is human. Today, the advancement and evolution of human societies and the ever-increasing need for communication have necessitated the development of modern communication methods (Fenech *et al.*, 2016). Telecommunication satellites can be considered to be the best, most efficient and sometimes the only way to connect between two points on the planet for electronic business and supply chain (Elbert, 2004).

3.4 Global positioning system and geographic information system

GIS can collect, store, integrate, manipulate, analyze and display data in a spatially referenced environment, which can analyze data visually and see patterns, trends and relationships that might not be visible in a tabular or written form (Li *et al.*, 2005). The built environments are evaluated through GIS (Badland *et al.*, 2010). The expansion of internet-based GIS has created many new research opportunities in GIS. In the Web-based environment with basic GIS functionalities, the map becomes dynamic, interactive and accessible to a wide selection of users as a visual communication tool (Dragicevic, 2004). Web GIS becomes a cheap and easy way of disseminating geospatial data and processing tools (Alesheikh *et al.*, 2002). GPS technology has a widespread growth throughout disciplines with a requirement for geographical information. A set of satellites and associated control systems are defined as GPS by Barnard (1992). GPS allows a suitable receiver to determine its location anywhere on earth 24 h a day (Cornelius *et al.*, 1994). IT in the SCM system can increase customer and customer responsiveness, create new relationships with customers to identify their needs and create sales channels, agile chain performance and competitive status (Fawcett *et al.*, 2011). GIS reduces inequalities in access to spatial and spatial information in different geographic regions. With this description, GIS is an inseparable part of the information infrastructure in most organizations (Davies, 2001). This system increases the ability of organizations to make better decisions based on all relevant factors and also increase the availability of information (Pick, 2004). The GPS does not depend on telephone or internet receivers, although access to these resources can make the information received from this positioning system more appropriate and practical (Chu *et al.*, 2017). Using GPS as one of the geographic technologies in the supply chain reduces costs by saving time and increasing the confidence level (Dubey, 2014). GPS and GIS include Web GIS, GPS manual and the cost of technology, which will be discussed in the following sections. Therefore, this study's research model adopts the design of GPS and GIS acceptance as a dependent variable comprising Web GIS, GPS manual and GPS aerial to evaluate the direct and indirect effects on the effectiveness of the agility of SCM systems. Thus, the hypothesis related to the design of GPS and GIS acceptance is:

H4. The design of GPS and GIS will positively influence the effectiveness of the agility of SCM systems.

3.4.1 Web geographic information system. The production companies benefit greatly when access to all the existing three-dimensional geotechnical subsurface information of a city/country is possible at any time through the internet (Kunapo *et al.*, 2005). Web GIS technology is a spatial information system distributed in a computer network, used to integrate and disseminate graphical information on the system on the internet. This technology allows users to access huge resources of spatial and descriptive data in the least amount of time and at the lowest cost at any place (Dragicevic, 2004). Mankhina's Web-based system increases the ability of business entities to compete (Fu and Sun, 2010).

3.4.2 Global positioning system manual. Handheld GPS receivers' small devices are mobile phones that accurately determine the user's position by about 3 m (Dye and Baylin, 1997). The mapper receiver has the ability to display the map. By connecting this receiver to a computer, they give the desired map to the recipient (Goswami, 2013). Using this GPS, the user can send products and services to arbitrary points and save time and money (Misra and Enge, 2006). In each enterprise, the agility of SCM systems depends on the use of a variety of advanced and modern technologies (Tsui, 2005). These technologies cover transportation, production, warehousing and delivery to the customer (Jiang *et al.*, 2018).

3.4.3 Cost of technology. Today, technology costs have become a cycle in which costs should be constantly reduced and technology deployment and development should be increased (Van Triest and Vis, 2007). This program allows companies to have a definite decision about the role of supply chain agility by having accurate information about the cost of technology (Cameron *et al.*, 2007). The suppliers are connected to industrial companies through the supply chain, and the companies also connect to customers in the same way (Hugos, 2018). The user's confidence in the superior customer service, low cost and short cycle times is crucial in managing the supply chain (Schermann *et al.*, 2016). Many organizations are successful because of their ability to deliver approved releases (Acemoglu *et al.*, 2007).

4. Methods and measurements

Designing a questionnaire is for evaluating the elements of the model. Researchers and specialists revise the questionnaires with significant experiences in the SCM. The standard and reliable resources are applied to assess the validity of the questionnaire. The questionnaire is presented to employees of the Golasal firm of East Azerbaijan[1]. All questionnaire items use five-point Likert-type scale (1 = completely disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree and 5 = completely agree) (Likert, 1932). The hypotheses are evaluated by standardized assessment questionnaire, which includes the research hypothesis and data collected from the research literature review. The SPSS 22[2] and SMART-PLS[3] (Partial Least Squares) 3.0 software packages are applied for statistical examination of the questionnaire. PLS avoids many of the restrictive assumptions underlying covariance-based structural equation modeling (SEM) techniques, such as multivariate normality and large sample size (Falk and Miller, 1992; Fornell and Bookstein, 1982). Furthermore, to test both formative and reflective constructs in the model, PLS is used (Chin, 1998). PLS is used in the formative constructs more than the other statistical techniques in data analysis. Our sample size is 120, which is more than adequate for the PLS estimation procedures (Hwang, 2009).

The target samples in this study are employees of a Golasal manufacturing company in Iran. The use of IT increases in the industry because of the development of IT in recent years. One of the most obvious signs of using IT is the agility of SCM systems. The use of IT in the industry saves time and cost and the agility of different sectors. A total of 120 people were involved in the sample. The selection of the target population is based on Morgan table (Appendix) in which 92 cases were selected randomly. A total of 92 questionnaires are distributed among the employees of the Golasal firm of East Azerbaijan in Iran. A total of 17 questionnaires out of 92 are incomplete; therefore, 75 questionnaires are analyzed. This research is conducted in 2017 and 2018. The research hypothesis and data collected from the research literature review are the basis for examining the hypothesis in the standardized assessment questionnaire. The male and female genders are involved in selecting samples. The descriptive statistics about gender, age and education are examined through SPSS software. The analysis results have shown that 57.3 per cent of the respondents were male and 42.7 per cent of the respondents were female in the sample studied. A total of 28 per cent of the respondents have had a bachelor's degree and 45.3 per cent of the respondents had a job experience of 6-15 years according to the evaluation of their education and age. The Cronbach's alpha value is above 0.7, calculated using SPSS software. Thus, this questionnaire has acceptable reliability.

5. Results and discussion

The social experts focus on PLS modeling in recent years (Chin and Dibbern, 2010). The researcher gets the ability to predict and understand the role and formation of individual constructs and their relationships among each other through the PLS approach, in accordance with standard SEM precepts (Hulland, 1999). Moreover, the advantage of PLS is more appropriate than covariance-based modeling techniques such as linear structural relations (LISREL) because the emphasis is on the prediction to maximize the explained variance in the dependent construct. Furthermore, sample size requirements are considerably smaller than the minimum recommended for covariance-based techniques, especially for complex models (Chin and Newsted, 1999). In the case of multi-group SEM, for group comparison, advanced procedures have been implemented in covariance-based SEM. This approach can pose high demands on data properties and sample size. The use of the component-based procedure is one of the least restrictive ways to test structural equation models across groups (Chin and Dibbern, 2010). The research model is tested through PLS, which is a component-based SEM technique. The used specific software package is smart PLS 3.0, a software that has attracted applications from scholars in the marketing and information systems domains (Zhou *et al.*, 2014). The PLS path modeling lacks a well-identified global optimization criterion so that there is no global fitting function to assess the goodness of the model. Thus, model confirmation mainly focuses on the model predictive capability (Navimipour and Soltani, 2016). Reliability, convergent validity and discriminant validity of all constructs are the features for evaluating the measurement model. The convergent validity was assessed by using average variance extracted (AVE), which must exceed a standard minimum level of 0.5 (Fornell and Larcker, 1981). The composite reliability and Cronbach's alpha are used to examine the reliability of measures. In general, the minimum value of composite reliability is 0.7 (Nunnally, 1978), and the minimum value of Cronbach's alpha is 0.7 (Cronbach, 1951). As shown in Table I, Cronbach's α and composite reliabilities of all of the constructs for the full sample were greater than 0.70, and AVE values were greater than 0.50, indicating the adequate level of reliability. Table II presents every construct's AVE values and the square of the estimated correlations for each pair of constructs. The discriminant validity exists between the constructs, as the AVE values are higher than the squared estimated correlations. In other words, divergent narrative is at an acceptable level that the AVE for each variable is greater than the variance shared between that variable and other variables in the model. This table shows that given the adoption of all criteria at standard levels, the results are acceptable.

As can be seen in Table III, the hypotheses were all positive and significant. IT skills and knowledge have a significant and positive effect on the impact of the agility of SCM systems, based on the results of sample *t*-test and path coefficient (b = 0.355, $t = 5.859$, $p < 0.001$), which supports *H1*. Also, *H2*, which proposed a positive relationship between the acceptance of IT-based systems integration and the impact of the agility of SCM systems, is supported (b = 0.34, $t = 6.313$, $p < 0.001$). The findings of *H2* indicate that IT-based systems

Cronbach's alpha	Composite reliability	AVE	Indicators
0.715	0.824	0.539	Agility SCM
0.891	0.913	0.567	IT skills and knowledge
0.892	0.919	0.536	IT-based systems integration
0.817	0.869	0.657	IT infrastructure
0.870	0.905	0.616	Design of GPS and GIS

Note: Bold diagonal numbers are the square roots of AVE

Table I. The convergent validity and reliability of measurement for the measurement model

Structures	IT infrastructure	Effectiveness supply	IT skills and knowledge	Design of GPS and GIS	IT-based systems integration
IT infrastructure	*0.726*				
Effectiveness supply Chain management	0.716	*0.734*			
IT skills and knowledge	0.450	0.721	*0.753*		
Design of GPS and GIS	0.417	0.685	0.429	*0.785*	
IT-based systems integration	0.373	0.625	0.303	0.332	*0.81*

Table II. The discriminant validity of the measurement model integration increases the agility of supply chain management systems. Specifically, as proposed in *H3*, which predicted a positive relationship between design GPS and GIS and the impact of the agility of SCM systems, the findings suggest that there is a positive relationship between the two, (b = 0.304, t = 6.047, $p < 0.001$). Also, *H4*, which proposed a positive relationship between acceptance IT infrastructure and impact of IT on the agility of SCM systems, is supported (b = 0.353, t = 9. 102, $p < 0.001$).

In PLS, R^2 is a statistical measure of the percentage of variance in a data set, which can be interpreted as "the relative amount of variance of the dependent variable explained or accounted for by the explanatory variables jointly" (Chen *et al.*, 2012). For instance, if R^2 = 0.988, we say that the explanatory variables explain 0.988 per cent of the variance of the dependent variable. The range of R^2 is from 0 to 1; however, there is no standard criterion, and in general, the higher the R^2, the higher the variance that can be explained. Consequently, our study provided an integrated model for examining the impact of IT on the agility of SCM systems. Overall, the model explains 0.988 per cent of the variance in environmental behaviors. Also, recently, a global fit measure for PLS path modeling has been suggested; GOF ($0 < \text{GOF} < 1$) is defined as the geometric mean of the average commonality and average R^2 value. GOF small = 0.1, GOF medium = 0.25 and GOF large = 0.36; these may serve as baseline values for validating the PLS model globally (Wetzels *et al.*, 2009). The overall model was proven just acceptable with a good fit for data analysis via GOF index. The GOF index was calculated by Equation (1):

$$\text{GOF} = \sqrt{\text{AVE} \times \text{R}^2} \tag{1}$$

We obtained a GOF value of 0.988, which exceeds the cutoff value of 0.36 for large effect sizes of R^2 and allows us to conclude that our model performs well compared to the baseline values defined above. Therefore, the structure of the model had a good fit with the data.

6. Conclusion, limitations and directions for future research

Businesses get the opportunity to deploy IT features for the agility of SCM systems through the rapid growth of IT. Many companies tend to use IT services to reduce costs and provide real-time services to compete with other organizations. The agility of SCM systems increases, moving from internal to external optimization, emphasizing business processes, orienting toward customer satisfaction and creating a competitive advantage in the marketplace. The results of this research have shown that IT in organizations plays an important role in increasing the agility of SCM systems. Also, it can support the internal operations of companies and their cooperation in the supply chain. Companies must always adopt new technologies for adapting their data to standardized data formats and inter-organization synchronization between organizations in the agility of SCM systems. The agility of SCM systems can provide more coverage, better access channels and optimal quality in the production, supply and

Table III. The *t*-value and path analysis of the structural model

Path	β	*t*-value	Contrast
IT infrastructure Effectiveness of agility SCM	0.353	9.102*	Accepted
IT skills and knowledge → Effectiveness of agility SCM	0.355	5.859*	Accepted
Design of GPS and GIS → Effectiveness of agility SCM	0.304	6.047*	Accepted
IT-based systems → Effectiveness of agility SCM Integration	0.34	6.313*	Accepted

Note: $^{*}p < 0.001$

distribution of products by considering the importance of information in the agility of supply chain. IT, information dissemination and transfer promote cooperation in both internal and external dimensions, improving effectively the agility of the supply chain. Our research findings have shown that the integration of IT-based systems would aggravate the SCM systems. Data integrity through ease of access to information and the transfer of data in an organization facilitates access to information and the agility of SCM systems. In service integrity, service requests are properly routed and directed and answered at the right time, and these services clearly and precisely proclaim their communications and interconnection policies, which in turn manifests itself in the agility of SCM systems. Our studies have shown that integrity in the organization contributes to the complexity of SCM systems through integration into the organization's activities and decisions. The agility of SCM helps companies use optimal resources, reduce costs, reduce inventories, prevent mistakes and damage, provide consistent delivery processes, improve the productivity of production and logistics and improve business and financial performance. The results have indicated that the agility of SCM is influenced by IT skills and knowledge, IT-based systems integration, IT infrastructure and GPS and GIS.

The limited research sample to a company is the main limitation of this study. It is costly and time-consuming to study in many different situations but it is very challenging for future research. Our research provides some important contributions to academics and professionals but it has some limitations as follows:

- The field of study is limited to one area. It cannot be guaranteed that the results are well known to other areas.
- The research design for this study is a cross-sectional study that shows the static relationships between the variables. As cross-sectional data takes variable relations at a single point in time, they are collected in other periods.
- Data are collected from a sample of one location because of the limitations of time and money.
- The use of variables to demonstrate the agility of SCM may be explicit and not comprehensive.

Considering the limitations of research and studies, we will consider the following points in a future study:

- To evaluate the agility of SCM, different dimensions should be considered.
- To show how effective it is for the SCM, a comprehensive sample that can identify other important factors should be gathered.
- To ensure generalizability, larger instances to perform cross-validation models should be encouragd.
- To lead to agility in SCM, the relationship between strategic management, enterprise resource planning, and customer relationship management should be explored.

Notes

1. www.foodkeys.com
2. www-01.ibm.com/software/analytics/spss/
3. www.smartpls.com/

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Further reading

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Appendix

Table AI.
The Morgan table

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2,800	338
15	14	110	86	290	165	850	265	3,000	341
20	19	120	92	300	169	900	269	3,500	246
25	24	130	97	320	175	950	274	4,000	351
30	28	140	103	340	181	1,000	278	4,500	351
35	32	150	108	360	186	1,100	285	5,000	357
40	36	160	113	380	181	1,200	291	6,000	361
45	40	180	118	400	196	1,300	297	7,000	364
50	44	190	123	420	201	1,400	302	8,000	367
55	48	200	127	440	205	1,500	306	9,000	368
60	52	210	132	460	210	1,600	310	10,000	373
65	56	220	136	480	214	1,700	313	15,000	375
70	59	230	140	500	217	1,800	317	20,000	377
75	63	240	144	550	225	1,900	320	30,000	379
80	66	250	148	600	234	2,000	322	40,000	380
85	70	260	152	650	242	2,200	327	50,000	381
90	73	270	155	700	248	2,400	331	75,000	382
95	76	270	159	750	256	2,600	335	100,000	384

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