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Regional innovative behavior: Evidence from Iran

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ABSTRACT

The present paper studied regional innovative behavior in Iran through a spatial knowledge production function approach by employing the principal components analysis (PCA). To this end, the determinants of regional innovative behavior, as measured by the number of Iranian patents granted to resident applicants, were analyzed. In addition to the total number of patents, the effects of the innovative factors were examined on company patents, university patents, and personal patent, separately. Fourteen explanatory variables were converted by PCA into three components: contextual index, industrial index, and low-welfare index. The results showed that the low-welfare index was relatively more important in explaining innovative behaviors at the regional level, while company patents were more sensitive to contextual index. Moreover, the results pointed to the lack of knowledge spillover across Iranian regions.

1. Introduction

Technological innovation is considered as a major driving force behind economic growth and prosperity. There is no wonder, then, why understanding the geographical nature of innovative behavior has long been a major policy concern. Scholars have widely examined the elements affecting the geographical distribution of innovative activities within countries and across the globe. The traditional research approach used in these studies focuses primarily on innovation input and output. This approach, however, is criticized by evolutionary theories of economics who consider innovation and technological change as the results of a complex interaction between innovation actors in what is referred to as innovation system (Lundvall, 1985; Dosi, 1988; Cooke, 2001).

Over the last several years, increasing attention has been paid to the concept of regional innovation system (RIS) in boosting regional economic growth and development. This is partly due to the growing empirical evidence that point to the highly localized nature of learning process and knowledge transfer (Enright, 2003). Regions are considered as good units of analysis for innovation systems due to the importance of regional resources in stimulating innovation capability (Asheim et al., 2005; Cooke, 2013). Regional innovation system is described as "constellation of industrial clusters surrounded by innovation supporting organizations" (Asheim and Coenen, 2005). In this context, the regional level provides the best context in economic development due to localized learning processes and "sticky" knowledge grounded in social interaction (Asheim, 2002; Gertler, 2004; Asheim and Coenen, 2005).

Despite the growing awareness of the importance of systematic approach to innovation, there is still much more to be researched and learned in this field of study (see D'Allura et al., 2012; Doloreux and Parto, 2005), especially when it comes to the nature and extent of innovation activities in the context of developing countries. Even in the context of developing countries, innovation studies have been mostly focused on a limited number of countries like China and Brazil. Regional innovative behavior in Iran, for instance, is a poorly researched subject.

There are some particularities about Iran that makes it a very interesting case for innovation research. For instance, being under economic sanctions for a rather long period of time has significantly discouraged non-residents to pursue innovative activities in Iran. Therefore, the role of non-Iranians in patenting activities in the country has been very limited. This is in contrast with most other developing countries where non-residents receive the majority of granted patents (WIPO, 2013, p. 46). Moreover, individual inventors are the main players of the Iranian patent system as around 87% of all patents are granted to individuals. Companies only own around 8% of all the patents registered in Iran, while in many countries, companies are by far the most active patent applicants (WIPO, 2013, p. 33).

The contributing factors to the innovative output of Iranian regions have never been investigated. In this paper, this gap was addressed by taking a closer look at the patenting activity of each region. This study uses a proprietary data set of Iranian patents that was built by daily record of the granted patent information as appeared in the "Iranian Official Journal." The data set covers all Iranian patents granted to Iranian residents during a three-year period, corresponding to the year 2008

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to 2010. The data were clustered at regional level for all thirty regions of Iran.

This study aims to investigate the regional innovative behavior in Iran and its contributing factors by looking at the geographical concentration of Iranian patents. The study further investigates if the effect of contributory factors of innovative behavior varied by patents institutional ownership. This research is particularly designed to answer the following three questions: (1) What are the factors that contribute the most to innovative behaviors across different regions in Iran? (2) Which factors are important in explaining the innovative output of individual innovators, as compared with legal entities, at the regional level? (3) Does spatial technological spillovers take place among Iranian regions?

The innovative behavior is studied by using the Griliches–Jaffe knowledge production function. Patent per capita is deployed to measure the innovative output of each region and different categories of patent applicants (i.e., individuals, companies and universities) therein. Fourteen different explanatory variables are used to capture the effects of research and development (R&D) investment, human capital, knowledge diffusion, demand factors, industrial factors, and welfare factors. To address the problems of multicollinearity and high dimensionality, the principal component analysis (PCA) method is used. The effects of components, extracted from applying PCA on the set of the explanatory variables, on the dependent variables are studied while spatial spillover between the regions is also taken into account. Moreover, thanks to the principal components regression methods, the effects of original explanatory variables are estimated.

The remainder of this paper is structured as follows: Section 2 gives a brief introduction to innovation studies and patent information in Iran, methodology is described in Section 3, Section 4 introduces the data, Section 5 explains the variables, the experimental results are summarized in Section 6, and Section 7 concludes the paper.

2. Studies on innovation in Iran

There have been very limited attempts to examine knowledge creation activities in Iran, especially at the regional level. Prior studies have mostly used qualitative analyses (e.g., Soofi and Ghazinoory, 2013), small-scale surveys (e.g., Mohammadi et al., 2013), and national-level data (e.g., Shahabadi and Heidari, 2011; UNCTAD, 2005; Mani, 2004). This is mainly due to a limited access to reliable data on innovation indicators. For instance, until recently, the Iranian Patent Office did not publish patent information like they do in other countries. There were no open-to-public databases for Iranian patents (Bagheri, 2014).

In recent years, a few attempts have touched upon the patenting activities of Iranians, e.g., Noruzi and Abdekhoda (2012) and Sarkissian (2013). These studies investigated the patents filed by Iranians before a number of patent offices, like USPTO, WIPO, and EPO (Noruzi and Abdekhoda, 2012; Sarkissian, 2013). However, since their research does not include patents registered inside Iran and due to the very low number of the observations (only 212 and 72 patents, respectively), the results cannot adequately portray the innovative activities of the country.

Bagheri et al. (2013) were the first who studied the regional innovative activities in Iran. They presented the provincial distribution of patents in Iran by looking at the number of patents granted per region of residence of the applicant in the period between 2008 and 2010. They only investigated the effect of distance from the capital and average household income of each region on the number of patents registered by residents of that region. Their results indicated a high concentration of the provincial distribution of Iranian patenting activities around the capital, Tehran, and a negative significant effect of distance from the capital on the number of regional patents.

This study furthers the work done by Bagheri et al. (2013) by investigating a more comprehensive set of innovation factors that could potentially affect the regional innovation capacity of the country.

3. Methodology

The *knowledge production function* (KPF) was initially developed by Griliches (1979) and ever since has been widely used by many innovation scholars. KPF is a function intended to represent the optimal transformation process leading from innovative inputs (e.g., R&D expenditure) to innovative outputs (e.g., patents as a proxy). Jaffe (1989) modified KPF by incorporating the geographical dimension into it and stressing the importance of geographical proximity in spillovers of knowledge and technological change. In the modified function, referred to as Griliches–Jaffe function, the production of new knowledge depends not only on regional innovative efforts but also on a set of other regional characteristics. A large number of empirical studies have been conducted to characterize potentially influencing regional innovation factors (for a literature review, see, for example, Crespi, 2004; Crossan and Apaydin, 2010).

Based on the systematic approach to innovation, which began in the late 1980s, innovation is the result of a complex set of interaction among innovation actors rather than a single and separate purely economic variable (Lundvall, 1985; Freeman, 1987; Dosi, 1988). In other words, to better explain regional innovative behavior, a broad number of interdependent and correlated explanatory variables are needed while all factors and agents do influence each other (for a literature review, see Kumar, 2007; Uriona-Maldonado, 2011; Carlsson, 2007). In this context, the traditional econometric models cannot be used to estimate the knowledge production function due to multicollinearity and high dimensionality problems.

Moreover, according to Carlsson (2007, p. 859), in order to investigate innovation based on a systemic approach, three issues need to be specified: first, components (and therefore the boundaries) of the innovation system; second, interaction between components; and third, attributes of the components.

For all these reasons, we estimated the knowledge production function (KPF), and we employed PCA and spatial analysis to address the questions of the study.

In this study, the theoretical framework of Griliches–Jaffe Knowledge Production Function is extended to investigate the determinants of the regional innovative capacity in Iran. A logarithmic form of the Cobb–Douglas function is employed in which the output of innovative behavior is measured by the number of patents per capita granted in each region. Fourteen explanatory variables are calculated and used to address different dimensions of regional innovation system (all the variables are explained in Section 5 in details).

The *principal component analysis* (PCA), introduced by Karl Pearson in 1901, is a multivariate statistical method that transforms the original data set into a number of new orthogonal variables, called principal components (PCs), which contains the same information as the original set. Each component is a linear combination of original variables such that accounts for maximum variance in the original variables. The next components maximize the variance from the residual matrix left over after extracting the first component. Since the first few components capture most of the variance of the data set "truncated component solution" is typically used, by focusing on the first few components. By this, the components with a larger variance considered as new variables capturing the most important dynamics and the component with lower variances are considered as noise.

The PCs can be used as new variables (latent variables) in regression analysis instead of the original variables. Since the PCs are a linear combination of the original variables, their usage directly keeps all the variables in the regression and original coefficients can be transformed back.

Despite the potentials of PCA in studying the dimensionality of innovative behavior, to the best of our knowledge, this methodology has not been frequently used in this domain. Among the rare exceptions is the work done by Breschi et al. (2000) to study the relation between innovation patterns and technological regimes using European patent data. Buesa et al. (2006) and Buesa et al. (2010) also used a similar method,

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