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**A bibliometric analysis of innovation-related research of the
former Soviet Union five “Stans”: are there distinct
patterns?**

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Abstract

The present study provides a general bibliometric overview of the last thirty years (1987- June 2016) of the innovation research produced on the former Soviet Union 'Five stans'.

Central Asia related research has been marked by a steady growth with increasing publications. However, innovation related studies on Central Asia only very recently received some attention by the scientific community. Of the 172 studies considered, 84% were published after 2011. In this sense we might considered an emergent field of research.

These studies focused mainly on Kazakhstan and Uzbekistan. Tajikistan, Kyrgyzstan and Turkmenistan are still underexplored in this regard. Moreover, quite few studies within innovation of the 'Five Stans' focused on industries (15% of the total). These latter refer mainly to Kazakhstan and Uzbekistan. Interestingly, albeit unfortunate, almost seldom focused on core industries where these countries are specialized (e.g., Oil, Gas, Banking or Automobile). Thus, in order to inform public policy authorities on innovation related matters further studies focusing on industries are on great demand.

The research produced was published in rather low visible and ranked journals, outside the innovation core journals. By far *Irrigation and Drainage*, a journal devoted to the science and art of irrigation, drainage and flood management, is the most important outlet publishing the studies on innovation in the 'Five Stans', comprising 37% of the papers published. The highest impact journals publishing innovation related research in the 'Five Stans' include *Health Affairs*, *Social Science and Medicine*, and *Waste Management Journal*. However, these journals lay outside the core innovation area/journals.

Summing up, our analysis showed that studies related to innovation on the 'Five Stans' are scarce, although rapidly emerging, and lack scientific influence and visibility, failing to address practical issues regarding 'Five Stans' economic specialization.

Keywords: Bibliometrics; Innovation; Central Asia; Five Stans

JEL-Codes: K11; O34.

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1. Introduction

Innovation is one of the most significant topics of research since the late 20th century (Sarwar & Hassan, 2015). Innovation can be defined as the application of new ideas for the products, processes, or other aspects of the activities of an organization that lead to increased value and meet the needs and desires of consumers (Cancino, Merigo, & Palacios-Marques, 2015). It is therefore a fundamental issue for the development of a country's economy (Zhu & Guan, 2012).

Interesting bibliometrics accounts, involving the statistical analyses of quantitative aspects of scientific publications (Broadus, 1987) have emerged in the last few years (Cancino et al., 2015). Some authors have developed bibliometric analyses in a wide range of fields: Management (Podsakoff, MacKenzie, Podsakoff, & Bachrach, 2008), Entrepreneurship (Landström, Harirchi, & Åström, 2012), Finance (Merigó & Yang, 2014), Engineering (Guan & Ma, 2007; Wang, Yang, Yanga, Long, & Li, 2014), Medicine (Betancourt & Silvente, 2014; Singh, Handa, Kumar, & Singh, 2016).

Innovation related research is becoming very significant during the last decades due to the strong development of research and technology worldwide (Owen, 2014). In the field of innovation the bibliometric exercises encompass various studies (Toivanen & Ponomariov, 2011; Seol & Park, 2008; Werker, 2006). As mentioned, there are a few studies on Innovation research that resort to bibliometrics, but their focus is not on assessing and analyzing of 'Five stans'. Rather, their main contribution centered on empirically analyzing the structure and the key components of the African regional innovation systems, European regional innovation policy in the light of the scientific findings. In addition, their analysis on innovation related research performed mostly in advanced countries (e.g. China, Germany, USA etc.).

As such, it also appears that the applicability of bibliometric techniques to the study of innovation is quite well established (Teixeira, 2013). Accordingly, bibliometrics helps to establish and reflect the innovation capability of a country, as a tool for the analysis of the scientific production of a country (Seol & Park, 2008). The results of this analysis might be used for many purposes, for example, to determine the patterns and latest innovation used or invented among specific countries, evolution of publications on innovation, citations and journal coverage with the hope to provide an insight in to the dynamics of the Innovation. Therefore we can use this knowledge for further innovative activities of the countries.

Despite the interesting results the above mentioned studies achieved, such analyses were focused mainly Western and well developed countries. To the best of our knowledge no such studies on the scientific production on innovation have been focused on Central Asia countries. This is unfortunate as Central Asia countries' development rely substantially on their innovation capability both at firm and research levels (Sakata, et al., 2012).

Central Asia is the core region of the Asian continent which has no outlet to the ocean region (Wang, et al., 2015). It is sometimes referred to as Middle Asia and includes Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan, also known as the 'five stans' (Wang, et al., 2015). It is a region rich in natural resources, including oil and gas, and water, and has a surprising variety of animals and plants (ADB, 2010).¹ Inclusively, all countries in Central Asia have a long tradition in cotton cultivation (Rho, 2015). The reform of the Soviet Union (or USSR - Union of Soviet Socialist Republics) summoned deep changes in the scientific research of Commonwealth of Independent States countries (further, the CIS),² including those from Central Asia (Alimov, 2004). Indeed, the separated budget devoted to research decreased invariably with scientists experiencing difficulties on undertaking their research (Alimov, 2004). Moreover, following by disintegration of the USSR, international scientific publications were continued to be written in Russian language. Notwithstanding, from 1991 herein a rapid shift occurred with a substantial number of studies being written in English language (Kirchik, Gingras, & Larivière, 2012).

The few bibliometric studies that exist focusing on Central Asia document a decrease in the scientific publications and lower international visibility of Central Asia between 1992 and 1999 (Wang, et al., 2015; Hamidov, Balla , & Helming, 2014; Purnell & Reuters, 2013). Although in the period of 1992 to 1999 research outputs have decreased, from then on it might had increased a lot. Evidence in this regard, however, is missing for the most recent period.

Extant studies on Central Asia, analyzed fields such as: Agricultural (Hamidov, Balla , & Helming, 2014), Engineering (Purnell & Reuters, 2013), Science (Wang, et al., 2015; Karamourzov, 2012). However, no study exists on the research production in the

¹ The Asian Development Bank (ADB) is a regional development bank established on 22 August 1966 to facilitate economic development of countries in Asia.

² CIS was a regional organization formed during the breakup of the Soviet Union, whose participating countries are some former Soviet Republics.

‘Five Stans’ regarding the innovation field. It would be illuminating to assess the scientific performance of these countries in the innovation area because they are developing countries and in fact, nowadays these countries face genuine obstacles for innovation and this is precisely why they remain underdeveloped (Aubert, 2005). This context is important for Central Asia as their development reliable on innovation (Aubert, 2005). However, they are attempting to channel the proceeds into research and innovation in order to provide a sustainable future for their future generations (Purnell & Reuters, 2013). We expect that the analysis of innovation research will provide some clues about real life innovation patterns and economic specialization of the countries in study.

Resorting to bibliometric techniques, the present dissertation aims at responding to the following main questions:

- 1) How do scientific publications on Innovation regarding the Five Stans evolved in the last decades?
- 2) Are there any distinctive pattern of research among these countries that might be associated with their economic profiles/industrial specialization?

In terms of structure, the dissertation is organized as follows. Section 2 presents a literature review on bibliometrics analyses focusing regions and countries. The methodology used and the sources of the data are described in Section 3. Section 4 presents the empirical results followed by a conclusion in Section 5.

2. A literature review based on bibliometrics

2.1. Studies that analyze the scientific production over time of countries and regions

2.1.1. Worldwide countries and regions

To date, a considerable amount of studies that analyses countries' research/scientific performance over time with use of bibliometrics exists. Within Scopus using keyword "Bibliometrics" has been found 4811 articles and 960 reviews (search date: 15 of May). Later, filtering by most cited ones; we determined top fields and its most cited articles. Eventually, we found out that Social Science, Engineering, Computer Science and Medicine are the most top fields using bibliometric techniques. Also, most analyzed countries are China, Italy, Brazil, and UK which they are well developed. In Table 1 we present some of these studies and provide some information about characteristics of social sciences areas followed by Business and Management and other files such as Engineering, Computer Science and Medicine.

There is a huge collection in the field of Social Science regardless to Business, Management and Accounting. Half of these studies focus on worldwide regions, specific journal or data sources and some others analyzed various regions in the field. Some of the performed studies (White III, Guldiken, Hemphill , He , & Khoobdeh , 2016) provide an overview of the international strategic management literature from 2000 through 2013. The results of their analysis reveal a substantial increase in the volume of international strategic management articles published in high quality journals over this period of time. Also, focusing Management Kumar & Kushwaha, (2015) analyzed the contributions of researchers in the field of management conducting a bibliometric analysis of the Supply Chain Management: an International Journal which is indexed in the Social Science Citation Index. The result concludes that in 2006, highest 59(12.94%) articles were published out of 458 articles in last ten years. Earlier, Dubois and David (2000) concluded that the slow development of these areas could be explained by the fact that some authors did not desire to investigate such a risky subject; instead, they would prefer to study other more conservative areas. Uysal (2010) examined the level of accounting ethics research. His result indicated that although, in general, accounting ethics research had not kept the common business ethics studies, there had been an increase in the level of the filed. He pointed out articles cited in peer-

reviewed journals, at least ten times over a 20 year period, to determine the most influential works. However, these studies do not focus on specific region. They mostly focus on analyzing Business, Management and Accounting in general.

In addition, researchers did some other studies in Social Science analyzing certain region (Fahimnia, Sarkisb, & Davarzani, 2015; Rafols et al., 2012). Rafols et al. (2012) compared the degree of multidisciplinary and the research performance of a number of Innovation studies units with that of leading Business & Management Schools in the UK. Relatively they developed empirical proof that “the fairly narrow and peculiar kind of superiority” of disciplinary elites uses to suppress the rankings of multidisciplinary research efforts in a way not supported by citation measures. On the other hand similar ranking has been performed earlier by other authors, however they do not compare Innovation Studies with Business & Management (Geary, Marriott, & Rowlinsonw, 2004). Geary et al. (2004) have critically analysed the British Journal Rankings in Business and Management and Research Assessment Exercise (RAE) system. They found out that wide number of journal ranking tables have been produced in the field of Business and Management (including Accountancy and Finance). In this way, the Social Sciences study fields have been quite under explored in what refers to the analysis of the scientific field, in particular the fields of Economic, Management, Business and Marketing. Overall, the result of these articles shows that in the last decades, there has been a noticeable increase within a discipline (Business, Management).

Another leading field which bibliometric techniques have become very popular comes out engineering. In the field, China was in the main focus of the studies by many authors. Wang et al., (2014) carried out research on global risk of engineering nanomaterials from 1999 to 2012 where the Chinese Academy of Sciences took the leading position of the institutions in total publications. It also reveals that research in the field is roughly consisted of two aspects: one is health effect and nanotoxicology and the other one is environmental behavior and ecotoxicity. Using same techniques Guan & Ma (2007) proposed research in the field of engineering subjecting on China’s semiconductor researches. Their main goal included evaluating growth of trends and level of performance of semiconductor research in China. They reported that China has greatly increased in scientific activities in the engineering-related research and quite developed comparing the other Asian countries. Moreover, in the same year Guan &

Ma, (2007) conducted research focusing on China's emerging presence in nanoscience and nanotechnology. When analyzing the rapid growth of Chinese publications in nanotechnology they noticed that Investment valued at approximately of 250 million US dollars in 2007 to China's nanotechnology R&D and this is reflected in an increased number of nanotechnology papers, although Liu, et al., (2009) cleared up that the paper research impact is still lower than the other leading countries. Later, Fu et al (2014) also pointed out on his statement declaring that, in recent years, there has been a significant improvement in knowledge and skills in Chinese research on chemical engineering. Subsequently, in research by other author has been adopted an empirical approach that software architecture was the initial motor of research in Engineering (Heradio et al., 2016).

Finally, in the area of Medicine there are huge amount of publication and actually concerning bibliometric analyses Medicine is in leading state in Scopus (search analysis date: 15 of May) . Analysis show that about 60% of article and review occurs in Medicine which consists of different sub-areas: Health, Nursing, Pharmacology, Toxicology, Immunology and Microbiology. Almost most half of studies focused on Brazilian health research. Bressan, Gerolin, & Mari (2005) applied bibliometric tools to map mental health research in Brazil, providing an overview of infrastructure, financing and policies in mental health research. Article indicates that number of mental health and psychiatric ISI papers has doubled between 1998 and 2001. However Zorzetto et al (2006) declared that the health research in Brazil requires urgent enhancement, and policymakers. This study concludes that the scientific production in this area is concentrated in 11 of the 27 Brazilian provinces or counties, most of them located in the Southeastern and Southern part of the country. About 40% of the articles published in each triennium are located at University of São Paulo (USP), Federal University of São Paulo (UNIFESP), State University of Campinas (UNICAMP). Using same techniques, (Tarkowski, 2007) describes a bibliometric review of the environmental health research literature in Europe for a period of 10 years. He considers that systematic cooperation between stakeholders all over Europe will increase the knowledge and stimulate innovation to solve modern problems in the field of public health.

Later, Sweileh, Al-Jabi, Sawalha, & Zyoud (2014) mentioned in his research that reducing nutrition-related health problems in Arab countries requires an understanding of the performance of Arab countries in the field of nutrition and dietetics research.

Interestingly, they investigated that interest in nutrition and dietetics research is relatively recent in Arab countries. Furthermore, one of the recent studies points out that 11.8% of the papers are contributed by Indian authors in collaboration with authors from United States (Singh et al., 2016). Similarly, it also mentioned that collaboration of Indian authors mostly with developed countries such as Germany, United Kingdom, and Canada.

Table 1. Synthesis of studies that analyzed the scientific production of given areas using bibliometrics

Field	Title	Affiliation Country/s	Analyzed country/s	Author/s	Citations *	Journal
Medicine	The scientific production in health and biological sciences of the top 20 Brazilian universities	Brazil	Brazil	(Zorzetto, et al., 2006)	79	Brazilian Journal of Medical and Biological Research
	Mapping cancer, cardiovascular and malaria research in Brazil	Brazil	Brazil	(Rodrigues, Fonseca, & Chaimovich, 2000)	35	Brazilian Journal of Medical and Biological Research
	Environmental health research in Europe - Bibliometric analysis	Poland	European	(Tarkowski, 2007)	36	The European Journal of Public Health
	The modest but growing Brazilian presence in psychiatric, psychobiological and mental health research: Assessment of the 1998-2002 period	Brazil	Brazil	(Bressan, et al., 2005)	45	Brazilian Journal of Medical and Biological Research
	A bibliometric analysis of toxicology research productivity in Middle Eastern Arab countries during a 10-year period (2003–2012)	Palestine Malaysia	Middle Eastern Arab	(Zyoud, Al-Jabi, Sweileh, & Awang, 2014)	37	Health Research Policy and Systems
Business, Management, Accounting	Business Ethics Research with an Accounting Focus: A Bibliometric Analysis from 1988 to 2007	Turkey	All	(Uysal, 2010)	57	Journal of Business Ethics
	Journal Rankings in Business and Management and the 2001 Research Assessment Exercise in the UK	UK	UK	(Geary et al., 2004)	61	British Journal of Management
	How journal rankings can suppress interdisciplinary research: A comparison between Innovation Studies and Business & Management	Spain The Netherlands UK	UK	(Rafols et al 2012)	173	Research Policy
	Green supply chain management: A review and bibliometric analysis	Australia USA	More developed countries	(Fahimniaa et al., 2015)	37	International Journal of Production Economics
Engineering, Computer Science	China-US scientific collaboration in nanotechnology: patterns and dynamics	UK	China	(Tang & Shapira, 2011)	51	Scientometrics
	Bibliometric analysis of publications by the chemistry department, Seoul National University, Korea, 1992-1998	USA China UK	Korea	(Kim & Kim, 2000)	36	Journal of Information Science
	A bibliometric study of China's semiconductor literature compared with other major Asian countries	China	China	(Guan & Ma, 2007)	53	Scientometrics
	China's emerging presence in nanoscience and nanotechnology. A comparative bibliometric study of several nanoscience 'giants	China	China	(Guan & Ma, 2007)	106	Research Policy

Source: Scopus, data gathered in 15 of May, 2016.

2.1.2. Bibliometric studies that focus on the scientific production of Central Asia countries/regions

Till the date, bibliometric research on Central Asia has focused mainly on underlying patterns in scientific outputs in global science, target high-impact countries, also on the collaboration profiles of different Central Asia countries (Suleymenov, Ponomareva, Dzumabekov, Kubieva, & Kozbagarova, 2011). Important overviews of science and technology have been undertaken by Purnell & Reuters (2013) and Karamourzov (2012), which both reviewed not only trends but identified key issues for future research policies in Central Asia. (Suleymenov et al (2011) indicated that although, Central Asia is culturally, geographically, traditionally is very similar to each other but referring to Science and Technology development they are in distinctive position. However, their research did not analyze deeply such distinctive patterns. According to their result in term of research publication Kazakhstan is in leading ahead of Uzbekistan and Kyrgyzstan by 8 times and outperforms Tajikistan and Turkmenistan by 32 times.

The most recent continental mapping of Central Asian research was undertaken by Wang et al (2015), who undertook bibliometric overview of Central Asia research in 1992–2014 based on the comprehensive ISI Web of Science coverage. Their main goal was to reveal underlying patterns in scientific outputs, pinpoint subject-specific research, target high-impact countries, institutions and authors, and identify qualified collaborations. Generally, this bibliometric study utilized necessary research tool to get a global overview of the actual progress and trends in Central Asia research field. The same study also pointed out the low level of collaboration in Central Asia. Similarly, in the case of collaborative research, it's most important collaborators between 1990 -2015 were mostly non Central Asian countries (Wang et al., 2015). The role of non-local partners research output has also been highlighted in the case of research by Suleymenov et al.,(2011), where according to both mentioned studies the most leading roles played by following countries focusing on various fields: the USA, Russia, China, Germany, the UK, Kazakhstan, France, Japan and Switzerland. Also, summarizing their research Wang et al., (2015) suggested to use of some other databases or materials then Web of Science, which would be beneficial to the rationality of the result.

Sarwar & Hassan, (2015) used bibliometric to analyze the scientific productivity and international collaboration of Islamic world in Science and Technology. Their study concluded that the highest percentage of publication of the Islamic World falls into the

areas of Veterinary and Density. Regarding Central Asian countries it shows that due to the strong research corporation of most developed countries within themselves, less developed countries like in Central Asian have less contribution and attention status.

Other study such as (Hamidov et al., 2014) examines the international research on Agricultural land use in Central Asia mentioning publications mainly focus on the importance of environmental and economical dimension of land use. On the other hand (Karamourzov, 2012) traces the evaluation scientific literature worldwide; however his study results that study on position of the scientific field in Central Asia certainly deserve more attention. The result of above studies uncovers the state and the development of trends in 'Five stans' and show that Kazakhstan is one of the leading countries in areas of Agricultural and Biological science.

Bearing in mind that concept of research based on Global Science in CA is in the beginning rate of development, however it is mentioned that since 1992 annually research publications in these regions were upgrading rapidly (Paul-Hus, et al., 2014). The researchers were studying several areas of science, focusing more in the period of reform and transmission. Particularly, larger half of publications faced with focus on Agriculture and Medicine. However, Central Asia countries as mined on review, it appears that nowadays they need for more attention (Hamidov et al., 2014) as reformation of Soviet Union and their transition to new stage induced big impact to a value of research publication in this region (Karamourzov, 2012; Wang, et al., 2015). To sum up, bibliometric analysis related to 'Five stans' countries have not yet received adequate theoretical and practical development, which once again confirms the relevance of this study.

2.2. Studies that analyze the scientific production regarding Innovation

Next, let us consider the relationship of Innovation related studies with previous efforts to review the field. There have been numerous attempts to do it. Around 2% of 5773 publications related to bibliometrics includes Innovation research which is about 104 articles and reviews (search analysis date (15 of May, Scopus). Last two years the number of publication in the field has doubled.(see Figure 1). Highly cited examples are (Sakata, et al., 2012; Fagerberg, Fosaas, & Sapprasert, 2012). However, most such efforts have focused on more developed countries (Werker, 2006; Seol & Park, 2008) than the less ones such as 'Five stans' (Aubert, 2005). For example, Klinecicz &

Miyazaki (2011) discussed embedded software related research activities in Asian countries regarding innovation focusing on outputs of scientific research for years 2002-2006, where main selected Asian countries were China, India, Japan, Korea, Singapore and Taiwan. Similarly, (Haslam, Jupesta, & Parayil, 2012) also focused to three Asian key car-manufacturing countries, such as, Japan, Korea and China. They use literature review and bibliometrics and patent analysis to analyze fuel cell vehicle technology and suggest how the particular innovation systems and policies adopted in these countries have influenced the development of fuel cell vehicle.

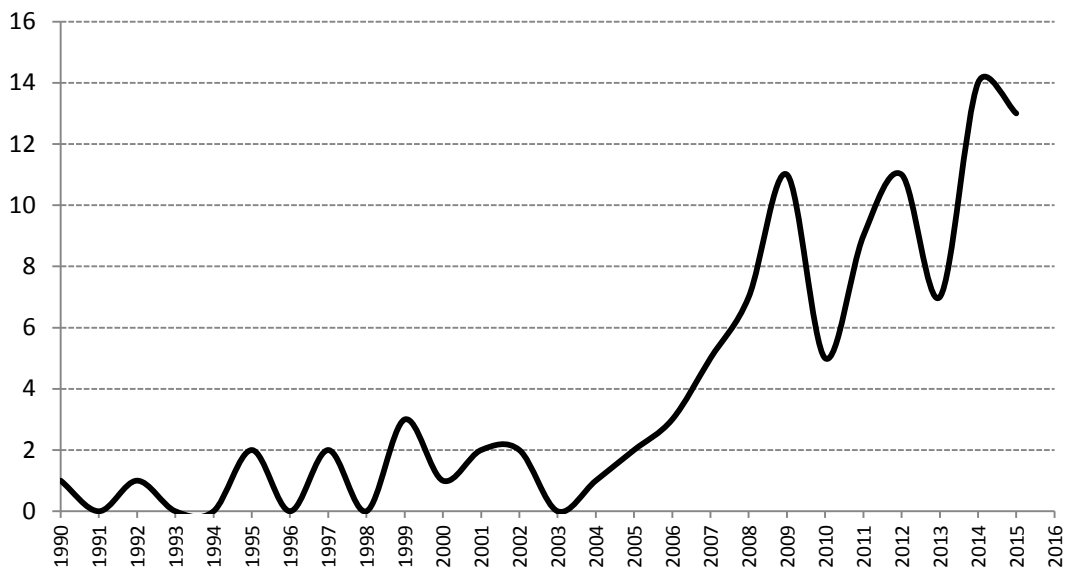


Figure 1. Number of publications on innovation related research

Source: Scopus, data gathered in 15 of May 2016.

Paper by Seol & Park (2008) deals with the concept of knowledge flow in innovation studies in Korea where their main contribution consist of investigation of the knowledge sources of Korean innovation studies using citation analysis, based on a Korean database during 1993–2004. However, in conclusion they mentioned about not being sure what stages the overall level of Korean innovation studies are currently at.

Toivanen & Ponomariov (2011) organized a study to investigate the collaborative structure of the African innovation systems research. Their main approach includes to empirically identifying clusters of scientific activity on the African continent as well as the structure of the collaborative linkages between them.

Later, Sakata et al. (2012) used bibliometrics for journal information analysis, citation network analysis to create the academic landscape in service innovation. Their result shows that there are two main groups of research relating to service innovation have

been growing rapidly in recent years: where one consist of fields such as health and medical care, IT and Web and the others are management, ecosystem. In addition, they showed that the research competencies of Asian countries lags behind that of the US and European Union. Similarly, other authors have analyzed service innovation research where their works also based on citation network analysis (Zhu & Guan, 2012). However, according to their result there are were more researchers who did investigation about service innovation in the category of Business and Economics, Engineering, Management Science than those in other categories.

As we see none of these studies analyzed or focused on region under this study. Also Aubert, (2005) mentioned in his research of not much of experiences accumulated in the field of innovation policy is directly applicable to developing countries. Verily, limited research has been conducted to sort out innovation approach specific to 'Five stans'. Therefore, there is a need on research about such area adapted to the needs and capabilities of 'Five stans'. Respectively, taking benefit from this, in this study, we choose Central Asia as a region consists of five developing countries where research in the field is indeed needed. The research described in this paper was motivated by, and seeks to address these important issues.

2.3. Filling the gap: a bibliometric account of the Five Stans on Innovation studies

As such, there are already some evidences certainly appears to be a high level of activity in Innovation research in the literature. However, there does not appear to have been a similar level of interest in using these tools for analyzing research in Central Asia. Have been found that research related innovation none studies devoted to reviewing and examining such publications. Thus, the present study aims to overcome this gap by focusing on Central Asia centering research to Innovation-related publications. It also would be useful to see if there are distinct patterns between them, because after independence each "stans" developed within different statistical flow (Suleymenov et al., 2011).

Previous recent study on Central Asia has analyzed the research publications on Central Asia from 1990 to 2014 based on Global Science (Wang, et al., 2015). In this study, we explore same period with different databases and focusing only on specific research filed like Innovation. This approach distinguishes our study from all previous empirical research and in the present study, we resort to a similar methodology of these later

studies, namely by categorizing an area of research (Innovation) but focusing on a rather unexplored context, the Central Asia related research. Respectively, bibliometric analyses, content analyses of publication were applied for this study, along with various above mentioned works. In spite of working with few publication of bibliographic material, it has been excellently analyzed and it helped to draw an accurate conclusion and understand the state of research up to now.

3. Methodology

3.1. Initial considerations

Until 2004, the Web of Science (WoS) was the only international and multidisciplinary database available to obtain the literature of technology, science, medicine and other fields. Nowadays, there is another powerful database controls a wide range of refereed information. In 2004 Elsevier introduced Scopus which is become a good replacement (Vieira & Gomes, 2009). WoS includes 12,000 of the highest impact journals worldwide and of over 150,000 conference proceedings, while Scopus has a scope of approximately 19,500 peer-reviewed journals and more than 4.6 million conference proceedings. Accordingly, two powerful databases control a wide range of refereed information; the WoS (created by Thomson-Reuters) and Scopus (created by Elsevier). Thus, our systematic database search was conducted using the two above mentioned databases.

We built our database within search on 9 of June, 2016 based on Scopus and ISI Web of Science. Each data were retrieved in CSV format. The search strategies from two different sources used to retrieve the data were as follows.

3.2. Search procedures

3.2.1. Scopus

1. The search criteria performed using the executed query TITLE-ABS-KEY (“innovation”) AND TITLE-ABS-KEY (“Central Asia”) considering all type and up to present documents within checking every subject areas (Life Sciences, Health Sciences, Physical Sciences and Social Sciences) . Total 74 publications appeared in a result to extract.
2. On the other hand, we carried a search within TITLE-ABS-KEY (Kazakhstan) AND TITLE-ABS-KEY (Innovation), TITLE-ABS-KEY (Uzbekistan) AND TITLE-ABS-KEY (Innovation), TITLE-ABS-KEY (Tajikistan) AND TITLE-ABS-KEY (Innovation), TITLE-ABS-KEY (Kyrgyzstan) AND TITLE-ABS-KEY (Innovation) and TITLE-ABS-KEY (Turkmenistan) AND TITLE-ABS-KEY (Innovation). Generally, collected 160 documents regarding on Kazakhstan, 35 on Uzbekistan; 11 on Tajikistan, 8 on Kyrgyzstan and 10 on Turkmenistan.

3. Finally, we repeated above two search strategy, but instead of Innovation term Technical change and Technological change keywords were used as synonyms. TITLE-ABS-KEY (“technical change ”) AND TITLE-ABS-KEY (“Central Asia”) and TITLE-ABS-KEY (“technological change”) AND TITLE-ABS-KEY (“Central Asia”). Unfortunately we could not find related data. Also search followed within TITLE-ABS-KEY (“technical change”) AND TITLE-ABS-KEY (“Kazakhstan”) and TITLE-ABS-KEY (“technological change”) AND TITLE-ABS-KEY (“Kazakhstan”). Respectively, same search conducted for rest countries where found out 3 papers related to Kazakhstan, 1 on Uzbekistan and 1 on Turkmenistan. Regarding to Tajikistan and Kyrgyzstan no papers found within the search date

In this way, 303 related studies extracted from Scopus. However, this data included various documents which may not relate to present study. Extracted data were passed to procedures of analyzing relevant papers within the following criteria:

- Repetition
- Document type
- Language (only English studies were considered)
- ‘Five stans’ related studies

The distribution of papers per repetition and document types is as follows: Duplicate papers of 33 (10.8 % out of 303 papers) and 2 unknown literatures sorted out and delated. The rest of 268 publications were consist of Conference Paper (26; 9.6 %), Article (211; 78.4 %), Review (10; 3.4 %), and Book Chapters (21; 9.3 %). From remaining data 155 retrieved studies as none related in the field with the base that most studies were analyzing ‘Five stans’ on topic different than innovation where later wecategorized them as studies related to: different regions than ‘Five stans’ (30; 17.9%) and different field than Innovation (125; 82.1%). Thus, from Scopus we selected only 113 (37.3% out of 303 papers) Net publications to extract the information for examining the current progress of Innovation related research in Central Asia.

3.2.2. Web of Science

During the same time period, we carried out a similar search, which is available through WoS. Our inquiry searched for all the articles published in a broad range of journals within search keywords TOPIC (“innovation”) AND

... TOPIC (“Central Asia”): 44 documents were obtained;

... TOPIC (“Kazakhstan”): 124 documents were obtained;

... TOPIC (“Uzbekistan”): 18 documents were obtained;

... TOPIC (“Tajikistan”): 9 documents were obtained;

... TOPIC (“Kirgizstan”) 4 documents were obtained;

... TOPIC (“Turkmenistan”) 6 documents were obtained.

Succeeding search with replacing keyword “innovation “ with “technological change” and “technical change” for every above conducted search queries found only 2 publications regarding to “technological change” AND “Kazakhstan”. Regarding Central Asia and other ‘Five stans’ no data captured within the result.

A set of 207 preliminary papers were then extracted for subject area to exclude irrelevant publications. Sum of 16 (7.3%) duplicate papers deleted where remaining 191 papers broke down based on document type. In the data, only 151 (79%) articles and reviews, 25(13%) proceedings and 15(7.8%) conference Papers were nominated as eligible data. However, from 191 papers 109(57%) of them considered as irrelevant and later ejected. Decisively, 82 (43% out of 207) articles and review were selected as a Net data from WoS.

Combining final made dataset from two sources (Scopus and WoS) faced 23 matched papers and ruled out that in total set of 172 publications (NETDATA) selected for analyzing of present study.

3.3. Procedures for getting a workable bibliometric database (NETDATA)

Next, generated data was categorized and analyzed by: author, journal, country, industry, research area and topic.

Primarily, we analyzed the evolution of publications related innovation in Central Asia based on the number published each year.

Second, the analysis process began with the name of the authors recovered in the selected publication records. We performed delamination processes using software MS Excel (HOME-TEXT TO COLUMNS) where “comma” was as delimiter between each author’s names. Later, we sorted out separate columns with list of the individual authors’ names which then we merged them all in one column. This column ordered out with alphabetical list of the authors’ names (DATA-SORT). Reordered list of authors checked for repeated authors name using specific technique (HOME-CONDITIONAL FORMATTING-HIGHLIGHT CELLS RULES-DUPLICATE VALUES) in order to find out top frequent authors in the field. In some cases, the author’s names were duplicated with a slight difference. Therefore, we developed a manual overview of the whole list of author’s names; however it was quite possible to check each data attentively as existing database for our study is not quite big. Thus, the top authors were fused directly from the list. Finally, we analyzed most prolific authors within following criteria: affiliation, country, core research area, number of publication in overall based on both database, number of citations, h-index. Based on this analyses also top country and affiliation of authors were detected.

Also, same strategy applied for analyzing top journals within area in Central Asia. Some repeated journals in both databases highlighted and check for ranking . We found out most frequently repeated journals within the number of publications. Later to find out top journal we compared with impact factor of each journal and accordingly, sorted out the leading journal within innovation related research in Central Asia. In addition, according this information also frequent research area separated within study.

Finally, the study processed analyzing industry and topic of the related studies. Based on abstract we retrieved information regarding the industry and topic of each study. Later, this result was used to analyze the matching between the industries analyzed and the patterns of economic specialization of the ‘Five stans’.

4. Empirical Results

4.1. Initial considerations

As mentioned in the previous section, we used 172 publication records to assess the current progress of Innovation research in Former Soviet Union five "stans". This section presents the results of the paper. First, the study analyses the publication evolution of innovation research in Central Asia during the last thirty years (1987- June 2016).. Next, the article sorts out the most top research areas, industries, countries, topics and contribution of leading authors and influential journals based on their h-index and impact factors within innovation research according to Scopus and ISI Web of Science and compares the results obtained with previous studies.

4.2. Evolution of publications on innovation research in Central Asia

Over the last thirty years, 172 documents have been published on innovation research on the 'Five stans'. Figure 2 presents the evolution of the number of papers published annually involving innovation. Of the 172 studies considered, 84% were published after 2011. It is evident that most of the research has published quite recently.

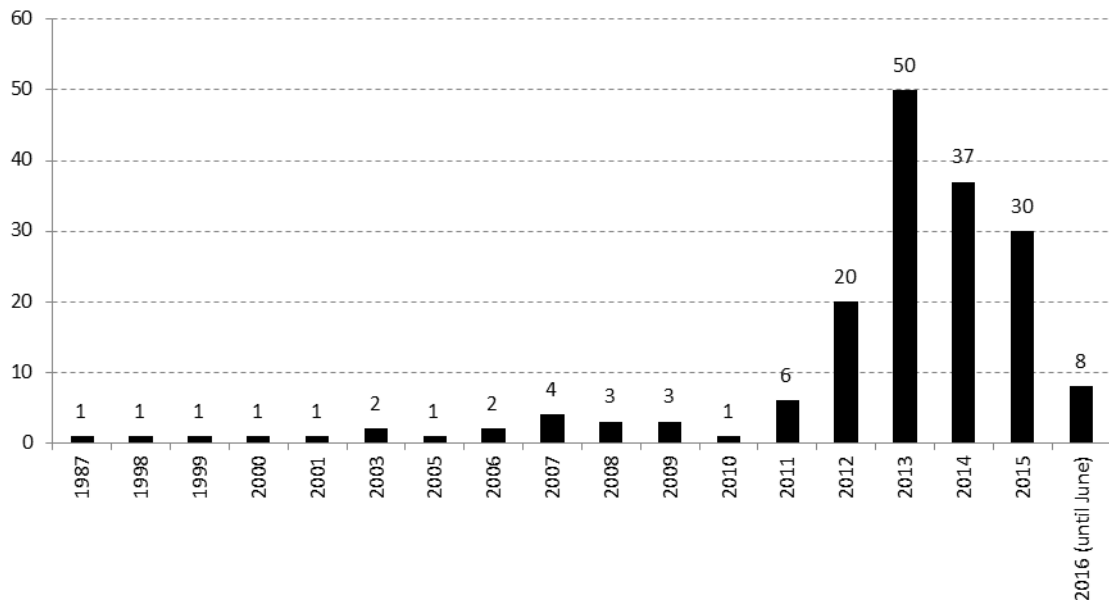


Figure 2. Annual number of studies on innovation in the five "stans"

Source: Scopus and Web of Science, 9 of June, 2016

In order to see the effective and relative growth of the field, Figure 3 presents the evolution of innovation research on the 'Five stans' comparing it with studies published on these countries in the science overall. The number of innovation research is quite

small comparing to the papers that exist in science targeting on Central Asia topic; however despite a very small number of publications shown in figure, last years the weights increased a lot. Barely, no one was really interested to target their analysis on Central Asia innovation before 2011, but after the number of papers increased a lot in absolute and relative (vis a vis Science) terms.

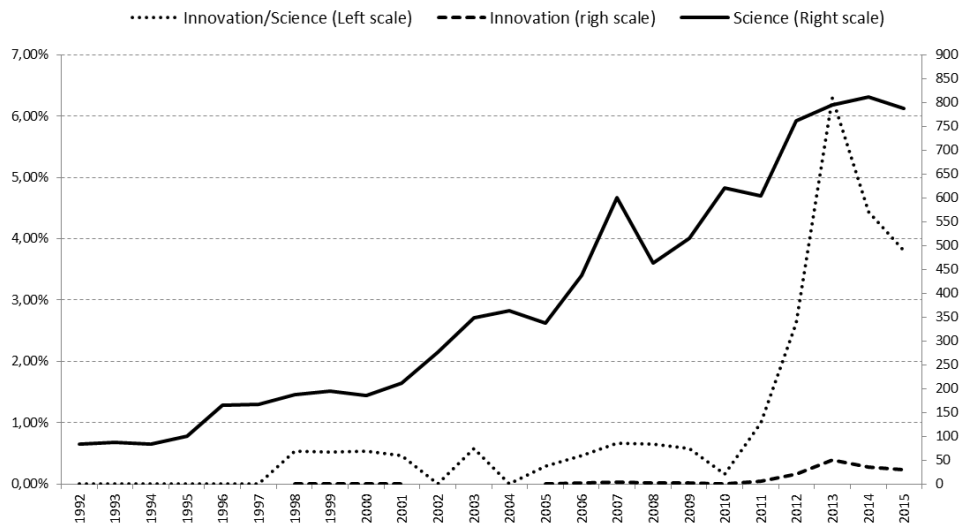


Figure 3. Evolution of innovation related research vis a vis all Science in Central Asia (annual growth rate, %)

Source: Scopus and Web of Science, 9 of June, 2016

Comparing to worldwide innovation related research the picture is similar (Figure 4).

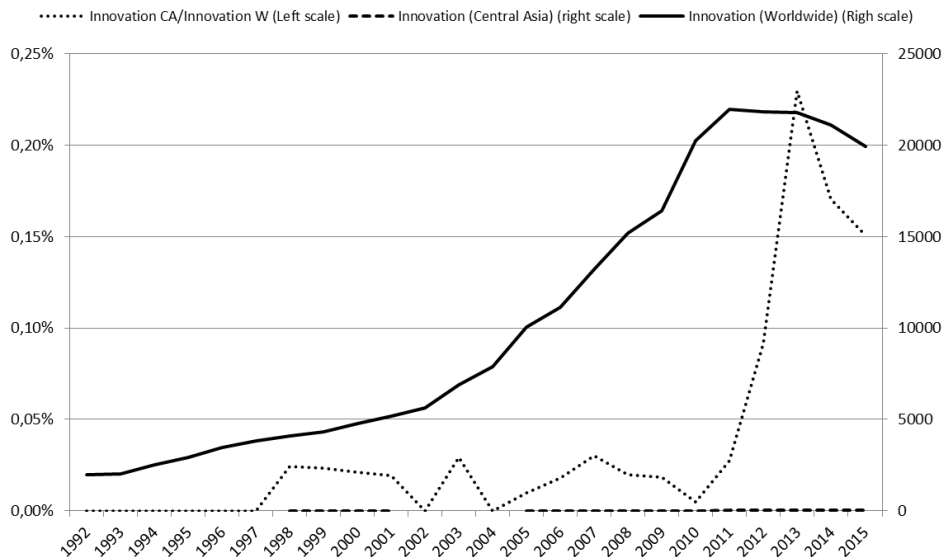


Figure 4. Innovation related research in Central Asia vis-à-vis worldwide innovation (annual growth rate, %)

Source: Scopus and Web of Science, 9 of June, 2016

4.3. Most prolific authors

The analyzed listed 284 authors, among whom 256 (76 %) had produced only by one paper, however, considering in average each paper had at least 3 authors about 256/3 papers had produced. A total of 76 (90 %) had produced ≥ 2 papers. Thus 10 most prolific authors altogether developed 38 papers, accounting for 5 % of cumulative publications. Among these top authors, 9 were from Kazakhstan and only one was from Germany. The three most prolific authors were Aubakirova Gulnar from Karaganda State Technical University, Kazakhstan, Mukhtarova Karlygash and Zhuparova Aziza from Al Farabi Kazakh National University, Kazakhstan with 6, 5 and 5 publications respectively (Table 2).

Table 2. Most ten prolific authors

Authors	Research Area	Affiliation	No. publications in the field	No. publications in overall	Citations	h-index
Anna Hornidge	Social Sciences	Universitat Bonn	3	20	79	6
Shuakhbay Zamanbekov	Biochemistry	Kazakh State Women's Pedagogical University	4	5	10	2
Aziza Zhuparova	Economics	Al Farabi Kazakh National University	5	8	2	1
Karlygash Mukhtarova	Multidisciplinary	Al Farabi Kazakh National University	5	3	2	1
Nurzhan Alzhanova	Economics	Almaty Management University	4	6	1	1
Rimma Sagiyeva	Social Sciences	Al Farabi Kazakh National University	3	2	1	1
Gulnar Aubakirova	Economics	Karaganda State Technical University	6	3	0	-
Rauan Danabayeva	Business Management	Al Farabi Kazakh National University	3	4	0	-
Alla Kireyeva	Economics	Institute of Economics of the Ministry Education and Science	3	1	0	-
Aygerim Abeldanova	Social Sciences	Turar Ryskulov New Economic University	2	2	0	-

Source: Scopus Sci Verse, 10 of June, 2016

Considering the total citations and h-index comprehensively, Hornidge Anna from University of Bonn, Germany, Zamanbekov Shuakhbay from Kazakh State Women's Pedagogical University, Kazakhstan and Aziza Zhuparova from Al Farabi Kazakh National University, Kazakhstan were leading in this review. As for Hornidge, he is a German researcher within Social Science area where he published in overall 20 papers and was cited 79 times by 54 documents

Based on Table 2 we can easily say that, most authors are not well known because they have very few numbers of citations and h-index, however these are ten authors publishing higher amount of papers on ‘Five stans’. Also, in Table 3 we provided top ten country and affiliations of authors where Kazakhstan with manly Kazakhs State University, Kazakh Economic University and Karaganda State Technical University considered as most enthralling ones on studying ‘Five stans’, mainly Kazakhstan itself.

Table 3. Top countries and affiliation of authors developing research on ‘Five stans’

Country	No. of documents	Affiliation	No. of documents
Kazakhstan	73	Kazakh National University	17
United States	8	Kazakh Economic University	11
Uzbekistan	6	Karaganda State Technical University	10
Germany	4	Gumilyov Eurasian National University	3
Russia	3	Ahmet Yassawi Kazakh, Turkish International University	2
Kyrgyzstan	2	Center for Development Research (ZEF)	2
Turkey	2	Kazakh National Agrarian University, Almaty	2
France	2	Kazakh State Teacher Training University	2
Italy	2	Kazakh State Women's Pedagogical University	2

Source: Scopus, 9 of June, 2016

4.4. Top journals and research areas in innovation on ‘Five stans’

There are many journals that publish material related to innovation research in Central Asia. Figure 5 provided most frequently publishing journals within innovation related research on Central Asia based on number of studies published.

However, to find top leading journals according to their impact factors we developed following tables. Table 4/5 presents a list with the 14 journals with the highest *impact factors* with ranking of area related top journal. We can see that impact factor of journals is quite low in the rank of the area related core journal. For instant, Irrigation and Drainage which one of the top journal that are publishing more articles on ‘Five stans’ in innovation. This journal has impact factor of 0.5, however within it is area of Agronomy and Water Resources the Global Change Biology Bioenergy with 6.1 and Water Research with 6 impact factor are the top once. This means that mostly studies are published but not in core journals of this area.

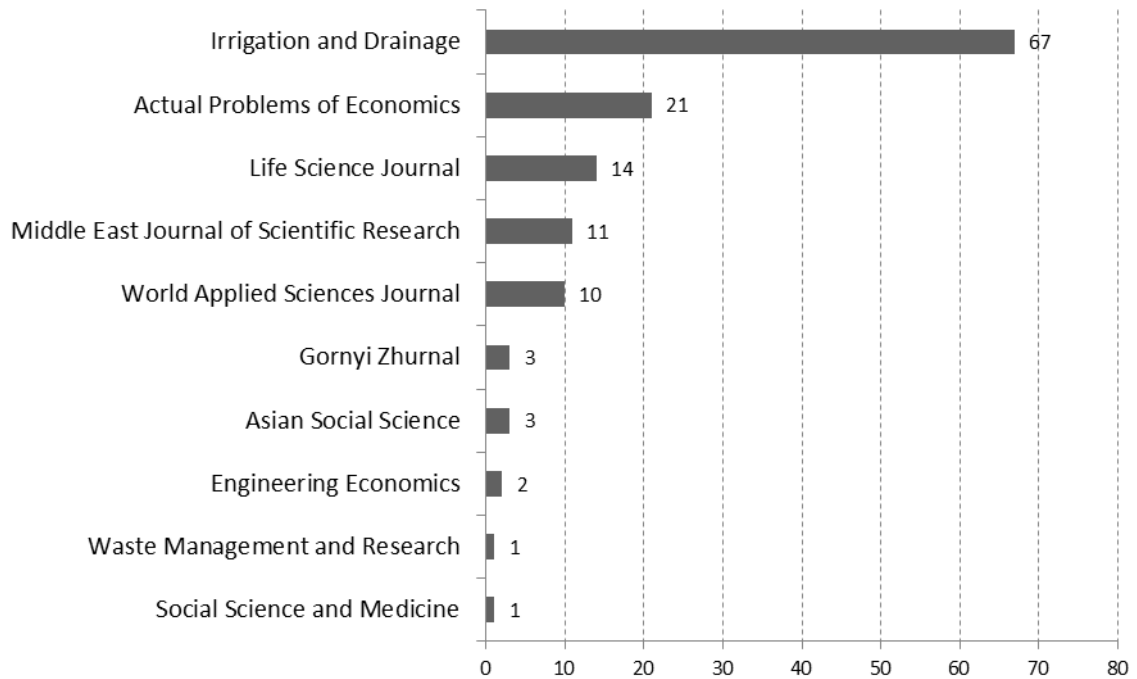


Figure 5. Most frequently publishing journals in the innovation related literature on the Central Asia (number of documents)

Source: Scopus and Web of Science

Moreover, it is also interesting to see if the results of this study are in accordance with top leading journals in area (Innovation). Journals that are publishing most frequently innovation related literature in Central Asia have not linkage with core innovation journals. Although, authors are publishing a lot on innovation, but they are not the leading ones in area; secondly they are out of innovation area. This means that the top journals within innovation are not interested in publishing “stans” related research and the literatures on the ‘Five stans’ about innovation is published outside of the boundary core journals. According to this information these are top journals within innovation area in Central Asia and we know from analyses that none of these journals appears among the core journals which means they are neglecting literatures that are being produced about innovation in “stans” and authors developing these type researches manage to be published but only in quite outside journals.

Table 4. Most influential journals in innovation research on five “stans”

Journal	Research area	Impact factor 2015	Area top Journal	Impact Factor of area Journal
Health Affairs	Health Care Services	5.230	Health Affairs	5.23
Social Science and Medicine	Health	2.814	Lancet Global Health	14.72
Waste Management and Research	Environmental Engineering	1.338	Applied Catalysis B-Environmental	8.382
Engineering Economics	Economics	0.806	Journal of Economic Literature	9.243
Criminology Journal	Criminology and Penology	0.676	Crime and Justice -A Review of Research	4.941
Middle East Journal of Scientific Research	Area Studies	0.605	African Affairs	1.904
Irrigation and Drainage	Agronomy/Water Resources	0.565	Global Change Biology Bioenergy/Water Research	6.151/5.991
Post-Communist Economies	Econometrics	0.548	Journal of Economic Literature	9.243
Applied Engineering in Agriculture	Agricultural Engineering	0.429	Bio-resources Technology	4.917
Economic Analysis and Policy	Economics	0.25	Journal of Economic Literature	9.243
Singapore Economic Review	Econometrics	0.221	Journal of Economic Literature	9.243
Life Science Journal	Biology	0.165	Plos Biology	12.69
Innovation: Management, Policy and Practice	Management	0.088	Academy of management annals	9.741
Actual Problems of Economics	Econometrics	0.039	Journal of Economic Literature	9.243

Source: Web of Science, 10 of June, 2016

Health Affairs and Social Science Journals have been the main leaders during the last ten years. The majority of the journals at the top of the ranking have a general orientation in health, environmental engineering, economics, criminology and Agriculture. Innovation research is growing comparing to previous years due to the strong increase of research in ‘Five stans’ however it is still very low in according worldwide innovation research and need of these countries for such research are. Thus, more researchers need to try publishing innovation research on Central Asia in core journals of area.

Table 5. Most influential journals in innovation research on ‘Five stans’

Journal	Research area	Impact factor 2015	Area top Journal	Impact Factor of area Journal
Health Affairs	Health Policy	5.23	Health Affairs	5.23
Social Science and Medicine	Health	1.894	Science	13.217
Waste Management and Research	Environmental Engineering	0.619	Energy and Environmental Sciences Open Access	10.475
New Library World	Library	0.594	Information Systems Research	4.397
Education and Information Technologies	Information	0.528	Information Systems Research	4.397
B.E. Journal of Economic Analysis and Policy	Economics	0.501	Quarterly Journal of Economics	20.761
Engineering Economics	Business, Management, Accounting	0.456	ACS Nano	7.12
Journal of Agricultural Education and Extension	Geography	0.43	Molecular Systems Biology Open Access	8.87
Irrigation and Drainage	Agronomy	0.409	Remote Sensing of Environment	3.369
Post-Communist Economies	Economics	0.337	Quarterly Journal of Economics	20.761
Economy of Region	Economics	0.33	Progress in Human Geography	4.951
Development in Practice	Geography	0.318	Molecular Systems Biology Open Access	8.87
Applied Engineering in Agriculture	Engineering	0.311	ACS Nano	7.12
Public Policy and Administration	Sociology	0.306	Administrative Science Quarterly	10.565

Source: Scopus, 10 of June, 2016

Present study also developed analysis to sort out the top research areas engaging innovation studies on ‘Five stans’ based on journals area. About 70% of research areas occupied by following areas presented in Figure 6 where Agronomy and Water Resources are the most frequent.

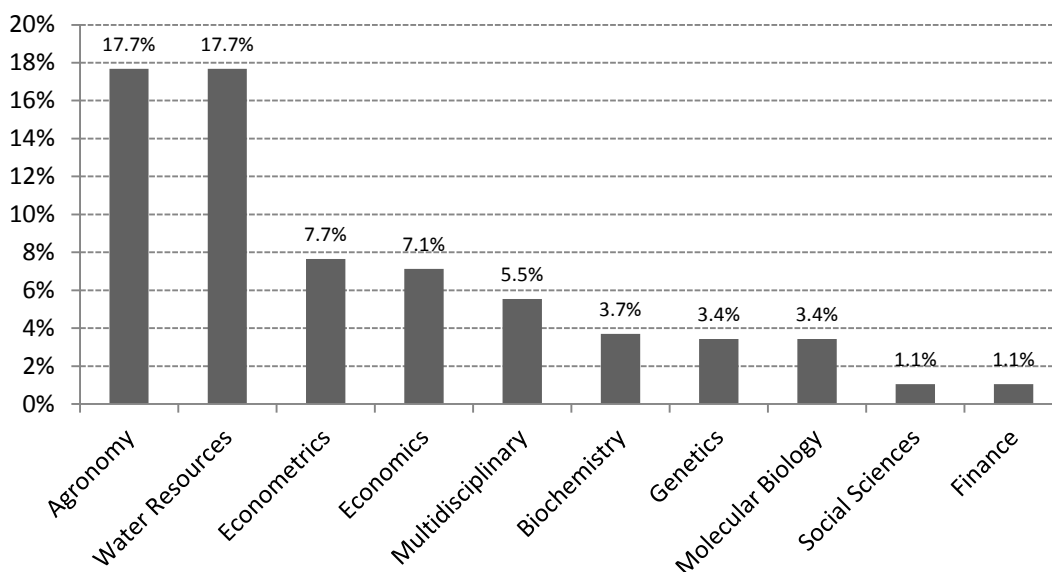


Figure 6. Most researched areas (in percentage of total papers)

Note: Number of total papers=349.

Source: Scopus and Web of Science

4.5. Main topic and industry analyzed

Total of 27 out of 172 literatures concerns to industrial studies. These studies primarily focusing on two countries of ‘Five stans’: Kazakhstan within Metallurgical, Energetics and Agroindustry and Uzbekistan regarding Oil and Cotton industries. Indeed these countries are developed in Central Asia comparing others. Almost more than half of publications concerns to Kazakhstan where all of affiliations belongs to this country. Comparing with core main industries Uzbekistan and Kazakhstan has some in common research that matches with their local main industries, however there only one research directed their empirical analysis about industry of Turkmenistan which is not main core industries of this country. For instance, there are no studies focused on gas industry of Kazakhstan however, such country has worked to develop its economy, especially its dominant gas (hydrocarbon) industry. Exceptionally, there have been faced a few publications focusing industries such as Insurance, Communication, Technological and High-Tech which they are not on putting the core of their analysis to specialization patterns. Although main industries of Tajikistan and Kyrgyzstan are as giving in Table 6, but none of the studies devoted their analysis on industry of this country. In general, these studies that focus on analyzing industries are far from the core industries of Central Asia. Although, many authors developing research on innovation related to some industries, they are not addressed to real life industries that might be very important for ‘Five stans’ (Table 6).

Table 6. List of ‘Five stans’ sorted by industry and frequent topic of research

Country	Studies that focused industries	Industries focused/analyzed	Main topics	Country’s core industries (by decreasing order of importance)
Kazakhstan	21	Energetics Agroindustrial Transport vehicles Textile Oil Cotton Coal High-tech	Management Education Agro culture National Innovation Entrepreneurship Energy Engineering Ecology	Oil Gas Banking Tourism Car Mining Energetics
Uzbekistan	5	Metallurgical Agroindustrial Cotton	Metallurgical combine Cultivator Collaboration State Support Transition Interdisciplinary	Automobile Tourism Cotton Coal Oil Silk
Turkmenistan	1	Technological	Drilling fluid technology	Tourism Gas Oil Construction materials Chemicals
Tajikistan	0		Ethno cultural education Economical Grow Research activity	Metallurgy Agriculture Cotton Energetics Rare metals (Non-ferrous) Coal Oil Silk
Kyrgyzstan	0		Health system	Metallurgy Gas Agriculture Coal

Source: Scopus and Web of Science, 15 of June, 2016

In addition, most influenced topic areas on innovation related research in Central Asia as given in Table 6. Based on our analysis Agriculture, Education, Management, Entrepreneurship and Ecological Cultural are in the main focus list of researchers.

5. Conclusions

5.1. Main results and contribution

The article provides a general bibliometric overview of innovation research on former Soviet Union ‘Five stans’, over a period of almost thirty years (1987-2016).

Central Asia research was marked by steady growth with a rapid increasing in publications on innovation in the last four years. A total of 172 papers were published in 49 distinct journals, with 70 papers published in journals indexed in Web of Science and 102 in Scopus.

Kazakhstan and Uzbekistan are the ones attracting more research on Innovation. Although, research collaboration was quite frequent within the ‘Five stans’, Germany stood as the main foreign collaborator in the field.

In terms of authors, countries and affiliations, of the top most prolific authors, nine were from Kazakhstan and one from Germany. Kazakhs State University, Kazakh Economic University and Karaganda State Technical University emerged as the most productive studying innovation in the ‘Five stans’.

The study also presents a journal analysis with a list of the 10 most frequent journals in the field based on their number of publication, such as *Irrigation and Drainage*, *Actual Problems of Economics*, *Life Science Journal* and *Middle East Journal of Scientific Research*. These, however, have in general low scientific impact and visibility in their corresponding area. Moreover, the very few high impact journals that published research on innovation in the ‘Five stans’, including *Health Affairs*, *Social Science and Medicine* and *Waste Management Journals*, fell outside innovation core area.

When comparing the results with the leading innovation journals, the specialized ones tend to publish more studies in the field while the leading ones publish less but received more cites and high impact factor. This result is quite logical because the leading journals are very selective regarding the articles published in the journal. Thus, top leading innovation worldwide journals are not interested in publishing ‘Five stans’ related research on innovation. Therefore, most publications managed to be published but in very far from core field journals rather than native ones.

Summing up, innovation related research in the ‘Five stans’ is not receiving a lot of attention by the scientific community, despite its recent upsurge.

5.2. Limitations and avenues for future research

When developing bibliometric analysis, some limitations occurred due to the specific nature of the research in the certain region. As we know Central Asia is former Soviet Union region and Russian is mostly used language concerning research. It might be a limitation that we only concerned our research only within English language, however while searching related papers on Google and Google Scholars itself, we did not face as much papers even within Russian language.

As usual, further studies in this direction are needed in order to obtain more general view of the state of the art in this field. This article has considered innovation related studies based on the Scopus and ISI Web of Science databases. However, future works should be developed by retrieving some other databases. Nevertheless, this bibliometric study used indispensable research tool to get a global overview of the current state of innovation related research in Central Asia. In spite of the limitation, this paper provided a good starting point to understand the evolution of research in the field and might serve as a potential basis for future research.

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Appendix