Innovation and knowledge flows in the Saskatoon City Region

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Abstract:

City regions are increasingly seen to be the engines of economic growth and innovativeness for a nation-state. This paper tests using Saskatoon specific data the hypothesis that the economic and creative performance of city-regions depends on three key characteristics: the strength of local knowledge flows within individual industries/clusters, the strength of local knowledge flows between individual industries/clusters and the strength of knowledge-based linkages between local and non-local economic actors. The working hypothesis is that the economic performance of city-regions depends on the density of local networks, the relative mix of local and non-local ties as well as the heterogeneity and diversity of economic actors belonging to these networks. This paper concludes that while the theory is convincing it does not lead to specific actionable policies, as there are only weak or ambiguous correlations between the hypothesized knowledge flows and city region economic performance.

Key words: innovation systems; innovation; knowledge; Saskatoon

1. Introduction

City regions are increasingly seen to be the engines of economic growth and innovativeness for a nation-state. An open question is to what to degree the social characteristics of a city region contribute to its success in the knowledge economy. The ISRN City-Region Initiative began in 2006 as a project intended to test how the social characteristics of a city region affect that region's economic success. One subsection of project looks at how social connections between firms and other actors contribute to the transfer of knowledge and how this contributes to a region's economic success.

The primary hypothesis for this theme is that the economic and creative performance of city-regions depends on three key characteristics: the strength of local knowledge flows within individual industries/clusters, the strength of local knowledge flows between individual industries/clusters and the strength of knowledge-based linkages between local and non-local economic actors. The working hypothesis is that the economic performance of city-regions depends on the density of local networks, the relative mix of local and non-local ties as well as the heterogeneity and diversity of economic actors belonging to these networks. This paper examines how these factors affect the nature of the innovation process in Saskatoon and looks at its impact on the economic performance of the city region.

This paper has four further sections. Section 2 examines the theory of innovation, innovation systems and the role of knowledge in the innovation process. Section 3 lays out the hypotheses and data sources. Section 4 examines the evidence derived from a variety of research projects. Section 5 offers some concluding comments.

2. Theory

Innovation is the focus of a wide range of disciplines and methods. Economist have been perhaps the most concerned about economic growth and progress (e.g. the Arrow-Debreu-Solow-Swan and Romer-Lucas models), but they have usually abstracted from the social context of the innovation process and instead look at the institutional incentives and macroeconomic impacts. While the business school literature examines the nature of R&D in firms and sectors, they tend to focus primarily on the firm and underplay the broader milieu of the activity. More recently a number of sociologists, economic geographers and applied political economists have attempted to open Rosenberg's (2004) 'black box' with a range of approaches that fit under the

rubric of innovation systems. A number of alternative models have been offered to explain how innovation actually happens. For the sake of this paper, the theory can be parsed into the theory that looks at the process of innovation and theory that looks at the nature of knowledge itself.

2.1 The process of innovation

The traditional model viewed innovation as a linear process where basic research led successively to applied research, development, commercialization and use.[1] The simplest of these models assumed the genesis of the initiative was serendipitous while the more sophisticated versions had a feedback loop from users to the basic research stage, where consumer and social demands influenced of the areas of research. This model actually worked quite well to describe the type of industrial research labs pioneered by Thomas Edison and his generation of inventors but has become increasingly less realistic.

Now there is a concern that the innovation process is much more diffuse. If one looks at systemic innovation processes, one can see that many inputs and outputs are generated in these newer innovation processes. No single firm or region can truly be viewed as self-sufficient or self-sustaining. Economists Stephen Kline and Nathan Rosenberg, for example, provide a non-linear approach that explicitly identifies the role of both market and research knowledge and the potential for open research systems.[2] Their 'chain-link model of innovation' (Figure 1) begins with a basically linear process moving from potential market to invention, design, adaptation and adoption but adds feedback loops from each stage to previous stages and the potential for the innovator to seek out existing knowledge or to undertake or commission research to solve problems in the innovation process. This dynamic model accentuates the role of transacting to find, transfer and use new types of knowledge and information.

[1] See Rogers, 1983.
[2] Klein and Rosenberg, 1986.

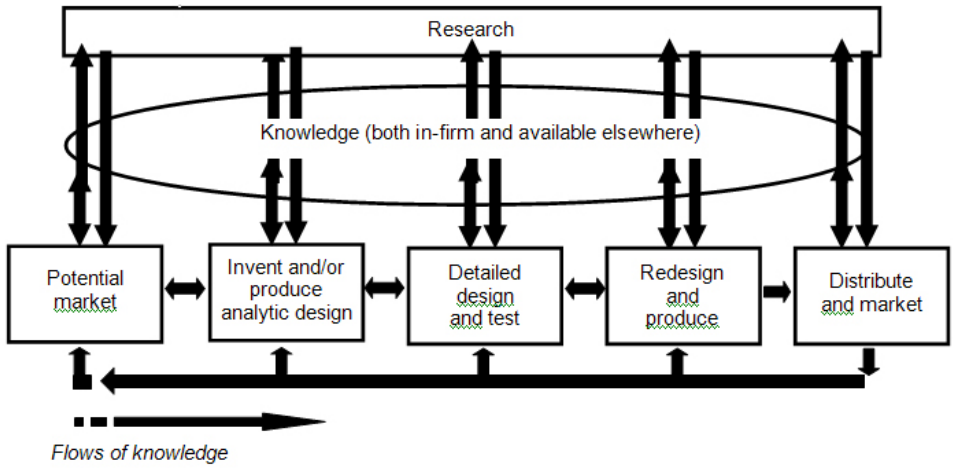


Figure 3.1: A chain link model of innovation
Adapted by author from Kline and Rosenberg, 1996.

A number of scholars have examined innovation systems from an array of approaches. Some are interested in the role of innovation systems in minimizing transactional costs[3] or generating economies of scale and scope,[4] while others have looked at these systems as an extension of social network theory. A wide range of approaches have been examined, including: industrial/managerial investigations of geographic concentrations of competing and co-operating companies, suppliers, service providers, and associated institutions that create industrial interdependencies[5]; analyses of networks and their relationships between markets and the visible hand of organizational authorities[6]; industrial milieu as a complex exhibiting synergies of economic and technological interdependencies[7]; value chain industrial clusters involving an extended input-output or buyer-supplier chain[8]; comparative institutional analysis[9]; and innovation systems as learning regions acting as collectors and repositories of knowledge and ideas that facilitate the flow of knowledge, ideas and learning.[10] Ultimately, all of these lines of research examine the role of "untraded interdependencies"—a term now extensively used to refer to an array of externalities of scale and scope.[11] These interdependencies are often characterized as involving region-specific conventions, informal rules and habits that coordinate economic

[3] e.g. Phillips, 2005.
[4] E.g. Porter, 1990.
[5] E.g. Porter, 1990.
[6] E.g. Powell, 1990.
[7] E.g. Maillat, 1991, 113
[8] E.g. Bergman and Feser, 2003.
[9] E.g. Peter Maskell and Lorenzen, 2003.
[10] E.g. Florida, 2002.
[11] Introduced by Dosi, 1984, and Lundvall, 1988 and 1992.

actors in localized production systems.[12] The resulting analyses examine how central actors, networks, culture, alliances and a myriad of other relationships manage uncertainties, thereby lowering transaction costs or increasing the rate and scope of innovative activity.

Most of the contemporary theoretical approaches build on the hypothesis that the defining feature of capitalism at the start of the new millennium is the central role of knowledge and learning in the creation of economic value and competitive success (Lundvall 2005). This thesis asserts that the ability of individuals, firms, regions and nations to learn and adapt to rapidly changing economic circumstances determines economic success in the global economy (Lundvall and Borrás 1998). While research institutions may play a major role in the production and dissemination of knowledge, the innovation systems approach posits a central role for interactive learning and knowledge circulation between economic agents (Morgan 1997; Maskell and Malmberg 1999; Feldman 2000; Gertler and Wolfe 2002; Cooke 2004; Asheim and Gertler 2005). This concept of learning implies that the organizational challenge for societies is how to pool and structure knowledge in social systems, rather than simply to access them on an individual basis. The capacity for social learning is assumed to require the collective intelligence of workers, firms and organizations at the local and regional level.

While this approach offers a starting point for understanding how social relationships can influence the scale, scope and timing of innovation, most of the studies narrow the focus to a narrowly defined set of actors, generally assuming *ceterus paribus* that potentially critical relationships will not change in response to innovative pressures.

Three points jump out from the literature. First, we can definitively say that innovation is clearly different than invention. Second, there is general agreement that innovation most frequently occurs within cultures, communities and organizations whose aim is to transform information into knowledge, to invent new applications of that knowledge and to convert those creations into socially valued goods, services, processes or organizations. Third, success is marked by the ease in which creations are introduced, absorbed into and persist in the economy and society. We can also extrapolate from much of the case study work on specific technologies and innovation systems to conclude that society usually reshapes in a major way what it uses. Seldom is the technology adapted and adopted in exactly the form in which it was conceived. Rather, the advent of a new transformative approach (be it technologically or socially derived)

[12] Storper, 1997, 5.

tends to be modified and directed in a wide range of ways that are seldom anticipated and at times are inimical to the interests of the original developer. Hence, change is not a linear pathway, but a cascading set of actions and reactions. The challenge is to understand the norms, rules and processes (either formal or informal) that govern those actions and reactions.

Phillips (2007) offers a generalized model of innovation by recasting the work of others (figure 2).[13] At its most inclusive, it allows for all assumptions about the scope and governing of innovation to be identified and tested. It disaggregates the stocks and flows: four stocks of information, knowledge and their by-products are identified in the squares; and four social processes are signaled in the ovals. The obvious place to start in the context of the contemporary innovation challenge is with the profusion of information. Information is explicitly separated from knowledge, in that the latter requires context and increasingly is governed by the complex knowledge 'industry'. At its root, new information, or newly mobilized information, is often the starting point of an innovation process. Formal and informal structures, incentives and processes identify, assemble, transmit and store an array of bits of information in multiple forms. Some information is readily accessible (i.e. it is codified and easily searchable) while other information may be tacit and only accessible through membership in some closed community.

[13] Leydesdorff (2005) offers a somewhat different but analogous treatment of the interrelationship between knowledge, innovation, geography and the economy.

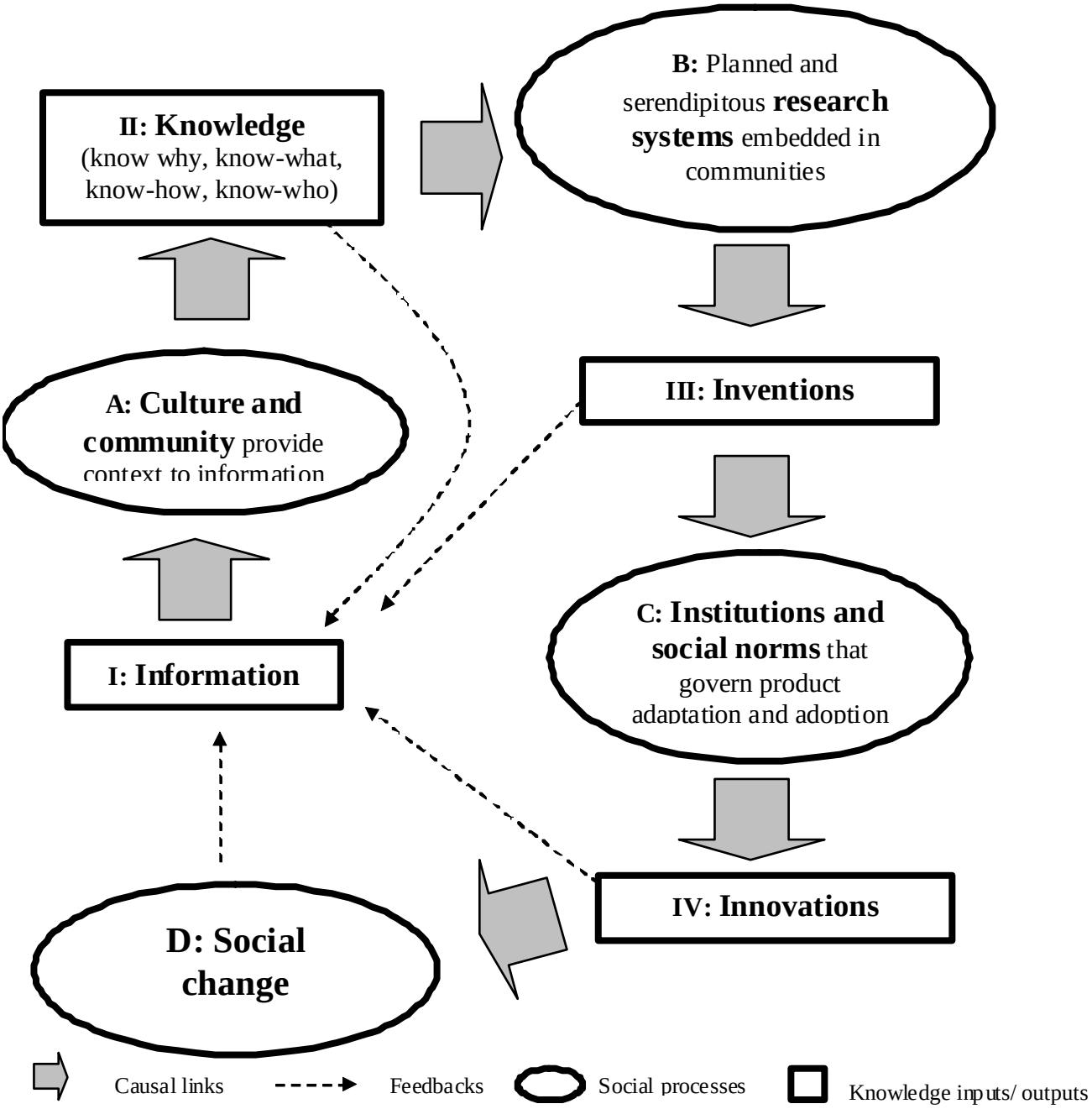


Figure 2: A general model of transformative innovation

Knowledge is generated through the context of cultural and community social processes. Knowledge is fundamentally a social good. To be judged knowledge, more than one person needs to accept it. While much of the work on innovation has focused on patentable, know-what

type knowledge, there is actually a wide range of other types of tacit and codified knowledge that are critical to the generation of an innovation (i.e., know-why, know-how, know-who and know-when types of knowledge, which will be discussed further in chapter 5).[14] The creative activity of generating an invention (something that is novel, useful and non-obvious) takes place within a social context and has organizational and social consequences. These three aspects of innovation tend to concentrate innovations in business, organizations and the economy in regional, sectoral or functional clusters in which new knowledge and skills complement imaginative industry leadership, all of which are supported by active partners, including communities and governments.

Translating an invention into a socially embedded innovation then involves a complex web of principals, agents, promoters and regulators on the supply side and middlemen, marketers and consumers on the demand side. Constructing new markets for new products or services is seldom straightforward or simple. Multiple governing systems come to the fore at this stage. The impact of a new technology depends both on improvements in the primitive form and also on complementary inventions.[15] Major technological innovations often necessitate new systems, which are unfathomable at the start. The ultimate impact of new technology is determined by satisfying human needs in ways and contexts that have not yet been articulated. Finally, as transformative innovations become socially embedded, they begin both to change society and to be changed by society. The end result is that innovations generate new information about our needs, wants, desires, opportunities and constraints. Thus, innovations tend to trigger successive waves of information that can sustain the innovation cycle. Smaller, iterative changes will certainly be changed by society but would be unlikely to have any measurable effect on the structure or operation of society itself.

2.2 Knowledge and innovation

A closely related set of arguments holds that innovation depends on the sharing of both codified and tacit knowledge (Nelson and Winter 1982). While codified knowledge at times may be easier to access and transfer, transferring tacit knowledge often requires a common code of communication, shared norms and matching expectations. Research on the geography of

[14] Mokyr, 2002, breaks knowledge down into propositional knowledge (what above is called know-why) and prospective knowledge (which appears to be a combination of know-what and know-how).
[15] Rosenberg, 1994.

innovation suggests that these features are most likely to arise in communities and regions (Saxenian 1994; von Hippel 1994, Morgan 1997; Maskell and Malmberg 1999; Audretsch 2002). These shared codes of communication and norms of behaviour in effect are regional intangible assets that underlie collaborations and learning activities by reducing uncertainty, building trust, and enhancing the flow of tacit knowledge between local economic players. Moreover, the theory suggests that cities offer more opportunities for inter-sectoral or inter-cluster knowledge exchange and spillovers that can enhance the learning potential for all local economic actors.

Even though these learning processes are mostly regionally based, recent conceptual and empirical work reminds us that the codes and norms that underpin learning are both shaped and constrained by institutions at the national and international levels. Basic science, labour markets, capital markets, corporate governance, regulation and market competition all are embedded in and highly influenced by national and international institutions (Whitley 1999; Hall and Soskice 2001; Gertler 2004; Phillips 2007). Bathelt et al. (2004) coined the notion of the two complementary forms of learning dynamics as 'global pipelines' and 'local buzz.'. Pipelines are the channels of communication and interaction with others outside the region. According to Bathelt et al., these long-distance knowledge flows help firms stay abreast of new ideas emerging from other locations. Storper and Venables (2004) posit that buzz involves gathering knowledge locally through intentional and serendipitous face-to-face interaction; in other words, people are more likely to share if they breathe the same air. Firms need both local buzz and global pipelines to develop and sustain creativity and innovative.

The theory does not, however, go into a detailed explanation of the types of information and knowledge involved in innovation systems. Knowledge displays mercury-like properties—we can see it but it is hard to grab on to. The difficulty is that knowledge exhibits an array of dichotomies: it can be both explicit and implicit; it can be local or global; and it can be individual or collective.[16] This array of attributes means the functional space encompassed by the term is wide.

There have been various attempts through the millennia to parse the concept of knowledge into more tractable components. Aristotle, for example, offered three classes of knowledge: universal and theoretical knowledge; instrumental and practice-related knowledge; and normative, common sense-based knowledge. Alternatively, knowledge could be parsed

[16] Jensen et al, 2004.

based on its degree of codification and formalization.[17] While codified knowledge (similar to Aristotle's universal and theoretical knowledge) is systematic and reproducible, tacit knowledge (those skills and corresponding understandings that defy articulation or codification and correspond to Aristotle's instrumental and normative knowledge types) is considered intangible—residing in individuals or communities. Knowledge could also be categorized based on it primary purpose: 'propositional' knowledge relates to natural regularities and phenomena (also called 'knowledge what'); and 'prescriptive' knowledge consists of instructions that constitute techniques or routines (or 'knowledge how to').[18]

We need more than taxonomy of knowledge, however. The late Professor Susan Strange, one of the key scholars who defined the nature of international political economy, argued that we need to understand what she called the knowledge structure which 'determines what knowledge is discovered, how it is stored, and who communicates it by what means to whom and on what terms… Power and authority are conferred on those occupying key decision-making positions in the knowledge structure.' [19]

Table 1: Modes of knowledge generation

	Mode 1 (traditional)	**Mode 2 (new)**
Problems set and generated in	Disciplinary communities	Transdisiplinary economic and social context
Communities	Homogeneous	Diverse and heterogeneous
Organization	Stable hierarchies	Transient heterarchies
Quality control	Peer review judgments about the contributions made by individuals	Temporary, heterogeneous sets of practitioners, collaborating in special and localized contexts

Source: Adapted by Author from Gibbons, et al. (1994)

A number of scholars have attempted to address that challenge. Professor Michael Gibbons from SPRU and a group of colleagues offered a complementary model, starting with the types of knowledge generated rather than with the institutions developing them.[20] They posit that two modes of knowledge generation now exist: Mode 1, which they call traditional knowledge, is generated within disciplinary, primarily cognitive, contexts; and Mode 2 knowledge is created in broader, "transdisciplinary" social and economic contexts (table 3.1). They argue that Mode 2

[17] Polanyi, 1962.
[18] Mokyr, 2002.
[19] Strange, 1992, 121.
[20] Gibbons et al, 1994.

knowledge tends to lead to a more socially distributed knowledge production system and, hence, is both socially accountable and reflexive. This, they argue makes Mode 2 knowledge a profound challenge to the traditional governing system because communications tends increasingly to take place across institutional boundaries and not only within established hierarchies.

Malecki (1997) extended this by parsing the concept of knowledge into four somewhat discernable types: know-why, know-what, know-how and know-who.[21] One might conclude that the four possibilities emerge from combining the dyads of form (codified or tacit) and structure (whether residing in individuals or the collective). Know-why knowledge is codified and collective, know-what knowledge is codified and individual, know-how is tacit and individual and know-who is tacit and collective (Table 2).

Table 2: Classification of types of knowledge

	Degree of Codification	Produced by	Extent of disclosure
Know-why	Completely codified	Universities and public labs	Fully disclosed or published in scientific journals
Know-what	Completely codified	Universities, public labs and private companies	Privately held but fully disclosed in patents
Know-how	Tacit, not codified	Hands-on in labs or teams	Limited dispersion; often due to trade secrets
Know-who	Tacit, not codified	Exists within firms or research communities	Limited to community

Source: Adapted by author from Malecki, 1997, p. 58.

Each type of knowledge has specific features.[22] 'Know-why' refers to scientific knowledge of the principles and laws of nature, which for the most part is undertaken globally in publicly-funded universities and not-for-profit research institutes and is subsequently codified and published in academic or professional journals. This knowledge would be in the knowledge block in the chain-link model (figure 3.1), having been created almost exclusively in the research block. 'Know-what' refers to knowledge about facts and techniques, which can usually be codified and transferred through the commercial marketplace. The stock of know-what is in the knowledge block in the chain-link model, having been created in the research, invention, design and adoption blocks. 'Know-how' refers to the combination of intellectual, educational and physical dexterity, skills and analytical capacity to design a hypothesis-driven protocol with a set

[21] Lundvall and Johnson, 1994, OECD, 1996, and Malecki, 1997. Boulding, 1984 and 1968, talked of three types of knowledge—know-what, which creates know-how artifacts and know-whether, which involves evaluation and decision making.
[22] See OECD 1996 for a good overview.

of expected outcomes, which involves the ability of scientists to effectively combine the know-why and know-what to innovate. This capacity is often learned through education and technical training and perfected by doing, which in part generates a degree of difficulty for the uninitiated and makes it more difficult to transfer to others and, hence, more difficult to codify. Know-how would be represented in the research block and also in the invention, design and adaptation stages. Finally, 'know-who', which involves information about "who knows what and who knows how to do what"[23] is becoming increasingly important. As the breadth of knowledge required to innovate expands, it has become absolutely necessary to collaborate. In today's context, know-who also requires knowledge of and access to private sector knowledge generators who at times may hold back the flow of crucial or enabling information, expertise and knowledge. Know-who knowledge is seldom codified but accumulates often within an organization or, at times, in communities where there is a cluster of public and private entities that are all engaged in the same type of research and development, often exchange technologies, research materials and resources and pursue common staff training or cross-training opportunities. The arrows in the chain-link model would represent this type of knowledge, as building relationships that lead to trusting networks of know-who is the basis for those flows.

This categorization of knowledge goes part way to finding and focusing on those who occupy key decision-making positions that determine what is discovered, how it is stored, and who communicates it by what means to whom and on what terms. In the first instance, the taxonomy reveals that there are both stocks and flows of knowledge, which would suggest that there will need to be correspondingly different actors engaged in stages. Furthermore, no one type of individual or institution will control all of the knowledge and its uses. Rather, there will be an array of individuals, public agencies, private enterprises and collective structures that will govern different types of knowledge, each potentially using a different set of processes and seeking a different set of objectives.

Fundamentally, we are faced with a complex systems problem. There is no single approach to understanding the dimensions of the challenge. Many other economists, sociologists and political scientists have accepted this necessity and have attempted to map out a more interdisciplinary framework. Each discipline has made tentative efforts to consider and accommodate actors not normally considered in their domain. A number of economists have

[23] OECD 1996.

noted the non-market collective efforts that underpin critical aspects of the market (e.g. Simon, 2000). Growth theorists have been particularly interested in the role of non-rival goods.[24] Institutional economists have been interested in the role of non-market actors (e.g. Hirschman, 1970). Those political scientists who focus on the nation state are concerned about the relational and structural power of the state (vis-à-vis other actors) in governing the knowledge system (e.g. Strange and Gilpin), while those who focus on intra-state relations are investigating distributed governing arrangements, based on a more diffused pattern of power (sometimes called 'meso-systems').[25] Meanwhile, sociologists have engaged in the analysis of the post-industrial, knowledge-based world through a variety of multi-dimensional framing devices, such as the triple-helix framing device.[26] Generally, they believe that while relational power is important in a post-modern liberal democracy, it is only effective if it conforms to the underlying norms of the society. In other words, non-state actors have structural power than can offset or reduce relational power. 'Mode-2' type knowledge, in particular, appears to be created, owned, controlled and used through an array of formal and informal relationships among three main actors—governments, industry and universities.[27]

Economist Kenneth Boulding offers a potential Rosetta stone that amalgamates the economic, social and political perspectives. He argues that human relationships can be classified as the compulsory, the contractual, and the familistic.[28] The compulsory system involves threats (such as 'you do something for me or I'll do something nasty to you') which fundamentally depend on the credibility of the threat and the capability of the partners to affect their sides of the relationship. These types of arrangement could yield either zero-sum or negative-sum results. The contractual, exchange-based system involves voluntary bids, offers and contracting, which generally yield positive-sum outcomes for both parties. The familistic, integrative system involves status relationships (e.g. 'you do something because I am your father, or a king, a priest, a teacher, a lover, child, student…'). This yields three different methods of integration: coercive relations that distribute rights and obligations, led by the state; quid pro quo exchanges in the market governed by the Marshallian scissors of supply and demand; and voluntary dealings,

[24] E.g. Romer, 1990.
[25] Paquet, 2001.
[26] Ettzkowitz and Leydersdorff, 1995.
[27] Gibbons, et al., 1994.
[28] Boulding, 1970, citing Polanyi, 1957, and Sorokin, 1959.

where cooperation, reciprocity and solidarity engage community and society.[29] Boulding argues that society can be viewed as a triangle (his 'social triangle'), where all organizations—including the state, the market and civil authorities—are built on one or a balance of the three relationship systems.[30] The array of different approaches can be distilled down to three functional types: governments that structure rights and obligations; markets that engage in voluntary economic exchange; and a variety of collegial or social groups—including universities and NGOs—that engage in social discourse and mobilize voice in society.

3. The operational hypotheses and data

The primary hypothesis for this theme is that the economic and creative performance of city-regions depends on three key characteristics: the strength of local knowledge flows within individual industries/clusters, the strength of local knowledge flows between individual industries/clusters and the strength of knowledge-based linkages between local and non-local economic actors. The working hypothesis is that the economic performance of city-regions depends on the density and/or of local networks, the relative mix of local and non-local ties and heterogeneity and diversity of economic actors belonging to these networks. This paper examines how these factors affect the nature of the innovation process in Saskatoon and looks at its impact on the economic performance of the city region.

The data for this analysis comes from a variety of sources. In 1997-99, the canola cluster in Saskatoon and globally was investigated, leading to a major book on the global oilseeds complex centred in Saskatoon (Phillips and Khachatourians 2001). More than 30 semi-structured personal interviews of supply chain and cluster actors were undertaken in 1997 and 1998, a survey of 390 personnel in the sector was undertaken in 1998 and a bibliometric and patent analysis of knowledge flows was completed. In 2002-3, the Saskatoon team of the Innovation Systems Research Network, a SSHRC funded Major Collaborative Research Initiative, undertook 75 in-person, structured surveys of actors within the biotechnology cluster, examining issues related to the structure and function of the industrial complex.

In 2007-8, the Saskatoon ISRN research team, part of the renewed SSHRC MCRI project, administered three surveys related to the creative community in Saskatoon. In May-August in

[29] Paquet, 2001.
[30] Boulding, 1970, 30.

both 2007 and 2008, teams of undergraduate students from the Department of Political Studies at the University of Saskatchewan undertook a total of 75 structured interviews using the ISRN instruments. These actors were chosen by the researchers based on the need for a wide variety of perspectives and from suggestions put forth from the interviewees (i.e. a 'snowball method" was used to create a list of possible interview targets). The interviews were usually conducted through face-to-face interviews at the firm's offices. Three of the 25 interviews were conducted over the phone due to scheduling conflicts precluding other options. All interviews were recorded and transcribed. Interviews usually took between 30 minutes and an hour to conduct. Usually interviews were between one or two researchers and a single subject, though on a few occasions multiple subjects from the firm participated in the interview. The interview guides were based on the research directions outlined by the ISRN with the inclusion of questions probing the specific political, cultural, and economic context of Saskatoon. Selection of subject firms was designed to query a broad cross-section of innovation in Saskatoon, with a particular focus on the agriculture-foods, biotechnology, and mining sectors that showed some evidence of both innovation and clustering in Saskatoon in the earlier ISRN study. The initial selection of firms to approach for participation in this project was based on their innovativeness but actual participation was mediated by interest and availability. Ultimately, 25 firms participated in the study, 10 in the summer of 2007 and 15 in the summer of 2008. Broken by industry, 7 firms were involved in biotechnology, 4 were in mining, 4 in agriculture and food, 3 in contract research, 3 in software development, and the remainder were involved in consulting, manufacturing, aeronautical engineering and applied art.

Finally, in 2008 a social network analysis was done on social entrepreneurs in Saskatoon. Over the course of its 2007 Theme III interviews (Inclusive Communities and Civic Engagement) the Saskatoon ISRN team was able to identify four main structures in Saskatoon that were of particular importance: the university, government, business and civil society.[31] Within these four structures, particular individuals and organizations were identified as playing key roles. Taken together, a list of key actors in the Saskatoon city-region was compiled. A refined copy of the list of important actors in Saskatoon was narrowed down to 253 individuals (73 from business, 63 from the university, 59 from government, and 58 from community based organizations). It was these individuals, and the networks of which they were a part, that formed

[31] Theme III, ISRN (2007)

the source population from which to study the level of infrastructure social capital in the Saskatoon city-region. Thirty individuals, from the refined list of 253, took part in this research. These thirty individuals were from all four major structures in the Saskatoon city-region (5 in government, 9 at the university, 7 in industry, 9 in civil society and 2 others)[32]. Their entrepreneurial orientation and social networks were elicited in a survey and analysed by Webb (forthcoming 2009).

The following analysis examine the three theoretical assertions using Saskatoon specific data—the strength of local knowledge flows within individual industries/clusters, the strength of local knowledge flows between industries/clusters and the strength of knowledge-based linkages between local and non-local economic actors.

4. Findings

4.1 Strength of local knowledge flows within individual clusters or industries

The work on the canola and biotechnology clusters and the ISRN II, Theme 1 survey, offer insights into the strength of local knowledge flows within the individual clusters and industries in Saskatoon.

Although current information is not available, a survey undertaken in the Saskatoon ag-biotechnology community in 1998 illustrated the critical role of the local education system (table 3). All but two of the employees surveyed with a technical diploma were trained in Canada and 82% of the employees with technical diplomas got their training from the Saskatchewan Institute of Applied Science and Technology, mostly through the two-year Biotechnology Technology Program in Saskatoon. Between 1969 and 1998, the program produced 335 graduates (SREDA, 1998), and employment surveys of those graduating from this course show that 88% are employed in their field within six months. The same trend is seen among employees with undergraduate level training. All but 22 of 85 of the respondents with a bachelor's degree were trained in Canada. There has been a bit more mobility at this level of training, however, with only 66% of the respondents getting their training at the University of Saskatchewan. The Saskatoon labour market draws from Ontario, Alberta and Manitoba extensively. The labour

[32] Two participants held positions in more than one sector. As a result, while there are only 30 participants, there are 32 sectoral tallies.

market becomes significantly more mobile at the graduate degree level. Less than half the employees with master's degrees and only about one quarter of the employees with doctorates are trained in Saskatchewan. Thus the local labour market depends critically both on local educational networks and systems and on attracting key personnel from away.

Table 3: Employees in the Saskatoon agri-food research community, by degree, 1998

	Technical diploma	**Undergrad degrees**	**Masters' Degrees**	**Ph.D. degrees**
Total	***88***	***235***	***67***	***73***
Saskatchewan as % of total	82%	66%	43%	27%
Canada as % total	98%	91%	84%	64%
US as % total	1%	2%	6%	10%
Europe as % total	0%	4%	7%	18%
Other as % total	1%	3%	3%	8%
Source: Canola industry employee survey, July 1998; Statistics Canada, Labour Force Survey, Aug. 1998				

When we asked employers where they sought for and found new employees, we discovered that about one third of companies got new employees from non-local markets, with firms relying more heavily on other markets for marketing, management and science, technology and engineering research staff. Local markets were more important for production and design workers.

Table 4: Sources of new employees in private firms

	Local	**Non-local**	**% non-local**
Management	11	6	35%
Sci., Tech., Eng.	17	9	35%
Design	3	1	25%
Marketing/Sales	11	9	45%
Production	15	3	17%
Freelance/Contract	8	5	38%
Source: Author's tabulation of ISRN Survey Part D: Q3.			

The local labour market also exhibits some thickness, as 82% of those surveyed indicated that they had previous employment experience in the local labour market, with the University and other the commercial sector providing most of the career opportunities. It is particularly notable that almost 30% of AAFC employees reported previous experience with private firms and 43% of employees working in firms reported that they had worked in other firms previously.

While the NRC and AAFC provided work experience for only 11% of employees in firms, they do account for a larger share of highly qualified employees in those firms.

Table 5: Labour market mobility in the Saskatoon agri-food research community

	Current	Past employment experience			
	Employer of respondent	*University*	*Other Companies*	*AAFC*	*NRC*
Companies	189	45	81	13	8
AAFC	162	42	50	--	4
NRC	39	19	9	3	--
Total	390	151	140	16	12
% total		39%	36%	4%	3%
Source: Phillips and Khachatourians 2001..					

Equally important is the flow of intellectual property around the cluster. An analysis by Niosi and Bas (1999) showed that in the 1989-1999 period, Saskatoon ranked fourth in Canada for patent issues (behind Montreal, Toronto and Edmonton or Vancouver, depending on the measure). The biotechnology-related patent activity was proportionately much higher in Saskatoon (67% of all University patents) relative to other universities in Canada (average 16% for all universities).

Moving beyond the labour market and research phases, there is some evidence that the Saskatoon biotechnology clusters offers unique opportunities for competitive intelligence and foresight. Survey results in table 5 suggest that once the companies were operating, they used a range of methods to keep track of opportunities and threats, most of which depended on face-to-face relationships, many which appear to have some local component.

Table 6: Methods used by companies to keep track of competitor activities

Method	**# of respondents**
Conferences and/or meetings	12
Personal contacts	10
Networking	9
Looking on their web sites	8
Publications	6
Customers	3
Patent searches	3
Collaboration	2
Buy and test products	1
Source: Phillips et al 2004.	

Firms in the biotechnology cluster also reported that they generate both tangible and intangible benefits of co-locating with competitors and collaborators (Phillips eta al 2004). A survey of canola firms in Canada and globally undertaken in early 1998 asked companies about the factors influencing their decisions to locate their research efforts. Half of all the respondents, representing the majority of private companies responding, acknowledged the importance of proximity to either collaborators or competitors. About 40% recognised the importance of being close to their collaborators, particularly the NRC and AAFC in Canada and key research universities. In the ISRN I survey, companies were asked to identify the significance of different relationships within their cluster on their ongoing operations. While 64% of the 22 companies interviewed reported that their key customers and clients are located globally, most of those companies (63.6%) stated that it is not important to be located near their key customers. More importantly, 81.8% stated that relocation to be near key customers would not be considered. In short, relationships with customers are important but collocation with customers is not critical. There was more diversity of opinion about whether it was important to be located near their suppliers. About 45% reported relying solely on non-local suppliers and another 32% reported they use both local and non-local suppliers, but more than half (55%) reported that it is not important to be close to suppliers. Overall, only about 9% would consider relocation to establish closer ties with their suppliers. Lastly, it is interesting to note who the companies view as their competitors. First, approximately half of the actors recognise their competitors as global and about 41% local. In contrast to ambivalence about co-location with suppliers or buyers, most firms reported (77%) that there was real value in being located near their competitors. Clearly, these actors—many at the R&D and early commercialisation stage—viewed that co-location improved their odds of competing.

Procyshyn (2004) took the results of the ISRN I surveys and undertook a further questionnaire of eight central actors in the biotechnology cluster identified as key in the surveys. Each central actors was asked to identify their relationships with each of 94 other institutions in Saskatoon, noting whether they were engaged in exchanges related to R&D, fee-for-service work, capital, human capital or contextual knowledge. Density measures for the entire network and each of the five ‘functional’ networks were developed. The results of our density analysis indicate that on average, over the core actors identified, there is an average of 89 linkages per

core institution, spread across the five functions analysed. The overall network density across all functions is 0.15 or 15% (712 linkages identified relative to an absolute possibility of 8,930). As one would expect, the density varied across function, from a low of 1.4% for financial exchanges and 2.3% for R&D links (which is consistent with a predominantly pre-commercial research based community) to a high of 7.6% for networking, which suggests a quite a highly linked community for industrial policy and promotional efforts but relatively weak networks for financial intermediation.

More recently, ISRN II, survey I, tested this issue among 24 firms. The first two questions of the survey—What goods or services does your firm provide? and On what products or services does your firm earn its highest profit margin?—were useful in provide a baseline for the rest of the responses. Of the 24 included in this paper, 7 had not, at the time of the interview, produced any products or services and did not have a positive revenue stream. The firms without a profit were either start-up biotechnology firms (4/7) or junior exploration companies in the mining sector (3/7).

To test to see whether we had included innovative firms in the sample, participants were asked about recent innovations (Q: During the last three years, did your organization offer new or significantly improved products—goods or services—to your clients, or introduce new or significantly improved production/manufacturing processes?). Twenty of the 24 firms answered that they had introduced a new product (11), service (6), or process such as the application of new technologies to old tasks (3). When asked whether their innovation was new to the world, Canada, the Saskatoon region or to their business unit, most considered their products 'new to the world.' This may be somewhat suspect as there was a great deal of uncertainty regarding what is the difference between a new product and only an incremental change from existing technology. In a few examples, particularly with biotechnology firms, there is uncertainty as to whether the product was indeed unique or if, unknown to the firm, it had been duplicated in other labs. Overwhelmingly, the development of these new products, services and processes have been the result of internal R&D in reaction to customer and market demand. Only one firm developed the new product, service or process through a direct collaboration with another firm though many firms cited collaborations which indirectly contributed to the development of the product (i.e. reliability testing of equipment under operating conditions).

The participating firms were then asked two questions relating to the advantages they saw their firm having over competitors (Q: What is your firm or business unit's source of competitive advantage? What is it that your firm does better than your competitors in the marketplace? "Please describe the processes by which this firm or business unit developed its top two or three sources of competitive advantage.). When appropriate, the interviewer prompted with possible responses (e.g. quality of service to customers). Participants commonly gave multiple possibilities as to the sources of their competitive advantage. The most common response was to credit their competitive advantage to superior innovation. Of the 24 participating firms, 12 firms expressed a belief that they had superior research and development, innovations, or had created innovative products.[33] Six firms stated that customer service was their source of competitive advantage. Three firms indicated their reaction speed, ability to adapt quickly, or quick decision-making capacity as a response. Other responses included competence of management team (3), better training and technical expertise (2), internal integration and communication (2), better product quality (2), international connections (2), the existence of alliances and partnerships (1), ability to raise money (1) and focused nature of research and scale of production (1). Other responses were relevant only to the particular business model of the firm. (MIKE: the many of the items yellowed area sound like r&d [e.g. focused nature of research; better product quality] or speed etc [management, training and tech exp, internal integ, comm.; can we aggregate them into the above three choices)

There was a strong connection between the sector of the firm and their responses regarding competitive advantage. Eight of ten (8/10) firms involved in ag-bio research believed that the quality of their research and development was a competitive advantage for their firm.

[33] Participants were also asked about the sources of any IP (Q: Does your establishment own unique products or services? Where was this IP created or obtained from? What strategies does your firm use to manage or protect these unique products or services?). Eighteen firms indicated they owned some IP—16 firms indicated that they owned intellectual property related to unique products or services and 2 firms reported that they chose to protect their secrets through other means such as industrial secrets, security measures, retaining employees, and confidentiality agreements—while 5 firms indicated that they did not have any unique products or services that could be protected. Larger firms were much more likely to indicate patents as their major form of intellectual property. Small and medium sized firms indicate that they still use patents in certain circumstances but look to other forms of intellectual property such as trademarks, industrial designs, software keys and industrial secrets to protect their secrets. An exception to this would be smaller biotechnology firms whose business model is to license patents to other firms. This tendency to look beyond patents was usually explained in terms of the greater cost of patents and the necessity of prioritizing resources. One firm expressed the concern that patents and, to a lesser extent, other intellectual property is overused and that small firms can have a difficult time defending their patents against encroachment from larger firms that are better able to absorb the legal costs of contesting a patent.

Three saw it as their only competitive advantage, which could simply be a reflection of the start-up status of many of these ventures: two of the firms who exclusively asserted research and development as their major competitive advantage were start-up biotechnology firms whose only activity was the development of a product.

Twenty-two firms gave an explanation of how they developed their firm's competitive advantages. The most reason cited was that the firm had the right people on board. This advantage was gain either by building a good team through hiring, by the exceptional skills possessed by the firm's founders (4) or by intensive training (1). Reactions to customer demand (4) and market assessment (3) were also common answers, usually in relation to the development of a customer service focus. Some firms attributed their competitive advantages to an effort toward product and process development (3) and the building of new capacities (2). Finally, foundational advantages such as being the first to the marketplace (2) and organizational culture bestowed by the founder or a larger parent corporation (2) were the last repeated answers. Other answers included staying abreast of technological development, strategic planning, the building of internal communication networks and interactions and cross-learning with other institutions.

Firms were also probed to see what role the local milieu plays in their innovation. To some extent, every firm responded that they gained something from collaboration (Q: *Has your firm collaborated with other players leading to innovation?).* For some, particularly those providing services like contract research, this collaboration simply consists of feedback from their customers. For others, their collaboration included large-scaled innovation projects executed with other firms and organizations. In response to this question, firms spontaneously mentioned collaborations with the University of Saskatchewan (5), clients (4), consultants or contract workers (4), other firms (3), contract research or product testing firms (4), universities and research organizations outside Saskatoon (4) and with various Saskatoon based research institutions (i.e. Saskatchewan Research Council (2), NRC/Plant Biotechnology Institute (2), POS Pilot Plant, Agriculture Canada, NRC/IRAP, the Innovation Place Bioresource Centre and VIDO. While all firms indicated that collaboration does take place, those that went on to describe the nature of the collaborations commonly indicated that the relationship usually related to a specific step in the innovation process, such as funding or product testing. Only two firms described a project in which the firm had worked closely with a partner throughout the development process of a unique product or service. When asked to describe the motivation

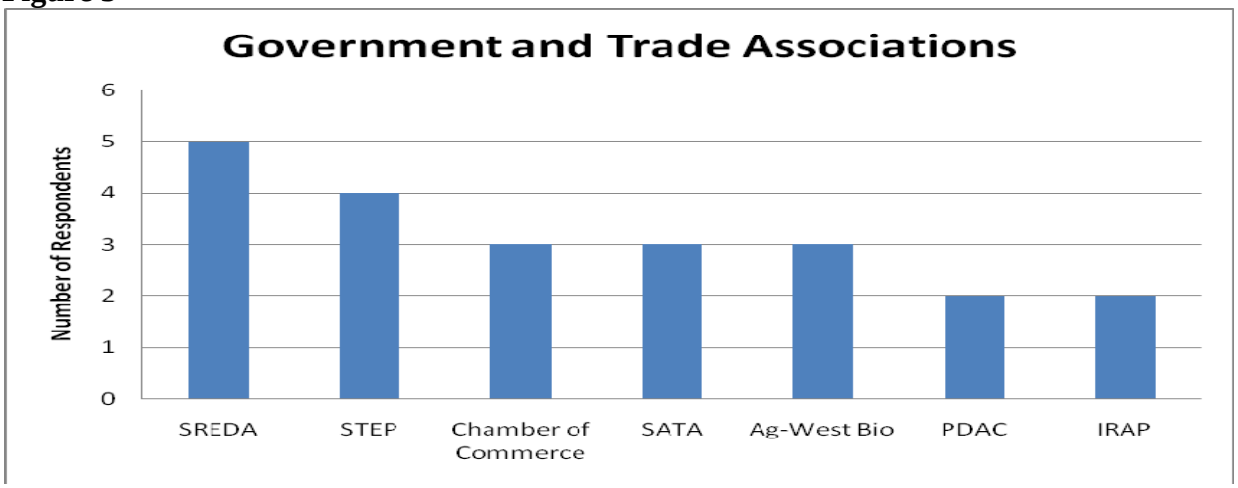
underlying their collaboration, the most common answer was the need for efficiency and to cut costs. Other answers revolved around gaining access to knowledge, innovation and expertise in order to stay at the cutting edge of advancements in science and technology. Smaller firms, such as the start-ups in biotechnology and the junior exploration mining companies, often cited their firm's limited capacity and the need to collaborate to access specific services, equipment, and infrastructure. In response to a query about how they relate to suppliers (Q: *What components or services do you rely on your suppliers to provide as opposed to what you produce on your own?)* yielded similar answers: firms sought out suppliers to remedy weak in-house (8), to gain efficiencies (7) or to ensure compliance with regulations (2).

Perhaps most revealing relative to the focus of this section, firms were asked about their collaborations related to R&D&C (Q: W*hen your firm or business unit has a problem with product design, production, market development, that it cannot solve on its own, where do you go for solutions?).* Nine firms, largely from the biotech sector, reported that they would look for help from academics. For many, though, these connections were informal and were often described as simply picking up a phone and calling an acquaintance at the University of Saskatchewan or elsewhere that was thought to be able to lend assistance. Only two firms reported that they have dedicated science boards to advise their activities (c.f. Zucker, Darby and Brewer 1998). Six firms, all from the mining or software sectors, said they would turn to consultants in those situations. Others reported that they would seek help from parent or sister companies (2) or other companies in their field (2). One innovative firm (in the biotechnology field) reported that they post their problems on a website and offer rewards for possible solutions.

Firms were also asked about how their relationships with the local government and various trade or industry associations affect their operations (Q: W*hat involvement does your firm have with local government structures and trade associations? What benefits does this give your firm?).* Respondents often had a difficult time thinking of the different trade associations and government structures that their firm was involved with. The key ones were the Saskatoon economic development authority (SREDA), the provincial trade and export marketing authority (STEP), the local chamber of commerce, and three industry associations—the provincial advanced technology association (SATA), the ag-bio industry organization located in Saskatoon

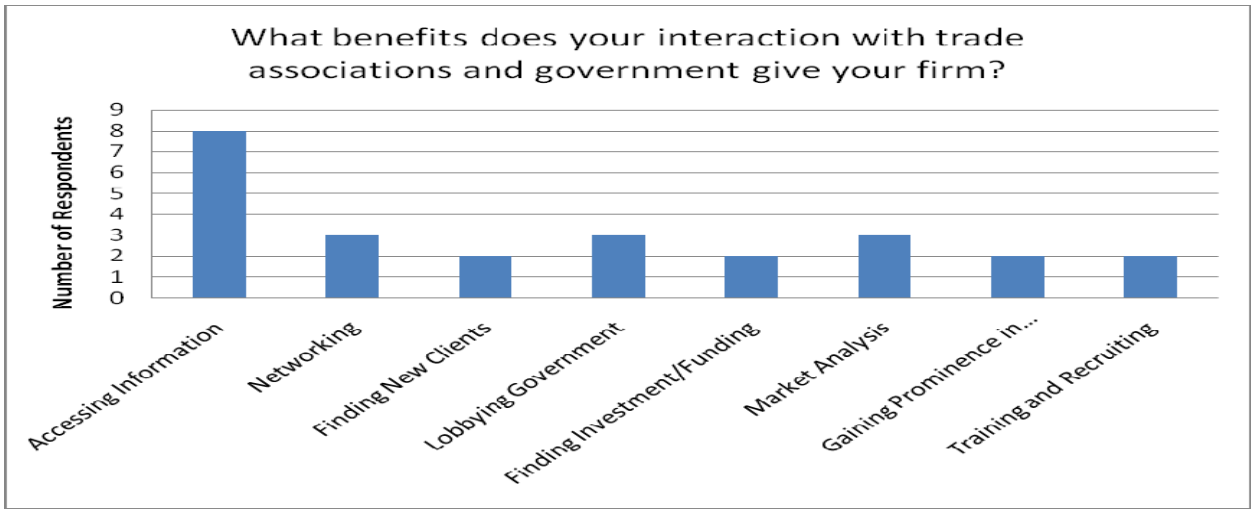
(AgWestBio) and the PDAC (which is?). could you remove IRAP from the graph/it is not a government trade organization)

Figure 3



Overall, it was rare for a respondent to indicate that trade associations or any level of government had a very important influence on their business. Even if a firm indicated it worked with a trade association, it often was unable to say what benefit, if any, they received from their involvement. That an organization was mentioned does not automatically imply that it was seen to be a benefit; some firms derided organizations of which they were members for not doing enough. Those benefits that were mentioned are shown in Figure 2 (e.g. information, networking, client identification, lobbying, financing, market analysis and training and recruitment). Only one firm (a very large employer) mentioned ever interacting directly with the municipal government.

Figure 4



In Saskatoon, it appears that a large proportion of collaboration and cooperation between firms and other organizations in the local economy occurs informally through personal contacts. These collaborations most often occur on the level of brief consultations. A common scenario is that when a problem occurs, an individual in a firm would simply pick up the phone and talk to a knowledgeable friend or acquaintance at the University of Saskatchewan or another firm in order to gain knowledge to help fix the problem. While formal connections are still very important, especially connections with public research organizations and universities, the perception from the interviews is that informal connections between individuals is a more important conduit of information in the average firm's day to day operations.

Firms were unlikely to refer to collaboration and cooperation with other firms as a major part of their business strategy. Only two firms cited collaborations with other firms as a strategic advantage and, in those cases, they were referring to a parent or sister firm. While many firms reported that they collaborated for components of their innovation process, i.e. product testing, in many cases this is indistinguishable from merely purchasing the services of another firm. Tellingly, when asked to describe a product, process, or service developed in the last three years that was representative of their innovativeness - a question which most firms, understandably, used to exhibit their most impressive innovation – only one firm talked about a product that was developed in close collaboration with another firm or organization. Otherwise, each firm described a product created solely by internal R&D, though often with inspiration from outside sources.

In general, Saskatoon residents are open to exchanging information whenever this was not a direct threat to their company. That the default would be to share knowledge was seen as the natural order of things. Most respondents reported that they had a number of knowledgeable acquaintances outside of their company that they could phone in order to seek help on specific issues. Likewise, the respondents stated they would also likely assist if the roles were reversed. Compensation for these brief consultations was never mentioned except in those instances where the interactions began to run over an extended period. Generally, these consultations were based on pre-existing contacts but this was not always required. And while these interactions may occur with individuals located anywhere, the majority of the examples given by respondents refer to connections with individuals in Saskatoon.

From the responses, it seems clear that most knowledge sharing is done within a framework of social norms instead of market norms. The concepts of social and market norms come from behavioural economics. While they seem simple – the main difference is that interactions regulated by market norms require immediate compensation while those regulated by social norms do not - these concepts represent two fundamentally different ways in which individuals think about social interactions; whether an interaction is perceived as being regulated by social norms or market norms radically changes the nature and outcomes of that interaction. Much research has, rather counter-intuitively, shown that the expectation of payment can radically decrease an individual's willingness to render a service to another individual in certain situation. Because of this, Saskatoon's environment of informal connections based on social norms may facilitate a greater level of knowledge transfer and willingness to assist other firms and individuals than another center where paid consultations are the norm. Additionally, in environments where social norms predominate, reputation becomes more important. It is possible that Saskatoon's small size contributes to its social norms-dominated environment by allowing for easier tracking of reputational factors.

4.2 Strength of local knowledge flows between industries/clusters

The theory suggests that communities can support more than one innovative cluster and that there can be spillovers between and beyond innovative agglomerations that contribute to local economic prosperity.

One way to test this is simply by asking people whether the local economy supports mobility of knowledge between jobs and sectors. The 2008 survey of 115 creatives in Saskatoon asked whether Saskatoon's economy enables mobility between sectors (Phillips and Webb 2008). On a 10 point scale (1=none; 10=high), 58 responses responded with an average of 6.5 (standard deviation 1.6) that the economy facilitates mobility. When asked whether the respondent uses knowledge gained in other sectors in their current work (0=never; 10=frequently), 62 responded with an average 6.6 average (2.2 standard deviation). Most interesting, however, a correlation analysis between the level of personal creativity (dubbed the talent index) of the respondents and the responses to these questions revealed no significant correlation. In short, labour and skills may be mobile, but it is not clear that that differentially assists creative people contribute in their own unique way..

The Phillips and Webb creativity survey in 2008 also asked individuals to indentify how the community supports creativity (Q: what particular aspects of Saskatoon … facilitate creativity in the city?). In all, 80 people responded saying there were specific aspects of the city that affected creativity. Of those who indicated specific institutions or features, 26 respondents reported that specific industry or infrastructure facilitated creativity while 31 reported that cultural aspects of the city supported creativity. Those citing institutions focused on the relatively large part the scientific community plays in the city, mentioning the important role of infrastructure at the University (including the CLSI and the federal labs), the biotechnology firms and the nature of a competitive yet cooperative community. Those citing the community and cultural aspects of the city cited the city amenities (cost, variety), the rural/agrarian/small town virtues (e.g., friendliness, acceptance, volunteerism), and the access to affordable and engaging cultural events and facilities. Statistical tests were done to determine whether there was any relationship between the citations and the talent index. The correlation coefficient between the constructed talent index for those individuals and their responses related to industry/institutions was .298 (statistically significant at the 99% level), indicating that those who have higher talent measures see value generated by those institutional/industrial features that are unique to Saskatoon. There is no statistical correlation between the talent index and community/culture features or the negative responses. This does not necessarily mean that cultural and community attributes are not a contributory factor, simply that they are not differentially recognized by those who form the 'talent' pool we surveyed.

Table 7: Industrial/institutional and community/cultural attributes that support creativity		
	# cites	Specific attributes cited
Industry and Institutions	26	• Inclusiveness; large scientific community; competition and cooperation • Biotech industry • Research infrastructure (university, CLSI, federal labs); large research community relative to small city
Community, Culture and cultural amenities	31	• Size; amenities; lifestyle; pace; cost; sense of community • Cultural events; affordable and accessible activities • Rural/agrarian/small town virtues (friendly, accepting, volunteerism)
Yes, NES	5	
None	20	Negative features included isolation, conservatism
Source: Phillips and Webb 2008.		

ISRN II in 2007-8 posed a number of questions to 24 firms in Saskatoon.

Firms were asked a series of questions looking at the extent that they benefited and learned from other sectors. While some firms indicated there was some benefit from other sectors in Saskatoon—e.g., mining firms are well-served by Saskatoon's metal-working and manufacturing infrastructure—the overwhelming response to these questions was bafflement at the idea of learning from another sector. While some were able to find areas where they could learn from other sectors such as in human resources and importing/exporting, most indicated that that interaction between sectors in terms of learning did not happen at all (38% of respondents) or was minimal (31%). A quarter of respondents said it happened to a noteworthy extent while only 1 firm claimed that they learned from other sectors to a great extent. Larger firms, presumably because of their greater range of activities, were more likely to say that cross-sectoral learning was taking place. Additionally, where learning from other sectors was identified it was usually in terms of a very closely related industry, e.g. a gold mining firm learning from a uranium mining firm.

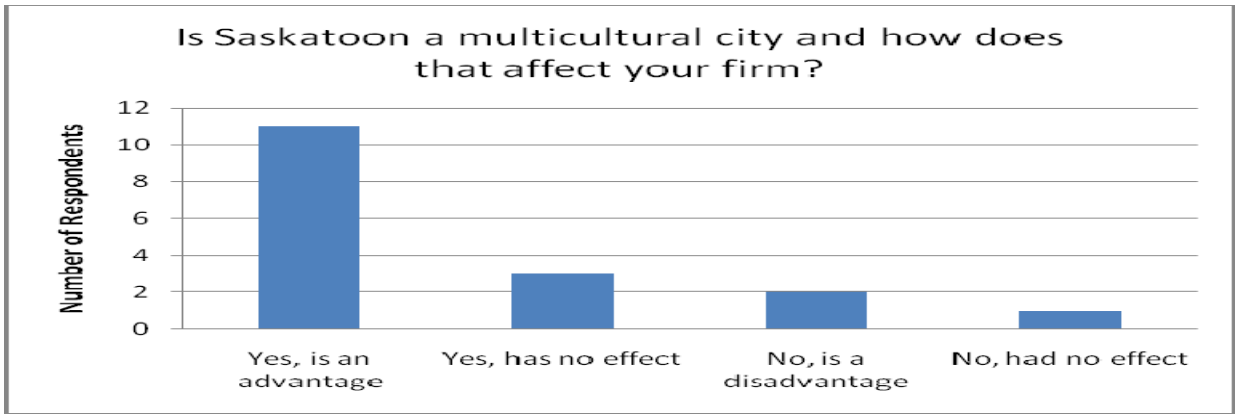
Similarly, when asked to what extent their employees worked across fields and the importance to their firm of recruiting workers from other sectors in the local economy, most firms reported that their workers were strictly confined to their particular industry and sector and did not work across fields in any significant way. In fact, 58% of firms reported that recruiting workers from other sectors never happened in their firm and 17% said it happened very rarely. However, the five firms which did recruit from other sectors often asserted that bringing in people from other sectors was important in bringing in new perspectives and skills. Some of the

largest firms stated that they hired outside of their sectors simply because they were forced to by Saskatoon's limited workforce.

Firms were asked where their primary sources of recruitment for creative and highly educated workers were, both in terms of location and institution. As noted in earlier surveys, the most common answer was Saskatchewan educational institutions: eleven firms stated that the University of Saskatchewan was a primary source for recruitment while seven mentioned SIAST or other local educational institutions. Only 7 firms said they commonly recruited directly from competitors while many other firms stated that they avoided the practice because they believed that it was either unethical or otherwise inappropriate. Moreover, while many firms stated their willingness to look outside Saskatoon, most recruiting happens directly from the local economy. Moreover, 12 firms reported that they had some sort of special relationship with a local educational institution. SIAST was the most commonly cited institution with 5 firms reporting that they had some sort of special relationship. Four firms mentioned the University of Saskatchewan and 2 mentioned the University of Regina. These relationships varied in extent from participation in job fairs to providing internships and guiding curricula.

As a test of the notion that the broader community features might influence creativity within and between clusters, firms were asked whether they believed Saskatoon is a multicultural city and how that affects their firm. Their responses are shown in Figure 5. Those responding that the city-region is multicultural and that this has a benefit to their firm usually point to the advantages of having a variety of perspectives along with an increased ability to integrate new members of the workforce as multiculturalism's most beneficial characteristics. Saskatoon's Folkfest was often used as an example of its multiculturalism, though some lamented that Saskatoon's true multiculturalism was only shown during the festival. To test to see whether this would matter, firms were also asked how many of their employees were born outside of Canada. While many had difficulty determining this, they hazarded best estimates: 8 firms said all their employees were Canadians while 14 firms reported some foreign-born employees (5 firms 1-10%; 3 firms 11-20%; 2 firms 21-30%; 3 firms 30-40% and 1 firm 40-60%)

Figure 5



Firms were also asked a variety of questions to test to see if the community attributes had any measureable effect on their decision to operate in Saskatoon (Q: w*hy did your firm choose to locate in Saskatoon?).* For 9 of the firms, Saskatoon was simply the founder's hometown and there was no desire to move to another location to start the business. Another common response, especially from biotech firms, was a desire to locate close to a center of knowledge in their industry. For mining firms, Saskatoon's proximity to their areas of operation in Northern Saskatchewan was a primary reason for locating in Saskatoon. Other firms reported locating in Saskatoon because they were spun-off from the University of Saskatchewan or as a result of government incentives and funding. The one business factor that some reported that influenced their decision was that Saskatoon generally has low operating costs and is centrally located in Canada. Firms were then asked what they believed to be Saskatoon's current strengths and weaknesses from their firm's perspective. Most subjects found it much easier to think of Saskatoon's strengths than its weaknesses. Many of the responses were similar to those given for why the firm chose to locate in Saskatoon, such as the desire to be close to centers of knowledge (including the university), the operating costs, the proximity to markets and various factors related to attracting and keeping skilled labour (figure 6). There are some negatives that detract from the city. The most commonly cited weaknesses of Saskatoon is related to travel options. The poor air connections between Saskatoon and other centres and the the city's distance from other major centers are seen as large problems for firms whose employees travel a great deal. Saskatoon's workforce was mentioned as both a strength and weakness of the city. The firms that believed that the workforce was a strength tended to be small firms in technology sectors for which Saskatoon is a prominent centre (e.g. biotechnology). Those reporting the workforce as a

weakness were either in a uncommon industry in Saskatoon or were very large employers. Saskatoon's negative image as—to quote one subject—a "dreadful, remote place in the middle of nowhere" was considered by some to be a detriment to the operation of firms in Saskatoon. Many spoke of the difficulty of competing with firms from larger centers which are unfairly assumed to be more competent.

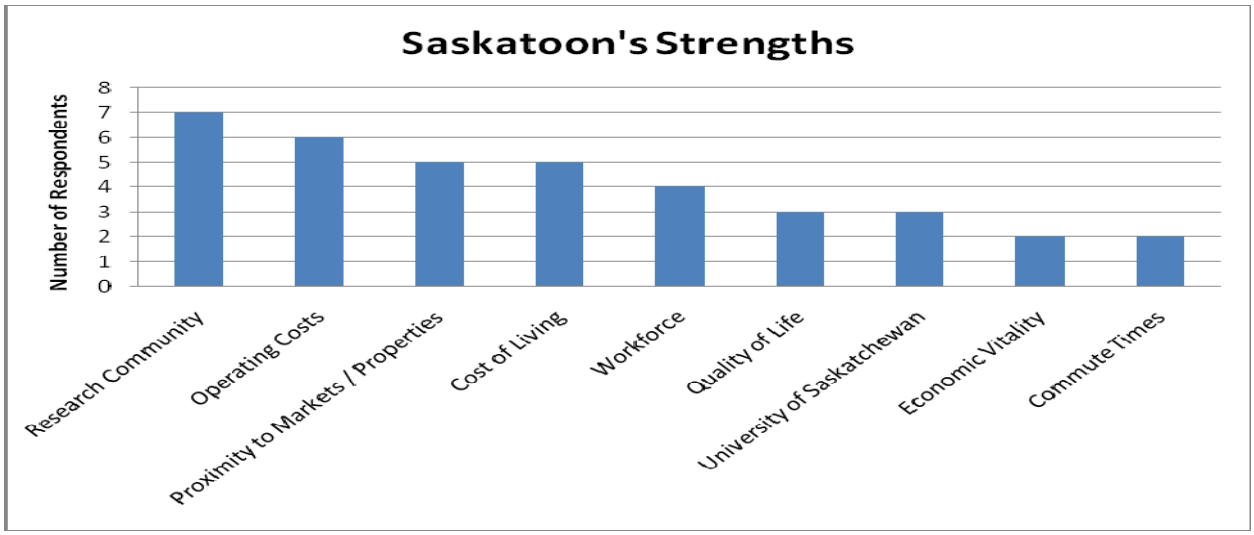


Figure 1

Firms were also asked what characteristics of Saskatoon enhance and what characteristics of Saskatoon undermine their firm's ability to attract and retain highly educated and creative workers. Figure 7 shows commonly cited positive attributes of Saskatoon. Most respondents believed that Saskatoon enjoys a high quality of life and that this is a major factor in helping attract workers. Many believed that Saskatoon's size was a benefit, often repeating that it's a "small city with big city amenities". Others believed that Saskatoon's science and business community made it an exciting place to work and offered alternative employment opportunities. Overall, most respondents were eager to extol Saskatoon's virtues and believed that Saskatoon's characteristics were generally positive and attractive. Weather was the primary factor cited as discouraging highly educated and creative workers; many believe that Saskatoon's climate is too cold to attract people who are accustomed to warmer weather. Interestingly, Saskatoon's aforementioned negative image is the second most mentioned deterrent to attraction and retention. While it was often said that Saskatoon's image is improving, many people believe that

the city's national and global reputation as a backwater community might put off some potential migrants. Wages are seen to be lower than other areas of Canada, especially in relation to Alberta. Lastly, Saskatoon's recent housing boom has driven up costs to the point that housing costs are seen as a barrier to the attraction of workers. The full range of responses is shown in Figure 8.

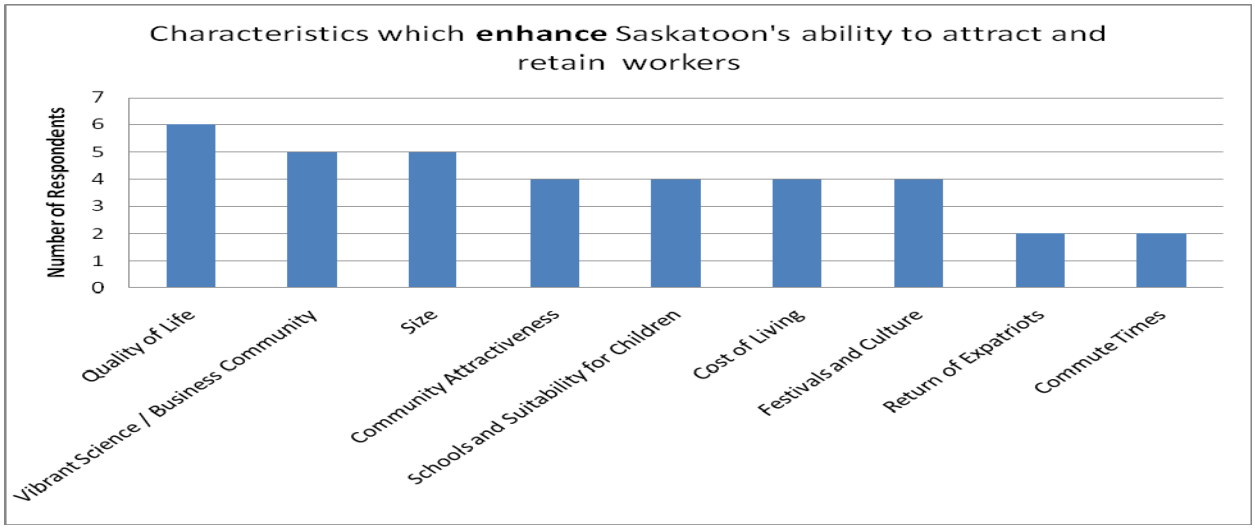


Figure 2

Symptomatic of these findings, there is limited local buzz. Firms were asked a series questions about their location in Saskatoon and how it affects their firm. Firms were located throughout Saskatoon including the North and South Industrial Areas, along Airport Drive, on campus, downtown and in Innovation Place. Of these locations, only those located in Innovation Place reported that their area helped to facilitate creativity and innovation. Most commonly, Innovation Place was praised for its beautiful buildings and grounds, its range of amenities, and the vibrant nature of its research community. It was the only location in Saskatoon that was said to have 'buzz' (esp. for biotechnology firms); most respondents reported that Saskatoon simply was not large enough to have areas inside of it with buzz distinguishable from the city as a whole.

However, this rich environment of information exchange never facilitates information transfers between different sectors. The proposition that firms might benefit from the existence of other sectors in Saskatoon was usually dismissed out of hand, especially when the question

was framed in terms of learning and sharing knowledge across sectors. When pressed, some firms talked about access to support services as a benefit to their firm while some of the larger employers said they needed workers from other sectors, especially considering the recent economic boom. However, the overall impression from the interviews is that the presence of other sectors in the local economy in terms of learning, overall benefit, or hiring was not an important consideration for a large majority of respondents.

Indeed, the difference between sectors in Saskatoon was a notable result of the research. Responds from different sectors did not agree on how characteristics of Saskatoon affect the attraction and retention of highly educated and creative workers. While most respondents agreed that Saskatoon has a high quality of life, the importance placed on quality of life considerations in general seemed to vary by sector. Unfortunately, from the results of this survey, it is difficult to compare the degree to which firms believe that social and cultural aspects of Saskatoon are important to the attraction and retention of highly educated and creative workers. Firms were not systematically asked to rate how important each of these characteristics were relative to each other and relative to aspects other than the characteristics of Saskatoon. Because of this, estimates of the importance of aspects of Saskatoon in the attraction and retention of highly educated and creative workers must be done based on an interpretation of their responses. From their spontaneous elaborations on their responses, it is clear that many biotechnology firms believed that career opportunities were more important than quality of place concerns. Workers attracted to Saskatoon biotechnology firms come because it is an important center for biotechnology and is a natural place for an aspirant biotechnologist to go. Social and cultural characteristics of Saskatoon, while of interest to possible employees, are not generally seen as being essential. In contrast, software firms tended to emphasize the importance of social and cultural factors in the attraction and retention of highly educated workers. Global competition for workers was seen as being so intense that qualities of place were essential to the firm's success because mobile creative and highly educated workers simply would not come to their firm if the city was less appealing.

From the responses it seems that there were two factors which determined whether quality of place attributes were seen to be important: the world-wide demand for highly educated and creative workers in that sector and the prominence of Saskatoon in the firm's sector. The first is obvious; when there is a high demand for workers they will have more choice and more

factors will play a part in their decisions. The second is more interesting. For sectors like biotechnology and mining, Saskatoon is a well-known business centre with a world-wide reputation. In these areas, firms tended to suggest that potential employees made their decision based on the specifics of the firm and the job opening and that characteristics of Saskatoon were secondary or unimportant to their selection. In contrast, software firms – a sector in which Saskatoon is at best a bit player - tended to emphasize the importance of characteristics of the Saskatoon city-region in the attraction of workers as it is already very difficult to attract workers to Saskatoon simply because there are no other employment opportunities if their job does not work out. In sectors where Saskatoon is known in the industry, going to Saskatoon is seen as a natural career progression. It may also be that, since workers in mining and biotechnology are more likely to have visited Saskatoon or, at least, know something about the region, respondents downplay the importance of quality of place considerations because they do not have to 'sell Saskatoon' to the same degree as employers in other sectors where Saskatoon is more obscure.

Interestingly, some respondents in the biotechnology industry seemed to indicate that high-mobility workers, especially young workers, were less likely to consider quality of life characteristics in their consideration of where to work. Since these workers are not interested in putting down roots, they would work in any location that would advance their career and then move on in a few years time. While only a few respondents made this claim, it would seem to run counter to the idea that young, mobile workers were seen as more likely to choose where to work based on quality of life considerations.

It is striking that, while generally reporting that Saskatoon is a wonderful city with a rich social and cultural environment, many respondents spoke of the stigma attached to Saskatoon as a major barrier to the attraction and retention of creative and highly educated workers. Some of the gap between the perceptions of Saskatoon of residents and outsiders can undoubtedly be explained simply by the tendency to defend ones home. Yet, many respondents had a real belief that Saskatoon was maligned without reason and in no way deserved a negative reputation. It was often claimed that the problem was simply a lack of information and that anyone who actually visited Saskatoon would see that it does not deserve its reputation.

This stigma about Saskatoon undoubtedly has a negative effect on the attraction of creative and highly educated workers but it may have more subtle effects. For example, a large proportion of respondents when asked why their firm was founded in Saskatoon simply reported

that it was the founder's hometown. If it is true that Saskatoon is seen as a desirable place to live to those that reside there and an undesirable place to those that do not, it may lead to a higher proportion of Saskatoon's businesses being founded by residents, accustomed to the good life that Saskatoon offers, would be unlikely to leave to found their business elsewhere and non-residents would be unlikely to consider Saskatoon as a location for their new business. However, the sample size in this study was not enough to say that entrepreneurialism in Saskatoon was greater or smaller than other centers in Canada.

3. Strength of knowledge-based linkages between local and non-local actors

The third issue is related to the questions related to effects within and beyond clusters, but goes beyond, asking how those localized communities of actors interact with the world. AS noted earlier, both clusters and the community recruit labour, technical services and codified knowledge from away.

The study by Phillips (2002) investigated these linkages specifically in the context of knowledge flows. The resulting global pipelines and local buzz suggested the canola research system in Saskatoon exhibited 'entrepôt' features, having variable local capacity to create knowledge, use knowledge and commercialise new products. While one might a priori conclude that Canada was the main canola innovator (based on its record as the lead innovator and early adopter of all the new traits over the past 50 years), that analysis showed that a significant share of the applied research to develop the processes used in the creation of those varieties has been done in other countries and much of the applications-based research (e.g. uses for new oils) is happening elsewhere. This suggests that Canada instead has operated in a niche in this global knowledge-based industry—as an entrepôt undertaking and assembling the know-why, know-how and know-who of varietal breeding and primary production—but that the bulk of the activities up and downstream of that stage in the production system are now and may continue to be done elsewhere.

The Saskatoon team in ISRN I added a module to the survey to examine the nature of these local-global relationships. About 20 firms and organisations responded. Three quarters had formal IP strategies, that about 35% relied exclusively on non-local management of that strategy and valuation of IP was generally undertaken using a wide range of approaches, but the that the key features of those valuation models about equally locally and non-locally controlled (table x).

An analysis of the most innovative firms (i.e. those firms with an innovative index 6 or greater as calculated by Prosychyn 2004) showed that they had a number of common approaches: they had formalised IP strategies and a management team approach to decision making; their IP strategies were managed locally; but the critical IP valuation process is generally handled non-locally by a multidisciplinary team.

Table 8: *Correlation between IP strategies and innovation*

	Value	**Frequency**	**%**
Formalised IP strategy	yes	15	75
	no	5	25
Local/non-locally based strategy	local	10	.50
	non-local	7	.35
	Local and non-local	3	.15
Valuing IP	multidisciplinary/team	8	.40
	N/A	4	.20
	market-based	3	.15
	science-based	1	.05
	management-based	1	.05
	customer-based	1	.05
	other	2	.10
Local/non-local valuation	local	7	.35
	non-local	7	.35
	local and non-local	4	.20
	N/A	2	.10

5. Conclusions and suggestions for further research

This paper sought to assess the theory and use evidence from Saskatoon to test the assertion that knowledge flows—within and between localized clusters and through global pipelines—are important for local innovation.

The theory offers a number of sensible and behaviourally grounded theories for why highly networked communities might generate greater and more diffuse levels of innovation. If anything, there is too much theory and not enough operationalization of the theory. The one theoretical insight this paper offers is the pairing of the innovation systems literature with the literature seeking to understand the nature of knowledge and the structures that govern its development, codification and use.

The data from Saskatoon offers mixed evidence that the theory is sustained, at least for mid-sized centres. First, the data offers some (but not universal) support for the assertion that knowledge flows within sectors and clusters matters for innovation. Both employees and firms

indicated in a variety of studies that thick labour markets and knowledge systems for advanced knowledge was important, but it is less clear that these matter for less knowledge-intensive industries. Second, the data does not offer much support that there are any acknowledged externalities between the innovative clusters and the rest of the economy—if anything, they seem to rest in solitudes. Third, there is some support for the need for global pipelines. Firms (and highly skilled individuals) seem to acknowledge the need to remain globally aware and connected, but there is limited evidence that this interconnectivity generates greater innovation—it seems to be necessary to remain aware of what others are doing, but the creative spark that drives innovation appears if anything to be locally centred.

This analysis suggests a number of ways that the ISRN data could be examined further.

Additional research may look at the reason why informal collaboration is so prevalent in Saskatoon and whether this is being repeated in other centres. One possibility is that some historical aspect of Saskatoon contributes to this attitude. The most obvious aspect is Saskatoon's agricultural background. There is a perceived tradition that farmers come together to do work that each of them would be unable to do on their own—the classic example being a barn-raising. Certainly, a large proportion of Saskatoon residents come from a rural background. However, there is always the possibility that this supposed ethic of cooperation is an urban—or rather rural –legend. More research needs to be conducted in order to see if people from an agricultural background now living in Saskatoon are more likely to cooperate without expectations of immediate remuneration. A simple test would be to give selected individuals a questionnaire testing their attitudes on cooperation and see how they vary by rural vs. urban backgrounds. However, it could be that this ethic has become so engrained in Saskatchewan culture in general that there would be no noticeable difference between those from a rural and those from an urban background. An alternative hypothesis is that mid-sized centres exhibit more communitarian features. This could be tested across the project.

The focus of the interviews in Saskatoon was, naturally, on interactions between firms and other organizations as each respondent was acting as a representative of the firm. Yet, many descriptions of how useful information came to their firm involve individuals apart from any organizations. When asked where their firm turns when faced with a problem the most common response was to individual academics. While we could clearly learn more by a more in-depth investigation of this in Saskatoon, it may first be valuable to check to see whether this is a

universal strategy when it comes to firms accessing university knowledge and services. Clearly the prevailing view in most Universities is that university-industry liaison offices and research offices are vital and important actors in the intermediation between university knowledge and industry. If person-to-person relationships are really the base, then our theory needs revisiting and many of our metrics are probably missing critical elements of the innovation process.

Future research may also need to take into account the great deal of variation between firms in different sectors. The survey used in this study was designed to be general enough to apply to all firms and sectors.[34] However, this project has shown that there is a great deal of difference between sectors in Saskatoon in terms of their responses. While this means there any survey results in Saskatoon are too sparse per sector to tell us much, there may be a way to aggregate our data across the ISRN network to gain enough scale to derive more substantive results.

As we do not have statistically significant samples to work with, we might gain some incremental value in undertaking a number of case studies to support the results of this study. Instead of approaching each interview as an opportunity to learn everything about a firm we might select a few firms and focus on the process by which particular innovations came into being. Going through individual innovations chronologically with someone who had been involved with that innovation might give a better perspective on how social interaction brings about innovation by looking at how each problem is solved and how each necessary piece of information is attained in a innovation process. Such a process might yield different and deeper results than simply asking questions about innovation in general terms.

Finally, as this project is intending to discover how norms, values and processes influence innovation, it might be beneficial to survey more explicitly for these values and norms in a variety of centres. Instead of a top-down approach looking at interactions between organizations to infer how social learning takes place, an alternative would be a bottom-up approach by going directly to workers to solicit cultural and social beliefs. Asking how a variety of workers would behave in regards to a series of scenarios involving problem solving and interactions might shine light on the sectoral differences in behaviour seen in this study. This

[34] One risk we all face is that this general survey can cause some fuzziness in our results. In future, surveys 'tuned' to at least broad classifications of sectors would likely be a better research tool by reducing respondents' confusion in regards to the meaning of questions and allowing for more probing questions that touch on the specifics of their business instead of dealing only with generalities.

approach could be useful in seeing in what situations social or market norms are predominant and what their effects are on interactions and learning.

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