



Neoclassical versus evolutionary economics in developing countries: convergence of policy implications

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Abstract This paper aims to determine whether the dichotomy between the science, technology, and innovation policy based on neoclassical and evolutionary schools of economics is applicable to developing countries. Regarding the fundamental differences in foundations of these two economic paradigms, policymakers have been forced to select and to follow one of the two seemingly competing views. However, in developing countries, due to various market and government coordination failures, complying with one of the schools has not been successful in practice. From the past, there has been some controversy between neoclassical and evolutionary schools on the subject of science, technology and innovation policy. Using a survey questionnaire and statistical analyses of the results, this paper shows that, due to the institutional setting and structural conditions in developing countries, despite the fundamentally different foundations of the competing schools of thought, the policy implications of the schools have converged. Drawing on Theme Analysis Method, the rationales are first conceptualized and then the fuzzy method is applied to reveal the respondents' tendency to the extracted rationales and implications of the two competing schools. In conclusion, the statistical results validate the proposed hypothesis.

Keywords Technology policy · Evolutionary economics · Neoclassical economics · Policy rationale · Fuzzy method

1 Introduction

During the last two decades, policy makers in the developing countries have faced major challenges in the selection of suitable economic policies. On the one hand, the

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international organizations, such as the World Bank and International Monetary Fund, have conditioned their financial support to the recipient country's willingness to implement neoliberal economic measures, which are based on neoclassical economic theory. Examples of measures include: avoiding selective industrial and economic adjustment policies, adopting free trade regimes, and reducing government expenditures as well as other economic interventions. On the other hand, the success of industrial policy states such as Austria, France, and Sweden in Europe, and China, Japan, South Korea and Taiwan in the Far East (Lall, Learning from the Asian Tigers 1996) point to the effectiveness of a different economic paradigm, which set the theoretical foundation for the pattern of technological development of these countries (Lall and Teubal 1998). The alternative economic paradigm is evolutionary economics, which sheds light on nature of development (Metcalfe 1994).

The challenge of selecting from the competing schools of economic thought as the theoretical basis for policy formation along with inefficiency of institutional structures, especially in the field of science and technology (Lundvall, et al. 2009), has led to difficulties in science and technology policy making. Alternative policy options available for the policymakers, which emerge from different schools of thought, tend to increase economic uncertainty, especially in developing countries. Some of these policy options may arise having to choose from contradictory policies¹ such as:

- Export promotion against import substitution,
- Policy analysis at micro or firm level against the macro and sectoral level,
- Adopting selective policy against avoiding it,
- Creating a competitive market against monopolies to achieve economies of scale
- Linear approach² to innovation against a systematic approach to innovation.

These policy options are different and policymakers react to them in different ways. Therefore, the main question of this study is "Are the developing countries faced with selecting one of the two different ways or they can benefit from hybrid choices?"

A vast literature has evolved that deals with the differences between neoclassical and evolutionary approaches in the study of theoretical foundations and economic implications of science, technology and innovation policy (Moreau 2004; Dolfisma and Seo 2013). However, it appears that, in many developing countries, not only do the two competing schools of thought not diverge, but seemingly they tend to converge in the science, technology and innovation (STI) policy arena.

The hypothesis of this research is "Policy implications of evolutionary economics and neoclassical economics in the science, technology and innovation policymaking fields in developing countries are not contradictory, but are convergent". In this paper, "Convergence" means that the policy implications of these two approaches are not only compatible but have some features in common. Our hypothesis has been tested through a case study of Iran, which is an example of a developing country, and its data are available to the authors. Although the especial conditions of Iran as many other

¹ Please see (Lall and Teubal 1998) and (Bach and Matt 2005).

² Basic research, applied research and development - R&D, collectively, make up a structure referred to as the linear model of innovation. The model postulates that innovation starts with basic research, then adds applied research and development, and ends with production and diffusion. For almost half a century, this formation has played a decisive role in policymaking (Godin 2006) .

developing countries, limits the generalization of the results, this country has most of the technological characteristics similar to other developing countries. These characteristics include low capacity of technology absorption and innovation at the firm level, low technological competitiveness, and institutional weakness in the components and relationships among different innovation systems. Therefore, Iran can be a good example of a developing country in terms of technological characteristics.

Despite existing similarities and similar structural issues between Iran's innovation and technology institutions and those of the other developing countries, imposing the sanctions related to Iran's nuclear program is an important factor, which challenges the generalizability of the results of this study. Reducing oil revenues and increasing the cost of international payments reached its peak in 2011 and 2012, confronting Iran's program of innovation and technology development with challenges. However, the sanctions have had positive effects on Iran's technology development program. For instance, the emergency situation for increasing the internal capacities of the oil and gas industry, especially in South Pars gas field development projects during the heyday of sanctions, is an example of institutional change towards enhancing technologies and innovation (Mirimoghadam and Ghazinoory 2015). Altogether, the sanctions have had both positive and negative effects on Iran's technology development system. As explained in the following sections, extracting the theoretical foundations and policy rationales of neoclassical and evolutionary approaches has been done generally and without regard to the specific circumstances of Iran. But, the special conditions of Iran, particularly the recent sanctions, influence the third part of the designed model, which is the selection of policy implications. In [section 6](#) of this paper, the impact of sanctions on the results is discussed further.

A mixed method is used to test the research hypotheses. In the first stage, using thematic analysis, the policy rationales of the two competing approaches for innovation and technology policymaking have been extracted and, on the basis of these rationales, the policy implications have been formulated. In the second stage of this study, using a quantitative survey (designed in the form of the distributed questionnaires) and by utilizing the fuzzy and differentiation tests, the trend of convergence among advocates of the two approaches is measured.

To facilitate the assessment of the two approaches, and comparison between them, both approaches are discussed in terms of three categories: theoretical foundations, policy rationales, and policy implications. The method of extracting these categories is explained in [sections 2](#) through four of this paper. In [section 5](#), to eliminate the hesitant respondents (people who cannot be assigned to one of the school of thoughts) and to identify the proponents of each approach, the fuzzy clustering method has been utilized.

We cannot reject the hypothesis, which is convergence of the policy implications of the contending schools. In fact, enabling the firms to enhance their technological capabilities building in the developing countries has occurred in a gray area, in which government provides a mix of competitive and supportive policies for firms. We note that too much emphasis on neoclassical approaches and the development of competition pressure limits the technological capabilities of the firms in developing countries, and ultimately leads to an increase in imports and decrease in industrial competitiveness. Based on evolutionary economics policy, to enhance the absorptive capacity in the developing countries is different from a policy of achieving the same goal in the

developed countries. The development of technological capability in the developing world requires intelligent intervention of the government. Indeed, for the developing economies, mere reliance on prescriptions issued by free market economics is not compatible with the existing institutional weaknesses. The conceptual changes in the analytical framework of conventional economics, changes such as providing more complete interpretations for market failures (Jaffe et al. 2005) identifying the special features of knowledge as a commodity (Dasgupta and David 1994), and emphasizing the presence of many uncertainties in the innovation process (Aghion et al. 2005), have been effectuated to cover these problems.

2 Neoclassical and evolutionary economic theories and technological development

Three periods can be identified concerning neoclassical and evolutionary approaches to the study of technology:

1. First Period: conventional economics is criticized because of its inability to explain technology and innovation processes. In this period, evolutionary economics as a new framework for analyzing the innovative changes and dynamism emerges.
2. Second Period: the assumptions of the conventional economics are violated, and in response to the criticisms, the restrictive assumptions of conventional economics are revised.
3. Third Period: Identification of common elements of the two schools.

During the first period, evolutionary economics emerged as a new approach in economic analysis, and was strengthened through criticizing neoclassical economics' treatment of technology as an exogenous factor in the growth process (Nelson and Winter 1974; Verspagen 2004). (Nelson and Winter 1974; Verspagen 2004).

In the second period, conventional economics approach was modified. Technological failures in developing countries that followed the prescriptions of conventional economics, the emergence of the Asian Tigers, which utilized alternative policy recommendations from those prescribed by the Washington Consensus (Lall 1996), and the serious criticisms of the theoretical assumptions and realism of the conventional economics (Lawson 2006; Colander et al. 2004) led to some changes in the framework of neoclassical economics (Arrow 1962; Fullbrook 2003; Romer 1994).

During the third period, which occurred in recent years, some efforts to synthesis the schools have taken place. These efforts include: developing a range of rationales in the field of science, technology and innovation policymaking (Laranja et al. 2008); proposing hybrid models (Dodgson, et al. 2011); explaining the commonalities and differences between these two approaches (Eparvier 2005; Silva and Teixeira 2009); emphasizing on a range of failures, such as market failures and system failures (Gustafsson and Autio 2011); and bringing together elements of neoclassical and evolutionary economics in the formulation of economic policy (Dosi et al. 2010, 2013; Fagiolo and Roventini 2012).

Although during the first period, the two approaches were very far from each other, the changes in conventional economics led to a decrease in the distance (Martina 2012).

The criticisms combined with the success of industrial policy of some developing countries, particularly the South East Asian and Latin American countries, were important factors in changing the conventional economics' approaches. Specifically, the full force of criticisms, which resulted in changes in conventional economics' assumptions and analytical frameworks, made it more relevant and compatible with the reality of institutions and market failures, especially in the developing countries. The maturity of Evolutionary economics and the modification of conventional economics make possible the development of policy advice, based on the two approaches for the developing countries particularly in area of science, technology and innovation policymaking. Accordingly, this research is conducted to understand the convergence between neoclassical and evolutionary rationales in describing the institutional conditions of developing countries.

Demonstrating the convergence of the two mentioned approaches in economic policy is essential in reducing uncertainty resulting from alternative, contradictory policies suggested by the two schools. Such a convergence of views forms a consensus on policymaking with respect to developing technology and innovation.

2.1 The theoretical foundations of the schools

In this study, we first examined the theoretical foundations of the two schools. In fact, policy implications have their roots in policy rationales, and policy rationales are developed based on the theoretical foundations. Indeed, the theoretical foundations and assumptions of the two schools, evolutionary economics and neoclassical economics, are different and contradictory. However, in this paper it is shown that, due to the special conditions of the developing countries, specifically the institutional settings in developing countries on the subject of economics of science, technology and innovation policymaking - notwithstanding the contradictions in theoretical foundations of the schools - the policy implications of the two approaches are convergent. In this subsection, we discuss the foundations of these two approaches.

At first we discuss the theoretical foundation of conventional, neoclassical economics. In Solow's growth model, which was developed in the 1950s, technology entered the model as an afterthought and was treated as an exogenous variable. The neoclassical school considered technology as readily available, which the firms could choose. The early neoclassical models essentially apply mechanistic assumptions to provide better forecasts by modeling the economy based on a closed system concept, and propose deterministic outputs (Verspagen 2004). The neoclassical world is full of causal relations, which could be understood empirically. To conduct economic analysis, the general equilibrium model takes into account, different conditions, analyzed with respect to the distance from the equilibrium point. Generally, neoclassical theories of the firms and consumers assume that both consumers and producers are rational, or at least have bounded rationality, and their utility or profit maximization behaviors are subject to budgetary, technological, and informational constraints (Eparvier 2005).

In contrast, the evolutionary approach tries to provide better understanding and interpretations for a sophisticated economic environment based on objective facts. In economic analysis, the evolutionary approach considers change and transition in conditions as a cumulative process, and studies the dynamics of the innovation methods, which create new products or processes. Agents' economic behavior, in

evolutionary economics, is a combination of imitation of others' methods, trial and error efforts for learning, and adapting to new and novel methods (Eparvier 2005). Moreover, agents' decisions are examined for different individual cognitive capacities regarding procedures, institutions, old ways, experiences, and learning (Muldera et al. 2001).

Table 1 shows the theoretical foundations of neoclassical and evolutionary approaches in science, technology and innovation.

As shown in Table 1, the two approaches have distinctive differences in their theoretical foundations. In this paper, to compare the policy implications of the two approaches, we employ an intermediate concept, that of policy rationale. In the following section, policy rationales of neoclassical and evolutionary approaches are introduced.

3 Policy rationales

Besides such concepts as policy tools, policy implications, and policy mix, there is another important notion of policy: policy rationale (Wieczorek et al. 2009). Depending

Table 1 Theoretical foundations of neoclassical and evolutionary approaches in science, technology and innovation economy field

Row	Subject	Neoclassical Economics	Evolutionary Economics
1	Goal of Model	Economic modeling should be based on closed system concept, providing deterministic outputs, and better capability for forecasting.	Economic modeling should be based on economic facts and provide better knowledge of objective complexity of economic environment.
2	Firm Modeling	In economic analysis, it would be better to consider one standardized economic firm as representative of other diverse organizations.	In economic analysis, it would be better to consider economic firms as heterogeneous organizations.
3	Role of information	Economic firms have complete required information. Some asymmetries in information also could be considered.	Information among agents is highly non-uniform and various and in many cases the types of information are different.
4	Decision Making	It would be better to consider the decision making model of economic agents as a comprehensive rationale model, or at least as bounded rationale model.	Different factors, including regulations, procedures, institutions, old ways and continuous changes in economic players' cognitive capacity affect their decisions.
5	Economic Behavior	Economic agents' behavior based on maximizing profit and desirability and in condition of facing different budgetary, technological and informational constraints.	The agents' behavior should be regarded as a combination of imitation of others' method, trial and error for learning and adapting to new and novel methods.
6	Economic Analysis	In economic analysis, it would be better to do the analysis based on an assumed general equilibrium condition and identify the imbalances periodically according to the distance from balanced condition.	In economic analysis, change/ transition in conditions should be analyzed as cumulative and evolutionary process, and innovation methods and creation of new products and processes should be identified dynamically.

on the level of analysis, policy scholars furnished different definitions of policy rationales. At the macro level, policy rationale is defined as the provision of a set of visions, that specify how and when policy actions should be undertaken (Bach and Matt 2005). Others have defined rationales as outcomes of theoretical concepts and frameworks, which suggest designing and applying specific policy tools and contradict other interventions (Salmenkaita and Salo 2002). Along with the above-mentioned macro and micro approaches in defining policy rationales, there is an intermediate approach that has more advocates in the policymaking field. From this perspective, rationales are intermediary between philosophical and theoretical foundations, on the one hand, and between advisory tools, on the other. Rationales are structured patterns that are the tacit or explicit outcome of academic concepts and theories, and guide policy design, utilization and assessment (Laranja et al. 2008). For implementing of the research plan for this paper, “policy rationales” is used as a conceptual connector between highly abstract theoretical foundations and policy implications.

Although in most cases, rationales do not end in detailed conclusive policy advice, they have a prominent importance in creating relations between theoretical and conceptual frameworks and applied and practical advice. Therefore, in this paper, to extract policy advice derived from neoclassical and evolutionary approaches, policy rationales are used for collecting, classifying and assessing various subjects in science and technology policy. Hence, we use a thematic analysis method (subjective analysis) in this research. We utilize the concept of policy rationales to extract policy advice.

Different procedures are available for applying thematic analysis. Although there are some apparent differences among these procedures, almost all of them have three steps, namely, collection and description, organization and adjustment, and, finally, interpretation and representation. Wolcott’s model is one of these procedures. We employ this model because it is easy to use and suitable for extracting key policy rationales. This thematic model has the above-mentioned three steps (describe, analysis, and interpretation) (Wolcott 2008). The data that has been collected in this study were gathered from secondary sources and scientific papers in indexed information databases. The main key words for doing the search in the title and/or abstract of the papers were “Technology Policy”, “Innovation Policy”, “Conventional/ Neoclassical Economics”, “Evolutionary Economics”. The searches were done mainly in the following databases:

- Science direct (www.sciencedirect.com)
- Springer (www.springer.com)
- Wiley (www.wiley.com)
- SAGE (www.sagepub.com)
- SCOPUS (www.scopus.com)
- Emerald insight (www.emeraldinsight.com)

The main criteria for selecting the final papers were:

- Focusing on rationales and theoretical foundations,
- Comparing and illustrating the policy implications of the two approaches.

It should be mentioned that, since the purpose of extracting policy rationales is comparing the two economics schools, the comparative papers take priority in

selection. Therefore, as mentioned below, these comparative papers are common in both content analyses (Neoclassical & Evolutionary Papers).

Regarding the importance of the papers that introduce the framework of the two approaches in the treatment of technology (Solow and Nelson), we selected a time interval between 1957 and 2012. After reviewing the relevant articles, thirty articles ([Annex No. 1](#)) for extracting evolutionary economics' rationales and thirty articles ([Annex No. 2](#)) for extracting neoclassical economics' rationales were selected. In these categories, 15 papers, focusing on comparing the two approaches, are selected. In other words, from grand total of 45 selected papers based on above-mentioned criteria, 15 papers belong to neoclassical economics school, and 15 papers belong to evolutionary economics school, while 15 papers are common to two schools.

For extracting the policy rationales of evolutionary economics, related papers (listed in [Annex No. 1](#)) have been reviewed by the authors based on theme analysis. Using this method led to a two-layer model: through the first layer, the nature of evolutionary economics, and in the second layer, the related policy rationales were formed. According to the theme analysis procedure, extracted data were organized, adjusted and categorized. To this end, data were read, annotated, classified and coded. The final stage is extracting the themes. After reducing data and developing the initial open codes, themes could be determined and then adjusted. The output at this step is five main themes, were extracted from initial coding of policy rationales in the field of evolutionary economics. Although the result of data reduction and initial coding is close to original texts, by organizing themes and creating clusters of concepts, appropriate main themes could be obtained (Narimani et al. 2013).

To compare the policy implications of the two economics approaches, extracting the policy rationales of neoclassic economics is required. Therefore, based on the above-mentioned procedure for theme analysis, the key concepts of conventional economics and related policy rationales have been extracted by reviewing and analyzing the related papers, which are listed in [Annex No. 2](#). The result of this stage is extracting five policy rationales in the field of neoclassical economics (Ghazinoory et al. 2014). Rationales of evolutionary and neoclassic economics on the subject of science, technology and innovation, determined by the conceptual analysis method (theme analysis), are explained in the next two subsections.

3.1 Policy rationales of evolutionary economics in science, technology & innovation

As mentioned, to compare the two paradigms we examine them in the frameworks of theoretical foundation, policy rationales, and policy implications. The evolutionary economics scholars generally state their policy proposals qualitatively, which could lead to different interpretations. In this section, to standardize these concepts the five extracted policy rationales for science, technology and innovation policymaking are explained by utilizing thematic analysis.

3.1.1 System integration

According to this rationale, the development of scientific, technological and innovative capability is a multilateral and multifactor subject, which requires coordination and

cooperation of various institutions (Sharif 2006). Venture capital funds, credit assessment and rating agencies and investment banks are some examples of these institutions, which should be established to improve the performance of technology and innovation systems. Appropriate legislation to achieve competition, improve the business environment, and increase the efficiency of the legal system should be considered as a means to develop technology and innovation. Also facilitating institution interactions, by reducing the cost of transactions, will lead to improvements in performance capacity, which will prevent systematic failures, especially at the sector level (Malerba 2002; Etzkowitz and Leydesdorff 2000).

3.1.2 Geographical proximity

The focus of this rationale is on advantages of geographical proximity, that is, decreasing costs associated with collecting information, transportation, support, and logistic activities (Silva and Teixeira 2009). Other advantages include the creation of the synergy that is a result of homogeneity in structure of knowledge (Fagerberg and Verspagen 2002), insights, ethnics, values, as well as cultures of inhabitants in adjacent geographical areas. Industrial zones, clusters and innovative spaces are some examples of these areas. Geographical proximity can be studied in different levels, such as region, district, cluster, sector, nation and even adjacent nations and blocks of neighboring countries.

3.1.3 Evolutionary cognition

This rationale implies that the cognitive capacity of economic agents and policymakers are affected by different processes (Nelson and Nelson 2002). Due to the complex nature of systems and uncertainty of future, the emphasis is on learning as a key advantage of firms. Various policy implications are results of this rationale. These implications consist of multi-level policymaking; interactive and cooperative policymaking; balance between top-down and bottom-up approaches; consideration of the role of intermediaries, negotiators, motivators, collectors and even the role of primary dealers; government pioneering in designing new routes, creating initial samples, and enabling agents (Vandenberg and Kallis 2009).

3.1.4 Societal, cultural and environmental sustainability

The key idea of this rationale is a consideration of the economic system as an open system, which is composed of noneconomic interactions (such as societal and cultural interactions), natural environment and ecosystem (Nill and Kemp 2009). Hence, the study of societal and cultural subjects in accordance with the development of science, technology and innovation should be considered (Jaffe et al. 2005). Furthermore, to create a sustainable environment, increasing types of firms, creating variety in firms as well as other involved agents, and improving the selection process based on market and non-market selection criteria should be placed on the agenda of policymaking. At the public policy level, the intergenerational influences, the effects of long-term economic activities, especially the effects on cultural and environmental activities, should be considered in the public field. The use of local institutions and multi-level legislation are the key tools in this rationale.

3.1.5 Science and technology chain

Classifying knowledge, especially into explicit and implicit types, as well as a consideration of all functions, from creating knowledge to utilizing knowledge, are the bases of this rationale (Foray and Lundvall 1996). Providing appropriate infrastructures, human resource mobility, paying attention to demands for enhancing absorptive capability, and utilizing knowledge are the most important policy implications, which are related to the knowledge dissemination field. To consider the entire chain of knowledge and technology in policymaking, transforming explicit knowledge into implicit, and vice versa, and knowledge accumulation as well as utilization are necessary (Wieczorek et al. 2009).

3.2 Policy rationales of neoclassical economics in science, technology & innovation

Before reviewing the extracted policy rationales of neoclassical economics, some key points should be mentioned:

1. Conventional economics is less concerned with addressing the concepts such as science, technology and innovation. In fact, in competition with evolutionary economics, these concepts entered into neoclassical models and their proposed policies.
2. Although conventional economics emphasizes modeling and forecasting (Friedman 1953), neoclassical economists recommend and promote the implied practical prescriptions and policies. Indeed, there is inconsistency between their theoretical assertions and their practices.
3. To extract the policy rationales of conventional economics, in addition to direct review and analysis of the context of the papers of the scholars in this stream, other comparative studies of these schools have been used. (Eparvier 2005)

Five extracted rationales are explained below.

3.2.1 Business environment improvement

Neoclassical economists emphasize the market mechanism as the key institution in the economy and believe that the market mechanism should have the main role in formulating policies, especially in the fields of science and technology (Aghion et al. 2009). The success of the market as an economic coordination mechanism presupposes the existence of certain institutions, some of the most important of which include improving the functions of legal institutions protection of the intellectual property rights to reduce cost of interactions and related risks, and developing professional financial institutions, reducing asymmetric information and increasing transparency.

3.2.2 Facilitating mobility and spillover effects

This rationale has entered into neoclassical economics due to influence of evolutionary economics and is based on the concept of “geographic localization of knowledge spillover” and as special characteristics of “Knowledge” goods and the conditions of supply and demand (Jaffe et al. 1993).

Immobility and the effect of spill over, which are the results of asymmetric information, transferring costs, geographical characteristics, and special features of goods and services cause market failures (Loasby 2000). Eliminating information asymmetry and facilitating the dissemination of research results and the mobility of human resources are some of the policies that can be derived from this rationale (Katz and Shapiro 1985). Due to the activation of geographical proximity advantage, convenient information dissemination among firms, and improving group learning, policies such as facilitating local cooperation also should be considered. In addition, creating networks can lead to appearing proximity and network spillover effects.

3.2.3 Confine to supporting the infrastructural technologies

In neoclassical economics, it is emphasized that the intervention and selection policies among competing sectors shall not be adopted by the government, because the market mechanisms will be disturbed. Thus, states shall interfere at the national level and only for the infrastructural technologies, which affect a wide range of technical, manufacturing and industrial activities. This approach will lead to the enhancement of general technological capabilities, and knowledge development in different fields (Laranja et al. 2008).

Generally, such technologies have spillover effects on different chains of manufacturing and industrial activities, and enhance the technological and economic infrastructures.

3.2.4 Internalizing the external costs

In the case of market failures and externalities, it is recommended to use policy tools, such as protection of the intellectual property right, handling market failures, tax and subsidies to alter the prices in such a way that the optimal allocation is achieved (Bach and Matt 2005). Science and technology have the characteristics of public goods, i.e. non-excludability and non-rivalries consumption features, which lead to market failure. Furthermore, due to the nature of science and technology are externalities government should invest in pure research and education to meet the social standards. Protecting the intellectual property rights, imposing tariffs on imports, and amending tax systems should be utilized to internalize the benefits of knowledge and technology production and dissemination, in a way that all economic agents are attracted to these activities.

3.2.5 Supporting public education and basic researches

Irreversibility of investment in public education and basic science research, at least in the short term, as well as the spillover effects of R&D activities done by firms are some of key justifications of neoclassical economics in need of governmental interventions and investments in scientific infrastructures, especially for basic scientific researches (R. Nelson, *The Simple Economics of Basic Scientific Research* 1959). In other words, neoclassical economists, by making distinctions between science development policies and technology development policies, provide some justifications for states intervention. In fact, neoclassical economics' support for government intervention in the development of basic science is stronger than their supports for government

intervention in the development of technologies required for firms and businesses (Bach and Matt 2005).

4 The survey

As mentioned and explained in the introduction, the hypothesis we test using the case study of Iran is: “Policy implications of evolutionary economics and neoclassical economics in science, technology and innovation policymaking in developing countries are not contradictory, but rather are convergent”. To test this hypothesis, we designed a questionnaire with three parts:

The first part of questionnaire contains six questions on the theoretical foundations of two approaches (conventional economics and evolutionary economics). The purpose of this part of the questionnaire is to divide the respondents into two groups, advocates of conventional economics and proponents of evolutionary economics. Items of the First Part are shown in Table 2.

The second part of the questionnaire dealt with the paired comparison between policy rationales. In this part, policy rationales of the schools for similar categories are placed at the two ends of the spectrum. In fact, policy rationales are the intermediate

Table 2 Questions on theoretical foundations in the first part of the questionnaire

Row	Questions on theoretical foundations of Evolutionary economics	Questions on theoretical foundations of Conventional economics
1	In economic analysis, it would be better that economic agents are considered heterogeneous.	In economic analysis, it would be better to consider one standardized economic firm as representative of other diverse organizations.
2	Information among agents is highly non-uniform and various. Also, in many cases, the nature and types of their information are different.	Firms have complete required information. Some asymmetries in information also could be considered.
3	Factors such as regulations, procedures, institutions, past paths, and continuous changes in cognitive capacity of economic actors, affect the actor's decisions.	Rational decision making by economic agents is a reasonable assumption
4	The agents' behavior should be considered as a combination of imitation of others' methods, trial and error for learning and adjusting to new and novel methods.	The postulates of profitable and utility maximization subject to budgetary constraint reasonably depict reality.
5	In economic analysis, change/ transition in conditions should be analyzed as a cumulative and evolutionary process, and innovation methods and creation of new species should be identified dynamically.	Economic analysis should be based on a general equilibrium condition, and the imbalances periodically identified according to the distance from the equilibrium.
6	Economic modeling should be based on economic facts and provide better knowledge of objective complexity of the economic environment.	Economic modeling should be based on closed system concept, as well as providing deterministic outputs, and better capability for forecasting.

Between two related questions, we use a 5 Likert scale questionnaire in this survey. Selecting each one of the two ends of the spectrum means that the respondent belongs to the related school of economic thought

category between theoretical foundation and the policy implications. Items in the second part are shown in Table 3.

Questions of the third part of the questionnaire are designed to extract policy implications for Iran and other developing countries. To this end, a 5×5 table (shown in Table 4) was designed through which all rationales of both approaches were compared pair-wise; this comparison led to the extraction of policy implications, particularly for Iran and other developing countries. Questions of the third part of the questionnaire are presented in Annex No. 3.

As shown in Table 4, to illustrate the manner of extracting the policy implications by paired comparisons of the two economic schools' rationales in Annex No. 3, evolutionary economics' rationales are indicated with numbers (1–5), and neoclassical economics' rationales are indicated with letters (A–E), so each of the extracted policy implications (25 policy implications presented in Annex No. 3) is shown by two characters (one letter & one number).

Measuring the technology and innovation policies of neoclassical and evolutionary economics should be done for various dimensions because these policies are multi-dimension. Therefore, after extracting the paired policy rationales and preparing the related questions, to increase the content validity of the questionnaire we benefit from the advice of experts and scholars active in the field of technology and innovation

Table 3 Questions about policy rationales paired comparison

Row	Questions on policy rationales regarding neoclassical economics	Questions on policy rationales regarding evolutionary economics
1	For science and technology development, facilitating business and enhancing the criteria for business environment improvement should be considered.	Because of the systematic relations between different elements of sciences and technology systems, facilitating systematic interactions among all elements of national system of innovation should be considered.
2	For decreasing the transaction costs, which are related to immobility of institutions, and to take advantage of spillover effects, selection of special zones for developing science and technology should be placed on the agenda	For taking advantage of the homogeneity in cognitive characteristics of adjacent agents, and to improve the group learning and decrease the structural uncertainties; policies based on geographical proximity should be placed on the agenda.
3	Due to the limitation of state's cognitive abilities, and to avoid the state coordination failures, selection among industrial and technological fields by state should be limited to emerging and infrastructural technologies.	Due to the main role of cognitive capacity of different agents, selection among firms, activities, industries, technologies by a development-oriented state is recommended.
4	State's general policy tools (such as tax, and subsidies should be considered in the field of science, technology and innovation policymaking to avoid the negative external effects of economic activities.	In the science, technology and innovation field, interactions among human, economy, society, culture and natural environment should be considered in a form of open system.
5	Governmental interventions and investments should confined to the development of scientific infrastructures and especially to basic scientific researches.	All functions of knowledge and technology, from education and idea generation to marketing and using, should be considered by policy makers.

Between two related questions, we use a 5 Likert scale questionnaire in this survey. Selecting each one of the two ends of the spectrum means that the respondent belongs to the related economic school of thought

policymaking. In order to prove the validity of the three questionnaires, before starting the field study and distributing the questionnaires, the text of the questions have been reviewed with several experts of the target population.³ At the end, final criteria (questions) are formulated in three parts (theoretical foundation, policy rationales, policy implications).

4.1 Questionnaire

The validity of responses to the questions in the questionnaire hinges upon the respondent's knowledge of economic theory and policymaking experiences.⁴ To meet the first characteristic, the scope of the research was limited to the people who have graduate degrees in economics. However, fulfilling the second requirement encountered barriers. First, academic programs in the field of economic of science, technology and innovation policymaking in Iran as in many other developing countries began not too long ago and only a few graduates in this field have work experience in policymaking. Second, in Iran as in many other developing countries, policymaking is not directly related to the academic and scientific studies, and research results⁵; hence, the key decision makers in the field of economic science and technology in Iran are perhaps not well-suited to respond properly to the questionnaire. Therefore, the scope of the research has been limited to the graduates in relevant major fields of study who are working in economic science and technology policymaking in Iran.

Employees in area of technology and innovation who graduated in fields related to economic policymaking for science development, technology and innovation constitute the target statistical population of this research. To recognize this population, first, the related sections (organizations) to technology and innovation policymaking were identified, then the related educational fields of study were determined. According to the researchers' estimation, which is confirmed by the vice-president for science and technology, the number of target population is around 140 individuals; half of this number was selected randomly, stressing all the related institutions (organizations), involved in technology and innovation

³ Similar to the other members of the target population, they are graduates of the related field of science and innovation policymaking, and have work experience in this field. Five People, who have related educational and work experiences, were selected randomly as the assessors, and after implementing the assessment, they were set aside from the target population and did not complete the finalized questionnaire.

⁴ The first educational program for technology and innovation policymaking in Iran was established in 2000 in the form of training courses (not an academic program), the participants in these training courses fewer than ten individuals. However, in 2010 a doctorate program was established in Tarbiat Modares University for science and technology policymaking studies. In the first year, four students were accepted. Also from 2005 four other universities in Tehran started other related programs such as technology management, entrepreneurship management, future studies in the frame of graduate programs (Master and PHD) with limited entrances. Based on the correspondence with the Vice-Presidency for Science and Technology, by 2013, when this study was conducted, fewer than 500 people in fields related to technology and innovation graduated.

⁵ Key institutions (organizations) related to science and technology policymaking in Iran are as follows: vice-presidency for science and technology; Supreme council of cultural revolution; Ministry of science, research and technology; sections related to technology policymaking in ministries of information and communication technology, Oil, Energy, Defense, Health and treatment and medical education, Agriculture jihad. According to the estimates, fewer than 450 individuals in above-mentioned organizations are working in related field of innovation and technology policymaking, and more than 70% of these people have studied fields other than innovation and technology policymaking.

Table 4 Comparison table for extracting policy implications

		A: Business Environment Improvement	B: Facilitating Mobility and Spillover Effects	C: General Purpose Technologies (GPT)	D: Internalizing the External Costs	E: Growth by Human and Intellectual Capital Accumulation
Policy Rationales Based on Neoclassical Economics						
Policy Rationales Based on Evolutionary Economics	1: System Integration	A1	B1	C1	D1	E1
	2: Geographical Proximity	A2	B2	C2	D2	E2
	3: Evolutionary Cognition	A3	B2	C3	D3	E3
	4: Societal, Cultural and Environmental Sustainability	A4	B4	C4	D4	E4
	5: Science and Technology Chain	A5	B5	C5	D5	E5

policymaking in Iran. Finally, 66 questionnaires were utilized for implementing the statistical tests.

Indeed, this combination of the respondents would be an important limitation for the current research. As is shown in Table 5, 28 people (42%) of the respondents have more than 5 years of work experience in field of science, technology and innovation policymaking, and the others have between 1 and 5 years of work experiences.

Most of the respondents replied via the Internet and a few people completed the questionnaires manually. After examining the answers, 66 usable questionnaires were selected and further analyses was conducted. We use S-Plus software to analyze the results.

Due to the lack of similar studies, the number of the final sample for this survey has been determined based on the estimation of standard deviation indicator for a preliminary ten (10) samples, as shown in Table 6:

According to the above Table, the maximum standard deviation indicator belongs to the six questions of the First Part of the questionnaire, Variables. Therefore, the final sample size for this study is calculated based on these variables and by considering 0.5 as the minimum acceptable error, (half of the space between Likert scales). The results are presented in Table 7.

Thus, with a sample size of 60 (or more), we ensure that the reality of the target population with a high confidence level can be achieved.

5 Survey results

The survey analysis involved two main steps, 1) Identifying the advocates of two schools based on the theoretical foundations, 2) discrimination test among

Table 5 The questionnaire respondents characteristics

Experience	No.	Position/ Post	No.	Major Field of Study	No.	Level of Education	No.
Less than 5 Years	38	Expert	56	Economics	28	MSc.	31
Between 5 and 10 Years	21	Manager	10	Science & Technology Policymaking	10	Ph.D.	35
Between 10 and 15 Years	2			Management/ MBA	9		
More than 15 Years	5			Industrial Engineering	5		
				Science Philosophy/ Future Studies	4		
				Energy Engineering	2		
				General Engineering	5		
				International Relations & Social Sciences	2		
				No Answer	1		
Total	66		66		66		66

Half of the respondents are employees of Iranian Vice-Presidency for Science and Technology's headquarters and its affiliates. The other respondents are generally employees of Ministry of Science, Research and Technology and the Ministry of Economic Affairs and Finance of Iran

three categories of questions in the questionnaire. These two steps are explained in the following sections.

5.1 First step: identifying the advocates of Two schools based on theoretical foundations

In this step, hesitant respondents were identified by using the "Fuzzy Partitioning and clustering" method, and eliminated from further analysis to divide advocates of two schools in two separated clusters. To assess the level of the clustering quality, we used Dunn's partition coefficient. Under the normalized condition, this index is equal to one when there is a certain difference among clusters, and in case of quite fuzzy clustering, the index is equal to zero. Thus, based on triple fuzzy clustering, responses to six questions of the first part of the questionnaire have been analyzed, through measuring the probability of each individual being a

Table 6 The results of the preliminary samples

Variables Indicators	Questions on Theoretical Foundations- 1st part of the questionnaire@(Table 2)	Questions on Policy Rationales- 2nd part of the questionnaire@(Table 3)	Questions on Policy Implications- 3rd part of the questionnaire@(Annex 3)
Mean Value	3.50	3.13	3.52
Standard Deviation	1.0031	0.6189	0.8486

Table 7 The results of the preliminary samples

Confidence Level Indicators	% 95	% 95	% 99	% 99
Statistical Power	% 80	% 90	% 80	% 90
Sample Size (n)	32	42	47	60

member of each of these three clusters. The respondents were assigned to clusters according to the probability of being a member of the cluster. After 37 iterations to determine eligible averages, 17 people were assigned to the hesitated cluster, 24 people to the conventional economics cluster, and 25 people to the evolutionary economics cluster. Because of the proximity of responses and closeness of the probability of samples assignment, the normalized quality coefficient in the first phase was equal to 0.07; therefore, the coefficient should be improved.

To improve the coefficient, in the second phase, 17 hesitated respondents were eliminated, and dual fuzzy clustering was implemented for the responses to the first part of the questionnaire. After 12 iterations, again respondents were clustered. The results of these two phases are shown in Table 8.

The closer to one the quality coefficient can achieve, the better the discrimination of the clusters, and vice versa. Based on the quality coefficient, although the assignments to the clusters of Neoclassical and evolutionary do not change, the quality of clustering prominently is improved. Moreover, the coefficient of samples assignment to the clusters for a deterministic categorizing is acceptable.

The centers of clusters of people belonging to Conventional economics are (2.04, 2.29, 2.08, 1.96, 2.29, and 2.46). In addition, the centers of clusters of people belonging to evolutionary economics are (3.92, 4.00, 4.48, 3.28, 4.04, and 4.40). The positions of these clusters are shown in Fig. 1.

Next, we focus our attention on a comparative analysis of the groups in the two schools of thoughts.

Table 8 The result of the clustering process

	Phase 1 (triple clustering: Conventional, Evolutionary, Hesitated cluster)	Phase 2 (Dual Clustering; the hesitated cluster is eliminated)
Normalized quality coefficient	0.07	0.28
Probability of assignment	Close and uncertain	With appropriate intervals and are acceptable
Number of clusters' members	Hesitated: 17 Conventional: 24 Evolutionary: 25	Conventional: 24 Evolutionary: 25

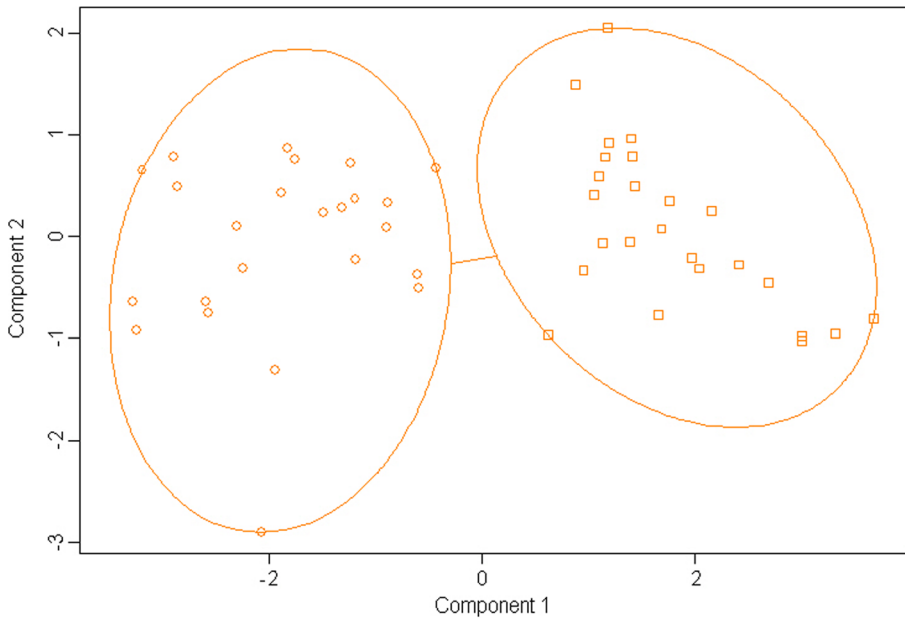


Fig. 1 The discrimination between two clusters related to Evolutionary economics and Conventional economics based on fuzzy clustering

5.2 Second step: discrimination test among three categories of questionnaire

In this step, regarding two resulted clusters from the first step, discrimination and classification tests⁶ have been undertaken on obtained data by studying three layers, namely, theoretical foundation, policy rationales and policy implications, particularly for Iran and other developing countries. The purpose of this step is to determine the discrimination between the advocates of the two schools of thoughts in theoretical foundation, policy rationales and policy implications.

In discrimination analysis, null hypothesis is equality of two means of population. The test-statistic that we used is “Hotelling T Squared”, and so, the result of the test is in the form of an F distribution. To calculate the means of the clusters distance, a Mahalanobis⁷ variable was employed. For each of the three layers, this variable was calculated.

We expect that the means of distance between centers of the two clusters in theoretical foundations part is high, for policy rationales decrease, and for policy implications become even smaller and the clusters centers become very close together.

In addition, to evaluate the accuracy of assignments, a Cross Validation test was conducted. In this test, every member of assigned cluster was taken out of the cluster and the sum of its distance with all other members of all clusters was measured to

⁶ The clustering method is utilized when the number of clusters is unknown, and when the numbers of clusters is given, the discrimination and classification test is utilized.

⁷ The Mahalanobis distance is a measure of the distance between a point P and a distribution D, introduced by P. C. Mahalanobis in 1936. It is a multi-dimensional generalization of the idea of measuring how many standard deviations away P is from the mean of D.

identify whether the assignment to current cluster is appropriate. The result of discrimination and classification test is shown in Table 9.

The test of means equality, based on six questions of the first part of the questionnaire related to theoretical foundation, and the test of means equality based on seven questions of the second part of questionnaire related to policy rationales, led to rejection of the null hypothesis (means equity). However, in the test of means equity according to twenty-five questions of the third part of questionnaire related to policy implications for Iran and other developing countries, the null hypothesis cannot be rejected. These results mean that proponents of both schools of thoughts have different ideas about theoretical foundation and policy rationales, while the extracted policy implications from these two schools do not have statistically meaningful differences.

The intervals of clusters in the first, second and third diagnostic tests are 22.75, 19.17, and 7.25, respectively. Thus, the difference of clusters means in first and second part of the questionnaire are meaningful with high certainty. As shown in Fig. 1, the difference between the two groups on theoretical foundation is significant. This difference in the second part of the questionnaire decreased but is still meaningful (see Fig. 2).

However, about the third part of the questionnaire, the differences between the two clusters are not significant. This implies that policy implications are more or less similar and convergent. (see Fig. 3)

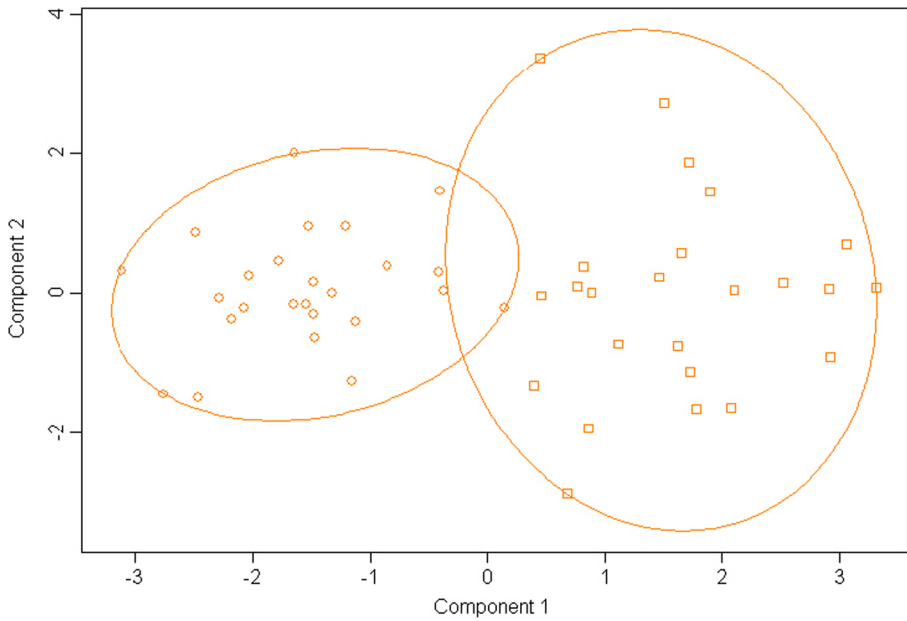
The accuracy of assignment to the clusters for the first, second, and third parts of the questionnaire are 100, 91.84, and 55.10%, respectively. This result shows the high proximity of the clusters in the third part.

The conducted analysis supports our hypothesis, that is, convergence of policy implications of Conventional and Evolutionary economics in the field of science and technology in developing countries.

It should be mentioned that assigning respondents in the clusters identified based on questions of policy rationales and policy implications of developing countries, and the

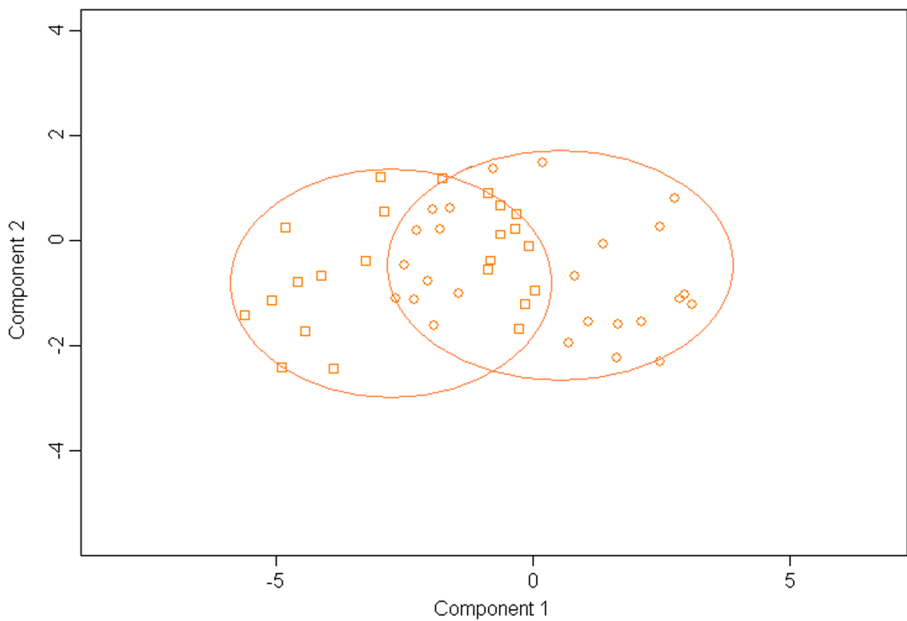
Table 9 The result of discrimination and classification test for the two clusters based on theoretical foundation, policy rationales and policy implications of Iran and other developing countries

	The probability in test of means equity	Mahalanobis variable (means of clusters' intervals)	Cross Validation (percentage of assignment correctness)
The test based on six questions of the first part of the questionnaire related to theoretical foundation	4.440892e-016 The null hypothesis is rejected	22.75436	100%
The test based on seven questions of the second part of questionnaire related to policy rationales	5.173639e-014 The null hypothesis is rejected	19.17125	91.84%
The test based on twenty five questions of the third part of questionnaire related to policy implications for Iran and other developing countries	0.0934552 The null hypothesis is supported	7.251161	55.1%



These two components explain 63.87 % of the point variability.

Fig. 2 The status of the two clusters of respondents, related to the second part of the questionnaire (questions on the contrast of the policy rationales)



These two components explain 43.34 % of the point variability.

Fig. 3 The status of the two clusters of respondents, related to the third part of the questionnaire (questions on the contrast of policy implications of Iran and other developing countries)

changes in assignments and quality coefficient has been studied and the result of discrimination test has been confirmed.

It is necessary to pay attention to the effects of Iran's certain circumstances on the obtained results of this study. Although recent sanctions against Iran reached high tide between 2012 and 2013 years, and ebbed again after nuclear agreement 2015, it should be considered that, after Iran's revolution in 1979, the country had been faced with different sanctions because of the political discrepancy between Iran and United State of America (Dobbins 2011). Reviewing the theoretical literature shows that the sanctions have had double-edged effects on Iran's economy, and its industrial and technological development trend (Majidpour 2013). On the one hand, sanctions lead to increasing the cost of providing technological knowledge and professional equipment from the international market, and, on the other hand, they reveal the essential need to rely on domestic power, and to develop the indigenous technological capabilities. Meanwhile, it should be mentioned that, since the main part of Iran's exports is crude oil, this industry has been the main target of imposed sanctions, with high impacts on this sector more than the other sectors of Iran's industries and economy (Cohen et al. 2011). Due to the double-edged impact of sanctions on Iran, adoption of dichotomous policies simultaneously becomes more important. Therefore, it should be considered that adopting the policies of evolutionary economics - which aim at enhancing the absorptive capacity and increasing the technological capabilities of domestic firms - and simultaneously adopting the neoclassic recommendations - trying to increase interaction with the renowned actors in international markets and entering into the international division of labor- is essential in order to alleviate the negative effects of the economic sanctions. In other words, since the economic sanctions have dichotomous effects on Iran's economy, technology and innovation development policy makers in Iran should adopt a combined policy emanating from neoclassical and evolutionary patterns. In fact, this is confirmation of the results of the present research. Although imposing the economic sanctions make essential the adoption of the combined policy of neoclassical and evolutionary policies, the specific circumstances of developing countries to join the leading countries (without sanctions), and require adoption of combination policies of support and competition, endogeneity and extraversion, and national selective policies and international cooperative interactions for technological development.

6 Discussion

In the majority of economic studies in the field of science, technology and innovation, scholars consider two economics schools of thought (neoclassical and evolutionary approaches) as totally separated and different. However, the situation of the developing countries is such that selecting and following one of the approaches is not possible. Indeed, in developing countries, the economy is unstable and in transition; firms do not have the required competitive capabilities for international markets, their innovation and absorptive capacities are too weak, so adoption of liberalization and open door policies leads to the destruction of the existing production capabilities. Regarding the generalization, it should be mentioned that these conditions in technology and innovation are valid for Iran and most of the other developing countries. This situation

requires the application of industrial policies, which are combinations of both approaches, particularly at the level of policy tools. In so doing, it is necessary to extract, separate and survey policy foundations and policy implications. To understand the theoretical constructs of the respective schools of thought it is necessary to identify an intermediate level between theoretical foundation and policy implication, which has not been defined in other research in this field; this intermediate level is called “Policy Rationales”. In this paper, policy rationales for each of the two approaches in the field of economic policy for developing science, technology and innovation have been determined separately. Our literature review reveals that scholars tend to create hybrid models, which are combinations of different approaches. Most of the studies attempt to move from the conventional dichotomy, mentioned above, to the efficient intermediate models.

The results of this study show that developing countries would benefit from an appropriate combination of policy implications and tools from the two approaches. The combination and arrangement of the policy elements are different according to the different conditions of the countries, although the current research faces some limitations, particularly because of the special condition of the case study and the respondents’ characteristics. In other words, some of the most important limitations in this study are (1) the specific situation of the available case study (Iran) in international technology trade and the limitations to import and export technology, and (2) lack of access to international experts in field of science, technology and innovation policymaking.

The result of statistical tests confirms the convergence of viewpoints of the two groups of advocates in policy implications. However, it should be considered that the specific institutional conditions of Iran, particularly economic sanctions, affected the result of this research. For instance, in the Cross Validation Test, fifty percent (50%) of advocates of neoclassical economics draw near to the evolutionary cluster, while forty percent of evolutionary economics advocates tend to the neoclassical cluster. Undoubtedly, the institutional problems of Iran economy in technology and innovation development alongside the issues related to the sanctions, which makes difficult the Iran economy’s entrance in the global competitive market, influenced neoclassical advocates to take some distance from the conventional prescriptions. Due to the current situation, the advocates of neoclassical economics cannot merely rely on the policy advice associated with the free market, so they have to consider the institutional and structural issues, especially for the developing countries such as Iran. On the other hand, because of the deep impact of globalization and pivotal role of international competitiveness in technology development, neoclassical advice cannot be neglected by the advocates of evolutionary economics. In the other words, the most important result of this study is the convergence of the policy implications of neoclassical and evolutionary economics for technology and innovation development in the developing countries. The important principle, which should be considered, is the necessity to utilize the mixed policies of neoclassical and evolutionary economics advice in the developing countries. However, the

manner of selecting components of mixed policy should be designed based on the local and specific conditions of the countries, and there is not one optimum prescription that fits all. Previous investments, the level of interaction with the global economy, natural and human resources advantages are important factors in selecting and mixing neoclassical and evolutionary policies.

Certainly, conducting this research on an international scale, which can benefit from the viewpoints of well-known economists and policymakers, could improve the reliability of the results. However, the result of the research, which shows the convergence of the two approaches and necessity of designing an optimized policy mix, is a key subject and can be a main solution for the developing countries.

7 Conclusion

This paper showed that, based on the limited set of observations in Iran as an example of a developing country, and notwithstanding the serious differences in theoretical foundations and some policy rationales, there is no major conflict between neoclassical theory and evolutionary in STI policymaking, especially in developing countries. This is a novel finding, given the widely held belief that these schools of thought advocate contradictory sets of policies. Through conducting a case study in Iran, we showed that these theories converge in policy recommendations. This means that the policy recommendations of the two approaches on science, technology and innovation policymaking are not only mutually exclusive, they also have numerous common features.

The results indicate that the various institutional inefficiencies in market and governmental institutions in developing countries require the application of a combination of advice of both approaches for achieving science and technology development. It should be taken into account that the design of the optimal combination of the mentioned approaches can vary depending on the special conditions of different countries.

The proposed procedure for implementing this research provides a framework for reviewing each of the economics schools via three stages (Theoretical Foundation, Policy Rationales and Policy Implications). This procedure can be used by policy makers in the field of science, technology and innovation.

The proposed Research Plan model in this paper can be a guideline for conducting similar studies at different levels, e.g. country, region and sector, to design the required procedure and model for developing science, technology and innovation. Although, the model presented in this paper is general, it has required flexibility to provide desired policies based on the special conditions under which policies should be determined. Therefore, theoretical and practical requirements can be taken into account in a comprehensive model.

Since this study focuses on the developing countries, its results cannot be generalized to the developed countries. In addition, it cannot make any claim on the type of relations between the two approaches in developing countries because their institutional conditions are different from our case study. Further research should address this question.

Annex No. 1

1. *science, technology and innovation for economic growth: linking policy research and practice in " STIG systems"*. Aghion, P., david, P.A. and foray, D. 2009, research policy, Vol. 38, pp. 681-693.
- Aghion, P., N. Bloom, Blundell R., R. Griffith, and P. Howitt. "Competition and Innovation: An Inverted-U Relationship." *The Quarterly Journal of Economics* (MIT Press) 120, no. 2 (2005): 701-728.
- Aghion, P., P.A. david, and D. foray. "science, technology and innovation for economic growth: linking policy research and practice in " STIG systems"." *research policy* 38 (2009): 681-693.
- Bach, B., and M Matt. "From Economic Foundations to S&T Policy Tools: a Comparative Analysis of the Dominant Paradigms." In *Innovation Policy in a Knowledge-Based Economy, Theory and Practice*, by P. Llerena and M. Matt. Strasbourg: Springer, 2005.
- Dasgupta, P., and P. David. "Towards a new economics of science." *Research Policy* 23 (1994): 487-521.
- Dodgson, Mark, Alan Hughes, John Foster, and Stan Metcalfe. "Systems thinking, market failure, and the development of innovation policy: The case of Australia." *Research Policy*, 2011.
- Dolfsma, W, and D. Seo. "Government policy and technological innovation—a suggested typology." *Technovation* 33 (2013): 173–179.
- Dosi, G, G. Fagiolo, and A. Roventini. "Schumpeter meeting Keynes: A policy-friendly model of endogenous growth and business cycles." *Journal of Economic Dynamics and Control* 34, no. 9 (2010): 1748-1767.
- Dosi, G., G Fagiolo, M. Napoletano, and A. Roventini. "Income distribution, credit and fiscal policies in an agent-based Keynesian model. I, ." *Journal of Economic Dynamics and Contro* 37, no. 8 (2013): 1598-1625.
- Eparvier, P. "Some Comments on the Methodological Principles of Nelson and Winter's Evolutionary Theory." *Evol. Inst. Econ. Rev.* 1, no. 2 (2005): 221-234.
- Etzkowitz, H., and L. Leydesdorff. "The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations." *Research Policy* 29 (2000): 109–123.
- Fagerberg, Jan, and Bart Verspagen. "Technology-gaps, innovation-diffusion and transformation: an evolutionary interpretation." *Research Policy* 31 (2002): 1291–1304.
- Fagiolo, G., and A. Roventini. "On the scientific status of economic policy: a tale of alternative paradigms. The Knowledge Engineering Review." 27, no. 2 (2012): 163-185.
- Foray, D., and Lundvall. "the Knowledge-Based Economy: From the Economics of Knowledge to the Learning Economy." (OECD, Employment and Growth in the Knowledge-Based Economy) 1996.
- Friedman, M. *The methodology of positive economics*. In: *Friedman M (ed) Essays in positive economics*. Chicago: University of Chicago Press, 1953.
- Fullbrook, E. (ed.). *The Crisis in Economics: Teaching, practice and ethics*. London and NewYork:

Annex No. 2

1. *science, technology and innovation for economic growth: linking policy research and practice in "STIG systems"*. **Aghion, P., David, P.A. and Foray, D.** 2009, research policy, Vol. 38, pp. 681-693.
2. **Bach, B. and Matt, M.** From Economic Foundations to S&T Policy Tools: a Comparative Analysis of the Dominant Paradigms. [book auth.] P. Llerena and M. Matt. *Innovation Policy in a Knowledge-Based Economy, Theory and Practice*. Strasbourg : Springer, 2005.
3. *Systems thinking, market failure, and the development of innovation policy: The case of Australia*. **Dodgson, Mark, et al.** 2011, Research Policy.
4. *Some Comments on the Methodological Principles of Nelson and Winter's Evolutionary Theory*. **Eparvier, P.** 2, 2005, *Evol. Inst. Econ. Rev.*, Vol. 1, pp. 221-234.
5. *the Knowledge-Based Economy: From the Economics of Knowledge to the Learning Economy*. **Foray, D. and Lundvall.** s.l.: OECD, Employment and Growth in the Knowledge-Based Economy, 1996.
6. *Market-Stimulating Technology Policies in Developing Countries: a framework with examples from East Asia*. **Lall, S and Teubal, M.** 8, 1998, *World Development* , Vol. 26, pp. 1369-1385.
7. *Policies for science, technology and innovation: Translating rationales into regional policies in a multi-level setting*. **Laranja, Manuel, Uyarra, Elvira and Flanagan, Kieron.** 2008, *Research Policy*, Vol. 37, pp. 823-835.
8. *Economic growth and technological change: A comparison of insights from a neo-classical and an evolutionary perspective*. **Muldera, P, Henri, HLF and Hofkes, MW.** 2001, *Technological Forecasting & Social Change*, Vol. 68, pp. 151-171.
9. *The Simple Economics of Basic Scientific Research*. **Nelson, R.** 3, 1959, *Journal of Political Economy*, Vol. 67, pp. 297-306.
10. *Technology, institutions, and innovation systems*. **Nelson, R.R. and Nelson, K.** 2002, *Research Policy* , Vol. 31, pp. 265-272.
11. *Institutions*. **North, DC.** 1, 1991, *Journal of Economic Perspectives*, Vol. 5, pp. 97-112.
12. **Verspagen, B.** Innovation and Economic Growth. [book auth.] Fagerberg. *The Oxford Handbook of Innovation*. 2004, pp. 487-513.
13. *Contemporary innovation policy and instruments: Challenges and implications*. **Wieczorek, Anna J., Heekert, Marko P. and Smits, Ruud.** s.l.: Innovation Studies Utrecht (ISU), 2009.
14. *The evolution of science policy and innovation studies*. **Martina, B.R.** 2012, research policy.
15. *Market Institutions and Economic Evolution*. **Loasby, BJ.** 3, 2000, *Journal of Evolutionary Economics*, Vol. 10, pp. 297-309.
16. *The Origins of Endogenous Growth*. **Romer, P.M.** 1, 1994, *The Journal of Economic Perspectives*, Vol. 8, pp. 3-22.
17. *Rationales for government intervention in the commercialization of new technologies*. **Salmenkaita, J. and Salo, A.** 2002, *Technology, Analysis & Strategic Management* , Vol. 14, pp. 183-200.
18. *A model of growth through creative destruction.*. **Aghion, P and Howitt, P.** 1992, *Econometrica*, Vol. 60, pp. 323-351.
19. *Neoclassical vs Evolutionary Theories of Economic Growth*. **Nelson, R. and Winter, S.** 336, 1974, *Economic Journal* , Vol. 84, pp. 886-905.
20. *Technical Change and the Aggregate Production Function*. **Solow, R.M.** 1957, *The Review of Economics and Statistics*, Vol. 39, pp. 312-320.
21. *The economic implications of learning by doing*. **Arrow, K.** 1962, *The review of economic studies*.
22. *Network Externalities, Competition, and Compatibility*. **Katz, M. L. Shapiro, C.** ., *American Economic Review*, Vol. 75, pp. 424-440.
23. *Transaction-Cost Economics: The Governance of Contractual Relations*. **Williamson, O.E.** 1979, *Journal of Law and Economics*, Vol. 22, pp. 233-261.
24. *Economic Performance through Time*. **North, D.C.** 1994, *American Economic Review*, Vol. 84, pp. 359-368.
25. **Acemoglu, Daron, Johnson, Simon and Robinson, James.** Institutions as the Fundamental Cause of Long-Run Growth. [book auth.] Philippe Aghion and Steven Durlauf. *Handbook of Economic Growth*. s.l.: ELSEVIER, 2005
26. *A tale of two market failures: Technology and environmental policy*. **Jaffe, A.B., et al.** 2005, *Ecological Economics* , Vol. 54, pp. 164-174.
27. *The role of the state in evolutionary economics*. **Moreau, F.** 2004, *Cambridge Journal of Economics* , Vol. 28, pp. 847-874.
28. **Rosenberg, A.** Neo-Classical Economics and Evolutionary Theory: Strange Bedfellows? *proceedings of the Biennial Meeting of the Philosophy of Science Association*. 1992, Vol. 1, pp. 174-183.
29. *A failure trichotomy in knowledge exploration and exploitation*. **Gustafsson, R and Autio, E.** 6, 2011, *Research Policy*, Vol. 40, pp. 819-831.
30. *Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations*. **Jaffe, A.B., Trajtenberg, M. and Henderson, R.** 3, 1993, *Quarterly Journal of Economics*, Vol. 108, pp. 577-598.

Annex No. 3

Questions related to paired comparison of policy implications for Iran *

Row	Questions on policy implications particularly for Iran regarding the conventional economics	Map	Questions on policy implications particularly for Iran regarding evolutionary economics
1.	Regarding the numerous institutional problems that disturb the optimal performance of market mechanism in Iran, government should implement only those activities to improve the business environment and optimize the market mechanism.	A1	Regarding the numerous institutional problems and bureaucratic drawbacks in the country's policymaking process and implementation, government should establish and activate the required institutions of innovation system to improve the performance of market institution.
2.	Government should generally support the capabilities of different geographical regions, which are activated through market priorities, and regular, spontaneous functions of business systems.	A2	Selective governmental supports of communities of different regions, which lead to learning improvement and enhancement of endogenous competitive capabilities contributing to technology development through establishing geographical facilities such as parks, clusters, incubators, corridors ...
3.	Corruption, economic rent and other existing issues in country's business environment should be rectified in a way that firms become more capable, acquire more technological capabilities, gain more market share and finally become the winner of the competition.	A3	Due to underdeveloped market mechanisms, which are related to the new technologies in the country, government should conduct the winners' selection and upbringing policy to improve the capabilities of economic players (individual or firms).
4.	Optimization of market resource allocation is the outcome of agents' decisions and lead to science and technology development in all countries; therefore, the environmental, societal and cultural issues gradually adapt to the market priorities by passing time and can be resolved by economic mechanisms in the long-run.	A4	Due to the differences in institutional structures in Iran in comparison with the developed countries, science and technology development is not possible without considering environmental, societal and cultural issues in the long-run, and government should plan for it.
5.	Competitive market is the main requirement for innovation; and to quickly reduce the size of the government, innovation policy makers should conduct privatization policy.	A5	Instead of quickly reducing the size of the government through privatization, the large and fully authorized government in Iran can be treated as an opportunity for providing required innovation functions such as: Research in governmental large enterprises, commercialization through organizing government purchases, establishing special markets for domestic productions...
6.	Duo to market inefficiency, which is related to inertia of all endowment mobility, policies to benefit from spillovers effects resulting from networking cooperation, and resulted value added should be placed in agenda of science and technology policymaking.	B1	Due to geographically dispersed institutions of science and technology and lack of adequate interactions among them in the country, in addition to facilitating corporations based on geographical proximity, networking in different areas should be considered by policymakers.
7.	Due to inefficiency of market system in Iran, which is partially due to geographical distances, the intervention by government is required to benefiting from the accumulated effects of interactions between supply and demand sides of technology.	B2	Because of differing in technological capabilities, learning facilitation and accumulation of tacit knowledge in different regions of Iran, establishing and empowering the special and professional geographical regions (such as science and technology parks, Industrial suburbs, industrial clusters and estates) are important in science and technology policymaking .
8.	Government can only support the geographical areas with successful market mechanism, the area which benefit from leading businesses, and should not to use the selective supports, the policy which leads to economic rent and corruption.	B3	Because of insufficient technological capabilities of the firms of the country policy makers should consider supports of pioneering domestic companies in different areas of technology in addition to the regional integration policies.
9.	Most of the problems for building a regional cooperation are related to the issues of competitive market, and cultural, societal and environmental issues have less effect on it.	B4	Different regions of the country have various characteristics; therefore, in technology and innovation development policy, region's sustainability capacity should be considered.
10.	The main causes of absence of regional cooperation are the issues emerging from competitive market environment, which are resolved spontaneously by appropriate policymaking.	B5	Considering the special specifications of every region such as forward and backward linkages, and the status of the required STI functions is essential.
11.	Government should only support the emerging technologies or infrastructural technologies.	C1	Government should facilitate the development of all technologies through providing and completing all institutions of innovation systems.

Questions related to paired comparison of policy implications for Iran *

Row	Questions on policy implications particularly for Iran regarding the conventional economics	Map	Questions on policy implications particularly for Iran regarding evolutionary economics
12.	Technology selection and development should be done through market mechanisms; therefore, government ought to support infrastructural technologies, which do not diminish the market performance.	C2	Government should plan for developing common technologies and domestic capabilities in different regions.
13.	Technology selection is not the responsibility of the government.	C3	The appropriate technology for a country is not necessarily the advanced or emerging technologies; it should be selected based on cognitive capability and environmental situations.
14.	The innovation and technology functions in different regions have many common features; in this respect, there are no major differences between developed and developing countries.	C4	Advanced and emerging technologies have the environmental, cultural and societal impacts, which should be considered for developing these types of technologies in the developing countries.
15.	Common functions, which are related to infrastructure development, promoting the emerging and widely used technologies should be considered by government in Iran, and the other functions should be fulfilled through market mechanisms.	C5	Not all emerging and widely used technologies are necessarily appropriate for the country; desired supporting technologies should be selected based on the national goals, the domestic economic problems, and capacities; and these policies ought to be conducted through different functions.
16.	The Iranian government should only rely on tax and subsidy policy to decrease corruption in science and technology developmental system.	D1	Government should not consider only taxes, subsidies in fighting corruption, implementing other actions such as establishing special organizations for standardizing, ranking, certifying are also essential.
17.	Supporting formation of the cooperative groups based on geographical proximities should be conducted in Iran through applying tools such as taxes, and subsidies.	D2	For internalizing the costs, facilitating cooperation based on geographical proximities should have high priority.
18.	Policy of internalizing costs should be followed in case of urgency. Government should avoid interfering in market mechanism through changing the prices.	D3	Due to the existing gap between technological capability of local firms and foreign competitors, government should avoid the liberalization policies based on reducing tariff barriers. The domestic market should be used for improving the competitiveness of local firms.
19.	Internalizing costs and changing the direction of price signaling are general tools, which can be used similarly by all governments in different societal and cultural situations. Selecting the type of technology is the decision, which is made by the firms and government only control and supervises the results.	D4	Besides the internalizing cost strategy based on taxes; eco-friendly and recycling technologies should be considered in science and technology policymaking to control the damages to the environment and minimize the different societal and cultural detrimental impacts, to achieve sustainable development.
20.	Policy of internalizing costs should be followed in a way that market functions, which are related to innovation, are taken into account such as levying tax on pollution.	D5	Government should focus the internalizing cost policy on building a series of functions, which are related to innovation development.
21.	Government should participate in developing the general infrastructures and institutions of education and research.	E1	Due to various structural inefficiencies in Iran, institutions related to innovation system (e.g. laboratory services, standardizing and credit assessment) should be supported by government.
22.	To facilitate cooperation in and among different regions of the country, government should only take into account the development of education and empowering the general research institutions.	E2	Facilitating collaboration and cooperation based on geographical proximity (e.g. clusters and parks) necessitates development of institutions, which are related to marketing and commercialization in addition to the development of education and research infrastructures.
23.	Going along with the international division of labor is the essential way for entering into market of developed countries. In fact, it is a way for learning by doing, which is done step by step.	E3	There is no advantage in entering international division of labor for developing countries. The government should use required tools such as foreign investment, in an organized manner, to develop the technological capacities and help to bring about the internal competitive capabilities.
24.	Government should take into account the general actions for developing education and research; other issues are resolved in long-term through market mechanism.	E4	In addition to general issues in field of education and research, government is responsible for environmental, societal and cultural impacts of technology developments
25.	The government responsibility is only for the basic functions related to education and research; other functions are done through market mechanism.	E5	In addition to education and research, other functions related to innovation development such as commercialization, production, and marketing should be considered by government.

References

- Aghion P, David PA, Foray D (2009) Science, technology and innovation for economic growth: linking policy research and practice in "STIG systems". *Res Policy* 38;(4)681–693
- Aghion P, Bloom N, Blundell R, Griffith R, Howitt P (2005) Competition and innovation: an inverted-U relationship. *Q J Econ* (MIT Press) 120(2):701–728
- Arrow K (1962) The economic implications of learning by doing. *Rev Econ Stud* 29;(3)155–173

- Bach B, Matt M (2005) From Economic Foundations to S&T Policy Tools: a Comparative Analysis of the Dominant Paradigms. [book auth.] P. Llerena and M. Matt. Innovation Policy in a Knowledge-Based Economy, Theory and Practice. Springer, Strasbourg
- Cohen A, Phillips J, Graham O (2011) Iran's energy sector: a target vulnerable to sanctions. The Heritage Foundation 2508
- Colander D, Holt RP, Jr Rosser JB (2004) The changing face of mainstream economics. *Rev Polit Econ* 16(4): 485–500
- Dasgupta P, David P (1994) Towards a new economics of science. *Res Policy* 23:(5)487–521
- Dobbins J (2011) Coping with a nuclearising Iran. *Survival* 53(6):37–50
- Dodgson M et al. (2011) Systems thinking, market failure, and the development of innovation policy: the case of Australia. *Research Policy*
- Dolfsma W, Seo D (2013) Government policy and technological innovation—a suggested typology. *Technovation* 33:(6–7)173–179
- Dosi G, Fagiolo G, Roventini A (2010) Schumpeter meeting Keynes: a policy-friendly model of endogenous growth and business cycles. *J Econ Dyn Control* 34(9):1748–1767
- Dosi G, Fagiolo G, Napoletano M, Roventini A (2013) Income distribution, credit and fiscal policies in an agent-based Keynesian model. I. *J Econ Dyn Control* 37(8):1598–1625
- Eparvier P (2005) Some comments on the methodological principles of nelson and Winter's evolutionary theory. *Evol Inst Econ Rev* 1(2):221–234
- Etzkowitz H, Leydesdorff L (2000) The dynamics of innovation: from national systems and “mode 2” to a triple helix of university–industry–government relations. *Res Policy* 29:(2)109–123
- Fagiolo G, Roventini A (2012) On the scientific status of economic policy: a tale of alternative paradigms. *Knowl Eng Rev* 27(2):163–185
- Fagerberg J, Verspagen B (2002) Technology-gaps, innovation-diffusion and transformation: an evolutionary interpretation. *Res Policy* 31:(8–9)1291–1304
- Friedman M (1953) The methodology of positive economics. In: Friedman M (ed) *Essays in positive economics*. University of Chicago Press, Chicago, pp 3–43
- Foray D, Lundvall BA (1996) The knowledge-based economy: from the economics of knowledge to the learning economy. In: *Employment and growth in the knowledge-based economy*. OECD
- Fullbrook E (ed) (2003) *The crisis in economics: teaching, practice and ethics*. Routledge, London
- Ghazinoory S, Narimani M, Afshari Z, Hasanzade A (2014) Analysis of conventional economics Policy rationales in science, technology and innovation scope. A thematic approach. *Modiriate Noavari* 3(2):1–22 (in Persian)
- Gustafsson R, Autio E (2011) A failure trichotomy in knowledge exploration and exploitation. *Res Policy* 40(6):819–831
- Godin B (2006) The linear model of innovation: the historical construction of an analytical framework. *Sci Technol Hum Values* 31(6):639–667
- Jaffe AB, Newell RG, Stavins RN (2005) A tale of two market failures: technology and environmental policy. *Ecol Econ* 54:(2–3)164–174
- Jaffe AB, Trajtenberg M, Henderson R (1993) Geographic localization of knowledge spillovers as evidenced by patent citations. *Q J Econ* 108(3):577–598
- Katz ML, Shapiro C (1985) Network externalities, competition, and compatibility. *Am Econ Rev* 25:424–440
- Lall S (1996) *Learning from the Asian tigers*. MacMillan Press, New York
- Lall S, Teubal M (1998) Market-stimulating technology policies in developing countries: a framework with examples from East Asia. *World Dev* 26(8):1369–1385
- Laranja M, Uyerra E, Flanagan K (2008) Policies for science, technology and innovation: translating rationales into regional policies in a multi-level setting. *Res Policy* 37:(5)823–835
- Lawson T (2006) The nature of heterodox economics. *Camb J Econ* 30:(4)483–505
- Loasby BJ (2000) Market institutions and economic evolution. *J Evol Econ* 10:(3)297–309
- Lundvall B-A et al. (2009) Bridging innovation system research and development studies: challenges and research opportunities. senegal: paper submitted for the 7th Globelics Conference
- Majidpour M (2013) The unintended consequences of US-led sanctions on Iranian industries. *Iran Stud* 46(1): 1–15
- Malerba F (2002) Sectoral systems of innovation and production. *Res Policy* 31:(2)247–264
- Martina BR (2012) The evolution of science policy and innovation studies. *Res Policy* 41:(7)1219–1239
- Metcalfe JS (1994) Evolutionary economics and technology policy. *Econ J* 104(425):931–944
- Mirimoghadam, M, Ghazinoory S (2015) An institutional analysis of technological learning in Iran's oil and gas industry: case study of south pars gas field development. *Technol Forecast Soc Chang*: 1–13 (Article In Press).

- Moreau F (2004) The role of the state in evolutionary economics. *Camb J Econ* 28:847–874
- Muldera P, Henri HLF, Hof kes MW (2001) Economic growth and technological change: a comparison of insights from a neo-classical and an evolutionary perspective. *Technol Forecasting Soc Chang* 68:151–171
- Narimani M, Ghazinoory S, Miremadi T (2013) Policy implication extracting of evolutionary approach in science and technology sector: a thematic analysis. *J Sci Technol* 5:(2)1–16
- Nelson RR (1959) The simple economics of basic scientific research. *J Polit Econ* 67(3):297–306
- Nelson R, Winter S (1974) Neoclassical vs evolutionary theories of economic growth. *Econ J* 84:886–905
- Nelson RR, Nelson K (2002) Technology, institutions, and innovation systems. *Res Policy* 31:265–272
- Nill J, Kemp R (2009) Evolutionary approaches for sustainable innovation policies: from niche to paradigm? *Res Policy* 38:668–680
- Romer P (1994) The origins of endogenous growth. *J Econ Perspect* 8:3–22
- Salmenkaita J, Salo A (2002) Rationales for government intervention in the commercialization of new technologies. *Tech Anal Strat Manag* 14:183–200
- Sharif N (2006) Emergence and development of the national innovation systems concept. *Res Policy* 35:745–766
- Silva ST, Teixeira AC (2009) On the divergence of evolutionary research paths in the past 50 years: a comprehensive bibliometric account. *J Evol Econ* 19(5):605–642
- Vanden Bergh J, Kallis G (2009) Evolutionary policy. *Papers on Economic and Evolution*. (Max Planck Institute of Economics, Jena.)
- Verspagen B (2004) Innovation and Economic Growth. [book auth.] Fagerberg. *The Oxford Handbook of Innovation*. pp. 487–513
- Wieczorek AJ, Hekkert MP, Smits, R (2009) Contemporary innovation policy and instruments: challenges and implications. s.l.: Innovation Studies Utrecht (ISU)
- Wolcott HF (2008) *Writing up qualitative research*. Sage Publications, london