Qualitative content analysis of factors affecting the relationship of science development, technology development and economic growth

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Abstract: The present research tries to investigate the effective factors that affect the relationship among science development, technology development and economic growth using thorough literature review and qualitative content analysis. After investigating several articles and books, nine factors were identified as key factors which affect science development. In addition, nine factors of increasing the amount of patents, basic and applied researches growth, expert human resources growth (human resources development), growth of research and development (R&D) budget, GDP growth, improvement of industrial policy, commercial system improvement, technology legal environment development and technology infrastructures, facilities and equipment development were determined as effective factors on technology development. Furthermore, eight factors of population growth rate, GDP per capita growth, economic-political convergence, investment in R&D, workforce quality, ownership rights and other macroeconomic factors and science and technology infrastructures, facilities and equipment development were determined as effective factors on economic growth. Finally, 14 cofactors were determined for the relationship among science development, technology development and economic growth. The results will shed light for future research in the field.

Keywords: economic growth; interdisciplinary; patent; qualitative content analysis; science development; technology development.

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1 Introduction

Science is a combination of phrases that scientists collected through scientific explorations on a given subject or meeting an objective (in subjective or non-subjective sciences such as Kalam) and scientists discuss among each other through these scientific languages. Furthermore, it sometimes includes philosophy (Rajayee, 2010, p.18). Anecdotally, in the turn of centuries, human being tried to acquire science via formal institutions or environment and today, acquiring of science has transformed as one of the most important goals of societies and countries. Science acquisition will lead to an improvement in skills and regulations and furthermore, will lead to an increase in productivity, which ultimately facilitate the economic growth (Behboudi and Amiri, 2010).

Technology is a skill for making software or hardware. In fact, it can be stated that, the rational human extracted the general rules through the interaction with the nature and recreate these rules with the usage of science and knowledge in the environment, in order to make his/her intended applications in an intended situation (Mahmoodzadeh, 2001, p.10). Several technologies, particularly information and communication technologies (ICT), affect both the supply side (producer behaviour) and the demand side (consumer behaviour) in an economy. This behaviour correction, in companion with other factors such as managerial experience, sectoral organising and rule making, Government policies and human capital, can lead to an economic growth (Moshiri and Jahangard, 2004).

Today, based on the above discussions, in all models of economic growth, a great attention has paid to knowledge and technology. Hence, science and technology advancement is a propeller engine for economic growth. Formation of knowledge-based economy is one of the most important policies of today’s societies. Main factors of growth in this economy are the technology creation, new knowledge and the application of advanced technology. To do so, about a decade ago, Europe, USA, Japan and some other developed countries put a great effort to the evaluation of innovation’s socio-economic achievements (Cozzens et al., 2002). Anecdotically, policy makers change their views to concentrate more on issues such as today’s advancement and tomorrow’s development, future generations, ecological sustainability, ICT development, social inequalities and the key role of institutions in development (Malone, 1979;
Factors affecting the relationship of science development


Science and technology development is the process in which the capability of science and technology creation has totally reinforced and improved in the society. In addition to economic growth, national science and technology development has a powerful and effective relationship with cultural and social foundations, which lead to an effect on people’s employment, health and living (Safavi and Safavi, 2003). In the majority of developing countries, sufficient level of knowledge and expertise, which is the fundamental component of technological development and advancement, is in the low level. Although, in all countries, it is the government’s responsibility to increase the general knowledge level and prepare facilities for low-level to high-level education, but due to the importance of growth in developing countries, it is recommended that governments put more effort to exert this growth. Science and technology development is impossible without research and development (R&D) institutions and development is not the development in the production unit, but it is a general development, which is impossible without establishing research institutions in industrial units and the sound relationship between universities and industries, which are also impossible without the intention of the government. In each country or organisation, effective factors and situations on science and technology development should be considered. These effective factors on science and technology development are called science and technology development infrastructures. In fact, science and technology search is viable in the presence of such infrastructures as R&D institutes, government and private sectors role-playing in science and technology development and human resources development (Vaez and Ghanbari, 2008).

According to the above explanations, creation and distribution of technological knowledge inside a country’s frontiers, to obtain economic growth, are necessary (Nelson and Romer, 1996). In the recent years, similar to other countries, in Iran, policy institutions tried to make foundations to help science and technology development towards economic growth in all dimensions. However, the problem is that there is no coordination among these institutions and they do not have a consensus on the effective factors on science and technology development towards economic growth (Tajerian, 2009). Investigating the effective factors on science development, technology development and economic growth and their relationships, using qualitative content analysis, can cover the economic growth and science and technology development inequality among nations, institutions and different places of the world, which, in part, leads to several planning for performance improvement and decreases this gap and achieves technological equality.

To do so, the present research tries to investigate the related literature thoroughly and applies qualitative content analysis to determine the effective factors on science development, technology development and economic growth and also justify their relationships. To fulfil this objective, the next part will cover the thorough literature review of the studied fields. The third part will discuss the factors and subfactors of science development, technology development and economic growth and finally, the fourth section will conclude the study and will offer suggestions for further studies.
2 Theoretical analysis

2.1 The relationship among science development, technology development and economic growth

The objective of economy in science is the perception of science effect on technological advancement, explanation of scientists’ behaviour and the perception of efficiency or inefficiency of scientific institutions. Adam Smith, who is the pioneer of ‘classical economy’, was the first economist who offered his theory in this field. In his ‘ethic’s emotions’ theory, he mentioned that newton’s motivation is the result of his curiosity, not his intention to wealth and fame. Anecdotally, the ‘modern’ science economy depends on the three main subjects. The first subject is the determination of the contribution of scientific advancements in technological advancements and then, determining their relationship to growth and productivity. The second subject is mainly having common issues with science history and philosophy and tries to determine how the scientific advancement takes place. In addition, the third subject is about the collection of empirical data and economic analysis of the sources of supply and demand and the productivity of scientists (Diamond, 2008, p.328).

Since the publication of Adam Smith’s great work of ‘wealth of nations’ in 1776, several authors highlighted the importance of technology, as a stimulus for welfare and economic growth. If technology is considered as the most important stimulus factor of economic growth, then the most important resource of technology should be investigated. Economists analysed Rosenberg’s views for several years. He called the new technologies as a ‘black box’. Further, economists and Rosenberg tried to describe the role of science inside this so-called black box. In addition, some historian economists such as Mokyr (1992), Rosenberg (1992) and Landes (1969) investigated the role of science in technological advancement and economic growth in the long period. They believe that scientific advancement is necessary for rapid growth of technology and economic growth, but it is not sufficient (Diamond, 1996).

Productivity enhancement via technological growth is one of the main objectives of each country’s economy, because with the available production resources, the only factor, which can transfer the production facility curve externally, is the productivity and technology enhancement. Technology import from abroad and investing in human capital and R&D activities will directly and indirectly affect the technology level and factors’ productivity (Teixeira and Fortuna, 2010). It should be stated that these factors’ direct effect is understandable, but their indirect effect should be searched in the collaboration and interaction with society’s scientific variables. In other words, the degree of indirect effect of technology import on technological advancement depends on the society’s capabilities (human capital and R&D) (Abramovitz, 1986).

Investing in human capital and R&D activities (capacity making activities) also has direct and indirect effect on technology and productivity enhancement. Direct effect of capacity making capital increases the society’s capabilities in making initiatives and forming new ideas and hence, leads to technology production and productivity enhancement. Though, its indirect effect is, when the foreign technology imported, the host society can learn the hidden science and techniques in foreign technology and can add these to the country’s technology circle based on the degree of its human capital and
R&D activities. This definition is the foundation of technology adoption hypothesis in the technological economy literature (Salmani et al., 2014).

The more powerful is the scientific infrastructure of a country, the more it will be successful in identifying technology and applying the foreign technology’s scientific domain and hence will have greater power for technology adoption (Savvides and Zachariadis, 2005). In contrast, a weak country cannot adopt the technology properly and cannot utilise the indirect benefits of the imported technology.

2.2 Literature review

At first, in order to determine the factors and the relationship among science development, technology development and economic growth, several researches were studied and analysed. The summary of the studied researches and their results are illustrated in Table 1.

Table 1 Summary of the studied researches

<table>
<thead>
<tr>
<th>Researcher(s)</th>
<th>Year of the research</th>
<th>Summary of the results</th>
</tr>
</thead>
</table>
Investigation of the historical trend of science and technology effect on economic growth  
Proposed the amount of private sector’s patents as the proxy for measuring technological knowledge |
| Arrow                  | 1962                 | Proposed technology as endogenous  
Stated that technology is grown with a fixed rate  
Economic growth depends greatly on population rate in the long-run |
| Baumol                 | 1986                 | Historical growth of productivity, GDP per capita and export of the studied countries depends greatly on the academic researches |
| Abramovitz             | 1986                 | Political-economic convergence of the 16 studied countries were depended on their academic researches |
| Jaffe                  | 1989                 | Created knowledge by US universities are spilled over towards private sector to play a role in their commercial innovations |
| Romer                  | 1990                 | Created knowledge in universities may even will not accept in the market |
| Mowery and Rosenberg   | 1991                 | Authors of the book “technology and Pursuit of Economic Growth”  
Mentioned the scientific knowledge, which often measured by the amount of academic scientific articles, as one of the most important factors of economic growth in USA |
Table 1  Summary of the studied researches (continued)

<table>
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<th>Researcher(s)</th>
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<tbody>
<tr>
<td>Mansfield</td>
<td>1991</td>
<td>Estimated that 10% of industrial innovation would not have occurred, or would have occurred with great delay, without the contribution of academic research</td>
</tr>
<tr>
<td>Cohen et al.</td>
<td>2002</td>
<td>Public academic researches have a key role in industrial projects’ idea creation and completeness</td>
</tr>
<tr>
<td>Plosila</td>
<td>2004</td>
<td>Post-world war 2s science and technology advancements have a prominent effect on USA’s post war economy</td>
</tr>
<tr>
<td>Mahmoodzadeh and Mohseni</td>
<td>2005</td>
<td>Technology transfer has a key role on GDP in Iran in the short and long run</td>
</tr>
<tr>
<td>Shiri</td>
<td>2006</td>
<td>Introduced internal usage of ICT as the economic development engine in Iran</td>
</tr>
<tr>
<td>Mazzoleni and Nelson</td>
<td>2007</td>
<td>A program of public research can be effective only in a context in which the user community has strong incentives to improve their practices, and the capability to use what is coming out of the research program</td>
</tr>
<tr>
<td>Rabiee</td>
<td>2008</td>
<td>R&amp;D has a positive effect on economic development in Iran</td>
</tr>
<tr>
<td>Vaez and Ghanbari</td>
<td>2008</td>
<td>Technology development has a positive effect on economic growth in Iran, Science and technology development and preparing a proper educational system in Iran, based on religious culture, will lead to economic growth and poverty reduction</td>
</tr>
<tr>
<td>Komeyjani and Mahmoodzadeh</td>
<td>2008</td>
<td>ICT affects the economic growth of Iran via three variables of infrastructure, application and spill-over to all economic sectors</td>
</tr>
<tr>
<td>Fagerberg and Srholce</td>
<td>2008</td>
<td>Four factors of innovative capability of innovation system’s development, governance quality, political system’s characteristics and the degree of economic freedom have the most effects on economic growth</td>
</tr>
<tr>
<td>Vinkler</td>
<td>2008</td>
<td>There is no significant relationship between academic researches and GDP in central and Eastern European countries, but a significant and positive relationship was observed in Western European countries, USA and Japan</td>
</tr>
<tr>
<td>Aghion et al.</td>
<td>2009</td>
<td>Factors such as education, competition, macro-economic variables and workforce market will affect science and technology and ultimately will affect economic growth</td>
</tr>
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</table>
### Table 1  Summary of the studied researches (continued)

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<th>Researcher(s)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Lee and Kim</td>
<td>2009</td>
<td>Prove that technological knowledge measured by patents and higher education matter significantly for growth in the upper-middle and high income countries, whereas basic political institutions and basic human capital matter for growth in low- and lower-middle-income countries. In low-income countries, major political institutions and human capital affect the economic growth.</td>
</tr>
<tr>
<td>Pourfaraj and Eisazadeh</td>
<td>2010</td>
<td>ICT has a positive effect on economic growth, based on redistribution of income, in Iran.</td>
</tr>
<tr>
<td>Licheng</td>
<td>2011</td>
<td>Positive and significant relationship between science and technology inputs and economic growth in China.</td>
</tr>
<tr>
<td>Pourfaraj et al.</td>
<td>2011</td>
<td>ICT showed the effect of tourism industry on economic growth and this effect is greater in developed countries, in comparison to developing countries.</td>
</tr>
<tr>
<td>Zaker Salehi</td>
<td>2011</td>
<td>Using content analysis, the researcher studied Iran’s science and technology towards higher education development pathologically and found that some inequalities like lack of coordination among policy making institutions and lack of ability to adopt research share from GDP have great effects on the issue.</td>
</tr>
<tr>
<td>Shahabadi and Sajadi</td>
<td>2011</td>
<td>Domestic R&amp;D accumulation, Foreign R&amp;D accumulation via importing of intermediate and capital goods, FDI and workforce accumulation have significant and positive effect on economic growth.</td>
</tr>
<tr>
<td>Lee et al.</td>
<td>2011</td>
<td>There is mutual causality between research and economic growth in Asia, whereas in Western countries the causality is much less clear.</td>
</tr>
<tr>
<td>Zhao and Hai-qing</td>
<td>2012</td>
<td>There exists a long-term stable equilibrium relationship between technology standard, technological innovation and economic growth.</td>
</tr>
<tr>
<td>Mehrgan et al.</td>
<td>2012</td>
<td>The relationship between human capital accumulation and physical capital accumulation in the long period has a significant and positive effect on economic growth. Human capital accumulation has the most effect on Iran’s Economic growth in the long period.</td>
</tr>
<tr>
<td>Dallali Isfahani et al.</td>
<td>2012</td>
<td>Larger scale economy and greater workforce market will lead to greater innovations in production methods, which accelerates economic growth.</td>
</tr>
<tr>
<td>Researcher(s)</td>
<td>Year of the research</td>
<td>Summary of the results</td>
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</tr>
<tr>
<td>All omran et al.</td>
<td>2013</td>
<td>Nano technology R&amp;D has a significant and positive effect on economic growth of developed and developing countries</td>
</tr>
<tr>
<td>Nikoo Maram et al.</td>
<td>2013</td>
<td>Factors of capital availability, innovation and ownership rights have positive and FDI has negative effect on Iran’s economic growth. Furthermore, import of external technology does not have an important role in Iran’s economic growth</td>
</tr>
<tr>
<td>Jie</td>
<td>2013</td>
<td>There is an internal relationship between financial, scientific and technological inputs and economic growth in China’s Chang King area</td>
</tr>
<tr>
<td>Inglesi-Lotz and</td>
<td>2013</td>
<td>Examined the relationship between economic growth and research output specifically in South Africa for the period 1980–2008. Using the autoregressive distributed lag method, they investigated the relationship between GDP and the comparative research performance of South Africa in relation to the rest of the world (the share of South African papers compared to the rest of the world). The relationship is confirmed for individual fields of science (biology and biochemistry, chemistry, material sciences, physics, psychiatry and psychology). The results of this study indicate that in South Africa for the period 1980–2008 the comparative performance of the research output can be considered as a factor affecting the economic growth of South Africa</td>
</tr>
<tr>
<td>Pouris</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naghdi et al.</td>
<td>2013</td>
<td>Nano technology development has a significant and positive effect on the economic growth of the studied countries</td>
</tr>
<tr>
<td>Inglesi-Lotz et al.</td>
<td>2014</td>
<td>The bootstrap rolling-window causality tests show that during the sub-periods of 2003–2005 and 2009, GDP Granger caused research output; while in 2010, the causality ran in the opposite direction. Using a two-state regime switching vector smooth autoregressive model, they found unidirectional Granger causality from research output to GDP in the full sample</td>
</tr>
<tr>
<td>Motaghed et al.</td>
<td>2014</td>
<td>ICT has a direct important role on Iran’s GDP and economic growth. ICT has an indirect effect on increasing the efficiency and productivity of exporting and non-exporting goods and therefore, increases Iran’s economic growth rate</td>
</tr>
<tr>
<td>Kim and Lee</td>
<td>2015</td>
<td>Scientific knowledge do not have a significant effect on the economic growth in Eastern Asia and Latin America, but technological knowledge have a significant and positive effect on economic growth in the studied areas</td>
</tr>
</tbody>
</table>
Table 1  Summary of the studied researches (continued)

<table>
<thead>
<tr>
<th>Researcher(s)</th>
<th>Year of the research</th>
<th>Summary of the results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fotros et al.</td>
<td>2015</td>
<td>One percent of increase in each of ICT development variables including number of cellphone and internet users and formation of fixed capital increase Iran’s economic growth</td>
</tr>
<tr>
<td>Pradhan et al.</td>
<td>2015</td>
<td>They investigated causal relationships between information and communications technologies (ICT) infrastructure, financial development and economic growth in Asian countries over the 12-year period 2001–2012. Using panel Cointegration techniques, their empirical results show these variables are cointegrated, with a myriad of short-run and long period causal links between ICT infrastructure and economic growth, between financial development and economic growth and between ICT infrastructure and financial development</td>
</tr>
<tr>
<td>Wang and Liu</td>
<td>2015</td>
<td>They show that there are a one-way granger causal relationship and positive nonlinear relationship between agricultural science and technology and agricultural economic growth</td>
</tr>
<tr>
<td>Yao et al.</td>
<td>2016</td>
<td>Technological innovation is the key for agribusinesses to develop sustainably</td>
</tr>
<tr>
<td>Ntuli et al.</td>
<td>2015</td>
<td>The empirical results support unidirectional causality running from research output (in terms of total number of articles published) to economic growth in US, Finland, Hungary and Mexico. The results showed opposite causality from economic growth to research articles published in Canada, France, Italy, New Zealand, the UK, Austria, Israel and Poland; and no causality for the rest of the OECD countries in 1981–2011 period</td>
</tr>
<tr>
<td>Inglesi-Lotz et al.</td>
<td>2015</td>
<td>There is no relationship between academic researches and economic growth in BRICS except in India</td>
</tr>
<tr>
<td>Norouzi Chakeli and Maddadi</td>
<td>2016</td>
<td>There is a direct relationship between the degree of investment in science and technology and the level of development of science in the studied countries. In addition, the researchers found that countries with higher economic power have a proper position in science and technology</td>
</tr>
<tr>
<td>Erumban and Das</td>
<td>2016</td>
<td>ICT has a positive role on economic growth in India</td>
</tr>
<tr>
<td>Teixeira and Queirós</td>
<td>2016</td>
<td>There is a positive and significant relationship between human capital and economic growth</td>
</tr>
<tr>
<td>Naym and Hossain</td>
<td>2016</td>
<td>There is a positive and significant relationship between investment in ICT and economic growth in Bangladesh</td>
</tr>
<tr>
<td>Pradhan and Arvin</td>
<td>2016</td>
<td>One-way and two-way Granger interrelationship existed between ICT and economic growth in 21 studied countries</td>
</tr>
</tbody>
</table>
Table 1  Summary of the studied researches (continued)

<table>
<thead>
<tr>
<th>Researcher(s)</th>
<th>Year of the research</th>
<th>Summary of the results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hatemi-J et al.</td>
<td>2016</td>
<td>They studied the relationship between research output and economic growth in G7 countries using the asymmetric panel causality test. The results showed that only the UK shows a causal relationship from the output of research to real GDP. However, when the signs of variations are taken into account, there was an asymmetric causality running from negative research output shocks to negative real GDP shocks.</td>
</tr>
<tr>
<td>Aziz Mohammadlou</td>
<td>2016</td>
<td>There is a significant and positive relationship between industrial clusters and economic growth in Iran.</td>
</tr>
<tr>
<td>Marković et al.</td>
<td>2017</td>
<td>The purpose of this research was to develop and apply the Extreme Learning Machine (ELM) to forecast the gross domestic product (GDP) growth rate. The GDP growth was analysed based on ten science and technology factors. These factors were research and development (R&amp;D) expenditure in GDP, scientific and technical journal articles, patent applications for non-residents, patent applications for residents, trademark applications for non-residents, trademark applications for residents, total trademark applications, researchers in R&amp;D, technicians in R&amp;D and high technology exports. The ELM results were compared with genetic programming (GP), artificial neural network (ANN) and fuzzy logic results. Based upon simulation results, it is demonstrated that ELM has better forecasting capability for the GDP growth rate.</td>
</tr>
</tbody>
</table>

Reference: Researcher findings based on the studied literature

3 Research methodology

3.1 Quiddity of qualitative content analysis

Content analysis is a scientific technique, which became popular in the twentieth century. Different branches of social sciences such as communication, sociology, political science and psychology applied this method in their researches (Poole and Folger, 1981). In the beginning, this method was applied in advertisement analysis and then, it was used for informational and military objectives, but; today researchers view content analysis as a method with a high flexibility for analysing information (Cavanagh, 1997). Content analysis implies different analytical approaches, from hunching, self-analysing and interpretive methods to systematic and accurate approaches (Rosengren, 1981). Each researcher can choose the proper kind of content analysis, based on the kind of his/her study and interest. Although the flexibility of content analysis is useful for different kinds of researches, lack of concrete definition and procedure can create a severe limitation in applying this research method. Content analysis is mainly categorised
Factors affecting the relationship of science development

into two types: qualitative and quantitative, and researcher should benefit from these methods based on the research subject to avoid ambiguity (Iman and Noshadi, 2011).

Quantitative content analysis is a systematic, objective and quantitative method for measuring and analysing quantitative variables. To do so, quantitative content analysis should have four features of being objective, sequential, vivid and quantitative. In this method, analysis unit and analysis category should be defined (Iman and Noshadi, 2011).

In the middle of the twentieth century, some criticisms were raised about the shallowness of the quantitative method, in which the critics believed in the ignorance of hidden contents of the analysis in the method. To cover the problem, qualitative content analysis was developed. Qualitative content analysis is a research method, which is widely applied for analysing textual data. In addition, it can be used for ethnography, grounded theory, phenomenology and historical researches. Fundamentally, reducing the text to numbers in qualitative technique was criticised due to lack of combined data and meaning. Qualitative content analysis is applied in situations where quantitative method has some limitations. Thus, qualitative content analysis is a proper research method for subjective interpreting of textual data content via systematic categorised processes, coding and designing (making themes) of the known patterns (Iman and Noshadi, 2011).

Based on the above discussions, with qualitative analysis, an empirical, methodological and controlled approach for texts can be extracted in a systematic process. Qualitative content analysis let the researchers to interpret the authenticity and reality of the data subjectively, but in a scientific method. Validity of the results is guaranteed via a systematic codified process. Qualitative content analysis will go inside the text and reveal implicit or explicit themes of the words (Iman and Noshadi, 2011).

Based on Hsieh and Shannon (2005), different approaches to qualitative content analysis can be divided into three categories: contractual and normative content analysis, directional content analysis and abbreviated or collective content analysis. In the normative content analysis, categories are obtained simultaneously with the text content analysis. In this approach, researcher will obtain a thorough understanding of the studied phenomenon. In directional approach, researcher design his/her codified plan based on the current/previous researches, prior to begin the data analysis. Furthermore, in the analysing process, other codes are obtained and previous codes (based on the theory) will be reviewed and corrected. Researchers who used directional content analysis approach can extend the current theory, which they applied. The abbreviated content analysis approach is mainly having fundamental difference from the two previous approaches. In this approach, the researcher looks for unique terms, which are in relation to a special text. This kind of analysis will lead the researcher to interpret the meanings of particular expressions or special content of words (Hsieh and Shannon, 2005).

Reliability of the content analysis researches are in the creation of a good plan for coding. The difference among the three categories is lied in their primary design for coding. The success of the qualitative content analysis depends on the coding process in which the studied text will categorise into smaller parts for interpreting. These categorisations are patterns or subjects which is directly obtained from the text or acquired through analysing the text. In order to do coding process in content analysis, the researcher should design a plan that guides the coder in the process of content analysis. This plan is a translation instrument for organising data in different levels. Coding plan includes data process and rules which should be systematic and logical (Hsieh and Shannon, 2005).
3.2 Argument of selecting qualitative content analysis

Qualitative content analysis is a proper method for extracting information of a qualitative context and based on speeches, texts or different people’s notes about a special issue. Due to the objective of this research, qualitative content analysis should be done in order to extract the factors, which affect the relationship among science development, technology development and economic growth. In addition to literature review, qualitative content analysis should be done in order to recognise the key factors and their relationship to sub-categories of these fields. This will lead to better understanding of the factors affecting the relationship of the studied fields.

3.3 Qualitative content analysis process

Some of the steps, which are done in quantitative content analysis, should be considered in qualitative content analysis, but there are some differences which are mentioned below:

- There are no hypotheses in qualitative content analysis, and subjective premises of the researcher will lead to design research’s questions.

- Qualitative content analysis is not generally started with the thorough review of references. At first, thorough review of the references will give researcher a view and some information about the job to be done which can lead to biases and personal idea engagement through the research process and also in collection and analysis of the information. Second, the thorough review of the references will make the researcher to guide the research in a direction which he/she concluded in his/her reference review. Therefore, in qualitative researches, it is better for the researcher to do reference review after the analysis of the data. This is because, the researcher’s objective to review references is not to make a context for the studied research as a conceptual framework to accept or reject the findings, but to show a consistency between findings and prior knowledge of the research readers (Adib Haj Bagheri et al., 2007, p.32).

In addition to the above discussions, the following steps should be considered in a qualitative content analysis:

- Defining the unit of analysis: the researcher should determine the unit of the analysis such as word, sentence, paragraph, article, news, etc.

- Data reduction: the purpose of this step is to delete and remove the same and redundant texts.

- Using a categorisation system: it is crucial for the researcher to develop a research categorisation system using inductive and deductive methods; because, the main core of the qualitative content analysis is making categories and levels. Categories or levels should be comprehensive, extensive and exclusive; that is, no data should be omitted due to it cannot be categorised in a certain level and also, no data should be categorised between two levels or in more than one level. Categories or levels can include different abstract levels of sub-categories or sub-levels.
Factors affecting the relationship of science development

- Correction of the categorisation system based on data: after determining categories based on research’s data, the researcher should correct the categorisation system and if it is needed, some categories can be deleted or added.

- Qualitative data report: in the final stage, based on the available data, a report should be prepared and presented. To do so, it is necessary that the content of categorisations be described. If it is needed, the amount and frequency of categorisations and other qualitative studies can be applied (Krippendorff, 2004, pp.15–18).

Qualitative content analysis steps are illustrated in Figure 1.

**Figure 1** Qualitative content analysis steps (see online version for colours)


3.4 Qualitative content analysis steps of the present research

- Step 1: defining and determining research problem and initial investigation of theoretical literature: this step is described thoroughly in the result analysis part.

- Step 2: determining factors that affect science development, technology development and economic growth and their relationships and extracting qualitative categories from theoretical literature of the research: after thorough investigation of the theoretical literature, several tables were presented showing the effective factors on science development, technology development and economic growth. The number of documents (articles) which was studied in each field of science development, technology development, economic growth and their relationships are shown in Table 2.

**Table 2** Number of studied documents (articles) in each field of study

<table>
<thead>
<tr>
<th>Subject</th>
<th>Number of studied documents (articles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science development</td>
<td>53</td>
</tr>
<tr>
<td>Technology development</td>
<td>96</td>
</tr>
<tr>
<td>Economic growth</td>
<td>28</td>
</tr>
<tr>
<td>The relationship between science development and technology development</td>
<td>53</td>
</tr>
</tbody>
</table>
Table 2  Number of studied documents (articles) in each field of study (continued)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Number of studied documents (articles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The relationship between science development and economic growth</td>
<td>32</td>
</tr>
<tr>
<td>The relationship between technology development and economic growth</td>
<td>92</td>
</tr>
</tbody>
</table>

Reference: Researcher’s Findings (there are some joint articles among the series of the list)

- Step 3: Information analysis and Defining pattern: information analysis was done using theoretical coding. This kind of coding includes operations in which data are analysed and conceptualised and are rearranged in a new format (Flick, 2009, p.11; danaei Fard et al., 2004, p.102; Pandit, 1996). In this research, coding was applied for the three studied fields.

- Step 4: Research Audit: in order to determine the reliability and stability of the research, experts’ opinions were used.

5 Analysis of the results

5.1 Results of the thorough review of the literature

The results of thorough literature review can determine the path of qualitative content analysis. Based on the previous studies, each factor that affects science development, technology development and economic growth is illustrated in Tables (3), (4) and (5), respectively.

Table 3  Factors affecting science development

<table>
<thead>
<tr>
<th>Factors affecting science development</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing educational level of the society and attention to science and scientist</td>
<td>Aghion et al. (2009)</td>
</tr>
<tr>
<td>GDP growth</td>
<td>Vinkler (2008), Aghion et al. (2009), Lee et al. (2011), Norouzi Chakeli and Maddadi (2015)</td>
</tr>
<tr>
<td>Coordination and integration of science policy making institutions</td>
<td>Zaker Salehi (2011)</td>
</tr>
</tbody>
</table>
**Table 3** Factors affecting science development (continued)

<table>
<thead>
<tr>
<th>Factors affecting science development</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Making a relationship between science growth and science production</td>
<td>Zaker Salehi (2011)</td>
</tr>
<tr>
<td>Development of science-oriented culture</td>
<td>Tofighi and Ferasatkhah (2002)</td>
</tr>
<tr>
<td>Development of management structures and scientific planning</td>
<td>Tofighi and Ferasatkhah (2002)</td>
</tr>
<tr>
<td>Science legal environment development (scientific ownership rights development)</td>
<td>Tofighi and Ferasatkhah (2002)</td>
</tr>
<tr>
<td>Development of standard and evaluation and credit rating system and national monitoring of science</td>
<td>Tofighi and Ferasatkhah (2002)</td>
</tr>
<tr>
<td>Development of ICT</td>
<td>Tofighi and Ferasatkhah (2002)</td>
</tr>
<tr>
<td>Science infrastructures, facilities and equipment development</td>
<td>Tofighi and Ferasatkhah (2002)</td>
</tr>
<tr>
<td>Development of scientific societies and their independence</td>
<td>Tofighi and Ferasatkhah (2002)</td>
</tr>
</tbody>
</table>

Reference: Researcher findings based on the studied literature

**Table 4** Factors affecting technology development

<table>
<thead>
<tr>
<th>Factors affecting technology development</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing the amount of patents</td>
<td>Gerschenkron (1962)</td>
</tr>
<tr>
<td>Expert human resources growth (human resources development)</td>
<td>Licheng (2011)</td>
</tr>
<tr>
<td>Industrial clusters development</td>
<td>Aziz Mohammadlou (2016)</td>
</tr>
<tr>
<td>External technology import</td>
<td>Mahmoodzadeh and Mohseni (2005), Shahabadi and Sajadi (2011), Nikoumaram et al. (2013)</td>
</tr>
<tr>
<td>Improvement of industrial policy</td>
<td>Haji Hosseini (2008)</td>
</tr>
<tr>
<td>Commercial system improvement</td>
<td>Haji Hosseini (2008)</td>
</tr>
<tr>
<td>Price of production factors</td>
<td>Haji Hosseini (2008)</td>
</tr>
<tr>
<td>Technology legal environment development</td>
<td>Haji Hosseini (2008)</td>
</tr>
<tr>
<td>Improvement of technology management system and coordination of industrial policy making units</td>
<td>Haji Hosseini (2008)</td>
</tr>
</tbody>
</table>

Reference: Researcher findings based on the studied literature
Table 5  Factors affecting economic growth

<table>
<thead>
<tr>
<th>Factors affecting economic growth</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population growth rate</td>
<td>Arrow (1962), Komeyjani and Mahmoodzadeh (2008), Dalali Isfahani et al. (2012)</td>
</tr>
<tr>
<td>Productivity growth</td>
<td>Baumol (1986)</td>
</tr>
<tr>
<td>GDP per capita growth</td>
<td>Baumol (1986)</td>
</tr>
<tr>
<td>Export growth</td>
<td>Baumol (1986)</td>
</tr>
<tr>
<td>GNP growth</td>
<td>Dejpasand (2005), Jalalabadi and Bahrami (2010)</td>
</tr>
<tr>
<td>Economic- political convergence</td>
<td>Abramovitz (1986)</td>
</tr>
<tr>
<td>Commercial innovation growth</td>
<td>Jaffe (1989), Fagerberg and Srholec (2008), Nikoumaram et al. (2013)</td>
</tr>
<tr>
<td>Costs related to scientific projects</td>
<td>Romer (1990)</td>
</tr>
<tr>
<td>Technological revolutions (technological innovations)</td>
<td>Plosila (2004), Aghion et al. (2009), Zhao and Hai-qing (2012)</td>
</tr>
<tr>
<td>Governance quality</td>
<td>Fagerberg and Srholec (2008)</td>
</tr>
<tr>
<td>Characteristics of the political system</td>
<td>Fagerberg and Srholec (2008)</td>
</tr>
<tr>
<td>Economic freedom and the degree of foreign trade freedom</td>
<td>Fagerberg and Srholec (2008)</td>
</tr>
<tr>
<td>Economic competition growth</td>
<td>Aghion et al. (2009)</td>
</tr>
<tr>
<td>Technological knowledge</td>
<td>Kim and Lee (2015)</td>
</tr>
<tr>
<td>Financial development</td>
<td>Pradhan et al. (2015), Shahabadi and Sajadi (2011)</td>
</tr>
<tr>
<td>Increasing the number of patents</td>
<td>Marković et al. (2017)</td>
</tr>
<tr>
<td>Increasing the number of brand declaration</td>
<td>Marković et al. (2017)</td>
</tr>
<tr>
<td>Increasing the number of researches and workers in R&amp;D</td>
<td>Marković et al. (2017)</td>
</tr>
<tr>
<td>Export of High-tech products</td>
<td>Marković et al. (2017)</td>
</tr>
</tbody>
</table>
Factors affecting the relationship of science development

Table 5  Factors affecting economic growth (continued)

<table>
<thead>
<tr>
<th>Factors affecting economic growth</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imported technology (intermediary and investing imports)</td>
<td>Mahmoodzadeh and Mohseni (2005), Shahabadi and Sajadi (2011), Nikoumaram et al. (2013)</td>
</tr>
<tr>
<td>Inflation rate</td>
<td>Komeyjani and Mahmoodzadeh (2008)</td>
</tr>
<tr>
<td>Tourism development</td>
<td>Pourfaraj et al. (2011)</td>
</tr>
<tr>
<td>Physical capital accumulation ownership rights</td>
<td>Dejpasand (2005), Jalalabadi and Bahrami (2010)</td>
</tr>
<tr>
<td>FDI</td>
<td>Shahabadi and Sajadi (2011), Nikoumaram et al. (2013)</td>
</tr>
<tr>
<td>Industrial clusters development</td>
<td>Aziz Mohammadlou (2016)</td>
</tr>
<tr>
<td>Educational capital accumulation</td>
<td>Dejpasand (2005), Jalalabadi and Bahrami (2010)</td>
</tr>
</tbody>
</table>

Reference: Researcher findings based on the studied literature

5.2  Findings of the qualitative content analysis

As it is stated, qualitative content analysis of this research contains four major steps:

1  Defining and determining research problem and initial investigation of theoretical literature.

2  Determining factors which affect science development, technology development and economic growth and their relationships and extracting qualitative categories from theoretical literature of the research.

3  Information analysis and defining pattern.

4  Research audit.

Steps 1 and 2 were done in the literature review section and analysed in part 5-1 of this research. Factors and sub-factors which were extracted from documents (articles) coding of the related fields, are illustrated in Tables 6–8.

In order to determine the reliability and stability of research, experts’ suggestions were applied.

Table 6  Factors and sub-factors affecting science development

<table>
<thead>
<tr>
<th>Factors</th>
<th>Sub-factors</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing the amount of articles in scientific and specialised journals</td>
<td>Quantity of ISI and ISC articles, active participation in national and international conferences and meetings, active participation in scientific speeches and TV scientific seminars, impact factor, g index and h index increase, growth of basic researches</td>
<td>Baumol (1986), Abramovitz (1986), Jaffe (1989), Mansfield (1991), Vinkler (2008), Lee et al. (2011), Inglesi-Lotz and Poris (2013), Inglesi-Lotz et al. (2014), Ntuli et al. (2015), Inglesi-Lotz et al. (2015), Hatemi-J et al. (2016)</td>
</tr>
</tbody>
</table>
### Table 6  Factors and sub-factors affecting science development (continued)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Sub-factors</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing educational level of the society and attention to science</td>
<td>quantity of workers in academic sectors, quantity of university students,</td>
<td>Aghion et al. (2009), Tofighi and Ferasatkhah</td>
</tr>
<tr>
<td>and scientist (science-oriented culture)</td>
<td>percentage of the students in comparison to non-students, percentage of</td>
<td>(2002)</td>
</tr>
<tr>
<td></td>
<td>educated people in comparison to non-educated people in the society</td>
<td></td>
</tr>
<tr>
<td>Growth of expert human resources (human resources development)</td>
<td>Growth of academic education, growth of elementary and high school</td>
<td>Licheng (2011), Tofighi and Ferasatkhah</td>
</tr>
<tr>
<td></td>
<td>education, growth of higher education degrees, growth of experts in R&amp;D</td>
<td>(2002)</td>
</tr>
<tr>
<td></td>
<td>sector</td>
<td></td>
</tr>
<tr>
<td>Increasing the budget of academic researches (finance and credit</td>
<td>Percentage of budget which ministries allocate to scientific researches</td>
<td>Licheng (2011), Jie (2013), Tofighi and</td>
</tr>
<tr>
<td>development)</td>
<td></td>
<td>Ferasatkhah (2002)</td>
</tr>
<tr>
<td>GDP growth</td>
<td>Portion of research and scientific budget from production</td>
<td>Vinkler (2008), Aghion et al. (2009), Lee et</td>
</tr>
<tr>
<td>Coordination and integration of science policy making institutions</td>
<td>Structural development of scientific management and planning</td>
<td>Zaker Salehi (2011), Tofighi and Ferasatkhah</td>
</tr>
<tr>
<td>Science institutions development and their independence</td>
<td>Making a relationship between science growth and science production</td>
<td>(2002)</td>
</tr>
<tr>
<td>Science legal environment development (scientific ownership rights</td>
<td>Special attention to intellectual ownership rights, development of</td>
<td>Tofighi and Ferasatkhah (2002)</td>
</tr>
<tr>
<td>development)</td>
<td>scientific national evaluation system standards</td>
<td></td>
</tr>
<tr>
<td>Science infrastructures, facilities and equipment development</td>
<td>ICT development</td>
<td>Tofighi and Ferasatkhah (2002)</td>
</tr>
</tbody>
</table>

Reference: Researcher findings

### Table 7  Factors and sub-factors affecting technology development

<table>
<thead>
<tr>
<th>Factors</th>
<th>Sub-factors</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing the amount of patents</td>
<td>Quantity of registered inventions and explorations, quantity of registered</td>
<td>Gerschenkron (1962), Marković et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>trademarks</td>
<td></td>
</tr>
<tr>
<td>Basic and applied researches growth</td>
<td>Quantity of commercialised articles</td>
<td>Mowery and Rosenberg (1991), Cohen et al. (2002),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mazzoleni and Nelson (2007)</td>
</tr>
<tr>
<td>Expert human resources growth (human resources development)</td>
<td>Quantity of workers and experts in R&amp;D sector</td>
<td>Licheng (2011)</td>
</tr>
</tbody>
</table>
## Table 7  
Factors and sub-factors affecting technology development (continued)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Sub-factors</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement of industrial policy</td>
<td>Development of technology management system and coordination of industrial policy making units</td>
<td>Haji Hosseini (2008)</td>
</tr>
<tr>
<td>Commercial system improvement</td>
<td>Growth of industrial units, increasing the amount of production, increasing the amount of products and services exports, price reduction of production factors</td>
<td>Haji Hosseini (2008)</td>
</tr>
<tr>
<td>Technology legal environment development</td>
<td>Special attention to industrial intellectual ownership rights, development of technology national evaluation system standards</td>
<td>Haji Hosseini (2008)</td>
</tr>
<tr>
<td>Technology infrastructures, facilities and equipment development</td>
<td>ICT development</td>
<td>Naym and Hossain (2016), Pradhan and Arvin (2016)</td>
</tr>
</tbody>
</table>

Reference: Researcher findings

## Table 8  
Factors and sub-factors affecting economic growth

<table>
<thead>
<tr>
<th>Factors</th>
<th>Sub-factors</th>
<th>References</th>
</tr>
</thead>
</table>
### Table 8  
Factors and sub-factors affecting economic growth (continued)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Sub-factors</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic-political convergence</td>
<td>Quality of governance, characteristics of the political system, economic freedom, degree of foreign trade freedom, tourism development policies, growth of economic competition</td>
<td>Abramovitz (1986), Fagerberg and Srholec (2008), Aghion et al. (2009), Dejpasand (2005), Jalalabadi and Bahrami (2010), Pourfaraj et al. (2011)</td>
</tr>
<tr>
<td>Workforce quality (human capital accumulation)</td>
<td>Quality and quantity of products and services</td>
<td>Aghion et al. (2009), Teixeira and Queirós (2016), Shahabadi and Sajadi (2011), Mehrgan et al. (2012), Dalali Isfahani et al. (2012), Nikoumaram et al. (2013), Dejpasand (2005), Jalalabadi and Bahrami (2010)</td>
</tr>
<tr>
<td>Ownership rights</td>
<td>Development of intellectual ownership rights</td>
<td>Nikoumaram et al. (2013)</td>
</tr>
<tr>
<td>Other macroeconomic factors</td>
<td>Inflation rate, interest rate, exchange rate, etc.</td>
<td>Komeyjani and Mahmoodzadeh (2008)</td>
</tr>
<tr>
<td>Science and technology infrastructures, facilities and equipment development</td>
<td>ICT development</td>
<td>Tofighi and Ferasarkhah (2002), Naym and Hossain (2016), Pradhan and Arvin (2016)</td>
</tr>
</tbody>
</table>

Reference: Researcher findings

6 Conclusion and further research

After several corrections, nine factors of the amount of articles in scientific and specialised journals, science-oriented culture, human resources development, finance and credit development, GDP growth, coordination and integration of science policy making institutions, science institutions development and their independence, scientific
ownership rights development and finally, science infrastructures and facilities
development were determined as effective factors on science development. In addition,
ineight factors of increasing the amount of patents, basic and applied researches growth,
expert human resources growth (human resources development), growth of R&D budget,
GDP growth, improvement of industrial policy, commercial system improvement,
technology legal environment development and technology infrastructures, facilities and
equipment development were determined as effective factors on technology development.

Furthermore, eight factors of population growth rate, GDP per capita growth,
economic-political convergence, investment in R&D, workforce quality, ownership rights
and other macroeconomic factors and science and technology infrastructures, facilities
and equipment development were determined as effective factors on economic growth.
Finally, 14 cofactors were determined for the relationship among science development,
technology development and economic growth. The results will shed light for future
research in the field.

It should be mentioned that each factor has some sub-factors which composed that
factor. After integrating the factors, 14 cofactors were determined which affect the
relationship of the three studied fields which are illustrated in Table 9.

Table 9 Integration of factors affecting the relationship of the three studied fields

<table>
<thead>
<tr>
<th>No</th>
<th>Determined cofactors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Increasing the amount of articles in scientific and specialised journals</td>
</tr>
<tr>
<td>2</td>
<td>Development of science-oriented culture</td>
</tr>
<tr>
<td>3</td>
<td>Development of the quality and quantity of expert human resources</td>
</tr>
<tr>
<td>4</td>
<td>Increasing in budget and investments of academic researches and industrial R&amp;D</td>
</tr>
<tr>
<td>5</td>
<td>GDP growth</td>
</tr>
<tr>
<td>6</td>
<td>Coordination, development and integration of science and technology policy making institutions</td>
</tr>
<tr>
<td>7</td>
<td>Development of science institutions and their independence</td>
</tr>
<tr>
<td>8</td>
<td>Development of science and technology legal environment</td>
</tr>
<tr>
<td>9</td>
<td>Science and technology infrastructures, facilities and equipment development</td>
</tr>
<tr>
<td>10</td>
<td>Increasing the amount of patents</td>
</tr>
<tr>
<td>11</td>
<td>Development of commercial system</td>
</tr>
<tr>
<td>12</td>
<td>Population growth rate</td>
</tr>
<tr>
<td>13</td>
<td>Economic-political convergence</td>
</tr>
<tr>
<td>14</td>
<td>Other macroeconomic variables (interest rate, inflation rate, exchange rate, etc.)</td>
</tr>
</tbody>
</table>

*Source*: Researcher findings

These cofactors can shed light on the further research in the relationship among science
development, technology development and economic growth using DEMATEL or
Interpretive Structural Modelling (ISM) techniques.
References


Flick, U. (2009) *An Introduction to Qualitative Research*, Sage, USA.
Factors affecting the relationship of science development


Factors affecting the relationship of science development


**Notes**

1 Brazil, Russia, India, China and South Africa.

2 Quantitative content analysis steps are as follows: making hypothesis, reviewing texts and references, subject definition, defining categories, coding categories, data collection, findings collection, data interpretation and offering suggestions (Stokes, 2012, pp.61–63).

3 This process will be done when interview and other oral methods of collecting information are applied in qualitative researches. If written texts are used, the initial study of the texts is allowed.