Research on progress: Role and management of research and technology organization (RTO) in national innovation system: Case CICITEM in Antofagasta, Chile

Tatu LYYTINEN

Technical Research Centre of Finland (VTT)/ Aalto University School of Economic

Tel: +358 40 1293409, Email: tatu.lyytinen@vtt.fi

Abstract: This paper, using Chile as a case study, we present general description of our work and contribute on understanding the role of research and technology organization (RTOs) in industrializing country. As new OECD country (since 2010), Chilean innovation system is not structured in a way to contribute on economic and social development related to science, technology and innovation. Chilean economy highly depends on primary material production and weak and fragmented innovation system slows down the development to knowledge based economy. In recent years, studies in innovation system in developing and emerging countries have increased. However, the role of RTOs in global development remains an understudied issue. To fill this gap, this paper offers preliminary insight into role of RTO in emerging countries in phase of renewing its innovation systems. This is done my reviewing the literature in innovation systems related role of RTO and innovation management of RTO in developing and emerging countries and presenting preliminary observations from Antofagasta, Chile. This study argues that there is need for context and practice based comparative case studies including action research and new interventionist methodologies to contribute on knowledge transfer and development of innovation systems in emerging countries.

1. RTOs in national innovation system

In January 2009, an OECD-UNESCO workshop was held on Innovation for Development examining the role of knowledge, its place in innovation systems, and in innovation strategies, and ways of supporting North-South knowledge flows (OECD 2010). The key conclusion of the workshop was that there is too little empirical evidence on how to improve innovation activities in developing and emerging countries and their connection locally and globally in order to create more value in local economic, social and environmental development.

The national innovation system has become an established conceptual framework in the analysis of innovation environments and provides an analytical context to study the role of research and technology organizations (RTOs). RTOs are important part of research and innovation systems in many developed countries and especially in developing economies in early "catch-up" phases of economic development (Mazzoleni and Nelson 2007). However, the role of RTOs in national innovation system remains scarce and most of them have been focusing on developed countries (see Loikkanen, Hyytinen and Konttinen 2011) and newly industrialized countries in Asia, such as South Korea and Taiwan (See Kim 1999).

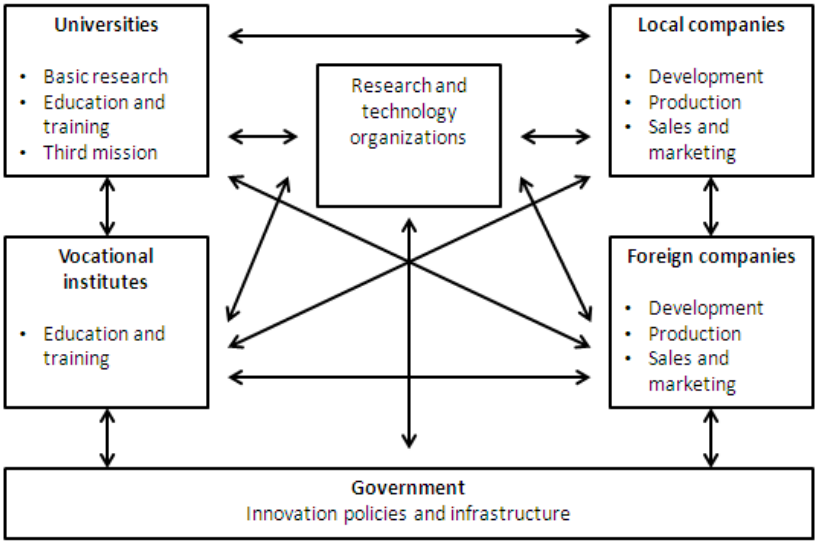
Research and technology organization (RTOs) are public, semi-public or private contract research organizations (EARTO 2007). The roles of RTOs in innovation system vary depending on country context and are characterized by their different kind of owners, different legal status, mission, organizational structure and outputs (Leitner 2005). Their functions partly related to knowledge creation in form of research and development and strategic basic research and partly on knowledge diffusion in form of operating as broker organization within innovation system (Loikkanen, Hyytinen and Konttinen 2011).

Many studies have been conducted and recommendations given, especially from OECD, for less industrialized countries how to establish or reorganize their innovation systems and establish RTOs as integral part of national innovation system. However it is argued that it would make little sense for emerging country to follow the path of more developed countries where the needs of the innovation system are quite different (Arnold, Rush, Bessant and Hobday 1998; and Nelson and Mazzoleti 2007). Accordingly, simply investing more on

research does not necessary increase the competitiveness. This has led to mismanagement RTOs and research and technological institutes in general in less industrialized countries.

This means that we need understand and pay more attention strategic management of organizations in innovation system. As argued above, RTOs play a key role in innovation system and they should be analyzed in more detail related to context and phase of development. Creating RTOs in developing economies has many time had little effect on innovativeness of the country (Intarakumnerd and Chairana 2008). According to Arnold et. al. (1998) reason for this has been fundamental misunderstanding of what is role of RTO in innovation system and how RTOs are managed.

Picture 1 is a preliminary presentation of components of national innovation system and role of RTO. Arnold et. al. (1998) argues that RTOs have a unique place in innovation system drawing on both national and international knowledge in order to support industry. Loikkanen, Hyytinen, and Konttinen (2011) remind that RTOs, especially public research organizations (PROs), have also public mission to respond the societal challenges created by market failures and externalities.



Picture 1.Conceptual framework on role of RTO in national innovation system (Adapted from Arnold et. al. 1998 and Mazzoleni and Nelson 2007)

Next different roles of different actors related to RTOs in innovation system are discussed, and after management of RTOs in context on national innovation system is discussed. First, the roles and relationship of universities, industry and government are widely discussed in

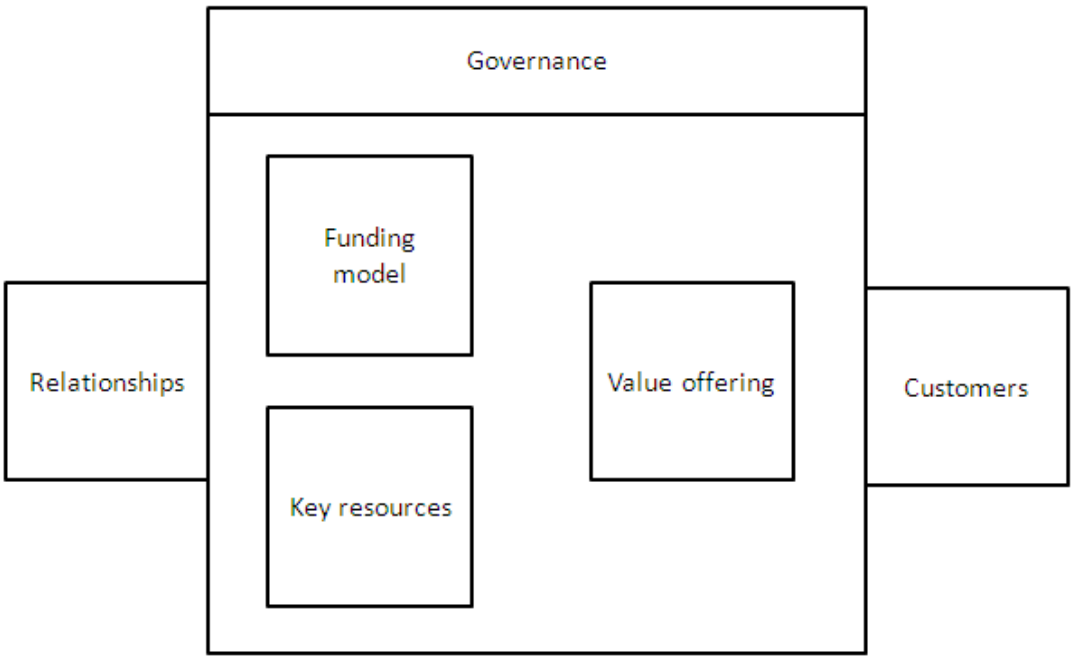
literature related to developed (See Etzkowitz and Leydesdorff 2000) and developing economy (See Etzkowitz, Mello and Almeida 2005) contexts. Accordingly, third mission of universities, emphasizing their societal and market benefits is blurring the boundaries between universities, RTOs and industries. Arnold et. al. (1998) remind that RTOs does not do the same job as universities in basic science and applied science or education, but operate as valuable partner in incremental development of technologies and operate as staging-posts for scientists and engineers moving from university to industry. RTOs has their own dynamics based on acquiring, assimilating, supplying and improving technologies and proving technology related services which industry needs, but cannot readily access in-house (Arnold et. al. 1998: Mazzoleni and Nelson 2007). Last, both universities and RTOs play an important role on knowledge acquisition through mobility and reverse brain drain (see for Kim 1999). In addition, vocational institutes are included in the framework, as their importance on capacity building, but are not discussed in detail in this paper.

Second, private sector is seen as main engine of economic development. Arnold et. al. (1998) argues that RTOs are not substitutes for innovative capacity of industry, which is true engine of innovation. In this paper the private sector is divided to foreign and local companies. Reason for this is that Kokko (2010) argues that global technological knowledge mainly resides in multinational companies (MNC). He points out that in 2004 top 25 R&D spending corporations invested about USD 175 billion, more than entire non-OECD world spend on R&D. Moreover, significant share of R&D performed in developing and emerging countries is controlled by MNCs. Acquiring, assimilating and diffusing of this knowledge is key factor for economic development for countries in early phases of industrialization and RTOs play key role in this process (Kim 1999; Mazzoleni and Nelson 2007; and Intarakumnerd and Chairana 2008). However, Mazzoleni and Nelson (2007) argue that simply acquiring knowledge and replicating the technologies through reverse engineering is challenging nowadays caused by creation and enforcement of intellectual property rights globally by companies from developed countries. This means that organizations in countries in early stage of industrialization need to find new ways to build international alliances and partnership to access advanced knowledge and know-how. To conclude, OECD (2010) argues that public research sector is a key issue for knowledge creation and diffusion as neither multinational corporation’s affiliates or local firms have the incentives and/or capabilities to do this.

Third, government and innovation policies are important part of innovation systems. The rationale for public intervention in society is many times argued by market failure (Martin and Scott 2000). Accordingly, particular needs for government funding differ across sectors in the economy and policy design should take these differences in account. Many RTOs have been established in areas of imperfect markets to support policy-making and to eliminate negative externalities by science and technology (Loikkanen, Hyytinen and Konttinen 2011). In this context innovation policies and infrastructure, such as banking system, venture capital, IPR, information systems, standards and regulations, are not discussed in detail, however understanding their crucial role on management of RTOs and functioning of innovation systems is included. The innovation policies are discussed more in conclusions and discussion part of this paper where future research directions are given.

Last, management of RTOs in innovation system is discussed. Arnold et. al. (1998) argues that operational reason for poor RTO performance in innovation system stem from a failure to run the RTOs as if they were business. They continue arguing that RTO management is often tempted to operate more in the style of a university. However, RTOs, as defined earlier, are not simply a business as they normally receive both public and private funding (Leitner 2005). To better understand the management of RTOs, we need to turn to management and organizational studies. Still, understanding, that RTOs cannot not be seen separated from innovation system discussion.

It can be argued that management of public research organization in context of innovation system remains an understudies in academic literature both in developed and developing country context (see Arnold et. al. 1998; Leitner 2005; Intarakumnerd and Chairana 2008; and Albors-Garrigos, Zabaleta and Ganzarain 2010). Conceptual model (Picture 2) is constructed based on discussion on RTO management by Arnold et. al. (1998), Leitner (2005) and Albors-Garrigos, Zabaleta and Ganzarain (2010).



Picture 2. Management framework for research and technology organization

The governance of RTO should guide type of work done in organization and assist on building a strategic relationships of RTO. This means that RTO governance need to have scientific and technological understanding and market and customer understanding (Arnold et. al. 1998) to fulfill its role in innovation system (Picture 1). In addition, RTOs normally operate closely with public institutes meaning that understanding of politics and innovation policies is required (Loikkanen, Hyytinen, and Konttinen 2011).

RTOs customers come from private sector such as multinational companies (MNCs) and small, state owned companies and medium sized companies (SME) and from public sector such as ministries, municipalities and associations (Loikkanen, Hyytinen and Konttinen 2011; Leitner 2005; and Arnold et. al. 1998). This means that specific customer relationship management resources are needed.

RTOs value offering includes creation of knowledge in form of strategic basic research, jointly funded research, and diffusion of knowledge in form of contract research including prototyping and new product development and incremental improvements, testing, standardization, certification and market intelligence services, mobility, publication and lectures and creation of spin-offs (Loikkanen, Hyytinen and Konttinen 2011; Leitner 2005;

and Arnold et. al. 1998). To manage RTOs efficiently, understanding of these different functions remains crucial.

RTOs resource management has its unique feature combining private sector business related and university science related resources. To move from academic style of management to business type of management RTOs need to acquire management related resources such human resource management, information systems management, project management, customer relationship management and marketing and sales and engineering skills such as prototyping and design (Arnold et. al. 1998) to complement university related scientific capabilities.

In general RTO funding comes from three sources (Loikkanen, Hyytinen and Konttinen 2011; Arnold et. al 1998). First many PROs receive basic funding from government related to industrial development. Second, majority of RTO funding comes from competitive funding including public and private and national and international funding. And third, contract based funding from private sector.

As one of the most important roles of RTOs in innovation system is to operate as knowledge broker, strategic relationships are key for success of RTO. The partners of RTOs are R&D units of private companies and universities as well as other RTOs locally (Albors-Garrigos, Zabaleta and Ganzarain 2010) and increasingly globally (Sharif and Baark 2011).

To conclude, RTOs are integral part of national innovation systems meaning that we need to understand their specific role on country context and phase of economic development to develop efficient ways to manage RTOs. Here we have discussed the role of RTOs in national innovation system and especially in context of industrializing economies and provided framework for TRO strategic management.

2. Methodology

This study focuses on understanding the process of innovation capacity building between Technical Research Centre of Finland (VTT) and Centro Investigación Científica y Tecnológica para la Mineria (CICITEM) in Antofagasta region in Chile. The purpose of this study is to take a practice oriented approach to understand the TRO management in context of national innovation system, and how international cooperation contributes on innovation and development from evolutionary perspective. However, this paper mainly focuses on describing the Chilean innovation system, role of newly established RTO in Antofagasta, and challenges encountered.

Accordingly, the increase of copper production has been the main cause for economic development in Antofagasta region since the 1960 (Lagos and Blanco 2010). However, production of copper has created systemic lock-in in Antofagasta region and a historic reference provides a warning example in the development that took place after saltpetre (sodium nitrate) was replaced by synthetic products. This dramatic change devastated the Chilean economy in general, plunging many areas and cities into poverty, and producing a string of ghost towns. The findings of OECD study in the 2007 indicate that the main obstacles for the economic and social development in Chile are the lack of human resources, and related inability to transfer the knowledge to productive sectors. Chile depends highly on foreign knowledge and technology to tackle the demand and challenges of the economy. This causes a vicious cycle of dependency and regrettable transfer of wealth and human resources beyond national borders, limiting abilities to develop, and find endogenous solutions to the challenges Chile is facing. In addition to the structural economic shifts, Antofagasta Region is an extreme risk area for ecological changes. Global climate change and contamination from the mining activities have had a high and lasting effect in especially on the water supplies of the region. To tackle this challenges regional RTOs has been established in Chile. In Antofagasta CICITEM (Centro de Investigación Científico Tecnológico para la Minería) was established in 2006. However, there is not much research done role of RTOs role in Chilean innovation system and especially management of RTOs in Chile related to innovation system and innovation policies (See OECD 2007; Lemola and Pena-Ratinen 2008). The research question follows “What is the role of CICITEM in Chilean national innovation system and how CICITEM is currently managed?”

In this paper, extended case methodology is applied to map the theoretical framework and draw some conclusions based on real evidence (Buraway 1998). With this case methodology, we make use of empirical data gathered about an actual case to re-conceptualize or extend existing theories. The researcher examines the literature relevant to the problem area, and employs the empirical data to fill in the gaps, reveal flaws, elaborate on their meaning and extend coverage. The extended case method approach goes through many cycles of confrontation between the data and the theory, directing the analyst to additional data and drawing on additional concepts and theories. This is also useful when the phenomenon under study is not readily distinguishable from its context. Interpretive studies generally attempt to understand the phenomena under study through the meanings that people assign to them. Interpretive research does not predefine dependent and independent variables, but focuses on the full complexity of human sense-making as the situation emerges.

First, unstructured interviews and participatory observations were conducted in research and technology organization CICITEM in Antofagasta and its two partner universities to understand the current barriers in local innovation management and strategic cooperation in context of innovation system. Second, visit to Finland was organized by CICITEM management to provide comparative understanding on role of RTO in national innovation system and practices in management of RTOs. The visit to Finland contributed to theoretical understanding of management of RTO in innovation system and revealed some challenges CICITEM is facing in local and national innovation system.

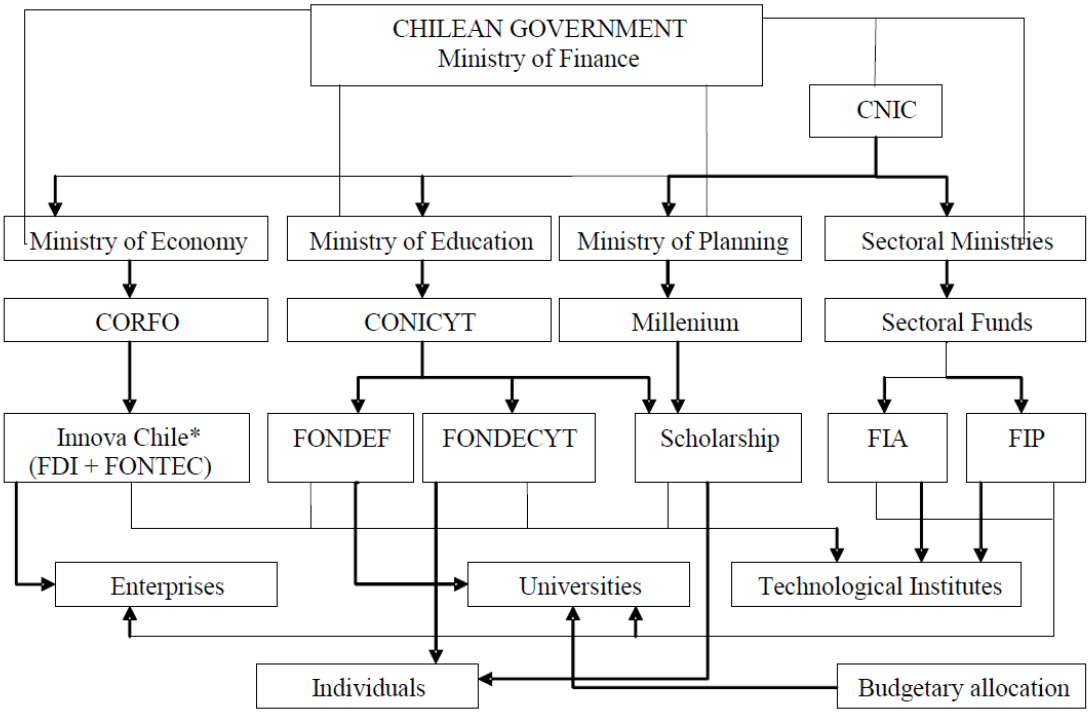
3. Analysis

Chile, stable, open and primary material based economy has recorded strong economic development during last decades. First, Chile has reduced significantly the gap in income per capita with advanced countries and has been one of the most progressive performers in Latin American region. Second, openness to international trade and foreign direct investment (FDI) has contributed to well-functioning market and modern technology base. Third, strong export-oriented and resource-based industries, mining sector responding 50% of Chilean export, have contributed to stable growth. However, Chilean innovation system remains underdeveloped and is facing major challenges.

The OECD innovation policy review of Chile in 2007 argues that main challenges Chile is facing are: (1) the modest role played by the local business sector in the financing and performance of R&D, and local subsidiaries of multinational companies carry out very little R&D and innovation activities in Chile; (2) Most R&D is financed by the government and carried out in universities; (3) research and technology organization play a questionable role in the innovation system and are seen as inefficient and detached from the sectors they are meant to serve. Next Chilean innovation system and innovation policies are discussed shortly and then role of CICITEM in Chilean innovation system and management of CICITEM are analyzed.

4.1. Chilean innovation system

In this section, we represent shortly the Chilean innovation system. First, main innovation policy instruments are discussed. Second, main innovation policies are discussed. And last sectoral innovation policies are introduced related to mining industry.



Picture 3. Institutional profile of Chile's innovation policy making (OECD 2007)

Chile has three main policy instrument to support science, technology and innovation in the country (Picture 1). First, CORFO (the Foundation for Promoting Development) in Ministry of Economy focuses on funding innovation in private companies, attracting foreign high-technology investment, and increasingly promoting entrepreneurship. Second, CONICYT (the National Commission for Scientific and Technological Research) in Ministry of Education focuses on financing research in universities, investing in research infrastructures and international cooperation. These two agencies administrate generally above 90% of public science, technology and innovation funding in Chile. Third, CNIC (National Innovation Council) provides guidelines for a long-term national innovation strategy. In addition, sectoral ministries allocate sectoral funds and administrates sectoral innovation activities and technological institutes such as CIMM (Centro de Investigación Minero y Metalúrgico).

Two major innovation policies have been established by CNIC to increase effectiveness of Chilean innovation system. First, law 20.241, established in 2008, provides companies incentive to participate in innovation activites with a 35% tax credit on R&D services contracted with registered research organizations. However, the Law 20.241 requires establishment of joint venture between research organization and private company making process complicated. Second, spesific mining tax was introduced to increase resources available to implement new innovation strategies.

CORFO's Integrated Terretorial Programme (PTI) promotes sectoral innovation activities related to given geographic zone. PTI allocates resources to salmon cluster in regions of Los Lagos and Aysén, to wine cluster in region of Region of O'Higgins, and to mining cluster in the region of Antofagasta. However, Chile has not implemented a fully articulated cluster-based approach to innovation policy.

4.2. CICITEM in Chilean Innovation system

In Chile, there are two different types of research and technology organizations (RTOs). First, public and non-profit RTOs have been founded under sectoral ministries. For example CIMM (Centro de Investigación Minera y Metalúrgica) was created in 1970 as a private non-profit foundation to carry out scientific and technological research in mining and SERNAGEOMÍN

(Servicio Nacional de Geología y Minería) was created in 1980 to produce and provide information on mining and geology to satisfy the needs of government agencies, companies, public and private organisations and individuals. Second, private RTOs were founded with narrower focus to support regional innovation activities during the 2000s. CICITEM (Centro de Investigación Científico Tecnológico para la Minería) is one of these private RTO and was legally established in 2006 and it has been operationally functional since 2008. According to OECD (2007):

"ITPs have contributed to the technological development of the Chilean economy. They have undergone an important institutional and collective learning process and accumulated vast experience that should be used when devising the future of the national innovation system (NIS). Today, however, their performance is quite uneven. Many are generally seen as expensive, inefficient and quite detached from the sectors they serve. The research they carry out is not considered of top quality and is not always economically relevant. They are also perceived as being cut off from international trends."

Next, role of CICITEM in Chilean innovation system is shortly described and after management of CICITEM is analysed (Picture 2). CICITEM was founded in 2006 by the Universidad de Antofagasta (UA), Universidad Catolica del Norte (UCN), with the support from the Antofagasta Regional Government, Conicyt (National Commission for Scientific and Technological Research), and sponsored by the regional private sector. CICITEM is a majority public owned entity, with majority public funding. CICITEM has a regional consortium institutional board, under which the management operates four units. Currently CICITEM has over 50 people, of which 30 are PhD. researchers. The researchers work on projects related to different areas of mining processes, water resource management, bioenergy, and environment and sustainability.

4.3.1 CICITEM governance and organizational structure

As argued by Arnord et. al. (1998) effective governance of RTO should combine in creative way both people with understanding from world of science and world of business. CICITEM governance currently consists of people from two universities, local government and CONICYT. There is no representation from CORFO, which focuses on managing innovation

policies related to private sector and no participation from local private sector or multinational companies.

In addition, CICITEM researchers are located in universities and CICITEM real-estate only provides facilities for 5 people responsible of management and administrative issues. This makes it difficult to build consistent organizational culture and effective innovation management practices. This has caused that CICITEM researchers continue working independently as they did as university researchers. CICITEM is not able to strategically direct its activities to neither serve better the private sector and local government nor benefit from physical proximity of multidisciplinary research. To conclude, current CICITEM governance model and organizational structure does not support CICITEM development to take a role of research and technology organization (RTO) in national and local innovation system (see picture 1).

4.3.2 CICITEM customers

CICITEM has not been able to attract customers from private sector. Majority of CICITEM activities are related to joint research projects with universities and some international organizations. CICITEM provides some research services to mining industry such as analysing the microbiology ecosystems related to copper leaching. However, there is no innovation related activities targeted to private sector. Other CICITEM research line focuses on development of biodiesel from micro algae, but major challenge has been lack participation from private sector in form of investment cooperation. To conclude, there should be analysis made for local private sector R&D activities and needs and study effectiveness of innovation policies such Law 20.421 on innovation activities of private sector.

4.3.3 CICITEM value offering

CICITEM consist from three research lines. First, mining processes focuses on research on mining processes, modelling and optimization. Second, biomining focuses on researching

bacterial ecosystems in mines. And third, bioenergy and sustainable development focuses on research in biodiesel production from micro algae and mining related water and waste research.

As argued above, CICITEM research activities are not aligned with private sector activities in the region. In addition, CICITEM does not provide research services that would respond to local government needs. To conclude, CICITEM value offering indicates top down strategy making.

4.3.4 CICITEM key resources

As argued by Arnold et. al. (1998) efficient management of RTO requires balance of multidisciplinary resources related to science, research, engineering, design and business. CICITEM organization consists currently from people with background on basic research and some additional resources such as accounting and marketing. There are no resources related to understanding private sector. This might be a major reason why CICITEM has not been able to engage more private sector participation on its activities.

As argued before, CICITEM also lacks physical resources such as real-estate, own laboratory equipment and information systems as well as intellectual resources such as own databases related to patents, publications or market related information. Weak resources of CICITEM are mainly caused by misunderstanding of RTO innovation management both from CICITEM personnel and its governing bodies. This has caused that there is not needed external financing available organization that would operate efficiently in innovation system.

4.3.5 CICITEM Funding model

CICITEM basic funding comes from CONICYT which is related to Ministry of Education, and from local government. Basic funding consists currently 61% of total funding. Funding from competitive sources is mainly related to CONICYT funding and some international funding sources such as European Research Area (ERA). There is only one jointly funded

research projects related to CORFO funding. Last, only 3% of funding comes from contract research related to direct cooperation with private sector. To conclude, there is a major misunderstanding on role of RTO in innovation system in Chile.

4.3.6 CICITEM key partnerships

CICITEM is a relatively young organization and it is still in initial phase of searching its role in Chilean innovation system. CICITEM has strong relationship with two local universities (UAC and UA) and strategic cooperation with Australian RTO CSIRO (Commonwealth Scientific and Industrial Research Organisation). In addition, CICITEM has relatively good support from local government and local industry association. However, there are still many challenges ahead.

First, regionally there are some challenges to cooperate in strategic way with two universities. The relationship between these two partner universities has suffered significantly from the competition and alliances in the Centre of Excellence Programme (ICE) race. The winner CSIRO and loser SMI (Queensland University) have further complicated the circumstances. The less successful pair (SMI-UAC) is heavily loyal to each other, to the extent some level of distance to the winning pair (CSIRO-UA). In addition, CICITEM is suffering from decreasing trust from local government caused by resignation of governor in 2010 who gave a strong support for the CICITEM since from beginning.

Second, as argued before, majority of public and private science, research and innovation activities are concentrated to capital area in Santiago. CICITEM argues to have some level of cooperation agreement with Centro de Investigación Minero y Metalúrgico (CIMM), Pontificia Universidad Católica de Chile (UC) and University of Chile (UCHILE). However, there are no incentives from innovation policies to build strategic research programs with these partners. And CIMM is nowadays rather political organization and majority of researchers have moved to CODELCO research centre IM2.

Third, majority of joint research programs with private sector come via SCIRO. And majority of CICITEM cooperation is done with traditional mining companies. Filippou and King (2011) argues that structural changes in mining industry has caused that majority of R&D and

innovation activities in mining industry is done by a spin-off companies of traditional mining companies. Good example is Outotec spin-off from Outokumpu in Finland. And as argues by Kokko (2010) majority of knowledge production is done by multinational companies. CICITEM does not have any strategic cooperation or join research projects with multinational companies operating in the region. In addition, majority of multinational companies have their headquarters in Santiago and there are no innovation policies in Chile providing incentives for multinational companies to invest in local R&D activities. CICITEM existing and potential partnerships are illustrated in picture 4.

Picture 4. CICITEM relationships in Chilean mining sector

4. Discussion and conclusion

Research and technology organization (RTO), public and private, are increasingly considered central actors in the process of economic, social and environmental development in regional

context in developed and developing countries. National innovation system literature provides a good framework to understand to understand role of RTO in country context. In this paper we have argued that there is not much studies made in role RTO is industrializing country context. In addition, we argue that general understanding of management of RTO is innovation system remains weak in academic literature. Understanding role of RTO in national innovation system related to management RTO and via versa is a key for developing innovation policies in developing and emerging countries.

This study shows how misunderstanding of role of RTO innovation system and management of RTO has lead inefficient impact of local RTO in national Chilean and Antofagasta regional economic, social and environmental development. However, this study only shows preliminary results and new approaches are need to further study the phenomenon. Next some further research directions are proposed.

In short, this study has concluded that we need to understand how RTO are managed in national innovation system context. In addition, journey of this study has indicated that developing and emerging markets can learn and transfer some practices from more advanced countries. First, comparative case studies are needed including joint publication to create efficient processes of knowledge transfer. Second, action research related to interventionist approaches is needed to facilitate and increase the development of innovation systems in emerging and developing countries. Third, innovation system and innovation policy studies focusing on RTOs and funding instruments and innovation policies related private sector – RTO relationship are needed. Fourth, innovation management of RTOs in context of national innovation system in emerging and developing countries are needed.

The research is part of project on innovation capacity cooperation between Technical Research Centre of Finland (VTT) and Centro Investigación Científica y Tecnológica para la Mineria (CICITEM) in Antofagasta region in Chile. The project is funded by Ministry for Foreign Affairs of Finland 2011 – 2013.

References

Albors-Garrigos, J., Zabaleta, N., and Ganzarain, J. (2010) New R&D management paradigms: rethinking research and technology organizations strategies in regions. R&D Management, 40/5, 435 – 454.

Arnold, E., Rush, H., Bessant, J., and Hobday, M. (1998). Strategic Planning in Research and Technology Institutes. R&D Management, 28/2, 89 – 100.

Buraway, M. (1998). The Extended Case Method. Sociological Theory 16/1, 4-33.

EARTO (2007) The Research and Technology Organizations in Evolving European Research Area. A Status report with Policy Recommendations.

Etzkowitz, H. and Leydesdorff, L. (2000) The dynamics of Innovation: From National Innovation Systems and "Mode 2" to triple helix of university – industry – government relations. Research Policy. 29/2. 109 – 123.

Etzkowitz, H., Mello, J.M.C., and Almeida, M. (2005) Towards "meta-innovation" in Brazil: The evolution of the incubator and the emergence of a triple helix. Research Policy, 34/4, 411 – 424.

Filippou, D. and King, M.G. (2011) R&D prospects in the mining and metals industry. Resource Policy, 36, 276 – 284.

Giuliani, E. (2006). Efficient Public Research Organization-Industry Network Structures? A Comparative Study in the Chilean and Italian Wine Industry. EUI Working Papers 2006/07.

Intarakumnerd, P. and Chairatana, P-A. (2008) Shifting S&T Policy Paradigms: An experience of an RTO in Thailand. International Journal of Technology and Globalization, 4/2, 121 – 138.

Kim, L. (1999) Building technological capability for industrialization: analytical frameworks and Korea's experience. Industrial and corporate change, 8/1, 111 – 136.

Kokko, A. (2010) Facilitating North-South Knowledge Sharing: Conditions for Enhanced Knowledge Flows. In OECD Innovation and the Development Agenda.

Lagos, G. and Blanco, E. (2010). Mining and Development in the Antofagasta region. Resource Policy, 35, 265 – 275.

Leitner, K-H. (2005) Managing and reporting intangible assets in research technology organizations. R&D Management, 35/2, 125 – 136.

Lemola, T. and Pena-Ratinen, C. (2008). Reorganization of the Chilean Public Technology Institutes. CNIC – Consejo Naticional de Innovacion para la Competitividade.

Loikkanen, T., Hyytinen, K. and Konttinen, J. (2011) Public Research and Technology Organization in Transition – The Case of Finland. Science, Technology and Society 16/75, 75 – 98

Mazzoleti, R. and Nelson, R. (2007) Public research institutions and economic catch-up. Research Policy, 36, 1512 – 1528.

OECD (2007) OECD Reviews of Innovation Policy: Chile. ISBN 978-92-64-03751-9.

OECD (2010) Innovation and the Development Agenda. International Development Research Centre. ISBN 978-92-64-08892-4

Sharif, N. and Baark, E. (2011) The Transformation of Research Technology Organisations (RTOs) in Asia and Europe. Science, Technology and Society. 16/1, 1 – 10.