A PROPOSED FRAMEWORK FOR ANALYZING INTELLECTUAL PROPERTY STRUCTURES IN THE AGRICULTURAL BIOTECHNOLOGY CLUSTER

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ABSTRACT

Saskatoon's agricultural biotechnology cluster is one of the few identifiable agricultural biotechnology (agbiotech) clusters in the world. Its narrow product focus and its reputation for introducing 'world firsts' illustrate the cluster's networking capacity and its comparative advantage in the global market. The cluster is situated near the U of S and consists of 115+ actors and is 'anchored' by the NRC's Plant Biotechnology Institute. Actors leverage this network through strategic alliances, joint ventures, and licensing agreements in an effort to access tacit knowledge.

The cluster grew out of post-war research efforts to improve the agronomic and food attributes of rapeseed. These research efforts resulted in the development of a new rapeseed variety, Canola. However, the landscape of the agricultural industry is radically changing. The ethical, environmental, and social issues that have moved to the forefront of the debate further exacerbate the complexities of intellectual property (IP) and ownership. These changes, combined with trends in alliance capitalism have radically changed the way in which business is being conducted how social capital is being leveraged.

In the context of the Saskatoon-based agbiotech cluster, we see a convergence of several IP structures: the base structure that has been associated with the development of the cluster thus far and which is now being impacted by the ethical, social and environmental debate. Additionally, the Canadian Light Source Synchrotron Inc. (CLSI) represents a new configuration that will further complicate the cluster environment. The CLSI expects to attract more than 2000 scientists and specialized personnel annually from all over the world. This trend will represent a new source of 'more transient' social capital for the cluster but represents challenges to the current IP structure.

INTRODUCTION

No one firm or region drives the innovation activity. Each actor in a given regional economy has a unique but complementary role and inter-regional co-operation is necessary to achieve sustainability. The changing nature of the global economy demands this more co-operative and synergistic relationship between all actors. Characterizing these clusters and subsequently characterizing their differences based on geographic region, provides the groundwork for future analysis and offers insight into the workings of successful regional economies. Clusters capture the linkages, complementarities, and spillovers that often cut across industries and firms, highlighting factors that may be omitted in more traditional industrial or sectoral studies.

Focusing on regional levels of economic activity and innovation requires examining cluster scope and capacity and the way in which actors leverage knowledge networks. Saskatoon's innovation cluster is one of the few identifiable agricultural biotechnology clusters in the world and is the focus of this paper. Its narrow product focus – in Canola - and its reputation for introducing 'world firsts' illustrate the cluster's networking capacity and its comparative advantage in the global market. The cluster is situated near the University of Saskatchewan and consists of 115+ actors and is 'anchored' by the NRC's Plant Biotechnology Institute. Industry and economic actors leverage this network through strategic alliances, joint ventures, and licensing and collaborative agreements in an effort to access both codified and tacit knowledge.

Access to knowledge is important, particularly in high technology sectors like agricultural biotechnology. Although knowledge may be considered inherently non-rival and non-excludable in nature, the changing landscape of the ag industry represents a significant shift in traditional paradigms regarding knowledge valuation and knowledge exchange. Incentives to create knowledge in a high technology industry such as agricultural biotechnology are contrasted by disincentive mechanisms – designed to limit the use of that knowledge.

It is these mechanisms - IP mechanisms - in the form of patents, plant breeders' rights, trade secrets and publications and copyright that are designed to encourage private and public sector investment in R&D. The endeavour to achieve *freedom to operate* (FTO) represents high private and public costs. There is presumed to be opportunistic behaviour on the part of the property owners to protect and closely guard vested interests to the neglect of broader, more collective concerns of the public. Conversely, to the detriment of industry actors, there are high transaction costs associated with knowledge exchange in this high technology industry.

In principle, however, the innovation cluster - with its inherent flows of social capital and its network setting - should mitigate these types of problems. Within the dynamism of the network, opportunistic behaviour is assumed to diminish under a unified culture, through collective goals for reciprocity and mutual trust. Similarly, the proximity of suppliers, competitors, and knowledge sources helps to reduce those transaction costs associated with FTO.

Converging IP Structures in Saskatoon - In the context of the Saskatoon-based agricultural biotechnology cluster, presently there is a convergence of several IP structures. First, there is the base structure that has been associated with the development of the cluster thus far. This consists of the collaborative ventures, joint initiatives, licensing agreements and subsequent patents[1] that have developed between actors – and between *star scientists*[2] - over the lifetime of the cluster. Secondly, this foundational IP structure is now impacted by the ethical, social and environmental debate. The Abiotic Stress Project[3], an initiative of Genome Prairie, is currently centered in Saskatoon. The project involves 21 principal investigators across 5 universities and 3 federal laboratories as well as 3 international collaborators in its efforts to investigate cold tolerance of Canola and wheat varieties. Genome Prairie's counterpart, GELS, is designed to complement the scientific research with an emphasis on the ethical, environmental, legal and sociological issues associated with the project. Thirdly, the introduction of the Canadian Light Source Synchrotron Inc. (CLSI) represents a new configuration that will add to the complexities of the current network dynamic and embedded structures of the innovation cluster. CLSI expects to attract more than 2000 scientists and specialized personnel annually from all over the world. This trend will represent a new source of 'more transient' social capital for the cluster but represents challenges to the current IP structure.

Social capital - embedded in this knowledge-based network - has the potential to increase knowledge transfer and to increase public and private investment in R&D. Examining innovation on the regional level requires an analysis of the intellectual property structures that frame the cluster environment. However, there are several other factors at work here: the interaction of actors at the local level; the impact of global factors (human capital and the role of the multinational enterprise); the function of social capital and trust; and, finally, the role of knowledge in the innovation process. What are the activities and objectives in terms of leveraging knowledge in the cluster? How is social capital leveraged in order to achieve objectives? In terms of their activities, how do cluster actors value and prioritize knowledge types? Finally, collectively, how do all of these factors serve to characterize and influence the intellectual property structure of an innovation cluster?

In order to address these questions, it is imperative that we devise a framework with which to analyze the IP structure within the Saskatoon-based agricultural biotechnology cluster. This paper proposes such a model that illustrates not only the interdependencies of actors, but also outlines cluster-based objectives and activities and emphasis on knowledge types within the innovation cluster. In part one, I examine the role of intellectual property in the ag biotech industry and its role as a driver in the agricultural biotechnology cluster. In part two, I review the four types of knowledge and which cluster activity – science, technology and collective initiatives – emphasizes which knowledge type in terms of organizational objectives. I also briefly explore the ways in

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[1] The Canadian patent database shows that since 1985 Canadian researchers have accounted for 75 of the 634 patents issued related to innovations in Canola. Of those 75, more than half of them were linked to a handful of research scientists in the AAFC and NRC (Phillips 2002).

[2] Zucker et al (1998) defined stars as those scientists that discovered 40 or more genetic sequences or scientists that wrote 20 or more articles on genetic sequence discoveries. Phillips (2002) identified Canada as the largest single geographic concentration of stars and near star in the world at 11%+. If assessed by their citation rates, Saskatoon has 15% of that total number or, in other words, about one third of all Canadian stars and near stars.

[3] Functional Genomics of Abiotic Stress in Wheat and Canola Crops. The emphasis of the project is on how plants respond to cold temperatures.

which actors attribute *value* to knowledge and knowledge types. In part three, I examine the Picciotto model (1995) devised to describe institutional structure and level of operation required for successful implementation of Third World development projects. I develop and propose an adaptation of this model for use in analyzing the institutional framework and IP structures of the agricultural biotechnology cluster in Saskatoon. Finally, in part four, I explore ways in which to operationalize the adapted framework by linking concepts to observable measures. I review some attempts that have been made to measure innovation and to map knowledge flows.

1.0 Intellectual Property Rights and the Agricultural Biotechnology Industry

The agricultural biotechnology industry is subject to the influences of public policy, particularly those policies that relate to intellectual property rights, such as plant varietal protection, and those that address market concentration (antitrust). Intellectual property rights (IPRs) coupled with opportunities for market concentration and increased power offer incentives for private sector research and innovation. Mergers in the industry have become commonplace, particularly in the last decade or so. Increased market share translates into strong patent portfolios and represents increased economic gains from research investments. Appropriating new technology through plant breeders' rights and hybrid seed technology provide additional incentives for private innovation.

Evidently, it is important to the industry as a whole to sustain relevant and efficient IPR regimes to facilitate private sector innovation. However, the private sector requires *access* to knowledge – all types of knowledge – in order to achieve its objectives for continuous innovation. Accessing knowledge, according to Marshall (cited in Johnson and Lundvall 2001), is a 'localized' phenomenon; knowledge is localized within regions – clusters – and is rooted both in the local labour force and in the local institutions and organizations. These localized organizations consist of both private and public sector actors as well as those organizations that operate in related and supporting industries. Cooperation – facilitated through these regional clusters – enables actors to have access to new and evolving information and knowledge within the complexities of an evolving global knowledge-based, high technology industry. The private sector actors in the agricultural biotechnology industry undoubtedly benefit from a localized network of organizations that are inherent in innovation clusters. Access to pure science and basic research (academic), to infrastructure (government based research institutes), to the supporting services and industries (soil testing labs, patent lawyers) and in close proximity to industry competitors provides resources and incentives for continuous innovation and, ultimately, a growing patent portfolio.

Regional innovation rests on the ability for *all* actors to interact. Interaction is facilitated through proximity and collaborative initiatives; joint research activities and licensing agreements between public and private sector actors. In this capacity, private sector actors can access and leverage the pure science competencies generated in public organizations and institutions and the public sector can realize the transfer and application of its technology into commercially viable products; thus achieving objectives for enhanced social welfare.

Illustrating clusters – particularly ag biotechnology clusters – according to actor-type alone and using this to analyze embedded IP structures may be limited at best. Therefore, it may be more appropriate to prioritize the *activities* and *objectives* of cluster actors instead. Which type of activity generates, specializes in, or emphasizes what kind of knowledge? How does the sharing of such knowledge lend to the dynamic competency of the innovation cluster? A review of types and sources of knowledge, and the valuation of knowledge, will help to link cluster actor activities and objectives into the overarching dynamism of the innovation cluster and its underlying IP structures.

2.0 A Typology and Valuation of Knowledge According to Actor Objectives

What drives the formation and evolution of innovation clusters and what is the foundation for IP structures? New growth theory emphasizes *knowledge* as a major driver of innovation and growth - complex processes that are important factors in economic and social life (OECD 1996). No one firm or region drives the innovation activity. Knowledge is an intangible asset that drives productivity in an economy; and knowledge management is quickly becoming a new and crucial challenge for both private companies and public organizations. Knowledge of how to do things or make things can raise the productivity or efficiency of a regional economy.

Knowledge has ancient roots in early civilization where Aristotle distinguished between universal and theoretical knowledge; instrumental and practice-related knowledge; and normative, common sense-based knowledge. A modern turn on Aristotle's *knowledge taxonomy* divides knowledge into four categories. According to Malecki (1997) they are *know-what, know-why, know-who* and *know-how*. Know-what and know-why are forms of *codified knowledge* which related to *facts or information* and *principles that explain*. Know-who and know-how are embedded forms of *tacit knowledge*, which relate to *competence and skills* and involve knowing how to obtain desired end-states, knowing what to do in order to obtain them, and knowing when to do it (OECD 2000, 12). Michael Polanyi delineates the term *tacit knowledge*, which is of particular importance here. He argues that when we acquire a skill, we acquire a corresponding understanding that defies articulation or codification (1966). Whereas codified knowledge is systematic and reproducible, tacit knowledge is considered intangible - residing in the heads of those working on a particular process or embodied in a particular organizational context.

Tacit knowledge is partially embedded in organizations, structures and institutions. Actors in innovation clusters attempt to leverage proximity and face-to face interactions to capture codified and, in particular, tacit knowledge in order to build the competency of the social network. Tacit knowledge is the primary catalyst that brings industry and academic cultures together in innovation networks or clusters, effectively breaking down modern divisions between disciplines and paradigms and enhancing the innovation process (Phillips 2002).

The question here might be is how to link these four kinds of knowledge to cluster activities. The character of these types of knowledge can differ in degree and form depending upon cluster actor perspective and objectives. Academics, those that operate in the realm of pure science, are motivated to publish and make research results (*know-*

why) accessible (public) in journals, on the internet or in presentations at conferences. Complementing this endeavour, databases serve to bring together this *know-why* knowledge in a (potentially) user-friendly form (i.e. such as the data available from StatsCan). Nevertheless, the efficacy of this data, in large part, is dependent upon the parameters upon which it was gathered, the efficiency of search engines, and the qualifications of the user. Therefore, open and public access to *know-why* knowledge could generally be considered a misnomer in that it takes considerable investment in learning before information that has been gathered is meaningful to the user. Therefore, *know-who* and *know-how* forms of knowledge are inextricably intertwined with meaningful access to *know-why* knowledge. For instance, the inexperienced researcher relies heavily on his/her more experienced counterparts to assist in the 'translation' of information into something more comprehensible.

Consequently, another objective of pure science is to strive or inform models of *know-what* knowledge. How can public-based, pure research achieve targets for maximizing social welfare if it cannot be applied to a relevant, marketable product or process that is of value to the consumer? Again, an important aspect of this process of technology transfer is leveraging *know-who* and *know-how* forms of knowledge. The motivation for private sector presence in government research institutions and universities is to gain access to *know-why* knowledge; to leverage knowledge that has potential marketability. However, with budget constraints it has become *equally* important for the public sector to leverage *know-what* competencies of the private sector; to fund the generation of *know-why* knowledge.

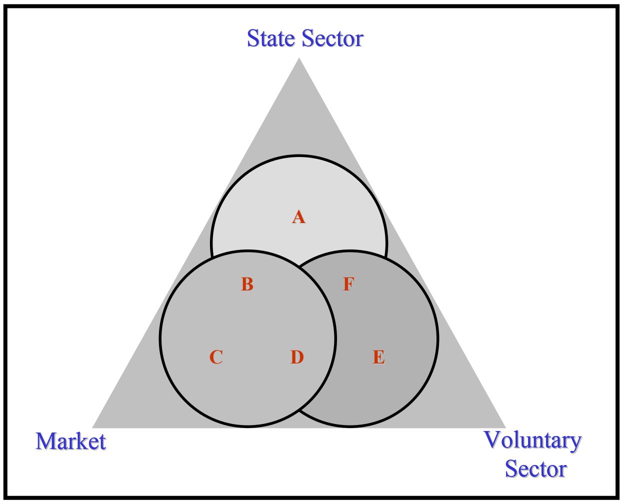
These interdependencies between public and private sector actors illustrate the power of the collective action of the innovation cluster as a whole. Also, this large and growing body of knowledge (all types) inherent within the innovation cluster is the object of transactions; there is a buyer, seller and, in some cases, a price (Johnson and Lundvall 2001:16). Therefore, understanding the intellectual property structure(s), as a foundation for knowledge exchange mechanisms, is an important part of characterizing the innovation cluster.

3.0 The Framework: Linking Actor Activities & Objectives with Knowledge Type, Knowledge Valuation and IP Mechanisms

The IP structure of an innovation cluster is founded on cluster-based activities and actor objectives as well as knowledge valuation and exchange. Therefore, a potential framework needs to include all of these elements.

Picciotto (1996) examines some of the fundamentals of institutional dynamics in his model for developing Third World development projects. The Model's objective is to illustrate and ensure that resources required for project development are utilized in the most economical way. Picciotto focuses primarily on the public, private and voluntary sectors and the interaction between them (fig 1).

Figure 1. Picciotto Model



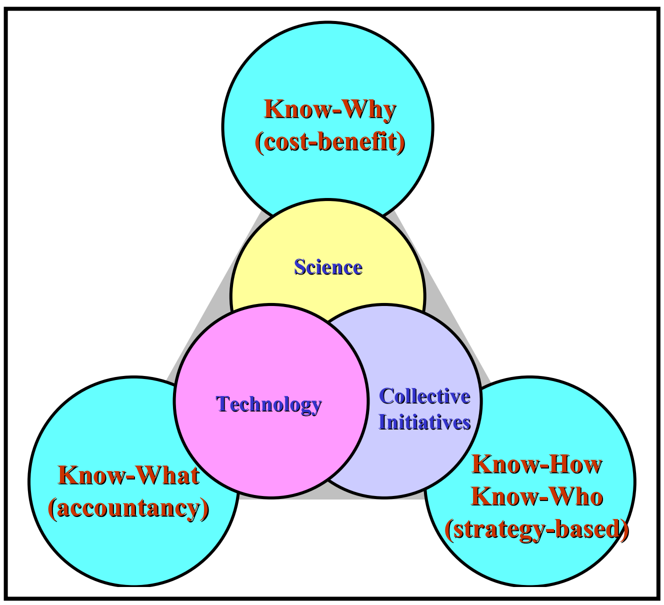
The public or government sector (A) represents the citizens of a country and pursues policies to maximize the interests of society altogether. The market sector (C) owns property and attempts to maximize profits on those investments. Finally, the voluntary sector (F) consists of those that join a project to reap the benefits of the collective action and to pursue goals that cannot otherwise be accomplished through individual action. The intersecting areas labeled B, D and F represent institutions that operate between and within the overlapping dominant parameters of the public, market and voluntary sectors (public organizations, NGOS, and hybrid corporations respectively).

If we consider the innovation cluster as a project or institution in and of its own right, the Picciotto model with its interacting parameters represents a foundational model upon which to develop a framework for analyzing IP structures in the innovation cluster. Adaptations are required, of course, in order to emphasize cluster *activity* as opposed to actors alone.

Cluster activity needs to be delineated according to knowledge emphasis and valuation. As mentioned previously, cluster activity is comprised of science, technology and collective initiatives and each parameter is depicted in Figure 2 by the dominant spheres. The *pure science* focus pursues know-why knowledge with knowledge valuation based on cost-benefit analysis and maximization of producer and consumer surplus. The *technology* parameter, on the other hand, with its focus on producer benefits works to operationalize the pure science in the form of *applied research* through an emphasis on know-what knowledge. The objectives of this type of activity (and its associated actors) focuses on the development of commercially viable processes and products with a focus on price and quantity or accountancy mechanisms in terms of valuing associated knowledge. Finally, collective activity focuses upon operationalizing know-what and know-how knowledge for the collective benefit of its membership. It is less clear as to how actors in this parameter value knowledge. However, the collective benefit of membership – operating within the context of an open platform – clearly transcends individual objectives of valuing and leveraging knowledge. Collective-based objectives lead to higher social returns.

Each cluster activity inevitably favours different IP mechanisms – formal and informal – according to organizational objectives and organizational ability to leverage different kinds of knowledge. Academics that operate with the parameter of pure science would emphasize publications and copyrights ("publish or perish"). Actors operating in the technology parameter would look to patents and trade secrets to protect interests. Actors operating in a collective capacity would value less formal mechanisms perhaps in the form of an open platform of pooled knowledge, a shared language, and a common culture exclusive to its membership. The other hybrid organizations favour a balance of mechanisms according to their position within the framework (See Appendix A).

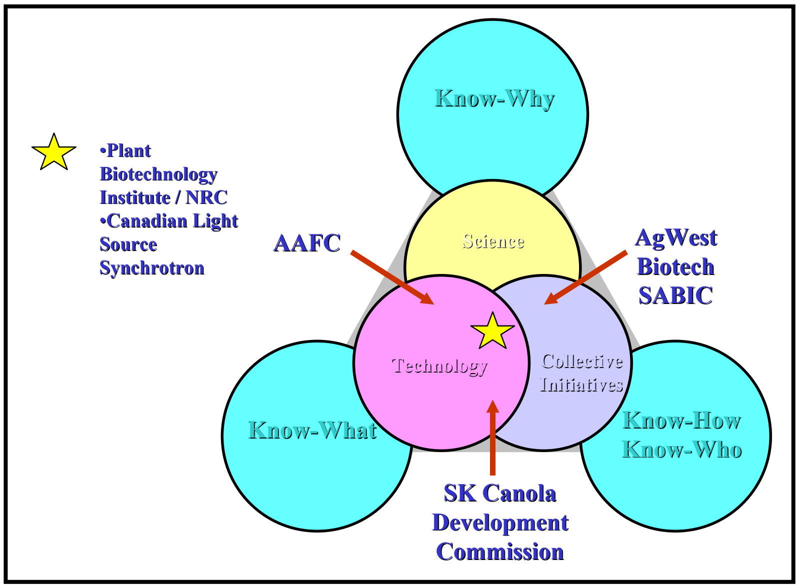
Figure 2. Adapted Framework for Analyzing IP Structures in the Innovation Cluster



The dominant spheres (activity parameters) in the framework are depicted as equidistant within the model *appearing* to be in equilibrium. However, the structure of the model, in terms of *size* and *number* of actors in the various categories, is not the most important criteria in evaluating the IP structure(s). Rather, evaluation rests on the *ability* of the actors to fulfill their roles and accomplish objectives associated with activities in facilitating knowledge exchange in the innovation cluster.

As no actor is, for instance, *purely science-based* or *purely collective* in nature, it is the ambiguities associated with activity overlaps that provide true insight into understanding and evaluating knowledge exchange in the innovation cluster. In the case of the Saskatoon-based agricultural biotechnology cluster (Fig 3), organizations operating within the overlapping parameters of the activity spheres serve as important catalysts in the knowledge exchange process. Bridging activities of pure science and technology is Agriculture and Agri-Food Canada. AAFC's objective is to improve the long-term competitiveness of the Canadian agri-food sector through the development and transfer of innovative technologies. The Saskatoon Research Centre and its research farms bring a long-term commitment in crops research to the agri-food industry in Western Canada (AAFC 2002).

Figure 3. Applying the Framework to the Saskatoon-based Agricultural Biotechnology Cluster



An organization that is situated within the intersection between technology and collective-based activity spheres is the Saskatchewan Canola Development Commission created in 1990. Funds gathered through a *producer check-off program* established in 1991 are directed towards research and market development[4]. Subsequently, in 1995, the Commission developed CANODEV – a private sector subsidiary – designated to continue the research process and to take advantage of research tax credits available to private companies (Gray, Malla and Phillips 2001).

AgWest Biotech straddles the intersection between activities associated with collective initiatives and pure science. Among its many roles, this government-funded organization operates a demonstration laboratory – the Saskatchewan Agricultural Biotechnology Information Centre (SABIC). SABIC opened in 1997 and is designed specifically to provide producers, international groups, businesses and the general public – including school teachers and students - with tours, demonstrations and information on the science of agriculture biotechnology.

[4] The Saskatchewan Canola Development Commission is an arms length organization of the provincial growers' association. The producer check off funds represent $0.50 per tonne. Since 1991, 40% of the funds have been used for research and the rest has been dedicated to extension and market development initiatives (Gray et al 2001).

The center of the adapted framework can be characterized as the hub of the model, embracing all activities. Essentially, actors identified within this realm of the framework are those whose objectives and interests are linked with all of the activity parameters of the cluster. Specifically, I have identified two actors – NRC's Plant Biotechnology Institute (PBI) and the Canadian Light Source Synchrotron Inc. (CLSI) – that both appear to operate within this portion of the model. PBI has long been considered an anchor for the Saskatoon-based innovation cluster. Not only is pure research conducted within this public research institution but several joint ventures and collaborative agreements with other cluster actors have also been carried out. PBI's omniscient presence in the cluster and its strategy for collective action in terms of knowledge exchange validates its central positioning within the framework. CLSI, scheduled to be operational by January of 2004, is bound to serve as, yet, another anchor for the cluster. Its impact in various research areas – information technology, medical imaging, biotechnology and geology – along with its functional capacity as a third generation synchrotron should, in principle, ensure its potential as a catalyst for innovation and knowledge generation in the region. However, as I mentioned previously, the success of the CLSI – like other cluster actors – is subject to its *ability* to effectively leverage localized social capital competencies and knowledge, its *ability* to implement and utilize effective IP mechanisms and in its *ability* to effectively differentiate itself on the global market.

This adapted model is distilled down to a very basic structure. Realistically, no actor or dominant activity parameter operates in isolation of other actors or activities within the innovation cluster. Nor does any one actor, in terms of objectives, utilize or benefit exclusively from only one type of knowledge. The same goes for the valuation process. The strategy behind this model is, simply, to illustrate dominant activities within the cluster and associated priorities in terms of valuing, leveraging and disseminating knowledge. Even in its uncomplicated form, this framework has the capacity to inform the analysis process and could, in fact, provide an effective model for comparing IP structures – and associated activities, objectives, and IP mechanisms – across clusters.

4.0 Operationalizing the Model

The next question is how do we operationalize this framework? How do we link framework concepts to observable measures? What methodologies can we adopt in order to reflect or measure the dynamics of the innovation cluster, its knowledge network within the context of this adapted framework?

Of course, one method would be to analyze or model the local knowledge network based upon the licensing agreements, strategic collaborations and/or joint initiatives that have been entered into by actors within a designated region. An example of such an approach is in the study conducted by Theodorakopoulous and Kalaitzandonakes (hereafter referred to as Theo & K) in 1999. The authors attempt to map the knowledge networks of the plant biotechnology industry by analyzing, comparing and investigating the impacts of the network structures in both the European Union and the United States. According to the authors, the formation of networks between the public and private sector promotes knowledge generation and transfer and influences national innovative capacity. The goal of the study was to measure the effect of the network position of each network participant on innovation performance. Information was gathered on existing public-private research agreements[5] in both the US and the EU.

Although applied at the national or supranational level, this notion of network analysis (as demonstrated by Theo & K) plays an integral role in mapping relationships and flows of knowledge and potentially could shed some light on IP structures within regionally based innovation clusters. However, there are some limitations to the methodology. Although the study offers insights into the number and intensity of the interactions and linkages between actors, it provides no indication as to the *quality* of those linkages. Additionally, the learning ability of the identified *core actors* is based on organizational differences *only* and the study only took into consideration universities, public research institutes and firms to the exclusion of other entities such as business consultants, venture capitalists, patent attorneys and other supporting organizations. And what about the global component? If, as Phillips (2002) suggests, that "innovation is actually a global activity that transcends any firm or region" then this should be factored into the modeling process. The Theo & K study makes no concession for the role of international linkages - co-ownership and co-authorship in international collaborations[6].

In another example, Stern, Porter and Furman (forthcoming) examine the determinants of country-level research and development capacity and productivity in measures of *National Innovative Capacity* (NIC). NIC, as defined by the authors, is *commercially valuable innovative output per given year* and is represented by the number of international patents per given year. This parameter, sourced through the United States Patent and Trademark Office (USPTO), is determined to be the number of patents granted to inventors from a country other that the U.S. Trajtenberg (1990) contends that patenting rates are "the only observable measure of inventive activity with a well-grounded claim for universality." However, the problem with using the USPTO and with international patent data, in general, is that it ignores the fact that most of the patenting that happens globally happens in the country of invention *first*. For example, out of the 650 patents for technology and products related to Canola only about 1/3 are patented in the U.S. (Phillips 2002). In the case of the Stern, Porter and Furman study, U.S. rates would be biased over and above those of other countries. Additionally, some would argue that firms use the patent system *offensively* in order to block new entrants from entering the market; not *defensively* in order to achieve commercial viability. We have seen this indicated by the trend towards cascading patents that firms utilize to retain market share over the long run.

This predominant nation-state focus of measurements of innovation and their often-ineffective output measures are problematic since the methods often overlook some important local-level elements. Unfortunately, approaches like these are emphasized in many innovation-based strategies. Even our newly developed Canadian-based

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[5] United States – USDA – Cooperative Research and Development Agency (CRADA)
European Union – Plant Biotechnology Agreements (CORDIS)
1985-1997

[6] Currently, the US is the center of international collaborations with its researcher involved in 25% of internationally co-authored articles.

Innovation Strategy looks at country-level innovation to the neglect of innovation at the regional level. Industrial Strategist David Wolfe (2002) pointed out the *Strategy's* broad nation-state focus stating that: "The development of new innovative capabilities *is location-based*…" He further criticizes empirical approaches that use output measures, [such as NIC], to explain innovation, growth and productivity:

> …the approach[es] fail to acknowledge how the various actors [at various levels of an] economy interact…[and] to focus exclusively on one indicator, such as R&D performance, can be misleading.

In their study *Modeling Regional Innovation and Competitiveness* (forthcoming), Padmore and Gibson attempt to mitigate the problems associated with nation-level measures by focusing on local capacities with a particular emphasis on the cluster phenomenon. They contend that both innovation and competitiveness are highly complementary; powerfully influenced by geographical concentrations of cluster actors. By linking two models – the Cycle Model and the GEM Model – the authors examine *how* innovation relates to competitiveness. The Cycle Model represents a system of innovation by diagramming flows of knowledge in terms of economic value and is intended to illustrate how and where firms allocate efforts and resources in innovation. The GEM Model then assesses the competitiveness of an industrial cluster, by tackling those factors that lie beyond innovation and linkages. According to Padmore and Gibson, both models are required in order to understand and inform public and private strategies in innovation. Although Padmore and Gibson propose some unique concepts and models, the paper appears to be more exploratory than explanatory; descriptive rather than prescriptive. Results are not testable at this point. However, it will be interesting to see if and how Padmore and Gibson apply and test their theory in the future.

Arguably, the ability for network actors to leverage social capital could be considered the driving force behind knowledge creation, dissemination and innovation. However, this is extremely hard to quantify or measure and is rarely accounted for in empirical methods or measures. Nevertheless, the influence of social capital must be considered when developing any models or frameworks in measuring innovation and competitiveness and, in this case, intellectual property structures. Also, given the global – local tension of knowledge exchange of the Saskatoon-based agricultural biotechnology cluster (Phillips 2002), accounting for social capital becomes even more obscure and elusive. Thus, the introduction of new actors into the cluster – such as the CLSI - represents a new organizational configuration and a shift in current IP structure(s). The CLSI's component of more transient social capital will greatly influence the competency of local intellectual property structures. Circumstances such as this – an influx of or change in format of social capital (either locally based or externally derived) – can profoundly influence knowledge exchange mechanisms and, thus, affect cluster character and competitiveness.

DISCUSSION

Intellectual property structures within innovation clusters, such as the Saskatoon-based agricultural biotechnology cluster, are subject to many factors:

- the scope of the innovation cluster in terms of market/product focus;

- the objectives and activities of all actors at the various stages of the value chain;
- the types of knowledge at work in the innovation cluster and the value that is attributed to them by the various actors and, finally;
- the role of trust, social capital and reputation mechanisms in the evolving innovation cluster.

These factors are all part of the incentive mechanisms that must be in place to encourage private and public sector innovation and investment in R&D and to ensure that relevant know-why knowledge realizes application in the market place in the endeavour to enhance social welfare.

The problem lies in how to effectively analyze and measure the effects of intellectual property structures (or converging structures) of an innovation cluster. The adapted framework presented here offers an introductory means for positioning cluster actors according to their objectives and activities and linking those objectives and activities to modes of knowledge valuation and preferred IP mechanisms within the context of an innovation cluster. Ultimately, how intellectual property is created and, subsequently, managed (through levels of activity) is an indicator of the cluster capacity for innovation. Underlying this paradigm, of course, is social capital that is fundamental to regional learning capacity and the competency of networks. Although difficult to measure and map, it is these ambiguities – in terms of social capital, actor activities and overlap, as well as knowledge exchange – that offer the most interesting insights into the nature of a given innovation cluster.

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Appendix A.

	Activity Parameters	Knowledge **Knowledge Valuation Process**	Objectives	IP Mechanisms	Actor Type	Example
A	Pure Science	Know-why Cost / Benefit	Advancing public knowledge through pure science / publications	Publication copyright	Public Sector	University of Saskatchewan
B	Science / Technology	Know-why / Know-what	Technology Transfer	Public / copyright with a shift towards patents	Public / Private Hybrid	AAFC UST (U of S)
C	Technology	Know-what Accountancy	Profit based	Patents Trade secrets	Private Sector	Aventis Crop Science
D	Technology / Collective	Know-what / Know-how / Know-who	Leveraging networks to achieve viability	Do not necessarily patent but require dissemination of knowledge	Private Sector / Cooperative	Council for Biotechnology Information (national) SK Canola Development Commission
E	Collective	Know-how / Know-who Strategy-based	Serve collective good of producers act as a liaison between growers and other canola industry stakeholders provide the latest agronomic and marketing information	Open platform of commonly pooled knowledge / common culture / exclusive to network membership	Cooperative	Saskatchewan Canola Growers' Association
F	Collective / Pure Science	Know-why / Know-how / Know-who	Leveraging networks to facilitate public understanding	Access to collective pre-codified knowledge / membership based / translator of knowledge	Cooperative / Public Hybrid	AgWest Biotech / SABIC