Measuring systemic failures in innovation systems in developing countries using innovation survey data: The case of Thailand

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1. Introduction

Innovation system (IS) research is increasingly important for innovation policy making. Since the approach was flagged by the OECD in the mid nineties, an increasing number of governments have adopted IS explicitly in their innovation policies (Mytelka and Smith, 2002). However, applying the concept in practice has been a daunting task (Chaminade and Edquist, 2006; Chaminade and Edquist, forthcoming). Policies based on the IS approach often collide with old paradigms, rationales and instruments (Intarakumnerd and Chaminade, 2008). Although most of the scholars in this line of research acknowledge the need to move from one-size-fits all policies to policies that take into account the specificities of the system, little is known on how to identify specific problems in the system.

The literature on national systems of innovation (Lundvall, 1992; Edquist, 1997; Nelson, 1993, Freeman, 1987) and particularly the strand of literature dealing with rationales for innovation policy (Lipsey and Carlaw, 1998; Smith, 2000; Chaminade and Edquist, 2006) has defined systemic failures or problems as systemic imperfections that might slow down or even block interactive learning and innovation in a given system of innovation (woolthuis et al, 2005:610). Among those systemic problems, different authors distinguish between infrastructure problems, transition & lock-in problems, institutional, organizational, network problems, information and coordination problems or problems with the complementarities or diversity of capabilities (Carlsson and Jacobsson, 1997; Norgren and Hauknes, 1999; Smith, 2000; Woolthuis et al., 2005; Chaminade and Edquist, 2006, Rodrik, 2004).

Although most systemic problems can be found in both developed and developing countries, the scope and extent of the problems are rather different in these two contexts. In developing countries, a vast majority of firms lack the minimum capabilities to engage in interactive learning and innovation (capability problems) and even when those capabilities exist, linkages among the actors within the systems of innovation are weak (network problems) and institutional frameworks are ill developed (institutional

problems) (Chaminade and Vang, 2006 and forthcoming; Dantas et al, 2008; Bell and Giuliani, 2005). Overall, in developing countries, the systems of innovation are weak and fragmented (Intarakumnerd et al., 2002) and in some countries and regions one may even see two separate and coexisting systems of innovation. One possibly dominated by Transnational Corporations (TNCs), indigenous global firms and world class universities, coexisting with the other with a majority of firms with low absorptive capacity, weak linkages with other organizations in the system of innovation and low-quality educational institutions (Vang et al., forthcoming; Intarakumnerd and Chaminade, 2007).

Despite the prior efforts *defining* what systemic problems are, no attempt has been done hitherto –to our knowledge– to empirically *identify* what the systemic problems of a specific system of innovation are. This paper aims at contributing to filling this gap by analysing the systemic problems of the Thai innovation system. For doing so, we use data from the Thai innovation survey in 2003 that seemingly allows a sufficient time lag for our analysis to identify systemic problems after a major transition initiated in 2001 from a traditional research policy (pre-Thaksin Administration) to a more explicit innovation system policy (Thaksin era). The Thai innovation survey has a particular advantage as it contains several detailed questions related to the issue (such as on institutional supports and innovation environment not available in the traditional European Community Innovation Surveys or CISs) that allow researchers to identify different systemic problems. We employ a hierarchical factor analysis in measuring institutional, infrastructure, capability and network problems and link them to the prior change in innovation policy in order to understand how and why such problems may have come about and existed.

The paper is organised as follows. In the next section, we discuss the implications of the adoption of the IS approach for innovation policy and introduce the different systemic problems discussed in the literature. In Section 3, we give a general account of the Thai innovation survey, describe the dataset and the questions selected to capture each systemic factor. Section 4 provides some descriptive evidence, present our hierarchical (two-stage) factor analysis and discuss it in the light of the recent transformation of the

Thai innovation system and innovation policy. The paper is rounded up with some conclusions and suggestions for further research.

2. Innovation systems and innovation policy

Since the seminal work of Freeman, Lundvall, Nelson or Edquist in the late eighties and mid nineties (Freeman, 1987; Lundvall, 1992, Nelson, 1993 and Edquist 1997) the innovation system approach has been largely adopted by scholars, practitioners and policy makers both in developed and developing countries (Lundvall et al, 2006; Muchie et al.; 2005; Mytelka and Smith, 2002; Edquist and Hommen, 2008). The extensive literature on systems of innovation has largely emphasized the importance of interactive learning for innovation and the systemic character of the innovation process (Kline & Rosenberg, 1986). Innovations are the result of the continuous interaction of firms with other organizations in the system that provide the knowledge and the technology required for the innovation process.

The IS approach emerged as an alternative to the dominant neoclassical paradigm, that understood innovation in a rather lineal way, assumed that knowledge was equal to information and was easily accessible to all firms. In contrast, the IS finds its roots in the evolutionary theory (Nelson & Winter, 1982) and considers that firms are a bundle of different capabilities and resources (Eisenhardt & Martin, 2000; Grant, 1996; Spender, 1996) which they use to maximize their profit. Knowledge is not only information, but also tacit knowledge; it can be both general and specific and it is always costly (Edquist, 2004). The main focus of the IS approach is the operation of the system and the complex interactions that take place among the different organizations and institutions in the system.

As we have argued elsewhere the general policy implications of the IS approach are different from those of neoclassical theory (Chaminade and Edquist, 2006) in terms of the rationales (Edquist and Chaminade, forthcoming) or the objectives and instruments (Borras et al, forthcoming). Often, a policy shift towards the IS approach collides with

existing practices, rationales, objectives and instruments that were developed under the previous neoclassical paradigm (Intarakumnerd and Chaminade, 2008).

The differences between the IS approach and the neoclassical approach to innovation policy are acute when it comes to the rationales for public intervention (Borras et al, forthcoming). For the scholars n the neoclassical tradition, policy makers need to intervene when there is market failure, that is, when markets cannot reach an optimal equilibrium. According to this stream of literature, due to the quasi-public nature of knowledge, individual firms will have no incentives to invest in basic research (Arrow, 1962, Nelson, 1959).

In the IS approach, the policy rationale is not based on market failures, but rather on systemic failures or problems[1]. The scholars in the IS tradition reject completely the option of optimality (and thus that of equilibrium or failure). Innovation processes are path-dependent and context-specific and it is not possible to specify an ideal or optimal IS (Chaminade and Edquist, 2006). Policy makers are expected to intervene when the system can not achieve the objectives of supporting the development, diffusion and use of economically useful knowledge and innovations (Edquist, 1997; Lundvall, 1992). Broadly speaking, one could argue that any factor hampering innovation at a system level could be considered a systemic problem. Although the literature on systemic problems is scarce and dispersed, some of the systemic problems mentioned by different scholars (Smith, 2000; Carlsson and Jacobsson, 1993; Rodrik, 194; Woolthuis, Lankhuizen et al., 2005 cf Chaminade and Edquist, 2006:) refer to the inadequate provision of research and innovation infrastructure, the lack of hard and soft institutions, the low level of firm's scientific and technological capabilities, the absence or ill nature of the networks between the different organizations of the system (too weak or too strong), the lack of information for innovation or the inability of the system to evolve and take advantage of new technological opportunities (transition and lock-in problems).

[1] As indicated in Chaminade and Edquist (2006) we prefer to talk about problems than failures, to avoid any possible connection with the notion of optimality.

Research infrastructure refers to the knowledge exploration subsystem (Asheim and Coenen, 2005) and includes the universities, research laboratories or research institutes that might provide the firms with some of the inputs of the innovation process (qualified human resources, basic or applied research, etc). The lack of an adequate scientific and research infrastructure for growth and development has long been discussed in the literature and much attention has been paid to the role of high-quality universities or research institutes in systems of innovation in developing countries (Gunasekara, 2006; Krishna, 2001, Basant and Chandra, 2006; Lall and Pietrobelli, 2005). Building up an adequate research infrastructure has traditionally been a role of the government due to the large scale, indivisibilities or long term horizons of operation and financing that characterise these infrastructures (Smith, 2000).

In their innovation process, firms usually need the *support from other organizations* rather than the scientific or technological ones. They need support services like consultancy, incubators or financing. The lack of these supporting infrastructures might also hamper the functioning of the system and thus can be consider as another systemic problem. Most of this services that, in a developed country, are supplied by the private sector, are lacking in less developed countries, thus limiting the ability of the indigenous firms to innovate and providing a reason for the government to create the conditions for these services to emerge.

But even when there is a fairly well functioning research and support infrastructure, firms might not be able to absorb the knowledge generated by these other organizations in the system because they *lack capabilities* or sufficient absorptive capacity (Cohen and Levinthal, 1990). The absorptive capacity of the firm is defined as its ability to identify, capture, adapt and exploit knowledge generated outside of the firm. It is a function of the firm's own *technological capabilities*[2] (its skill base, technological effort and networks) (Lall, 1992). In the absence of enough absorptive capacity, there is no knowledge transfer and thus no systemic interactive learning taking place. In developing countries,

[2] We use the term capability here as used by Lall (1992). As Padilla (2007) and Dantas et al (2008) acknowledge, Lall's initial definition of capabilities could be closer to what Pavitt and Tunzelmann understand by competences (passive learning) than capabilities (active learning).

indigenous firms are often characterised by their low level of technological capabilities and thus absorptive capacity (Dutrenit, 2000; Bell, 2002 and 2007; Padilla, 2006). This, in turn, hinders the possibilities of those firms to engage in interactive learning with local or international sources of technology, like MNCs or local universities.

Interactive learning will only take place when firms and other organizations in the system have adequate capabilities and they are part of formal and informal networks. *Network problems* refer to problems derived from linkages that might be too weak or too strong. If the linkages are too weak and the distance between the partners too large, the two organizations will have limited incentives to share knowledge (Nooteboom, 2000). If the linkages are too strong, the organizations in the network might be too blind to what happens outside the network (in the SI) (Woolthuis et al, 2005). The literature on IS systems in developing countries has largely emphasize the weak nature of the linkages between the different organizations of the system (Intarakumnerd, 2002).

Innovation is largely affected by the institutional framework (Hollingsworth, 2000). By institutions we refer to "sets of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organizations," (Edquist & Johnson, 1997). *Hard and soft institutional problems* are linked to formal rules (regulations, laws) as well as more tacit ones (such as social and political culture). Factors such as government incentives to innovation, IPR laws or the openness to innovation of different actors in the IS are considered to be part of the institutional framework.

The innovation system might be malfunctioning when firms and other organizations of the system *lack information* on technological opportunities, market opportunities for new innovations, potential sources of knowledge etc (Rodrik, 1994). The basic infrastructure might be there, but the indigenous firms might not be aware of their existence. This is particularly acute among small and medium size firms in developing countries (Szogs, 2008; Szogs et al, 2008). The role of the government in this case, is to facilitate the flow of information among the different organizations in the system.

Finally, the path –dependent character of the system might lead to *transition problems* or *lock-in problems*. Transition problems occur when firms are not able to respond to new technological opportunities or emerging problems because they have very limited technological knowledge or this is based on a very old technology (Smith, 2000). This is frequently the case in developing countries, where most of the firms are adopters of mature technologies rather than producers of new ones. Transition problems are particularly frequent in small economies in developing countries "which posses relatively small number of players in many sectors" (Smith, 2000: 95) and thus very dispersed capabilities. The concentration of capabilities in certain technological field can lead to another type of systemic problem, the lock-in of the system. Systems might be locked-in in particular technological trajectories that impede it to take advantage of new technological opportunities (Smith, 2000). Interaction within an IS might reinforce existing technological specializations which, in turn, might have positive or negative effects in some of the firms (Narula, 2002).

While the literature is rich in defining what is a systemic problem and the different problems that the system might face, there has been no attempt –to our knowledge- to empirically identify the problems of a specific system of innovation. In the following section, we propose a framework to identify systemic problems and we test its validity using the innovation survey data of Thailand in 2003.

3. Data

R&D and Community Innovation Surveys have been carried out periodically in Thailand since 1999 by the National Science and Technology Development Agency (NSTDA). While R&D surveys are launched every year, there have been three waves of Thai innovation surveys in the year 1999, 2001 and 2003, with the fourth one currently being undertaken. The very first innovation survey in 1999 covered only manufacturing firms. The scope then has been expanded to be more appropriate by also including firms in the service and other industries from the year 2001 onwards. The Thai surveys adopt

definitions and methodologies used by OECD (i.e., Frascati Manual 1993 and Oslo Manual 1997) and other countries in Asia (i.e., Singapore, Malaysia, Japan, Taiwan and Korea) to meet international standard.

Technically, the sampling methodology was developed in order to obtain unbiased estimates of the population R&D/Innovation parameters to be measured – expenditure on R&D/Innovation, and total R&D/Innovation personnel in manufacturing and service enterprises. The Business On-Line (BOL) database, with comprehensive information on around 50,000 establishments registered with the Commercial Registration Department, Ministry of Commerce, was used. In addition to the BOL database, other sources of information such as the Board of Investment, the Department of Export Promotion and the Computer Professional Information 2002 were also utilized for the service sector's sampling frame.

The third innovation survey in Thailand used in this paper has a time span of one year (i.e., throughout the year 2003 only). The size of total firm population in 2003 was 21.653 firms and the sampling frame included 6.031 firms in total, 4.850 from manufacturing and 1.181 from service and other sectors. The overall response rate of 42,8% (42,3% for manufacturing and 45,0% for service firms) was deemed of satisfaction and the original dataset of firms participating in the Thai third innovation survey thus consists of 2.766 firms. However, due to the structure of the Thai questionnaire (similar problems apply to most, if not all, European CIS questionnaires), we were restricted to focus on 184 innovative firms which were allowed (by the questionnaire's structure) to answer a number of questions relevant to our analysis.

Variables used in the analysis were derived from many relevant sets of questions in which some of them are considered special in the Thai case (not available in the standard CISs). These approximately 25 questions that are very crucial for the present study ask firms about current innovation environment (e.g., openness to innovation, financial situation, regulations, qualified workers, venture capital, supports from universities, R&D institutes and other organizations) as well as services and incentive programs provided by

the government agencies or support networks (e.g., various technical and consultancy services, technology transfer arrangements, tax incentive) for R&D and innovation in Thailand. Besides, variables extracted from CIS-standard sets of questions in the Thai survey were used in the analysis. These include questions about factors affecting innovation, sources of information for innovation, innovation expenditure, R&D expenditure, employment structure and other categorical information.

4. Method and Empirical Results

This section discusses the empirical results obtained from the hierarchical (two-stage) factor analysis which covers every relevant part in the third Thai innovation survey (for the period of one year – 2003) so as to take into consideration every relevant piece of information and allow them to demonstrate which variables or indicators jointly underlie which systemic factors. Whether and the extent to which these factors are problems or failures in the Thai innovation system are then assessed by linking them to the policy objectives made to transform the system from research based to innovation based during the major transition in Thailand in early 2001. This investigation, therefore, relies on a lag of about two years.

In our hierarchical procedure, factor analysis was performed separately in the first stage on several groups of variables derived from each relevant set of questions in the survey. Factor scores produced by the first-stage estimates were thereafter employed in the second-stage factor analysis to identify systemic factors in Thailand. The alternative scheme is to run factor analysis on all variables included at once. However, our constrained focus on only innovative firms yields significantly reduced sample size that cannot take factor analysis having a fairly large number of variables at the same time. In addition, prior research points out that this fast-track option would not be appropriate for a rather complicated data analysis (see, e.g., Srholec and Verspagen, 2007), as we shall see, in this paper.

The Thai innovation survey contains various detailed questions not available in the European innovation surveys like CISs which are specifically important to the issues of interest. The first set of such questions is concerned with business environment for innovation in Thailand. Seventeen variables extracted from this first set were examined in the first-stage factoring procedure. As shown in Table 1, five principal factors were detected. We label the first factor "Knowledge Resource" which loads highly on availability of suitable manpower, technological sophistication of suppliers and consultancy support. This is not surprising, given that innovative firms in Thailand view in-house R&D as very important source of information, and the in-house R&D and other innovative activities largely depends on availability of suitable manpower. This last variable also has a moderate factor loading in column 2 where other supports from and collaboration with universities and other institutions shown up with high factor loadings, which points out to the importance of the skill base to build absorptive capacity and engage in interactive learning with other actors in the system. We accordingly label this principal factor "Technical Support and Collaboration". The third dimension incorporates attitude of people towards innovation and openness of customers and suppliers to innovation, which leads to the "Open Innovation" label. Next, the indicators for acceptance of failure, regulatory environment, intellectual property protection and finance for innovation correlate and jointly form the "Regulation and Other Institutional Conditions" dimension. An overlap was found in stock exchange listing requirements as it has a factor loading shared about halfway between the previous and the last factor "Government Incentive and IT Infrastructure", which also correlates with government innovation incentives and communication services for innovation. The listing requirement of the stock exchange can be viewed as a regulation and institutional condition, as it provides the access to external funding sources for firms' innovative activities. At the same time, it can also be regarded as a government incentive. The 'Market of MAI Stock Exchange' has been especially set up to particularly support innovative SMEs in 1999.

Table 1 – 1st stage factor analysis on business environment for innovation in Thailand

	Knowledge Resource	Technical Support & Collaboration	Open Innovation	Regulation & Other Institutional Conditions	Government Incentive & IT Infrastructure
Government incentives for innovation	0,27	-0,01	0,17	0,24	**-0,65**
Suitable manpower in scientific/technological sector	**0,67**	0,19	0,03	-0,02	-0,02
Suitable manpower in business sector	**0,69**	0,00	0,10	0,08	0,06
Technological sophistication of suppliers	**0,87**	-0,13	0,01	-0,02	-0,08
Consultancy support services	**0,61**	0,39	-0,13	-0,07	0,04
University technical support & collaboration	-0,05	**0,88**	-0,01	0,04	0,05
R&D institution technical support & collaboration	0,00	**0,88**	0,07	0,02	-0,05
Other technical supporting services	0,26	**0,50**	0,00	0,22	-0,10
Acceptance of failure	0,19	0,09	-0,03	**0,55**	-0,16
Attitude of people towards innovation	-0,06	-0,04	**0,77**	0,07	-0,31
Openness of customers to innovation	-0,02	0,05	**0,87**	-0,07	0,05
Openness of suppliers to innovation	0,18	0,08	**0,67**	-0,02	0,27
Regulatory environment	-0,11	0,03	-0,11	**0,80**	-0,03
Intellectual property protection	-0,01	0,08	0,04	**0,79**	-0,01
Telecommunications & IT services for innovation	0,11	-0,02	0,25	0,31	**0,45**
Finance for innovation	-0,03	0,17	0,23	**0,42**	0,14
Listing requirements on stock exchange	0,26	-0,12	0,09	**0,43**	**0,46**

Note: 61.1 % of total variance explained (principal components factoring with oblimin oblique rotation)

Three factors came out in the second first-stage estimate referring to incentive programs and services offered by government agencies to support innovation in the Thai firms (see Table 2). The label "Government Technical Support" is given to the first principal factor retained which integrates different services provided by NSTDA and the Ministry of Industry including information services, testing and analytical services, and supports for quality systems and human resource development. The second column refers to the group of "Government Financial, Consultancy and TT Support" which consists of loans and grants, industrial consultancy services and technology transfer arrangements. We label the last principal factor "Tax Incentive" as it combines two tax deduction programs for training and R&D activities. It is obvious that government consultancy, testing, quality systems, and technology transfer services were loaded more highly than R&D tax incentives. This is because the level of technological and innovative capability of Thai firms, in general, is relatively low. Many firms have their main problems in absorbing and using imported technologies efficiently. Only a small number of firms have capability to perform R&D. Therefore, government services enabling firms to solve these main problems are regarded higher than R&D incentives.

Table 2 – 1st stage factor analysis on government supports for innovation in Thailand

	Government Technical Support	Government Financial, Consultancy & TT Support	Tax Incentive
Industrial consultancy services	0,21	**0,72**	0,10
Technology transfer arrangements	0,33	**0,62**	-0,17
Loans and grants	-0,17	**0,85**	0,04
Support for quality systems	**0,67**	0,14	-0,05
Testing and analytical services	**0,75**	-0,05	0,00
Information services	**0,52**	0,22	0,11
Support for human resource development	**0,71**	-0,03	0,10
Tax deduction for training	0,24	-0,12	**0,76**
Tax deduction for R&D activities	-0,11	0,10	**0,90**

Note: 60.5 % of total variance explained (principal components factoring with oblimin oblique rotation)

Table 3 reports the results of the first-stage factor analysis on various obstacles to innovation in Thailand. The first hampering factor labeled "Financial Constraint and Uncertainty" comprises high cost and risk, and monetary limitation. Second, the "Lack of Knowledge and Other Supports" dimension includes the problems of lacking information on markets and technology, qualified personnel, government and other supports. The last factor retained, "Hampering Market Condition" loads highly on lack of domestic competition and customer's interest in innovation, and also moderately on lack of information on markets.

Table 3 – 1st stage factor analysis on obstacles to innovation in Thailand

	Financial Constraint & Uncertainty	Lack of Knowledge & Other Supports	Hampering Market condition
Perceived risk too high	**0,70**	0,08	0,08
Perceived cost too high	**0,83**	-0,07	0,16
Limited financial resource	**0,75**	0,12	-0,24
Lack of information on technology	0,09	**0,59**	0,07
Lack of information on markets	0,05	**0,55**	0,40
Lack of qualified personnel	-0,06	**0,72**	0,12
Inadequate support services	0,09	**0,79**	-0,05
Lack of government support	-0,02	**0,77**	-0,14
Lack of customer's interest in innovation	0,14	-0,07	**0,82**
Lack of competition in the domestic market	-0,06	0,08	**0,87**

Note: 61.0 % of total variance explained (principal components factoring with oblimin oblique rotation)

The results of the last factoring estimated in the first stage for the sources of information for innovation in Thailand are provided in Table 4. The label "Universities and non-profit Research" is given to the first principal factor that combines information from universities, public and private non-profit research institutes. Next, the "Supplier" dimension embraces information from both local and foreign suppliers. The third factor labeled "Professional Knowledge Sources and Internet" brings together information from literature, internet, conferences and other events. The fourth factor loads primarily on competitors and business and technical service providers. This factor also loads, though only modestly, on patent disclosures and private research institutes, and we label it "Industry". This is also not surprising since most Thai firms do not have enough

capabilities to understand and absorb knowledge and information embodied in patents. The last factor labeled "Customer, Competitor and Internal Source" correlates most with information from clients and within the company or group of companies, and to some degree with competitors.

Table 4: 1st stage factor analysis on sources of information for innovation in Thailand

	Universities & non-profit Research	Supplier	Professional Knowledge Sources & Internet	Industry	Customer, Competitor & Internal Source
Within the company	-0,11	0,02	0,15	0,05	**0,79**
Parent/associate companies	0,26	0,04	-0,13	-0,10	**0,78**
Clients	-0,06	0,12	0,21	0,17	**0,61**
Local suppliers	0,14	**0,81**	0,01	-0,04	0,08
Foreign suppliers	-0,09	**0,92**	-0,03	-0,01	-0,03
Universities/academic institutes	**0,89**	0,02	0,10	-0,04	0,02
Public research institutes	**0,81**	-0,02	-0,02	0,14	0,09
Private non-profit institutes	**0,44**	0,24	0,08	0,35	-0,19
Business Service Providers	-0,06	0,03	-0,02	**0,85**	-0,04
Technical service providers	0,19	-0,04	0,08	**0,77**	-0,06
Competitors	0,00	-0,02	-0,09	**0,67**	0,38
Patent disclosures	0,26	0,18	0,28	**0,36**	-0,13
Fairs and exhibitions	-0,04	0,09	**0,73**	-0,05	0,08
Professional conferences	0,03	-0,09	**0,90**	0,00	-0,02
Specialist literature (e.g., journals)	0,24	0,02	**0,66**	-0,03	0,01
Internet	-0,16	0,26	**0,50**	0,19	0,19

Note: 67.3 % of total variance explained (principal components factoring with oblimin oblique rotation)

Scores for all factors detected in each first stage estimate were then computed and used in the second stage factor analysis. Four additional variables were included: (i) a dummy for venture capital/business angle investment; (ii) innovation intensity; (iii) R&D intensity; and (iv) knowledge workers. The results suggesting four distinct but related Thai systemic factors are provided in Table 5.

We give "Institutional" as a label to the factor in the first column. This factor covers various institutional components in the Thai innovation system including available

knowledge resource, technical supports, e.g., from universities and research institutes, openness to innovation, existing regulations and financial supports such as in the form of venture capital or business angel investment. The Thai "Capability" is built upon firms' innovation and R&D intensity and their knowledge workers as well as information and technical support from and collaboration with universities and non-profit research institutes.

Table 5: 2nd stage factor analysis on systemic factors in Thailand

	Institutional problems	Capability problems	Network problems	Information problems
Knowledge Resource	**0,72**	-0,21	0,06	-0,07
Technical Support & Collaboration	**0,61**	**0,37**	-0,12	0,06
Open Innovation	**0,46**	-0,21	**0,40**	0,02
Regulation & Other Institutional Conditions	**0,66**	0,13	0,08	-0,03
Government Incentive & IT Infrastructure	-0,14	0,21	**0,46**	**-0,42**
Government Technical Support	0,18	0,20	0,08	**0,36**
Government Financial, Consultancy & TT Support	0,25	-0,08	-0,09	**0,47**
Tax incentives	-0,11	-0,04	0,23	0,16
Financial Constraint & Uncertainty	-0,14	-0,11	0,09	**0,60**
Lack of Knowledge & Other Supports	-0,02	0,16	0,00	**0,74**
Hampering Market condition	-0,09	-0,22	0,33	**0,34**
Universities & non-profit Research	0,03	**0,45**	**0,40**	0,18
Supplier	0,08	-0,15	**0,68**	-0,03
Professional Knowledge Sources & Internet	-0,02	0,14	**0,63**	0,00
Industry	0,14	0,07	**0,57**	0,12
Customer, Competitor & Internal Source	-0,07	0,02	**0,54**	-0,01
Venture Capital/Business Angel Investment	**0,44**	0,02	-0,08	0,18
Innovation Intensity	-0,02	**0,76**	-0,05	-0,02
R&D Intensity	0,01	**0,79**	0,06	0,02
Knowledge Workers (University Graduates)	0,07	**0,36**	-0,04	**-0,35**

Note: 41.0 % of total variance explained (principal components factoring with oblimin oblique rotation)

The “Network problems” factor combines openness of people including customers and suppliers to innovation and different sources of information both internal and external, i.e., from universities, research institutes and other professional knowledge sources, customers, suppliers, competitors and other actors in the industry. This factor seems to also correlate with part of government supports for innovation like IT infrastructure.

The last factor labeled “Information problems” is reported to include several supports from the government and other elements in the Thai innovation system. The factor loads primarily on government incentives and financial, consultancy and technology transfer supports, technological and market information, and financial and other conditions. It also loads relatively modestly on knowledge workers, government technical support and market condition.

5. Conclusions and further research

The paper contributes to the current debate on rationales for innovation policy and innovation systems by providing a *framework* to identify systemic problems in a given system of innovation and testing it *empirically*. In this respect, we use the data from the Thai innovation survey in the period after a major change in the IS policy had been initiated. The framework and methodology of this research can be applied for similar analyses in other developing countries facing more or less the same types of systemic failures. It will also be useful for policy makers trying to identify systemic failures and devise better policies addressing those failures or problems in their countries.

The paper also illustrates that for developing countries, measures to strengthen firms’ capabilities in absorbing and exploiting external information and knowledge like industrial consultancy, testing, technology transfer, quality system services are more important than R&D tax incentive, which is a conventional government policy measures adopted by most countries regardless of the level of technological capabilities and needs of firms in those countries.
(to be completed)

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