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A Tale of Two Networks: Promoting Software Development in Brazil

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Abstract

This paper aims to provide evidence on how the network governance (coordination) and structure may influence the effectiveness of technology policy directed at local firms? innovativeness through network formation and evolution in a developing country context. For developed countries, studies have shown that regional networks and industry development involved some degree of co-evolution. Inspired by these findings, governments in developing countries have been seeking to address both industry and regional development through the formation of innovation networks, which have become an important instrument to support the interaction between firms and other agents. Networks are supposed to foster firm-level innovation, as government policies tend to assume that firms learn-by-interacting and that new knowledge is essential for innovation. This paper investigates two Brazilian software networks, examining network governance in terms of the feature and motivation for dyadic tie creation through the network?s history. This evidence illuminates the drivers for local firms seeking external collaboration for their innovation activities. In addition, the investigation of network governance from the firm?s perspective brings evidence about the consistency of the sub-networks that are part of the regional innovation system. So far, such types of investigation have concentrated on the experiences of developed economies and it is necessary to investigate whether developing countries? networks reveal the same patterns.

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1. Introduction and background

Networks are a structure of interactions and an intermediate form between market and hierarchy (Powell, 1990), in which the actors do not act in an isolated fashion (Callon, 1999). Networks, it is supposed, 'breed trustworthy relations' among economic actors (Giuliani, 2010: 264; Granovetter, 1973, 1985), potentially reducing transaction costs and favouring the creation and diffusion of knowledge and information (Burt, 2010). The literature on networks and innovation emphasizes their conceptual relevance for supporting firm-level innovation. Firms learn through interaction (Lundvall, 1992), and this learning includes new knowledge that is essential for innovation (Cimoli, 2002; Freeman, 1991; Powell and Grodal, 2005). Innovation networks are a sub-set of interactions in innovation systems (Cantner and Graf, 2006; Cimoli, 2002).

Empirical evidence on networks and innovation performance in advanced countries supports the interpretation that firms embedded in networks are likely to be more successful in their innovative activities (Ahuja, 2000; Bresnahan et al., 2001; Cantner et al., 2010; Ceci and Iubatti, 2012; Lazerson, 1993; Saxenian, 1990). In recent decades, government technology policy in developing countries has begun to address network formation as a mechanism to foster firm-level innovation aimed at mirroring successful innovation performance in the advanced countries (Dodgson et al., 2008; Kim and von Tunzelmann, 1998). The relevance of government technology policy in the economy to assure higher levels of social welfare is based on the definition of technology as a partial public good. Technology policies address the formation and evolution of networks by different channels (Ergas, 1987; Mowery, 1995; Pavitt, 1987; Steinmueller, 2010); however, the potentials and shortcomings in the replication of such policies are still unclear.

There are some studies that focus on understanding how, why and with whom firms in developing countries combine internal and external knowledge through the creation of formal dyadic ties outside the firm (Giuliani and Bell, 2005; Ramirez and Dickenson, 2010). However, there is no consistent evidence on: whether local firms in such contexts rely on formal innovation networks to support their innovation activities; what drives local firms to create formal dyadic ties to support their innovation activities, or their ability to engage in innovation networks; or the

full meaning behind dyadic ties created by local firms and other network actors. That is, we do not have clear evidence about how network governance and structure influences the formation and evolution of networks.

Governance is defined here as coordination (Bevir, 2009), and, based on previous studies on networks (Jones et al., 1997: 913), network governance and structure are the inter-organizational coordination exerted in a particular institutional setting in which innovation network actors are embedded. Coordination occurs when two (or more) network actors have a common goal and establish a tie in order to pursue it (Bevir, 2009: 57).

Although studies on networks have often relied on social network analysis (SNA) (Scott, 1991) to clarify the role of networks in innovation (Cantner and Graf, 2010; Giuliani, 2010), the meaning behind dyadic ties remains largely unexplored. The strength of a tie does not always determine its full value because ties can play different roles (Burt, 1992, 2010; Granovetter, 1973), and the structure in which they are embedded is also critical (Granovetter, 1985; Storper, 1996). Were the meaning of the relationships behind dyadic ties starts to be better clarified, then an understanding of how and why network of innovators can emerge and evolve within innovation systems in developing countries contexts would be advanced. In these contexts the lack of engagement of actors in innovation networks ('missing' links) seems to be frequent (Bell and Albu, 1999; Chaminade and Vang, 2008; Cimoli, 2002), and there is a low level performance of the components of innovation systems compared to what might be expected ('dysfunctional' links) (Bell and Pavitt, 1993; Cassiolato et al., 2003; Lastres and Cassiolato, 2001). Indicators that 'reflect the quality of relationships' are required for an understanding of multi-organizational interactions in developing country contexts (Lundvall et al., 2009: 19).

Provan and Kenis (2008) note that organizational studies of networks tend to pay less attention to multi-organizational networks and even scanter attention to their governance, and rarely consider the age (infancy) and evolution of the network, which normally is referred to implicitly under the heading of network controlling mechanisms. The incorporation of infancy and evolution of networks into analyses of firms' innovation activities can enrich studies of industrial development (Dodgson, 2011). It provides evidence on how and why multi-organizational networks form in developing country contexts, highlighting the full meaning of dyadic ties

created by network actors, through the employment of consistent indicators. In an attempt to address these issues we propose the following research questions: 1) What is the responsiveness of network governance and structure to technology policy aimed at the promotion of networks in a developing country context? 2) Do network governance and structure influence government technology policy effectiveness in a developing country context?

The definition of network governance and structure employed in this research allows an investigation of networks that goes further than studies that examine the structure of dyadic ties and consider governance as an emergent or collateral property of the network. Here we examine networks and their role in supporting innovation activities at firm-level in developing country contexts by articulating relational embeddedness (dyadic ties) and structural embeddedness (institutional setting) (Jones et al., 1997) into a single analytical framework. This brings meaning to the relationships among network actors and especially addresses the effectiveness of government technology policy aimed at supporting dyadic tie formation.

We investigate two regional Brazilian software innovation networks created by a federal government programme, Softex, in the early 1990s and address network governance and structure by combining a qualitative case study approach (Yin, 2003) with a quantitative approach, using SNA to visualize a representation of the network of innovators (de Nooy et al., 2005). The empirical evidence was gathered in 103 semi-structured (mostly face-to-face) interviews with representatives of the investigated Brazilian regional software network of innovators. In the context of government technology policy aimed at promoting network formation as a mechanism to foster local firm-level innovation, the results show the role of formal innovation networks in firm-level innovation performance in different regions within a developing country context. The main contribution of the research is to indicate that the nature of networks may not be principally about either knowledge exchange or joint development, and to provide an assessment of the comprehensive role and dynamics played by networks, in government technology policy aimed at firm-level innovation facilitated by networks. We show shows that the usual representations of networks and network measures can be misleading for an interpretation of network dynamics; this has some crucial implications for policy (discussed in Section 6).

Following this introduction and background, Section 2 describes the methods developed in the research and introduces the case study selected for analysis. Sections 3 and 4 respectively discuss the results for the Campinas and Recife cases. Section 5 develops the analysis of the selected case studies. Section 6 concludes the paper, outlining its main contributions and discussing some implications for policy.

2. Methods

The research follows a qualitative case study approach based on the following: governance, defined as coordination (Bevir, 2009); the introduction of exploratory research questions; and an analysis of network features referring to contextual conditions and changes over time. We also understand the relation between network structure, the ties created by network actors over time, and governance, as multivalent. As argued in Yin (2003), these types of relations are best explained using qualitative case study methods. The employment of a quantitative approach is used to complement these methods, using SNA, which is an important tool especially with regard to visual representation of the network, which provides insights into bridges within networks and the structure of the network, although it captures neither historical trends nor regulatory and institutional issues (Grasenick et al., 2008 :309-310). Hence, both approaches combined may be extremely relevant for explaining collaboration among network actors and network structure.

We employ original indicators, developed elsewhere (Pamplona da Costa, 2012), to examine network governance and structure. To our knowledge, although there has been increasing interest in methods aimed at capturing the meaning behind network ties (see Ceci and Iubatti, 2012), the literature lacks indicators that can be replicated consistently to investigate governance and structure of networks. We examine the infancy and evolution of networks, their controlling mechanisms, features and motivations for dyadic tie formation, thereby contributing to the operationalization of the network alignment concept developed by von Tunzelmann (2003, 2010). Infancy and evolution refer respectively to whether networks are emergent or purposive, and to which actors participate in the network. The investigation of controlling mechanisms allows identification of how power has been (or might be) exercised within the network.

Network actors were identified partly a priori from publicly available reports, academic studies and specialized press on technology policies implemented in Brazil. We group actors into

categories, allowing investigation of the consistency of the network. We use four sub-network categories: business; skills; technological; and financial. This is in line with the argument that innovation networks are a sub-set of systems of innovation (Cimoli, 2002); hence, network actors that belong to the same 'group' of components within the innovation system and have overlapping aims, can be grouped accordingly.

The investigation of dyadic ties supported an examination of network governance by providing evidence on: number and type of actors tied to each firm; frequency of collaboration; tightness of ties among actors; consistency among sub-networks; level of network openness; and network structure. The tightness of ties relates to the motivation for firms to create external formal ties with network actors, and tie frequency. In this study we analyse only direct ties to investigate whether the creation of direct ties involves (mainly) the characteristics associated with strong or weak ties as discussed by Granovetter (1973). Ties are tightly-connected if they are based on trust, affiliation, collective identity and knowledge availability and accessibility; tightly-connected ties are supposedly less vulnerable to breaking under pressure. Loosely-connected ties are also direct ties, based on opportunity or cost, and supposedly are more vulnerable to breaking under pressure.

The consistency of the sub-networks indicator relates to overlaps between the features of ties created by firms with other network actors (based on OECD, 2005), the general aims of the sub-network to which the actor belongs, and the self-defined, the specific aims of the tied actor (see Table A1). Hence, consistency provides an evaluation of the performance of tied organizations. The level of openness of the network relates to the geographical localization of collaborating network actors, and supports conclusions about the regional network's vulnerability to lock-in (Grabher, 1993; Grasenick et al., 2008; Semlinger, 2008).

The structure of the network refers to how the network actors are connected - fragmented or well-knit. Fragmented networks occur when the number of indirect ties is small and network actors are generally isolated. Conversely, well-knit networks occur when the number of indirect ties is high, and network actors have frequent - direct or indirect - connections (intermediate stages between fragmented and well-knit are possible, and the visualization of the network

supports our conclusions on the structure of the network).[1] Table 1 summarizes the network governance indicators, suggesting the expected predominant network outcomes as derived from the literature. Indicators to measure firm-level innovation follow the Oslo Manual recommendations (OECD, 2005);[2] the data we collected for firm-level innovation are for the period 2006-2009. The core concepts discussed above are summarized in Figure A1, which corresponds to the analytical framework for this research.

[1] Well-knit is the term used in this research to classify the structure of the network; it refers to how ties among network members are connected. The higher the number of inter-connected ties, the higher the likelihood of a healthier/stronger network. This follows the system of innovation and network of innovator approaches, where connections are crucial for learning by interacting.

[2] These indicators are well-diffused: the Community Innovation Survey (CIS) collects data on innovation in several European countries, employing Oslo Manual recommendations, and has had six rounds. The same methodology has been applied elsewhere, e.g. Australia and Brazil, and its use allows comparisons among firms within a network, and among different regional levels (including national and international), and different sectors (OECD, 2005: 139).

Table 1 - Summary of network governance indicators and variables for analysis

Indicators	Variable	Potential network features	Possible outcomes
Tightness	Motivation for external tie creation by each firm and frequency of ties occurrence	Tightly-connected ties = Higher number and frequency of strong ties	i) Lower vulnerability to break when put under pressure ii) More reliability in the transmission of information within the network
		Loosely-connected ties = Lower number and frequency of strong ties	i) Higher vulnerability to break when put under pressure ii) Less reliability in the transmission of information within the network
Structure	Number of external ties created by each firm	Well-knit network = Higher number of ties among local firms and network actors	i) Lower probability of missing links among actors
		Fragmented network = Lower number of ties among local firms and network actors	i) Higher probability of missing links among actors
Consistency	Feature of external tie created by each firm	Consistent sub-network = High overlap between feature of external tie created by each firm and aims of each network actor	i) High occurrence of overlapping aims ii) Higher chance of policy effective results
		Inconsistent sub-network = Low overlap between feature of external tie created by each firm and aims of each network actor	i) Low occurrence of overlapping aims ii) Lower chance of policy effective results
Openness	Geographical location of each collaborator	Intra-regional ties only, close-like network = Higher number and frequency of intra-network collaboration	i) Higher vulnerability to lock-in ii) Lower absorptive capacity
		Intra and inter-regional ties, open-like network = Higher number and frequency of inter-network collaboration	i) Lower vulnerability to lock-in ii) Higher absorptive capacity

Source: own elaboration based on literature review.

2.1 Selection of case study, data collection and data analysis

The Brazilian federal government Softex Programme implemented in 1993, was aimed at promoting the local Brazilian software industry through the creation of regional networks, that is, purposive networks. The first years of the programme supported the creation of 13 Nuclei (Stefanuto, 2004). We selected two software networks that were created at the same time, under similar incentives and regulations, based in two Brazilian regions that present different stages of

socioeconomic and industrial development: i) Campinas, a city based in the Southeast region and considered Brazil's leader region for the software industry; and ii) Recife, a city based in the Northeast region that has been trying to catch up to Brazil's leading software region.

The main source of empirical information was face-to-face interviews using semi-structured (majority), and open-ended questionnaires. The questionnaires used different criteria for each type of organization. The firm questionnaire collected data on their innovation processes. The public and private organization questionnaires collected additional evidence, which was validated by information available on websites, in reports and from formal studies (data triangulation discussed by Yin, 2003: 97). A total of 103 interviews was conducted, 94 face-to-face and 9 by telephone (see summary in Table 2).

Table 2 Total number of interviews by type of organization

Type of organization	Number of interviews Campinas	Number of interviews Recife	Total number of interviews
Consultants	2	1	3
Firms	21	17	38
Government representatives	4	2	13*
Incubators	3	2	5
Research centres	7	4	8
Research foundations	1	2	3
Supporting organizations	9	6	13
University faculties	9	2	6
Venture capital fund	2	0	2**
Total	58	36	103

Legend: *= total number of representative including national government. Number of government representatives interviewed in Campinas=4, Recife=2 and national government= 9.
**= venture capital fund representatives were based in Campinas city, but their activities related to the Brazilian national territory.
Source: own elaboration from fieldwork data collection.

The other information sources allowed the evidence provided by interviewees to be corroborated (Yin, 2003) and provided additional knowledge about the history of the case studies.

Data analysis occurred in three stages. The first comprised transcription of interviews and elaboration of notes to produce comprehensive and accessible data and to create comparable data among the units of analysis. The second stage involved the compilation of tables classifying the information collected to construct indicators of network governance (network tie tightness, structure, consistency and openness). The third stage comprised analysis of the variables in

Table 1, using the network governance indicators to understand and explain possible relationships among them. In this third stage, quantitative research methods and SNA software Pajek (2-mode matrix) (de Nooy et al., 2005) were used to support individual visual representation of the two networks, supporting the identification of patterns within the network as well as its structure. Finally, examination of the networks of innovators, employing the indicators developed above and Pajek to visualize the network, allowed conclusions about the structure and transaction completeness of the networks. Whenever these network features showed more positive outcomes we concluded that the governance of the network was more effective; conversely, if they were less positive the governance of the network was less effective. Governance effectiveness was then related to the innovation performance of the sampled firms, allowing propositions about whether more effective governance leads to better firm innovation performance.

3. Results I - The Campinas software innovation network

3.1 The consistency of the Campinas four sub-networks

The features of the dyadic ties created by Campinas firms indicated the consistency of the four sub-networks examined.[3] We found that the business sub-network was the network most frequently accessed by Campinas software firms and presented the highest consistency of all the investigated sub-networks. This means a high level of overlap among the reasons for firms creating ties and the aims of the business organizations with which ties were formed. The three business actors with the highest number of ties were: incubators, customers, and other software firms. Unexpectedly, some other features, such as 'acquisition of knowledge and technology', were rarely cited; the firms develop customized software applications and are expected to acquire knowledge in the process.

The skills sub-network was the second most frequently accessed sub-network, universities being the most frequently accessed type of actor. Technical colleges, continuing education organizations, research councils and research foundations were scarcely if ever accessed. We found inconsistency within this sub-network, explained mostly by the absence of 'acquisition of knowledge' in the ties formed by local firms with eight university departments. The absence of this feature was an unexpected result because educational organizations and, especially

[3] Table A2 shows the aims of some of the Campinas software network actors.

universities, produce new knowledge that potentially can be used in the private sector. Similarly, 'acquisition of technology' was expected to be relevant for tie creation with skills sub-network actors, but was scarcely mentioned: it was relevant for (only) one firm engaged in the network, and referred to a tie with university department. 'Innovation co-operation' and 'access to open information sources' were also absent, confirming the inconsistency of this sub-network. There was a lack of reasons such as 'acquisition of knowledge' and 'acquisition of technology' in dyadic tie creation with research councils and research foundations. These actors aim to provide funding to firms to support the performance of basic and applied research and development (R&D) activities, which are supposed to be directly related to the creation of new knowledge and technology by firms. However, only 'access to new sources of financing' was cited as relevant for tie creation, showing again the inconsistency of this sub-network.

The technology sub-network was the third most frequently accessed sub-network by the Campinas local software firms. The features of tie creation included 'innovation cooperation', which suggests that the sub-network is consistent. However, the absence of 'acquisition of knowledge and technology' was an unexpected result and was an indication of inconsistency of the sub-network.

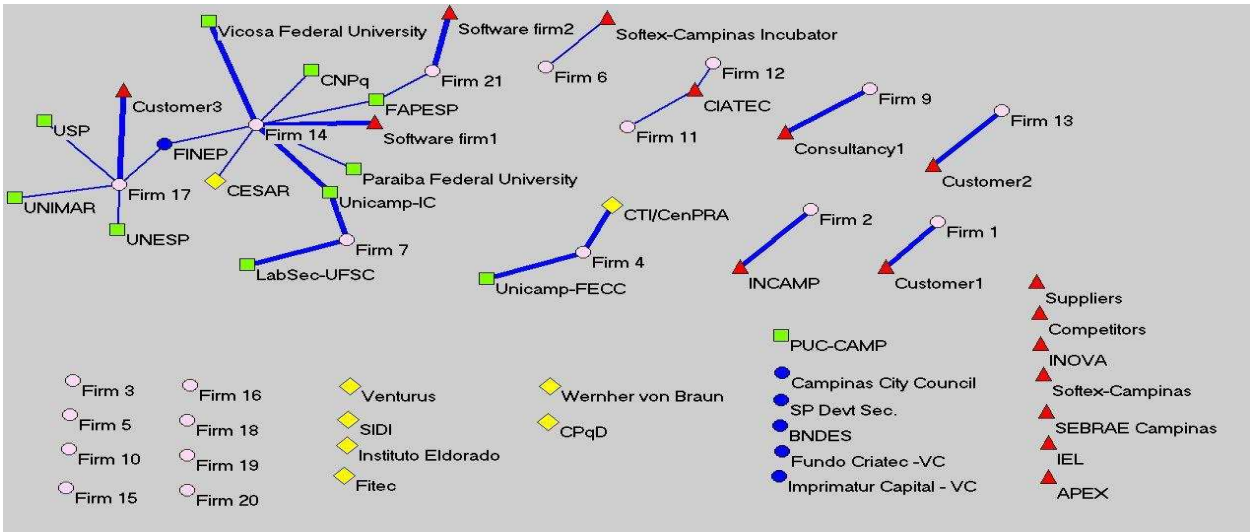
The number and frequency of ties created by firms with the financial sub-network were the lowest among the four sub-networks investigated. Ties motivated by 'access to new sources of financing' show the consistency of the sub-network. However, there was evidence of some level of inconsistency in that only one firm referred to 'innovation cooperation', 'acquisition of knowledge and technology' as reasons for creating ties with a funding agency for finance for firm-level innovation; all three features are crucial for innovation.

3.2 Network relations for innovating and non-innovating Campinas software firms

This section presents the results for how many and which firms perform innovation, and exploits the indicators developed above2. The representation of the network of innovators supports the empirical evidence represented in Figure 1, which in turn supports the visualization of the network of innovators that produced commercialized innovations during the period April 2006-April 2009. Figure 1depicts the actors engaged in the network of innovators, and the clusters of

nodes to which they belong, and also which actors function as bridges within the network of innovators. It shows whether ties are tightly or loosely-connected.

Figure 1 - The Campinas software network of innovators: commercialized innovations during 2006-2009



Legend:
● Firms
♦ Technology sub-network
■ Skills sub-network
▲ Business sub-network
● Financial sub-network
Tight connections = ▬▬▬
Loose connections = ———

□= Firms that did not create external ties to support their commercialized innovation.

○= Autonomous private non-profit R&D organizations originally set up by multinationals that are disengaged from the network of innovators.

Note: Firm 8 did not commercialize innovations during the period under analysis.

Source: own elaboration based on fieldwork data collection.

The examination of how many and which firms innovated during the period 2006-2009, and whether they created external ties to support their innovation, shows that almost all Campinas firms innovated during that period.[4] Forty per cent of interviewed firms innovated on their own, and did not create an external tie to support their innovation activity. These results lead to the conclusion that the Campinas network of innovators is fragmented rather than well-knit.

[4] The exception is one firm that was incubated and had yet to commercialise the innovation at the time of data collection.

Tightness of inter-organizational ties

Although the structure of the network is not well-knit, the majority of ties are tightly-connected. However, we found that loosely-connected ties occurred more frequently among network actors in the skills and technology sub-networks and generally involved two of the firms (Firms 14 and 17) in the main cluster of nodes. The existence of loosely-connected ties was an unexpected result, because ties created with organizations involved in the creation of new knowledge or technology supposedly are motivated by trust, collective identity, knowledge availability and accessibility. Instead, loosely-connected ties involved cost and opportunity motivations, and were inter-regional ties, highlighting that actors engaged in the Campinas network were able to and did access network actors outside the region.

Bridging organizations within the network of innovators

The network of innovators depicted in Figure 1 suggests that there are some organizations with indirect ties to firms within the main cluster of nodes. The functioning of these organizations requires special consideration.

The first consideration is that there are a few bridging organizations (as opposed to firms) in the main cluster of nodes, and they are part of the skills (FAPESP and IC-Unicamp) and financial (FINEP) sub-networks. The second consideration is that close investigation of the aims of FAPESP and FINEP combined with empirical evidence from local firms, indicates a small likelihood of these two organizations fostering the creation of ties among firms indirectly connected to them. This is mainly because proposals for grants are subjected to 'blind' assessment, with no personal contact between firms and grant application reviewers. Nevertheless, both organizations act as bridges by providing funds through special calls or programmes that require the creation of ties among firms, or between firms and actors which may belong to the skills and technology sub-networks (this conforms to the 'thematic funding' technology policy channel discussed by Steinmueller, 2010).

IC-Unicamp (Computing Science Institute) also plays a bridging role. Empirical evidence shows that IC-Unicamp can and is likely to function as a bridge between two tied firms and other firms within the network of innovators. However, according to our interviewees, this role is unlikely to be at the organizational level, and relates to faculty member's individual initiatives and relationships. Over its history, IC-Unicamp has created a community of former students

(alumni). These individuals are part of an informal network in which 'collective identity' is relevant for the sharing of information on new market opportunities and firm strategies (see Pavitt, 1987, on communities of common knowledge). A final comment on bridging organizations not depicted in Figure 1 relates to the role of local incubators. Although none of the three local incubators is tied to the main cluster of nodes, they function as bridges for creation of ties between incubated and 'graduate' firms. This is because the managers of incubators are knowledgeable about both groups of firms, and are likely to suggest contacts for collaboration (either formal or informal).

Commercialized innovation: Campinas software network (2006-2009)

The results show that more commercialized innovations relate to software services (17 firms) than to software products (6 firms). In software products, two firms (Firms 2 and 7) stand out for their number of innovations. Table 3 summarizes the innovation performance of local firms that commercialized software products.

Table 3 New software products commercialized by Campinas software firms during the period June 2006- June 2009

Firm number	Total number of innovations	Innovation new to firm	Innovation new to national market	Innovation new to international market
Firm2	6	6	**0**	**0**
Firm5	2	2	1	**0**
Firm7	10+	10+	10+	3
Firm13	3	3	1	**0**
Firm14	3	3	2	**0**
Firm16	2	2	1	**0**
Total	26	26	15	3

Source: own elaboration based on fieldwork data collection.

Firm2 commercialized innovations that were new to the firm, and has external ties with the Incamp incubator. Firm7 commercialized the most product innovations, all of which were new to the national market, and three of which were new to the world. However, none of these innovations had been exported at the time of data collection. This firm has external ties with two skill sub-network actors (university departments) that supported two of their commercialized innovations.

We found that most firms introduced a maximum of four new services to the market during the period 2006-2009, mostly innovations new to both the firm and the national market. Firms that had innovated at world level were in the minority. Table 4 summarizes the software services innovations commercialized during the period 2006-2009; eight firms produced more than four software services innovations.

Table 4 New software services commercialized by Campinas software firms during the period June 2006-June 2009

Firm number	Total number of innovations	Innovation new to the firm	Innovation new to national market	Innovation new to international market	External collaborator
Firm1	7	7	1	1	Yes
Firm2	3	3	0	0	Yes
Firm3	99	99	9	1	No
Firm4	1	1	1	0	Yes
Firm6	3	3	0	0	Yes
Firm7	3	3	3	3	Yes
Firm9	4	4	4	0	Yes
Firm10	1	1	0	0	No
Firm11	1	1	0	0	Yes
Firm12	35	35	0	0	Yes
Firm14	4	2	2	0	Yes
Firm15	30	10	15	5	No
Firm17	3	3	0	0	Yes
Firm18	1	1	1	0	No
Firm19	6	6	6	0	No
Firm20	3	3	2	1	No
Firm21	3	3	2	1	Yes
Total	207	185	46	12	Yes

Source: own elaboration based on fieldwork data collection.

Firms 14 and 15 re-employed software services developed in the firm before the period 2006-2009, to provide new services for the national market. Firms 3 and 15 stand out for the number of commercialized software services at both firm and national market levels. Both these firms also innovated at the international level and, in the case of Firm 3, the new service had been exported. These firms had common characteristics: they were between 6 and 10 years old; they

had not established external ties to support their innovation; they had graduated from the same incubator; they had grown through mergers with other Brazilian software firms; and they had developed complementary software related to mobility.

Firm 12 showed outstanding innovation performance at firm level, had been a member of the same incubator as Firms 3 and 15, and had developed software services related to mobility. These findings may indicate that, due to the relatively youth of the mobility software industry, which is related also to the development of customized software (e.g. mobile games), there might be more market opportunities for Brazilian software firms to perform and innovate in this industry than in more mature and consolidated software market niches (e.g., development of ERP platforms, historically an oligopolistic market).

Firms 1, 20 and 21 had commercialized new to the world innovations. None of them had been incubated. Firm 1 is one of the most successful software firms in the region, has international CMMI[5] (SEI, 2007) certification level 5, exports outsourcing services and has external ties only to customers. Firm 20 is a case of an informal 'spin-off' from IBM Brasil, which guaranteed procurement for the first years of the firm's operation. Firm 21 is one of the oldest and largest local firms in the region and is involved in automated banking, an industry where Brazil has a good international reputation, although this industry mostly supplies the domestic market (Softex, 2005).

Among new software services commercialized during 2006-2009 are the innovations produced by Firm 14. According to Table 4, this firm's innovation level is not outstanding in terms of inventions new to the world, Figure 1 shows that this firm had the highest number of external ties to support its innovation activities. Two of its innovations were new to the national market, which means that they had no competitors in this market when their services were commercialized.[6] Firm 14 was a spin-off of one the most successful software firms in the region, had been incubated for two years, and had received some private venture capital investment as well as funding from FINEP and CNPq.

[5] CMMI is a training and certification programme aimed at process improvements to software. CMMI certification is recognized worldwide and classifies software process into 5 maturity levels (from level 1 the lowest level of maturity to 5 the highest level). Brazilian software firms awarded CMMI certification (above level 3) benefit from access to public calls, and greater credibility in the market.

[6] Only 2 other firms (16 and 9) in the same age group as Firm 14 managed to commercialize innovations that were new to the firm and to the national market.

4. Results II - The Recife software innovation network

4.1 The consistency of the four Recife sub-networks

The business sub-network was the most frequently accessed by Recife local software firms, that is, there were more firm ties with business sub-network actors than with actors in the other three sub-networks.[7] This sub-network shows complete consistency. Customers were the most frequent type of actor tie within the business sub-network; most firms develop customized applications, and show features of tie creation that confirm the consistency of the sub-network (with the exception of 'access to commercial information'). Three firms had created ties with locally based software firms that develop complementary software, showing the highest frequency of consistent features including 'acquisition of technology', 'access to commercial information' and 'innovation cooperation'. The creation of ties between Recife firms and local incubators was related mostly to 'access to new sources of finances'. There are two incubators in the region, which host software firms and provide infrastructure and business support at subsidized cost.

Finally, ties between Recife software firms and private non-profit organizations involved NGPD and Softex Recife, which are based in the region and aim to support the development of the local software industry. The ties created by local firms with both NGPD and Softex Recife were related to these organizations' introduction of two local firms to large and sophisticated local customers. In both cases, the customers were divisions of the Pernambuco State government, so the referral involved government procurement. NGPD and Softex Recife have excellent reputation in the region and, according to the interviewees, state government relies on their knowledge for choosing local firms to interact with. From the firms' perspectives, these referrals were crucial because they provided access to large customers that previously had used providers in other Brazilian regions.

The skills sub-network was the second most frequently accessed sub-network: i) five firms had created six ties with four types of actors. The skills sub-network was partly consistent, with universities and research foundations being the most frequently accessed types of actors. Two findings stand out. Firstly, the highest frequency of ties created by firms was with the national research council (CNPq) and the local research foundation (FACEPE), ties that were associated

[7] Table A3 shows the aims of some of Recife's software network actors.

with the inconsistency found in the sub-network. All the firms that created ties with CNPq (Firms 4 and 14) and Facep (Firms 2, 4, 7, and 16) were seeking 'access to new sources of financing'. This was expected since both CNPq and FACEPE provide funding to support firm research-related activity. However, absence of reference to 'acquisition of knowledge' and 'acquisition of technology' was unexpected because the stated aims of both CNPq and FACEPE include provision of funding for the promotion of the scientific and technological development of firms through the performance of in-firm research activity.[8] Hence, local firms did not associate ties with CNPq and FACEPE for funding research, with improvements to their own scientific or technological development, which demonstrates inconsistency in the skills sub-network. Secondly, among the features of ties created with Cin-UFPE that indicated consistency, 'innovation cooperation' requires further comment. Although departments from UFPE (research university) develop academic-related scientific knowledge, they are open to collaboration with the private sector through the development and employment of applied research.

The technology sub-network was the third most frequently accessed sub-network, showing a high level of consistency; however, we also found some features related to inconsistency. The results show absence of ties with CESAR explicitly for the 'acquisition of knowledge and technology'. Instead, Firm 3 benefitted from the subsidized infrastructure offered by the CESAR incubator, and legal assistance related to labour regulations and taxes, and advice on business plans. Rather surprisingly, Firm 3 had not engaged with CESAR software developers or its R&D division, confirming the inconsistency of the technology sub-network.

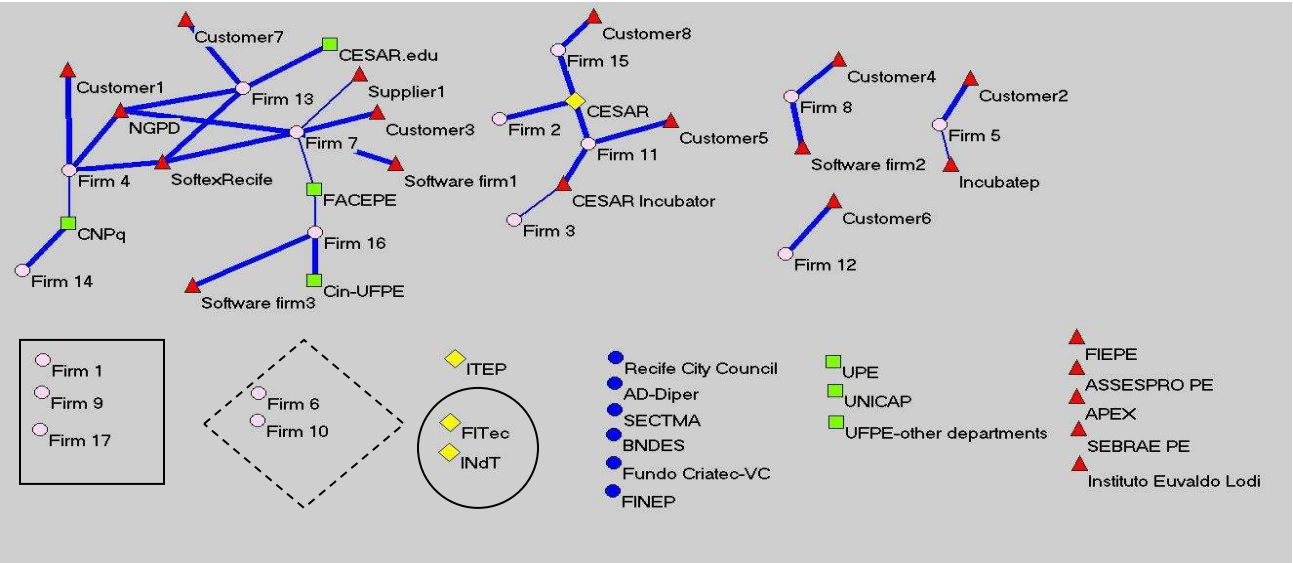
The financial sub-network was not accessed by Recife software firms during the period under analysis. Our in-depth interviews showed that four Recife firms were involved in ties with one national public agency – FINEP – for innovation projects that would be developed only if funding was granted. These results indicate that the financial sub-network is infrequently connected to local firms, which is partly consistent.

4.2 Network relations for innovating and non-innovating Recife software firms

This section exploits the indicators developed in Section 2. Figure 2 is a visualization of the Recife software network of innovators in the period April 2006-April 2009.

[8] http://www.FACEPE.br/modules.php?name=Content&pa=showpage&pid=1, and http://www.cnpq.br/english/cnpq/index.htm, accessed 19 February 2011.

Figure 2 The Recife software network of innovators: commercialized innovations during 2006-2009



Legend:
● Firms
♦ Technology sub-network
■ Skills sub-network
▲ Business sub-network
● Financial sub-network
Tight connections = ▬▬▬
Loose connections = ——————
□= Firms that did not create external ties to support their commercialized innovation during 2006-2009.
○= Autonomous private non-profit R&D organizations originally set up by multinationals that were disengaged from the network of innovators.
◊ = Firms that did not commercialize new software products of services during the period 2006-2009.
Source: own elaboration based on fieldwork data collection.

The results show that 70% of the sample of interviewed firms had external ties to support their innovation activities. However, the structure of the Recife network of innovators is fragmented rather than well-knit. This characteristic suggests diffusion of information within the network, with the result that effectiveness of access to new and valuable information by network actors will be low.

Tightness of inter-organizational ties

Although the structure of the network is not well-knit, the majority of the ties are tightly-connected as opposed to loosely-connected ties, indicating that the creation of ties is motivated mainly by issues such as trust, collective identity, personal relationships, and knowledge

availability and accessibility. In most cases, geographical proximity supports the creation of tight ties, which corroborates claims that local contexts support trust building and cognitive proximity. Direct loosely-connected ties are present, motivated by opportunities and financial issues, and are an unexpected result. There were six cases of loosely-connected ties, related to Firms 3, 5 and 7 for the business network, and Firms 4, 7 and 16 for the skills sub-network. Unexpectedly, the former involved loosely-connected ties with incubators; although firms are considered part of the organization, firms mostly considered low infrastructure costs as a motivation for tie creation. These ties included links with FACEPE (Pernambuco State Research Foundation) and CNPq (national research council), were motivated by 'cost' and 'opportunity', and confirm the inconsistency of the skills sub-network discussed above.

Bridging organizations within the network of innovators

Figure 2 shows that four organizations could function as bridges in the Recife network of innovators; two are part of the skills sub-network – CNPq and FACEPE, and two are part of the business sub-network - NGPD and SoftexRecife. However, CNPq and FACEPE are unlikely to act as bridges because it is not part of their remit. Funding programmes are based on open calls and blind assessment of applications. However, some of FACEPE's funding programmes require participation of academic researchers in the firms' projects and the funding application, which would mean that FACEPE would be functioning indirectly as a bridge. Which researchers and which organizations are invited to participate in the firm's application project is the firm's not FACEPE's decision. The same could apply to CNPq; however, the research council more often supports research in firms by funding the secondment of university students through bursaries and scholarships rather than research grants.

With regard to the main cluster of nodes, NGPD and SoftexRecife may function as bridges because of their position within the network of innovators, and closer examination shows that firms are tied to customers, other local software firms and local organizations through NGPD and SoftexRecife (e.g., the case of Firm 13). Although Figure 2 shows that the firms connected to NGPD overlap with the firms that are connected to SoftexRecife, our results show that the number of firms benefiting from these organizations' support is not limited to those represented in Figure 2. For instance, Firm 1 has used SoftexRecife facilities (testing laboratory), and Firm 10 received support from NGPD for writing a grant application to FINEP.

Investigation of the secondary cluster of nodes in Figure 2 shows that CESAR is the main bridging organization, and links local firms indirectly. All the ties between firms and CESAR are tightly-connected, suggesting that firms are likely to regard referrals from CESAR as reliable, possibly increasing the chances of CESAR's bridging activities being successful. However, Figure 2 shows CESAR's disengagement from the main cluster of nodes within the network, and its own cluster of nodes. This was an unexpected result because CESAR is the main information technology R&D organizations in the region (and one of the most important in the country), and was identified by nine firms as being an important asset for the region.

Commercialized innovation: Recife software network (2006-2009)

The empirical findings reveal that most commercialized innovations are software services: 113 new services and 11 new products. The former involved 10 firms and the latter 7 firms.

Table 5 New software products commercialized by Recife software firms during April 2006-2009

Firm #	Total number of innovations	Innovation new to the firm	Innovation new to national market	Innovation new to international market
Firm 1	0	n.a.	n.a.	n.a.
Firm 5	0	n.a.	n.a.	n.a.
Firm 7	2	2	1	0
Firm 9	1	1	1	0
Firm 13	1	1	1	0
Firm 14	3	3	3	2
Firm 15	1	1	1	0
Firm 16	2	2	2	0
Firm 17	1	1	1	0
Total	11	11	10	2

Legend: n.a.= not applicable
Source: own elaboration from fieldwork, April 2009.

Table 5 shows that most firms commercialized one new product in the period 2006-2009, and introduced an innovation to the national market. Firms 14 and 16 produced more than one innovation, and Firm14 introduced two new-to-the-world innovations.

The innovations achieved by Firm 16 required external ties with actors in the business and skills sub-networks. Firm 16 created one tie with a local firm that develops complementary software, and also ties with Cin-UFPE (the only example of a firm tie for this organization) and FACEPE, which part-financed the innovation. According to Firm 16, Cin-UFPE involvement was crucial

because it supported the firm's access to new knowledge, which put it at the national technological frontier.

Firm14 stands out as the only firm that introduced an innovation at the international level, and was exporting. This firm is one of the most successful software companies in the Recife region, it competes in the international market, it participated in the Cin-UFPE incubation programme 'Recife BEAT', and its first product resulted from Master's level research conducted by one of the firm's founder. It forged a tie with CNPq for its international level innovation and is the only firm in the sample with a tightly-connected tie to this organization.

Of the 10 firms that commercialized software services, 3 account for 90% of total firm level innovation. Table 6 shows that there were much smaller numbers of national level innovations (compared to new software products) and especially international (new to the world) innovations, and shows that four firms stand out for innovative performance.

Firm 5 achieved the highest number of innovations (44), but all were firm level innovations resulting from the firm's participation in one-off projects.

Table 6 New software services commercialized by Recife software firms during the period April 2006-2009

Firm #	Total number of innovations	Innovation new to the firm	Innovation new to national market	Innovation new to international market
Firm1	3	3	2	1
Firm2	1	1	0	0
Firm3	1	1	1	0
Firm4	2	1	1	0
Firm5	44	44	0	0
Firm6	0	n.a.	n.a.	n.a.
Firm7	2	2	1	0
Firm8	1	1	0	0
Firm9	0	n.a.	n.a.	n.a.
Firm10	0	n.a.	n.a.	n.a.
Firm11*	18	18	18	15
Firm12*	40	40	Not answered	Not answered
Firm13	0	n.a.	n.a.	n.a.
Firm14	1	1	0	0
Firm15	0	n.a.	n.a.	n.a.
Firm16	0	n.a.	n.a.	n.a.
Firm17	0	n.a.	n.a.	n.a.
Total	113	113	23	16

Legend:
n.a.=not applicable
* = Firm produces both services and products; was unable to state whether the innovation referred to a service or product.
Source: own elaboration from fieldwork, April 2009.

Firm 1 produced fewer innovations compared to Firms 5, 11 and 12. However, most of Firm 1's innovations were new to the national market and one was new to the world, although at the time of data collection had not entered the export market. The firm directs its investments mostly to the domestic market. Firm 1 is among the group of a few firms with no external ties to support innovation.

Firm 11 had involvement in all the types of innovations in Table 6, most of them new to the international market, which involved new technologies and, in some cases, involved the application of a business model not previously used for the type of software developed.

5. Analysis

Studies of innovation highlight the promotion of networks through different technology policy channels, including networks that enable firms to increase the possibilities of learning-by-interaction, and of acquiring new knowledge crucial for innovation (Lundvall, 1992). Brazilian government introduced policies in the early 1990s to foster the formation of regional software networks in different regions of the country. The two networks analysed, Campinas and Recife, have different histories in the ICT industry (Pamplona da Costa, 2012).

Campinas is in the most economically developed region of Brazil and has benefited from national and state level policies to support regional industry development, mainly through the establishment of organizations that are directly related to research and scientific activities. Campinas is the leading software region in Brazil. Government policy has played a role in its leadership position.

In contrast, Recife is in an economically lagging Brazilian region, which is geographically distant from the country's most economically dynamic region, and has received less support from national policies directed to the development of the software industry. This lower level of national support triggered the implementation by the government of Pernambuco state, where Recife is located, of state-level technology policies directed towards development of the local software industry and supporting economic catch-up by Recife and Pernambuco state (SECTMA, 2006).

The results for the Campinas case show that the structure of the network of innovators is fragmented, which suggests low level diffusion of formal interactions within the network. This finding suggests that the rate of response of Campinas software firms to government policies to promote network formation, is low compared to the potential for interactions among firms, and between firms and other organizations. The results for the Campinas case show that there are limited interactions between technology policy, and network governance and structure in Campinas, where firms achieve high levels of innovative performance and where a large share of innovative firms relies on internal resources for developing their innovation activities. Firms prefer learning from experience rather than by interacting.

The results for the Recife case show that the level of diffusion of formal interactions is slightly higher in the Recife software network of innovators. Although the structure of the network is

fragmented, key local actors, keen to support the development and growth of Recife local software firms, are active in the network, although not always hugely. The results for the Recife case show broader interaction between technology policy and network governance and structure in Recife (compared to Campinas), and a large share of innovative firms engaged in the network to develop their innovation activities. Based on the implementation of state policy to promote networks and our findings, we can conclude that the promotion of local networks has increased the effectiveness of policy directed at improving local innovation performance.

Our results reveal that the network governance and structure of the Campinas software network of innovators has had a mixed influence on the effectiveness of government technology policies directed at firm innovation. This is indicated by the different results for structural embeddedness of the network compared to the results for relational embeddedness. The results for structural embeddedness indicate inconsistencies in a crucial sub-network, the skills sub-network, low engagement of technology sub-network actors, and low levels of interaction among local firms for innovation related activities. The results for relational embeddedness of the Campinas network reveal that most direct ties are tightly-connected ties, crucial for interactions aimed at knowledge exchange and learning among actors. These findings indicated that the relational embeddedness of the Campinas network's governance and structure had a more positive influence than its structural embeddedness on the effectiveness of technology policy in relation to the promotion of firm-level innovation through network formation.

The influence of network governance and structure in the Recife software network of innovators is also mixed in terms of its effect on government technology policies for firm innovation. Again, the results for the network's structural and relational embeddedness differ. The findings for structural embeddedness indicate some level of inconsistency in the skills sub-network (although this primarily is related to funding). They show also low levels of engagement in the network of crucial actors such as university departments. Examination of the ties with local technology sub-network actors shows that local firms had ties with only one local R&D organization, although this organization strongly related to its cluster of nodes. The level of interaction among local firms in Recife is also low. The results for relational embeddedness of network governance and structure are similar to the Campinas case for tightness of ties, with most direct ties tightly-connected; as discussed above, a crucial feature of interactions aimed at knowledge exchange and learning among actors is tightly-connected ties. These findings indicate

that the relational embeddedness of the Recife network's governance and structure had a more constructive influence than its structural embeddedness in terms of effectiveness of technology policy directed at firm-level innovation through the promotion of networks.

6. Conclusions

Our findings show that high-technology (software) firms, in a country (Brazil) that is at an intermediate level of development, and which has large regional disparities (Lastres, 2007; Teixeira, 2008), engage differently in networks and present different innovative performance. Brazilian software firms embedded in regions with different structures (i.e. socio-economic and industrial development), show different engagement in networks and contrasting innovative performance. We found that firms less engaged in networking, that is, the Campinas software firms, show higher levels of innovative performance in absolute terms, and produce innovations that are closer to the technology frontier compared to regions, such as Recife, where software firms focus more on networking. However, although Recife showed comparatively lower innovation performance, networking in this region seems to have supported regional catching up. This study contributes to the knowledge on technology policy effectiveness; adoption of a general technology policy prescription for the formation of networks as a mechanism to improve firm-level innovation and regional catching-up, requires careful consideration of the intended effects. Firms' engagement in networks may not be a necessary condition for firm-level improvements related to innovation. Regional path-rigidity and contextual as well as network specific influences in new networks and during their evolution must also be considered in technology policy formulation.

Another contribution of this paper is its combining qualitative methods with SNA. For instance, the representation in Figure 2 of the network of innovators does not do full justice to the role played by CESAR within the Recife network of innovators. From this representation it might be assumed that CESAR's disengagement from the network would cause little disruption to network evolution. However, the empirical evidence shows that, CESAR has become the network's anchor, and its reputation has spilled over to all the organizations in the network. Its withdrawal from the network (were its headquarters to be relocated for instance) would cause huge disruption to the evolution of the network.

In relation to implications for policy, our results suggest that there is no one-size-fits-all network governance and structure, which is consistent with the findings from other studies on networks (e.g. Ahuja, 2000; Grasenick et al., 2008). The institutional, cultural and economic settings may differ among regions, and policies aimed at promoting network formation to improve firms' innovation performance should take into account that reproducing the network governance and structure of successful regions may not be appropriate for (all) other regions. Network promotion policies on their own may not be an efficient mechanism for improved innovation performance and economic catch-up. Finally, the findings of inconsistency of sub-networks, and poor engagement of organizations expected to play a primary role in fostering development and catch-up or to be relevant throughout the innovation development process, suggest some reformulation of their organizational missions, and policies aimed at promoting formation of networks should take account of these issues.

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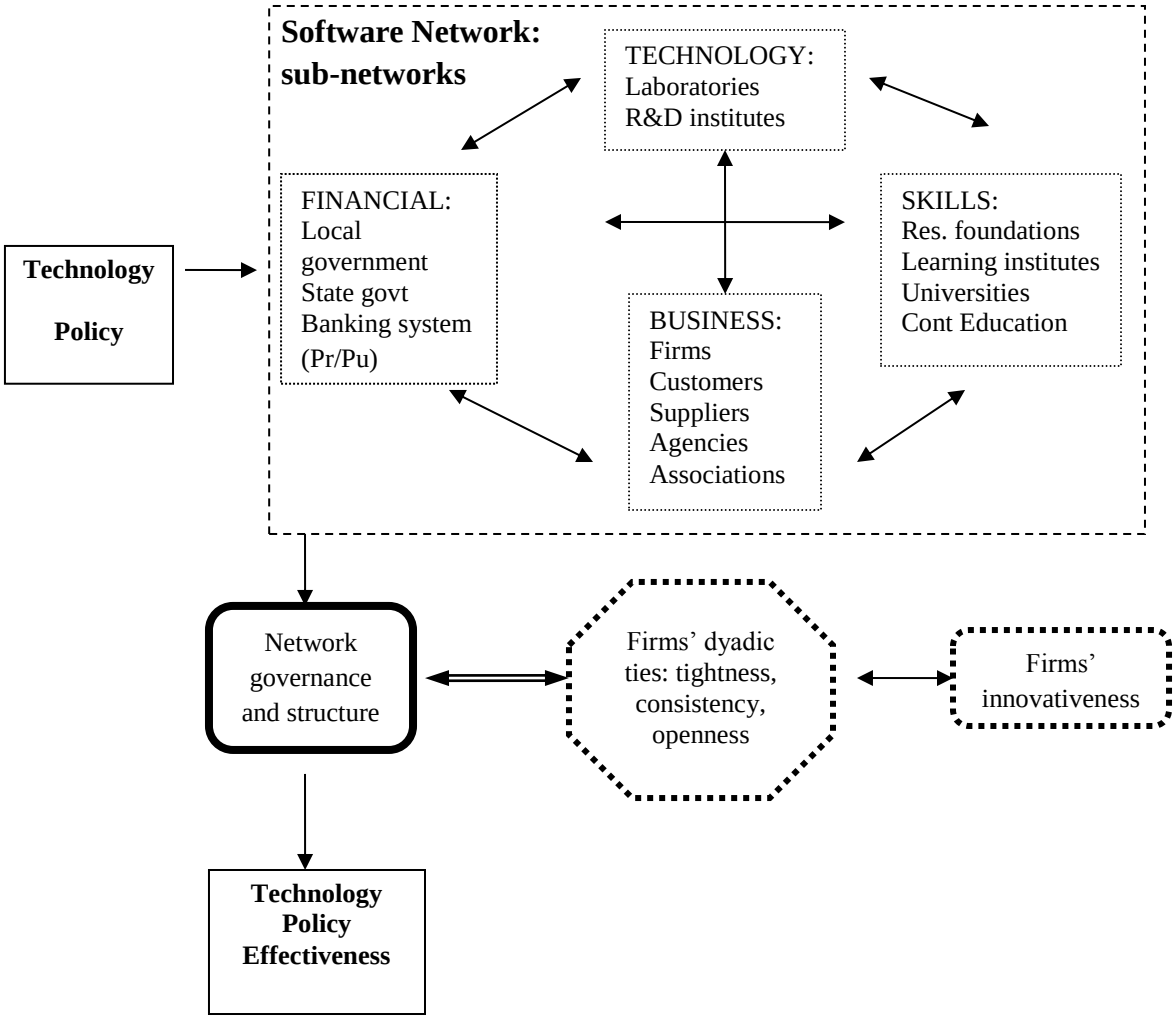
Table A1 Indicators for consistency of sub-networks[9]

Sub-network	Type of sub-network actor	General aims by sub-network	Features indicating consistency
Business	a) industrial associations b) competitors c) customers d) suppliers e) consultancy firms f) incubators g) private non-profit organizations acting on behalf of the public interests	i) foster and support interactions among firms and between firms and customers ii) support for research funding applications iii) access to information on national and international markets iv) provision of facilities or knowledge for software development, training and workshops v) support the design of business plans and training on organizational matters vi) support software process improvement vii) incubation programmes	1. Access to open information source 2. Acquisition of knowledge 3. Acquisition of technology 4. Access to new sources of financing 5. Access to commercial information 6. Innovation co-operation
Skills	a) universities b) technical colleges c) continued education organizations d) research council e) research foundation	i) IT training in different levels, such as undergraduate, Masters, Doctorate and Post-Doctorate and continued education; ii) support new knowledge creation through basic or applied research funding programmes; iii) support new knowledge creation through funding programmes for development activities.	1. Access to open information source 2. Acquisition of knowledge 3. Acquisition of technology 4. Innovation co-operation
Technology	a) research organizations b) development organizations	i) perform basic or applied research for, among others, the commercialization by the private sector ii) development activities for, among others, the commercialization by the private sector.	1. Acquisition of knowledge 2. Acquisition of technology 3. Innovation co-operation
Financial	a) private and public banking organizations b) public funding organizations c) venture capitalists d) government authorities	i) grants or loans for firm-level basic or applied R&D activities ii) venture capital for start-ups iii) tax incentives for firm-level innovation activities iv) creation of technological parks or incubation programmes	1. Acquisition of knowledge 2. Acquisition of technology 3. Access to new sources of financing

Source: Pamplona da Costa (2012: 143).

[9] Consistency here is understood as what von Tunzelmann (2003) calls alignment.

Figure A1 Analytical framework



Legend:

= mono-directional influencing factor

= bi-directional influencing factor

= bi-directional influencing and causation factor

Cont= continuing
Govt= government
Pr= private
Pu= public
Res= research

Source: Pamplona da Costa (2012: 147), adapted from von Tunzelmann (2010: 16).

Table A2 Campinas network actors

Actor	Year of Foundation	Main activities
APEX-Brasil	1997	Promotion of Brazilian exports
Campinas City Council	n.a.	Fiscal policies
Ciatec	1991	Manage the two Campinas High-Technology Parks
Ciatec Incubator	1996	Incubation programme
CNPq	1951	Brazilian Research Council
CPqD	1976	R&D centre
Criatec-Fund	2007	Venture capital fund/ BNDES and private sector
CTI/CenPRA	1982	R&D centre
FAPESP	1962	State level research foundation
FINEP	1967	Brazilian Innovation Agency
FITec-Campinas	2002	R&D centre (founded by MNC)
Incamp	2001	Incubation programme
Inova Soft	2003	Inova Centre for Information Technology
Inova Unicamp	2003	Unicamp Innovation Agency
Instituto Eldorado	1997	R&D centre (founded by MNC)
Prosoft-BNDES	1999	BNDES programme for software
PUC-CAMP	n.a.	Training in IT undergraduate.
Sebrae-SP	1972	Support for micro and small entrepreneurships
Secretary for Development/SP	1965	Promote sustainable economic growth and technological innovation in the São Paulo State.
SIDI		R&D centre (founded by MNC)
Softex Campinas	1993	Fostering and support local software industry.
Softex Campinas Incubator	1995	Incubator programme: software only
Unicamp-FEEC	1967	Training in IT undergraduate, Master's, professional Master's, Doctorate and Post-Doctorate
Unicamp-IC	1969	Training in IT undergraduate, Master's, professional Master's, Doctorate and Post-Doctorate
Venturus	1995	R&D centre (founded by MNC)

Legend: n.a. = not available
Source: Pamplona da Costa (2012: 111).

Table A3 Recife network actors

Actor	Year of Foundation	Main activity
APEX-Brasil	1997	Promotion of Brazilian exports
Assespro-PE	1976	Industry association
CESAR	1996	Local R&D centre
CESAR Incubator		Incubator programme
CESAR.edu	2006	Training in IT- Master's and continued education
Cin-UFPE	1974	Training in IT undergraduate, Master's, professional Master's, Doctorate and Post-Doctorate
CNPq	1951	National research council
Criatec-Fund	2007	Venture capital fund/ BNDES and private sector
DEINFO-UFRPE	2005	Training in IT undergraduate
DSC-UPE	2004	Training in IT undergraduate
FACEPE	1989	State level research foundation
FIEPE	1939	Pernambuco Industrial Association
FINEP	1967	Brazilian Innovation Agency
FITec-Recife	2002	R&D centre (founded by MNC)
IEL-PE	1969	Support the improvement of firms' management skills and their entrepreneurial capabilities.
Incubanet	2005	Incubator Association
Incubatep	1990	Incubator programme
INdT-Recife	2006	R&D centre (founded by MNC)
ITEP	1945	Pernambuco Technological Institute/ State level
NGPD	2000	Porto Digital Management Unit
Recife City Council	n.a.	Fiscal incentives to software firms based in Porto Digital
Recife-BEAT	1997	Pre-incubation programme/ Cin-UFPE
Sebrae-PE	1972	Support for micro and small entrepreneurships
SECTMA	1993	Foster scientific, technological and innovation development of Pernambuco
Softex-Recife	1993	Fostering and support local software industry.
UNICAP	n.a.	Training in IT undergraduate

Legend: n.a. = not available
Source: Pamplona da Costa (2012: 130).

Bibliography

Ahuja, G., 2000. Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study. Administrative Science Quarterly 45, 425-455.

Bell, M., Albu, M., 1999. Knowledge Systems and Technological Dynamism in Industrial Clusters in Developing Countries. World Development 27, 1715-1734.

Bell, M., Pavitt, K., 1993. Technological Accumulation and Industrial Growth: Contrasts Between Developed and Developing Countries. Industrial and Corporate Change 2, 157-210.

Bevir, M., 2009. Key Concepts in Governance. SAGE Publications, London.

Bresnahan, T., Gambardella, A., Saxenian, A., 2001. 'Old Economy' Inputs for 'New Economy' Outcomes: Cluster Formation in the New Silicon Valleys. Industrial and Corporate Change 10, 835-860.

Burt, R.S., 1992. Structural Holes: The Social Structure of Competition. Harvard University Press.

Burt, R.S., 2010. Neighbor Networks: Competitive Advantage Local and Personal, First ed. Oxford University Press, New York.

Callon, M., 1999. Actor-netwrok Theory - The Market Test, in: Law, J., Hassard, J. (Eds.), Actor Network Theory and After. Blackwell, Oxford, pp. 181-195.

Cantner, U., Graf, H., 2006. The network of innovators in Jena: An application of social network analysis. Research Policy 35, 463-480.

Cantner, U., Graf, H., 2010. Growth, Development and Structural Change of Innovator Networks: the Case of Jena, in: Boschma, R., Martin, R. (Eds.), The Handbook of Evolutionary Economic Geography. Edward Elgad, Cheltenham, pp. 370-387.

Cantner, U., Meder, A., ter Wal, A.L.J., 2010. Innovator networks and regional knowledge base. Technovation 30, 496-507.

Cassiolato, J.E., Lastres, H.M.M., Maciel, M.L., 2003. Systems of Innovation and Development: Evidence from Brazil. Edward Elgar, Cheltenham.

Ceci, F., Iubatti, D., 2012. Personal relationships and innovation diffusion in SME networks: A content analysis approach. Research Policy 41, 565-579.

Chaminade, C., Vang, J., 2008. Globalisation of Knowledge Production and Regional Innovation Policy: Supporting Specialized Hubs in the Bangalore Software Industry. Research Policy 37, 1684-1696.

Cimoli, M., 2002. Networks, Market Structures and Economic Shocks: the Structural Changes of Innovation Systems in Latin America. LEM Working Paper Series 2003, 1-34.

de Nooy, W., Mrvar, A., Batagelj, V., 2005. Exploratory social network analysis with Pajek. Cambridge University Press, Cambridge.

Dodgson, M., 2011. Exploring new combinations in innovation and entrepreneurship: social networks, Schumpeter, and the case of Josiah Wedgwood (1730â€“1795). Industrial and Corporate Change 20, 1119-1151.

Dodgson, M., Mathews, J., Kastelle, T., Hu, M.-C., 2008. The Evolving Nature of Taiwan's National Innovation System: The Case of Biotechnology Innovation Networks. Research Policy 37, 430-445.

Ergas, H., 1987. The importance of technology policy, in: Dasgupta, P., Stoneman, P. (Eds.), Economic Policy and Technological Performance. Cambridge University Press, Cambridge, pp. 51-96.

Freeman, C., 1991. Networks of innovators: A synthesis of research issues. Research Policy 20, 499-514.

Giuliani, E., 2010. Clusters, Networks and Economic Development: an Evolutionary Economics Perspective, in: Boschma, R., Martin, R. (Eds.), The Handbook of Evolutionary Economic Geography. Edward Elgad, Cheltenham, pp. 261-279.

Giuliani, E., Bell, M., 2005. The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster. Research Policy 34, 47-68.

Grabher, G., 1993. The weakness of strong ties: the lock-in of regional development in the Ruhr area, in: Grabher, G. (Ed.), The Embbeded Firm: on the Socioeconomics of industrial networks. Routledge, London, pp. 255-277.

Granovetter, M., 1973. The Strength of Weak Ties. American Journal of Sociology 78, 1360-1380.

Granovetter, M., 1985. Economic Action and Social Structure: The Problem of Embeddedness. The American Journal of Sociology 91, 481-510.

Grasenick, K., Wagner, G., Zumbusch, K., 2008. Trapped in a Net: Network Analysis for Network Governance. VINE: The Journal of Information and Management Systems 38, 296-314.

Jones, C., Hesterly, W.S., Borgatti, S.P., 1997. A General Theory of Network Governance: Exchange Conditions and Social Mechanisms. Academy of Management Review 22, 911-945.

Kim, S.-R., von Tunzelmann, N., 1998. Aligning internal and external networks: Taiwan's specialization in IT, SPRU Electronic Working Paper Series, pp. 1-41.

Lastres, H.M.M., 2007. Avaliação das políticas de promoção de arranjos produtivos locais no Brasil e proposições de ações. Centro de Gestão e Estudos Estratégicos, Brasília, pp. 1-37.

Lastres, H.M.M., Cassiolato, J.E., 2001. Globalização e os Sistemas de Inovação no Mercosul nos anos 90: Implicações para Políticas, in: Guimarães, N.A., Martin, S. (Eds.), Competitividade e Desenvolvimento: Atores e Instituições Locais. Editora SENAC São Paulo, São Paulo, pp. 129-148.

Lazerson, M., 1993. Factory or putting-out? Knitting networks in Modena, in: Grabher, G. (Ed.), The Embbeded Firm: on the Socioeconomics of industrial networks. Routledge, London, pp. 203-226.

Lundvall, B.-Å., 1992. Introduction, in: Lundvall, B.-Ä. (Ed.), National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. Pinter Publisher, London, pp. 1-19.

Lundvall, B.-Å., Vang, J., Joseph, K.J., Chaminade, C., 2009. Innovation System Research and Developing Countries, in: Lundvall, B.-Å., Joseph, K.J., Chaminade, C., Vang, J. (Eds.), Handbook of Innovation Systems and Developing Countries. Edward Elgar, Cheltenham, pp. 1-30.

Mowery, D.C., 1995. The Practice of Technology Policy, in: Stoneman, P. (Ed.), Handbook of the Economics of Innovation and Technological Change. Blackwell Publisher, Oxford, pp. 513-557.

OECD, 2005. Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. OECD: Organization for Economic Co-Operation and Development, Paris.

Pamplona da Costa, J.O., 2012. Technology Policy, Network Governance and Firm-level Innovation in the Software Industry: a Comparison of Two Brazilian Software Networks, Science and Technology Policy Research (SPRU). University of Sussex, Brighton, p. 299.

Pavitt, K., 1987. The Objectives of Technology Policy. Science and Public Policy 14, 182-188.

Powell, W.W., 1990. Neither Market Nor Hierarchy: Network Forms of Organization Research in Organizational Behavior 112, 395-336.

Powell, W.W., Grodal, S., 2005. Networks of Innovators, in: Fagerberg, J., Mowery, D.C., Nelson, R.R. (Eds.), The Oxford Handbook of Innovation. Oxford University Press, New York, pp. 56-85.

Provan, K.G., Kenis, P., 2008. Modes of Network Governance: Structure, Management, and Effectiveness. Journal of Public Administration Research Theory 18, 229-252.

Ramirez, M., Dickenson, P., 2010. Gatekeepers, Knowledge Brokers and Inter-firm Knowledge Transfer in Beijing's Zhongguancun Science Park. International Journal of Innovation Management 14, 93-122.

Saxenian, A., 1990. Regional Networks and the Resurgence of Silicon Valley. California Management Review 33, 89-112.

Scott, J., 1991. Social Network Analysis: a Handbook. Sage Publications, London.

SECTMA, 2006. Marcos de uma Geração Voltada para o Futuro: Cência, Tecnologia e Meio Ambiente em Pernambuco 1999-2006. Secretaria de Cência, Tecnologia e Meio Ambiente, Recife, pp. 1-100.

SEI, 2007. Capability Maturity Model Integration, Version 1.2 Overview. Software Engineering Institute, Carnegie Mellon, p. 41.

Semlinger, K., 2008. Cooperation and competition in network governance: regional networks in a globalised economy. Entrepreneurship & Regional Development 20, 547-560.

Softex, 2005. Banking Automation: Brazil in the International Scenario, in: Digital, S.-O. (Ed.). Sociedade Softex, Campinas.

Stefanuto, G.N., 2004. O Programa SOFTEX e a Industria de Software no Brasil, Departamento de Politica Cientifica e Tecnologica. Universidade Estadual de Campinas, Campinas, p. 170.

Steinmueller, W.E., 2010. Economics of Technology Policy, in: Hall, B.H., Rosemberg, N. (Eds.), Handbook of the Economics of Innovation. Elsevier, p. Chapter 28.

Storper, M., 1996. Innovation as Collective Action: Conventions, Products and Technologies. Ind Corp Change 5, 761-790.

Teixeira, F.L., 2008. Políticas Públicas para o Desenvolvimento Regional e Local: o que Podemos Aprender com os Arranjos Produtivos Locais (APLS)? Organização e Sociedade 15, 57-75.

von Tunzelmann, N., 2003. Historical Coevolution of Governance and Technology in the Industrial Revolutions. Structural Change and Economic Dynamics 14, 365-384.

von Tunzelmann, N., 2010. Alignment, Misalignment and Dynamics Network-Based Capabilities, in: Dyker, D.A. (Ed.), Network Dynamics in Emerging Regions of Europe. Imperial College Press, London, pp. 3-22.

Yin, R.K., 2003. Case study research: design and methods, Third ed. Sage Publications, London.