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Relationship between macroeconomic environment and technological readiness: A secondary analysis of countries global competitiveness

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Abstract

The concept of competitiveness has attracted abundant attentions of both scholars and governors during the past decade. During this period, the world economic forum has published its annual reports which encompass Global Competitiveness Index (GCI) in order to measure national competitiveness in different countries. This paper aims at investigating the interaction between the two sets of "Technological readiness" and "Macroeconomic environment" as the two basic pillars of national competitiveness in order to provide information for improving national competitiveness in countries which are transiting from stage I to stage II of deveopment. In our study, we used descriptive-correlation methodology. The statistical population was 139 countries whose GCI data were included in GCI 2010 report. Also, we employed Canonical Correlation Analysis (CCA) to investigate interaction between two sets of "Technological readiness" and "Macroeconomic environment". Our findings show that there is a significant and positive relationship between the set of "Technological readiness" and that of "Macroeconomic environment".

Keywords: Global Competitiveness; Technological readiness; Macroeconomic environment; Canonical Correlation Analysis.

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1. Introduction

In globalization age, the economic competition among countries and economic enterprises has increased globally. The concept of competitiveness has been applied by Michael Porter to a large extent from competitiveness in enterprise and industry to national and global competitiveness (Porter & Schwab, 2008).

In global economy, competitiveness means the ability of obtaining a suitable and constant position at international markets. In view of Organization for Economic Cooperation and Development (OECD), the ability of a country in producing commodities and services for presentation in international markets is one of the most important dimensions of competitiveness. Competitiveness means access of internal commodities and services to international markets. Competitiveness has been also defined as the ability of an economy in stabilization of its share in the market and in all these definitions, the concept of competitiveness attracts attention as obtaining a suitable place in international markets for products of a country (Karimi-Hesenijeh, 2007).

Changes in the globalization process means that nations cannot reach suitable development just from producing commodity and services for their national markets. In 21st century, the degree of development of nations depends on their political, national and economical capacity, on their leaders, and also on the speed of their national institutions in adjustment to globalization process. Therefore, an exact identification of globalization process and an exact scrutiny of this trend is necessary in different countries, especially in developing countries which have entered into this scene (Safari and Asgharizadeh, 2008).

The countries and enterprises and industrial organizations have justified the relationship between innovation and economical success. The development of technology helps the innovators to move at first line of market. Therefore, the application of technology (in addition to its development) is one of the key factors of success in global competition (Khalil, 1999).

The rapid progress of globalization has alarmed nation states worldwide to develop stable macroeconomic policies in order to enhance the competitiveness of their domestic markets. The State has an important role to play in this process. This also means greater efforts to reform education and science to promote advanced technologies, and to strengthen the private sector (Ivaniashvili-Orbeliani, 2009). Economic management agenda in many economies around the world is transition from factor-driven economy to an efficiency-driven one. To this end, their economic policy making should benefit from valid orientation and indicators for this transition. Utilizing comparative approach and benchmarking from successful economic experiences around the world, can help the policy makers and business leaders manage the economy and achieve a higher level of prosperity. In this regard, improving the national competitiveness is a key factor (Vares et al., 2011).

The concept of competitiveness has attracted abundant attentions from both scholars and governors during the past decade to the extent that World Economic Forum (WEF) has developed GCI to measure competitiveness of countries around the world (Vares et al., 2011).

The purpose of WEF of issuing the annual GCI reports is to provide benchmarking tools for business leaders and policymakers to identify obstacles to improved competitiveness, thus stimulating discussion on the best strategies and policies to overcome them (Schwab, 2010).

However, before adopting the GCI as a benchmark or spending any resources and efforts to improve national competitiveness, policymakers must determine their countries' priorities for improving national competitiveness. In our study, we seek to provide information for countries transiting from stage I development to stage II in order to improve their national competitiveness (Vares et al., 2011).

2. Literature review

Competitiveness. According to Dutta (2007) in today's perspectives, competitiveness has become a fundamental force in economics like gravity in physics. Competitiveness is a concept, which tries to explain why some countries develop faster than others. Also, it connects the macro- and micro-economic views of social-economic development (Kovacˇic, 2007).

McFetridge (1995) identified competitiveness at three levels: firm, industry and national. In that context, Porter (1990) believed that "The only meaningful definition of competitiveness at the national level is national productivity". Furthermore, Heap (2007) pointed out that: "Improving productivity is the only way of baking a bigger cake - most other changes simply give us different sized slices".

From a macro policy perspective, the primary goal of competitiveness is the well being of the citizens of a country, be it through individual income, standard of living, human development, or social justice (Kovacˇic, 2007).

Measuring nation's competitiveness. Since 1979, annual Global Competitiveness Reports of World Economic Forum (WEF) have examined the many factors enabling national economies to achieve sustained economic growth and long-term prosperity. In these reports, competitiveness has been defined as the set of institutions, policies, and factors that determine the level of productivity of a country (Porter & Schwab, 2008). Also, since 2005, the WEF has developed the Global Competitiveness Index (GCI), as a highly comprehensive index. The GCI captures the microeconomic and macroeconomic foundations of national competitiveness. According to GCI reports, "A nation's level of competitiveness reflects the extent to which it is able to provide rising prosperity to its citizens" (Schwab, 2009).

The GCI captures the open-ended dimension of competitiveness by providing a weighted average of many different components, each of which reflects one aspect of the complex concept of competitiveness (Schwab, 2009). The GCI contains 12 pillars which are classified as Table 1:

Table1. GCI pillars in three main sub-indexes

Main sub-indexes	**Pillars of GCI**
Basic requirements	1. Institutions 2. Infrastructure 3. Macroeconomic stability 4. Health and primary education
Efficiency enhancers	5. Higher education and training 6. Goods market efficiency 7. Labor market efficiency 8. Financial market sophistication 9. Technological readiness 10. Market size
Innovation and sophistication factors	11. Business sophistication 12. Innovation

It is important to keep in mind that these 12 pillars of competitiveness are not independent: they tend to reinforce each other, and a weakness in one area often has a negative impact on other areas. For example, innovation (pillar 12) will be very difficult without a well-educated and trained workforce (pillars 4 and 5) that are adept at absorbing new technologies (pillar 9), and without sufficient financing (pillar 8) for R&D or an efficient goods market that makes it possible to take new innovations to market (pillar 6) (Schwab, 2010).

Three stages of development and GCI. Another useful classification of GCI reports considers three different stages of development in which each country falls into. , In this regard, Schwab (2009) pointed out that: different pillars of GCI affect different countries differently: the best way for Burkina Faso to improve its competitiveness is not the same as the best way for Switzerland. According to the GCI, in the first stage, the economy is factor-driven and countries compete based on their factor endowments, primarily unskilled labor and natural resources. Companies compete on the basis of price and sell basic products or commodities, with their low productivity reflected in low wages. Maintaining competitiveness at this stage of development hinges primarily on well-functioning public and private institutions (pillar 1), well-developed infrastructure (pillar 2), a stable macroeconomic framework (pillar 3), and a healthy and literate workforce (pillar 4). As wages rise with advancing development, countries move into the efficiency-driven stage of development, when they must begin to develop more efficient production processes and increase product quality. At this point, competitiveness is increasingly driven by higher education and training (pillar 5), efficient goods markets (pillar 6), well-functioning labor markets (pillar 7), sophisticated financial markets (pillar 8), a large domestic or foreign market (pillar 10), and the ability to harness the benefits of existing technologies (pillar 9). Finally, as countries move into the innovation-driven stage, they are able to sustain higher wages and the associated standard of living only if their businesses are able to compete with new and unique products. At this stage, companies must compete through innovation (pillar 12), producing new and different goods using the most sophisticated production processes (pillar 11) (p. 7). Researchers believe that there is a common agreement about the importance of change rate of technology in determination of the economic growth rate (Feldman, 1999). On the other hand, the variability of competition rules in business world shows the process of new product presentation into markets with a special importance. Today, most organizations more than any other time have found that it is not enough to depend on just traditional competition leverages such as quality improvement, decrease of cost or differentiation in presentation of products and services. Instead, concepts such as speed and flexibility in competition have arisen and the trend toward the presentation of new products and services into market itself is the adequate reason of this change of attitude (Jafarnejad et al., 2010).

The technology is the factor of wealth creation. The more effective use of technology strongly affects the competition conditions. Technology management urges invention and innovation management and these in turn are the main parts of every system that creates and uses the technology (Khalil, 1999).

Saint-Paul (1993) studied the link between aggregate fluctuations and technological choice. It was shown that a more volatile environment discourages the adoption of product-flexible technologies and it induces the adoption of volume-

flexible technologies. Also Justman and Teubal (1991) presented an integrated view of what is termed a "Structuralist" perspective to economic growth and development that stands in contrast to the mainstream orthodox or neoclassical view. In their view, "Structural changes are causes of growth rather than outcomes of a process of capital accumulation and of rising per capita incomes. Moreover, the growth process may be punctuated by periods of discrete shifts in resource allocation (creative destruction) and growth acceleration rather than being smooth throughout. Also they said that "Structural" changes require a skill-specific infrastructure of new capabilities which, when established, generate new comparative advantages. Market failures may be pervasive due to problems of human capital accumulation, critical mass and discrete choice among alternative growth paths. Thus in addition to creating a favorable environment for business and assuring, through macroeconomic policy, adequate investment, successful growth may require an adequate industrial and technological policy, particularly at nodes of structural change".

As mentioned in the Introduction, this research seeks to investigate interactions between pillars of "Technological readiness" and "Macroeconomic environment" in GCI in order to provide information for countries which are transiting from stage I of development to stage II to improve their national competitiveness in an efficient way.

Macroeconomic stability. The stability of the macroeconomic environment is important for business and, therefore, is important for the overall competitiveness of a country. Although it is certainly true that macroeconomic stability alone cannot increase the productivity of a nation, it is also recognized that macroeconomic disarray harms its economy. The government cannot provide services efficiently if it has to make high-interest payments on its past debts. Running fiscal deficits limits the government's future ability to react to business cycles. Firms cannot operate efficiently when inflation rates are out of hand. In summary, the economy cannot grow in a sustainable manner unless the macroeconomic environment is stable. This issue has captured the attention of the public most recently through discussions on exit strategies to wind down deficit spending, and in the context of the recent buildup of sovereign debt. It is important to note that this pillar evaluates the stability of the macroeconomic environment, so it does not directly take into account the way in which public accounts are managed by the government. This qualitative dimension is captured in the institutions' pillar described above. Box 1 discusses the relationship between fiscal imbalances and competitiveness, where particular relevance is given to recent fiscal stimulus spending and the discussions related to the importance of winding down spending and articulating clear exit strategies.
The "Macroeconomic stability" sub-indexes are:
1. Government budget balance;
2. National savings rate;
3. Inflation;
4. Interest rate spread;
5. Government debt;
6. And Country credit rating (Schwab, 2010).

Technological readiness. In today's globalized world, technology has increasingly become an important element for firms to compete and prosper. The technological readiness pillar measures the agility with which an economy adopts existing technologies to enhance the productivity of its industries, with specific emphasis on its capacity to fully leverage information and communication technologies (ICT) in daily activities and production processes for increased efficiency and competitiveness. Whether the technology used has or has not been developed within national borders is irrelevant for its ability to enhance productivity. The central point is that the firms operating in the country have access to advanced products and blueprints and the ability to use them. (Schwab, 2010).
The "Technological readiness" sub-indexes are:
1. Availability of latest technologies;
2. Firm-level technology absorption;
3. Foreign Direct Investment (FDI) and technology transfer;
4. Internet users;
5. Broadband Internet Subscriptions;
6. And Internet bandwidth (Porter & Schwab, 2008).

Canonical Correlation Analysis (CCA). CCA is a multi variables statistical approach for measuring linear relationship between different groups of variables. This approach can play an important role in exploratory mean when multi attribute variables have some relations to an analytical category (Lima et al, 2004). CCA is obtaining linear composition of predicting variables that has the most correlation with linear combination of criteria variables. These combinations are shown as follow: (LeClere, 2006).

$W = a_1x_{1+} a_2x_2 + \ldots + a_px_p$
$V = b_1y_{1+} b_2y_2 + \ldots + b_qy_q$

The number of dependent variables (six) or the number of independent variables (six), whichever is smaller, determines the maximum number of canonical functions. Thus the analysis is based upon the derivation of four canonical functions (Mai and Ness, 1999). Table 2 is showing some researches in CCA field.

Table2. Some previous research which applied CCA technique

Author(s)	Methodology
Mohaghar et al. (2011)	Using by Canonical Correlation Analysis, this study examined the interdependencies between supply chain relation quality and supply chain performance in automotive industry in Iran.
Asghari-zade et al. (2011)	Using by Canonical Correlation Analysis, this study examined the interdependencies between Enabler and results in EFQM model in TAVANIR Company in Iran.
Tutuncu and Kucukusta (2009)	They demonstrated a meaningful relationship between Job satisfaction and EFQM by utilizing CCA.
Macinati (2008)	They used CCA to study relationships between TQM and organizational performance.
Jang and Ryu (2006)	Using Canonical Correlation Analysis, this study examined the interdependencies in investing And financing decisions of restaurant firms.
Bou-Llusar et al. (2005)	They used CCA to study relationships between enablers and results in EFQM.
Baloglu et al. (1998)	This study utilized a canonical correlation approach to segment the senior pleasure traveler market.

3. Problem description

This Proposed model is composed of two kinds of variables: "Technological readiness" and "Macroeconomic environment" as in the following figure. This model is a pattern for presenting the research problems.

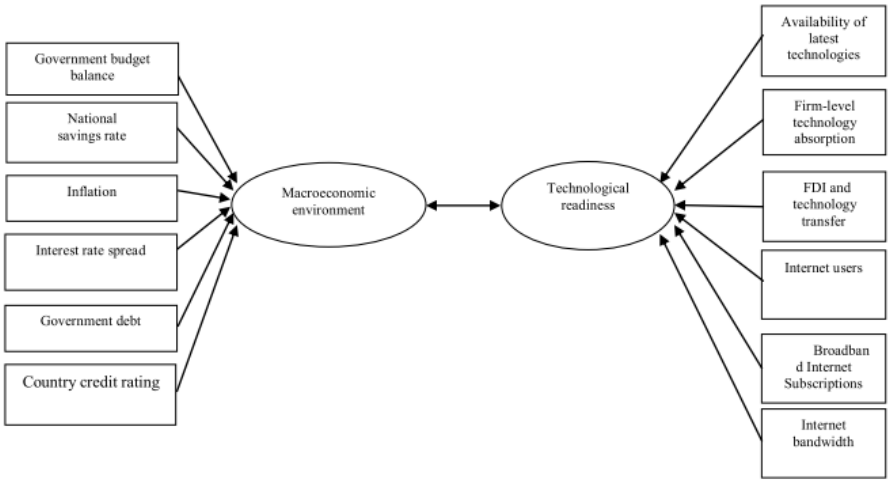

Figure1. Research proposed model

According to Figure1, the research question is: Is there any meaningful relationship between "Technological readiness" and "Macroeconomic environment"?

The research sub questions are. 1. Is there any correlation between "Technological readiness" sub-index and "Macroeconomic environment" sub-index?
2. In the set of "Technological readiness", which sub-indexes has the most and the least impact on creating a meaningful relationship between "Technological readiness" and "Macroeconomic environment"?
3. In the set of "Macroeconomic environment", which sub-indexes has the most and the least impact on creating a meaningful relationship between "Technological readiness" and "Macroeconomic environment"?

4. Methodology

Research method. The research method used for this study is descriptive-correlation. Secondary analysis method was also used for analyzing secondary data source. First, we studied literature of Competitiveness, GCI, "Technological readiness", "Macroeconomic environment", and CCA. Then, we used the GCI report data in 2010, for doing our secondary analysis. The statistical population in this study was 139 countries whose data were included in GCI report in 2010. Finally, we utilized Canonical Correlation Analysis (CCA) by SAS9 software; thereafter, analysis output was obtained.

Information gathering tools. According to De Vaus (2002) it would be appropriate to use data collected by other people or agencies to address the relevant research questions. Such data is called secondary data resource. So we utilized the data published by World Economic Forum (GCI report in 2010) as our secondary data resource.

5. Results and discussion

Using SAS9 software, we investigated correlation between two pillars of "Technological readiness" and "Macroeconomic environment" by using CCA. For answering the first sub question, based on table 3, we can see a meaningful positive correlation in significance level of 0.05 between some of "Technological readiness" sub-indexes and some of "Macroeconomic environment" sub-indexes. "Country credit rating" and "Availability of latest technologies" have the strongest correlation and "Government budget balance" and "Broadband Internet Subscriptions" have the least correlation in this table. Several interesting relationships were detected in Table 3. For example in "Technological readiness" sub-indexes, "Country credit rating" has the most correlation and "Government budget balance" has the least correlation with "Firm-level technology absorption".

Table3. Correlation coefficient between "Technological readiness" and "Macroeconomic environment"

Technological readiness Macroeconomic environment	Availability of latest technologies	Firm-level technology absorption	FDI and technology transfer	Internet users	Broadband Internet Subscriptions	Internet bandwidth
Government budget balance	0.052	**0.08**	0.02	0.01	**-0.00**	-0.02
National savings rate	0.14	0.19	0.07	0.10	0.08	0.09
Inflation	0.47	0.42	0.29	0.43	0.49	0.47
Interest rate spread	0.54	0.52	0.31	0.57	0.61	0.54
Government debt	-0.38	-0.33	-0.23	-0.33	-0.35	-0.32
Country credit rating	**0.85**	**0.76**	0.60	0.77	0.82	0.79

Table4. Canonical Correlation Analysis summary

N=139	Macroeconomic environment	Technological readiness
Number of variables	6	6
Extracted variance	100%	100%
Redundancy index	28.81%	63.56%
Variables: 1	Government budget balance	Availability of latest technologies
2	National savings rate	Firm-level technology absorption
3	Inflation	FDI and technology transfer
4	Interest rate spread	Internet users
5	Government debt	Broadband Internet Subscriptions
6	Country credit rating	Internet bandwidth

Table 4 is showing enveloped data variation by CCA. The extracted variance for "Technological readiness" and "Macroeconomic environment" is showing that 100% of canonical roots are covered by internal "Technological readiness" variation and also 100% of canonical roots are covered by internal "Macroeconomic

environment" variation. These statistics are very considerable and support CCA utilization.

Table5. Statistical tests

Canonical roots	Chi-square tests with successive roots removed					
	Canonical R	Canonical R^2	Chi-sqr	df	P	Lambda Prime
0	0.9183	0.8434	267.65	36	0.0000	0.1306
1	0.3106	0.0965	23.79	25	0.5309	0.8344
2	0.2146	0.0460	10.45	16	0.8411	0.9235
3	0.1378	0.0190	4.253	9	0.8939	0.9681
4	0.1104	0.0122	1.730	4	0.7851	0.9869
5	0.0296	0.0008	0.115	1	0.7341	0.9991

The level of significance of a canonical correlation generally considered to be the minimum acceptable level for interpretation is the 0.05 level, which (along with the 0 .01 level) has become the generally accepted level for considering a correlation coefficient statistically significant (Hair et al., 1998). In this study, only Canonical function 1 has been found statistically significant ($p < .05$). In addition, multivariate tests like Wilk's lambda and Pillai's trace are also performed (Table 5). Consequently, just the first variable pair may be interpreted.

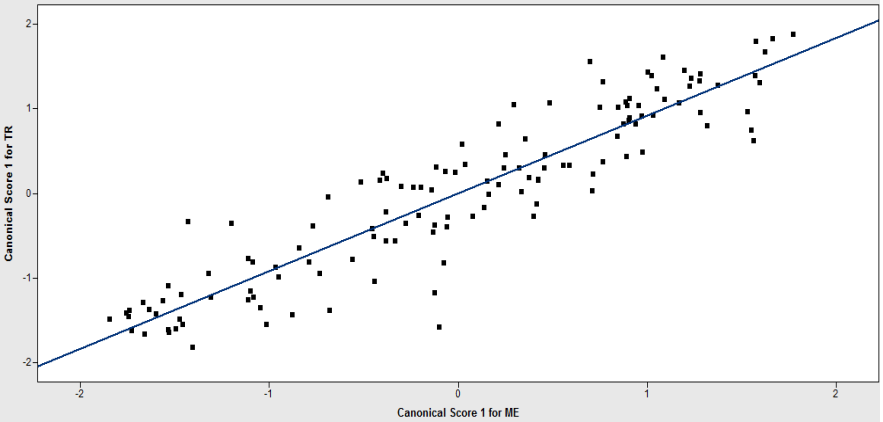

Diagram 1. Paired correlation between first canonical variable

For answering research question, we focus on table 4 and 5. Relationship importance between "Technological readiness" and "Macroeconomic environment" is determined by canonical correlation (R_c) and Eigen value (R_c^2). Based on Table 5, first variable R_c is 0.918% and R_c^2 is 0.843%. Because R_c cannot directly prepare the shared variation, we utilize redundancy index. Redundancy index for R_c^2 is in multiple regression analysis.

Table 4 is showing that we can predict more than 63% of changes in "Technological readiness" by studying changes in "Macroeconomic environment". These findings are mentioning a meaningful relationship between "Technological

readiness" pillar and "Macroeconomic environment" pillar; also "Macroeconomic environment" pillar has a positive effect on "Technological readiness" pillar.

Table6. Canonical loading and canonical cross loading for meaningful canonical variables in "Technological readiness" & "Macroeconomic environment"

Results	Canonical variable 1		Canonical variable 2	
	loading	Cross loading	loading	Cross loading
Technological readiness				
Availability of latest technologies	0.9275	0.8520	-0.0201	-0.0064
Firm-level technology absorption	0.8476	0.7787	0.2282	0.0727
FDI and technology transfer	0.6522	0.5991	-0.3487	-0.1112
Internet users	0.8878	0.8156	-0.0302	-0.0096
Broadband Internet Subscriptions	0.9460	0.8690	0.0243	0.0077
Internet bandwidth	0.8903	0.8179	-0.1133	-0.0361
Extracted variance (%)	31.48		13.64	
Macroeconomic environment				
Government budget balance	0.0238	0.0219	0.2409	0.0768
National savings rate	0.1239	0.1138	0.5432	0.1732
Inflation	0.5876	0.5398	0.1665	0.0531
Interest rate spread	0.6851	0.6293	0.5903	0.1882
Government debt	-0.3872	-0.3557	-0.0225	-0.0072
Country credit rating	0.9714	0.8923	-0.0407	-0.0130
Extracted variance (%)	74.39		0.28	
Redundancy index (%)	62.75%		0.2%	

For answering second and third sub-questions, we used canonical cross loading for evaluating the importance of every criterion in meaningful canonical variable. In general the researcher faces the choice of interpretation of the functions using canonical weights (standardized coefficients), canonical loadings (structure correlations) or, canonical cross loadings. Given a choice, it is suggested that cross loadings are superior to loadings, which are in turn superior to weights (Hair, 1998).

According to table 6, all sub-indexes in Technological readiness pillar have a high canonical cross loading in creating a canonical variable. So they are very effective in creating a meaningful relationship between "Macroeconomic environment" and "Technological readiness".

In "Technological readiness" sub-indexes, "Broadband Internet Subscriptions", "Availability of latest technologies", and "Internet bandwidth" have the highest effect and "FDI and technology transfer" has the lowest effect in creating this relationship. Furthermore, in the "Macroeconomic environment" sub-indexes, "Country credit rating", "Interest rate spread" and "Inflation" have the highest effect and "Government budget balance" has the lowest effect in creating this relationship. On the other hand "Government debt" sub-index has negative effect in creating this relationship.

Also, for CCA validity, we used sensitivity analysis on independent variables. For this validation, we eliminate one of "Macroeconomic environment" sub-indexes every time and utilize CCA. Outputs depicted no impression change in construct coefficient of variables. So we assured that data were valid.

6. Conclusions and future works

This research intended to investigate the relationship between "Technological readiness" and "Macroeconomic environment" by using CCA for GCI 2010 data. First, we studied literature of Competitiveness, GCI, "Macroeconomic environment", "Technological readiness", and CCA. Then, we used the Global Competitiveness report data in 2010 to do our secondary analysis. The population in this study was 139 countries whose data was included in GCI report in 2010. Eventually, we utilized Canonical Correlation Analysis (CCA) through SAS9 software then analysis output was obtained.

According to research findings, there is a meaningful relationship between "Technological readiness" pillar and "Macroeconomic environment" pillar, and "Macroeconomic environment" pillar has a positive effect on "Technological readiness" pillar. In "Technological readiness" sub-indexes, "Broadband Internet Subscriptions", "Availability of latest technologies", and "Internet bandwidth" and in "Macroeconomic environment" sub-indexes, "Country credit rating", "Interest rate spread" and "Inflation" have the most impact on creating a meaningful relationship.

Being familiar with national competitiveness indexes provides a suitable ability for different industry agents to analyze their country environment with regional countries and even world countries. Generally, the findings of this research increased our knowledge about the relationship between pillars of "Technology readiness" and "Macroeconomic environment".

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