

# Services Offered to Manufacturing Firms by Technology Transfer Organizations

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## Abstract

This paper addresses three questions: What services do knowledge and technology transfer organizations (KTTOs) provide to private firms? What are the factors that explain the provision of knowledge transfer services? To what extent are knowledge transfer services provided to firms complementary or independent from each other? Contrary to most studies which deal with university technology transfer offices (UTTOs) and public research organizations (PROs) while focusing on services linked to patenting, licensing, spin-off formation and contract research, this study includes two other types of KTTOs, the community college technology transfer organizations (CTTOs) and the nonprofit knowledge and technology transfer organizations (NPOs), while taking into account 21 services provided by KTTOs in order to help firms to develop or improve their products and production processes. Looking simultaneously at 21 services would have prevented us from considering the innovation process of firms as a whole. To avoid this pitfall, we classified the services in reference to their contribution at three generic stages of the firm's knowledge value chain: the exploration of knowledge-based opportunities (4 services), the validation of knowledge-based opportunities (5 services), and the exploitation of knowledge-based opportunities. A factor analysis led us to subdivide the third stage into three sub-stages: services linked to legal issues (3 services), access to capital (4 services) and commercialization (6 services). By looking simultaneously at the five packages of services linked to the different stages of the value chain, the statistical approach used in this study also provides new evidence on complementarity effects that exist between the services offered at the different stages of the value chain. The results suggest different patterns of complementarities between many packages of service offerings. Overall, with a few exceptions, these results suggest that the KTTOs' business model is built around the following building blocks: they offer mixed or customized solutions to their clients, target very small firms, do not primarily depend on revenues from the sale of services, develop strong ties with their partners and clients, formulate differentiated strategies for the different stages of the value chain, and dispose of differentiated types of human resources for different stages of the value chain.

**Key words:** technology transfer, intermediary organizations, services provided to firms, survey, regressions

## Introduction

Knowledge is recognized as a fundamental asset for firms and organizations (Teece, 1998), as the main resource upon which competitive advantage is founded (Albino, Garavelli & Schiuma, 1999; Kogut & Zander, 1992; Nonaka, 1994; Reisman, 2005), and its transfer as a critical factor necessary to improve productivity (Martyniuk, Jain & Stone, 2003; Janis, 2003) and to innovate (Albino, Garavelli & Gorgoglione, 2004; Cohen & Levinthal, 1990; Reisman, 2005). Moreover, as studies on determinants of innovation have shown the importance of external sources of market and research knowledge for the development and improvement of product and process innovations (von Hippel, 1988; Amara, Landry & Traoré, 2008; Amara & Landry, 2005; Landry, Amara & Lamari, 2002), more attention has been paid to the various types of actors who act as knowledge and technology transfer intermediaries in the innovation process (Howells, 2006). These knowledge and technology transfer intermediaries are considered by many as «crucial nodes» connecting the suppliers to the users of knowledge (Bessant & Rush, 1995; Howells, 2006; Howard Partners, 2007; Spithoven & Knockaert, 2009; Matt & Schaeffer, 2009).

This paper focuses the attention on KTTOs. Prior studies on KTTOs can be subdivided into three broad streams. A first and dominant stream of studies focuses the attention on linkages forged between KTTOs and firms. This literature has laid the emphasis on knowledge exchange channels, types of firms interacting with KTTOs, and benefits for both parties (Sharma, Kumar & Lalonde, 2006; Kodama, Yusuf & Nabeshima, 2008; Yusuf, 2008; Kodama, 2008; Wright, Clarysse, Lockett & Knockaert, 2008; Geuna, Fontana & Matt, 2006; Laursen & Salter, 2004; Arundel & Geuna, 2004).

A second more recent and increasingly important stream has shed light on the performance and productivity of KTTOs. Overall, these studies have concentrated their effort on the impact of UTTOs resources, UTTOs strategies, and UTTOs organizational structures and practices on the patenting and licensing outcomes, contractual research and spin-off companies (Siegel, Waldman & Link., 2003; Jensen, Thursby & Thursby, 2003; Siegel, Waldman, Atwater & Link, 2004; Debackere & Veugelers, 2005; Acworth, 2008).

A third and slowly emerging stream of studies on KTTOs focuses the attention on the services provided to firms by intermediary organizations. These studies focus on services supplied by KTTOs to help firms to solve specific problems related to the exploration, validation and exploitation of knowledge in order to develop or improve their products or production processes (Howells, 2006; Spithoven & Knockaert, 2009; Janis, 2003; Lee & Win, 2003; Rasmussen, Moen & Gulbrandsen, 2006; Diaz-Puente, Cazorla & De Los Rios, 2009).

Hence, following the approach adopted by Howells (2006, p. 719), this paper aims to shed new light on KTTOs by paying attention to «a much wider, more varied and holistic role for many intermediaries in the innovation process». More specifically, this study will address three questions: What services do KTTOs provide to private firms? What are the factors that explain the provision of knowledge transfer services? To what extent are knowledge transfer services provided to firms complementary, substitute or independent from each other?

To answer these questions, we will first review prior studies to derive our dependent variable «services supplied to firms by KTTOs» and its explanatory variables. Second, we will present the survey data collected from four types of Canadian KTTOs who have been established in most countries: university technology transfer offices (UTTOs), community college technology transfer offices (CTTOs), public research organizations (PROs), and nonprofit

knowledge and technology transfer organizations (NPOs). Third, we will use these data to explain differences in the knowledge and technology transfer services offered, using a set of complementary statistical approaches. The final section of the paper will conclude with a discussion of implications, from the results, for the management of KTTOS and public policies supporting KTTOs.

### **1. Issues associated with the definition of the dependent variable knowledge and technology transfer services provided to firms**

Most studies on technology transfer organizations (KTTOs) are based on data regarding patents, licensing and spin-offs because they offer a perfect tool for an objective, quantitative analysis of knowledge transfer (Agrawal, 2001). The use of these easily available quantitative data has come at the expense of investigations into other forms of knowledge and technology transfer. We suggest that focusing on patents, licensing and spin-off launching captures only a small fraction of economically valuable services provided by KTTOS to firms. Indeed, they deliver value to their clients in the manufacturing sector through a much larger variety of services. There are no consolidated directories of services provided to firms by KTTOs. Therefore, an important part of our initial task was to identify a list of such services. During this identification process, we were led to explicitly redefine KTTOs as organizations who provide services to firms in order to accelerate the use of new or existing knowledge and technology in the development or improvement of products and production processes. To identify potential services, we relied on two complementary approaches. First, we relied on the literature on technology intermediation, and knowledge and technology transfer to develop a first list with regard to the services offered to firms by intermediary organizations (Seitzer, 1999; Janis, 2003; Lee & Win, 2003; Reamer, Icerman & Youtie, 2003; Rasmussen et al., 2006; Spithoven & Knockaert, 2009; Diaz-Puente et al., 2009). This first procedure allowed us to progressively differentiate nearly 30 services. Then, in order to develop a second list, we relied on the web sites of the 416 Canadian KTTOs who were offering knowledge and technology transfer services to firms. We thus set up an exhaustive list of service identifiers including 444 services of which 55% of the identifiers were in English and 45% were in French. We then merged the services according to their thematic similarity. This procedure allowed us to progressively differentiate 24 services. We submitted this list of services for comments and suggestions to an advisory committee composed of the executive directors or CEO of nine KTTOs. The wording used to describe some services was modified following this consultation, and then pretested with ten other KTTOs. A final version of the list of services was developed after the pretest.

Developing a list of ad hoc services grounded in prior literature and existing organizations is necessary but not sufficient. The next step was to classify the KTTOs' services into the technologically and economically distinct value creation processes of a knowledge value chain. We suggest that the services provided to firms by KTTOs contribute to create value at three generic stages of the firm's knowledge value chain: the exploration of knowledge-based opportunities; the technical validation of knowledge-based opportunities, and the exploitation of knowledge-based opportunities. Such a three-stage process does not intend to suggest that the knowledge and technology transfer process taking place through service offerings is a linear process. It should be considered as a tool to put some conceptual framework on a large repertoire of the knowledge and technology transfer services which are offered by KTTOs. One might expect that different types of KTTOs might emphasize the provision of services at different

stages of the knowledge value chain. One might also expect that the services provided at different stages might be explained by different factors. In the end, a crucial challenge for KTTOs is figuring out where to position themselves in the knowledge value chain. These issues carry important implications for both the management of KTTOs and public policy supporting KTTOs.

Hence, in this study, the services provided by KTTOs are considered as services linked to the exploration of knowledge-based opportunities when they:

- Help firms to specify their needs related to technologies, production equipment and patents;
- Help firms to specify their needs related to research;
- Help firms to access ideas and information on relevant technologies, equipment and patents;
- Help firms to access pertinent research.

Moreover, the services provided by KTTOs are considered as services linked to the technical validation of knowledge-based opportunities when they:

- Help firms with prototype design and tests of technical feasibility (product testing);
- Help firms with product and process safety certification;
- Help businesses to scale up their manufacturing practices, processes and technology;
- Help businesses to access specialized equipment or facilities to scale up production (e.g., testing specialized equipments, etc.);
- Help businesses to access expertise to scale up production (e.g., student interns, engineers, faculty, experts of the industry, etc.).

Finally, the services provided by KTTOs are considered as services linked to the exploitation of knowledge-based opportunities when they:

Exploitation of knowledge-based opportunities: Legal issues

- Help firms to prepare patent applications;
- Help to create spin-offs in order to exploit inventions;
- Help firms regarding negotiation and management of contractual agreements.

Exploitation of knowledge-based opportunities: Access to capital

- Help firms to access commercial bank loans linked to the development of new or improved products and processes;
- Help firms to access angel investors or angel networks linked to the development of new or improved products and processes;
- Help firms to access venture capital linked to the development of new or improved products and processes.

Exploitation of knowledge-based opportunities: Commercialization

- Provide assistance related to product positioning (first on the market, creating a niche, etc.);
- Help firms to develop a business case;

- Help firms in the design and implementation of business processes (customer needs assessment service, inventory management);
- Help firms regarding advertising and promotion of new products;
- Help client firms access markets/distribution channels;
- Help client firms access international markets/distribution channels.

Such a perspective to the provision of services by KTTOs can clearly be considered as a supply side or technology push perspective and is associated with public policy relying on KTTOs to provide services to firms in order to accelerate the transfer and integration of knowledge and technology in the development or improvement of products and production processes. The supply side perspective is also important as firms, especially SMEs, frequently do not have the resources required to explore, validate and exploit knowledge for the development or improvement of their products and production processes. Existing studies based on the supply side perspective suffer from many shortcomings. According to Howells (2006, p. 719), «Many studies stop here (at the exploratory stage of the knowledge value chain), seeing the primary role of intermediaries as providing information, scanning and exchange functions». By taking into account, as its dependent variable, a larger number of services provided by different types of KTTOs, not only at the exploratory stage, but also at the validation and exploitation stages of the knowledge value chain, this paper is likely to shed light on the more proactive roles of intermediaries in the innovation process.

## **2. Issues associated with the identification of factors explaining the knowledge and technology transfer services offered to firms by KTTOs**

The explanation of knowledge and technology transfer services is still problematic. There is no general theory for the field of knowledge and technology transfer (Reisman, 2005; Molas-Gallart, Salter, Patel, Scott & Duran, 2002). To identify potential explanatory variables, we relied on two complementary approaches. Firstly, we relied on the literature on technology intermediation, and knowledge and technology transfer to develop a first list of factors likely to influence the supply of services to firms. Secondly, we developed a second list of explanatory factors by relying on the information available on the web sites of 416 Canadian KTTOs. We thus set up a large list of explanatory factors that we merged into categories of explanatory variables according to their thematic similarity. These broad categories of factors might be considered as building blocks of business models (Chesbrough, 2006; Chesbrough, 2007). Therefore, we integrated these factors into a business model framework comprising six factors: customer value proposition, market segment, revenue generation mechanisms, positioning within the value network, strategies, key resources. Three control variables were also derived from these two procedures: size of organizations, size of urban agglomeration where KTTOs operate, and finally, the types of organizations. Let us now review these categories of explanatory variables in turn.

**Customer value proposition:** The value created by the services provided by KTTOs is likely to vary according to the degree of customization of the service solutions provided to firms.

**Market segment:** KTTOs cannot avoid identifying a market segment. They must ask themselves for what groups of firms the services provided create value.

**Revenue generation mechanisms:** The sustainability of KTTOs depends on the revenue they can capture from their provision of services to firms at the different stages of the knowledge value chain. The KTTOs' revenue streams come primarily in the form of government subsidies and the sale of services to firms.

**Client relationship:** Are the working relationships forged between the KTTOs and their clients in industry, government agencies, universities and community colleges crucial to satisfy firms' expectations? Do KTTOs and their clients forge very close working relationships, practically like if they were in the same work group? Conversely, at the other extreme of the continuum, do KTTOs and their clients forge very distant working relationships, practically like people that KTTOs do not know well?

**Strategies:** Strategy refers to a set of decisions and actions that aims to give the KTTO a superior performance and ultimately a competitive advantage over rival organizations (Porter, 1996; Porter, 2008). Developing a strategy helps the KTTO to understand what to do, what to become and how to plan to get there. A strategy defines the scope of a KTTO's intentions, in particular in relation to how it will mobilize professional knowledge in order to develop and improve its services. KTTOs without strategy likely react to short term opportunities without achieving medium and long term goals (Miles & Snow, 1978).

**Key resources:** Key resources needed by KTTOs, which are fundamental to the production and delivery of knowledge and technology transfer services to firms, are people and technical resources. KTTOs need to rely on the highly specific knowledge of their employees in order to successfully produce and deliver services to their client firms. The production and delivery of the services provided by KTTOs require employees with scientific and business expertise. A scientific background is necessary for an understanding of the underlying science and technology issues involved in the services being provided. Such a background allows for a deeper understanding of the needs, requirements, and expectations of firms with respect to the services acquired from KTTOs. Likewise, a training in business helps KTTOs' employees to understand the business issues involved in knowledge and technology transfer, and to develop and provide the business components of knowledge and technology transfer services. Based on this rationale, one might hypothesize that as the number of scientists and engineers employed by KTTOs increases, so does the level of services provided at the exploratory and technical validation stages. The development and improvement of the services provided by KTTOs also depend on investments in technical resources linked to various ways of generating and finding knowledge, as well as to ways of storing and spreading knowledge. One might here hypothesize that increasing the use of such technical resources in KTTOs contributes to enhance the level of services offered at all three stages of the value chain.

**Control variables:** Three control variables are introduced in this study. Organizational size (number of employees) is introduced because it likely influences the organizational capability of KTTOs to produce and deliver services. Size of the agglomeration where the KTTO is located is also considered as a control variable because it captures differences in opportunities to provide services that likely differ from agglomeration to agglomeration. The type of KTTO, in our case university technology transfer offices (UTTOs), college technology transfer offices (CTTOs), public research organizations (PROs), and nonprofit organizations (NPOs), is the third control variable introduced because one might hypothesize that each type of KTTO differs significantly with respect to the level of services it offers at the various stages of the knowledge value chain.

### **3. Data collection and data coding**

#### **3.1. Data**

##### **3.1.1. Studied populations**

Listings are available for the identification of the university technology transfer offices (UTTOs) and the community college technology transfer offices (CTTOs). However, there are no directories for the other types of KTTOs targeted in this study: the public research organizations (PROs) and the nonprofit knowledge and technology transfer organizations (NPOs). This last category of organizations is mostly composed of regional industrial extension centers and R&D centers established by industrial associations. To identify the population of the PROs and NPOS, we relied on three complementary approaches. We initially relied on the web site of various Canadian and provincial government agencies to develop a list of KTTO organizations. We added other organizations to this initial list by using Internet HUBS. We also used a snowball strategy, using references to other web sites to identify additional organizations. This set of complementary search approaches allowed us to identify more than 900 organizations.

This procedure was taken up by three research assistants who worked independently from one another. It generated results that matched at more than 95%. A subset of 416 organizations was kept, following the use of an inclusion criterion with regard to the offer of services to firms. Thus, all the organizations that did not offer services to firms were excluded from the population of organizations to be surveyed. Then, each organization's web site was visited three times. First, each organization's web site was visited to collect information on the services offered. Second, the sites were revisited to collect information on the resources and variables explaining the offer of services. Finally, the sites were visited a third time to identify the contact persons and contact information in anticipation of the survey.

##### **3.1.2. Questionnaire development and data collection**

As indicated in the previous section regarding the dependent and independent variables of this study, the questionnaire was developed by using the academic literature on KTTOs and information available on the web sites of 416 Canadian KTTOs. The questionnaire was administered, by phone, by a survey firm, to the general manager of the KTTOs. The interviews were conducted between November 19, 2008 and February 21, 2009. In short, by February 19, 218 interviews had been completed, for a possible population of 269 organizations. The response rate is thus 81,0% (218/269 organizations). Six of these organizations are not considered in this study because they did not offer any services to firms.

#### **3.2. Data coding**

##### **3.2.1. Dependent variables**

There are five dependent variables considered in this study. These variables capture the offering of services related to the different stages of the knowledge-value chain presented previously. To measure the offering of services offered to firms, KTTOs were asked to qualify, on a 5-point Likert scale, the frequency with which they had offered 24 services to firms during the three years preceding the survey (1=*Never* to 5=*Very often*). First, we checked the correlation matrix between the 24 variables referring to different services offered to firms. As recommended by Field (2006, p. 641), before performing a factor analysis, any variables that do not correlate with any other variables (or very few) and any variables that are very highly correlated with all other variables, should be excluded before the factor analysis is run. This check showed that

there were no variables that did not correlate with any other variables nor that did correlate very highly with other ones. Overall, correlations between the pairs of the 24 variables ranged from 0.06 to 0.67, with a majority of correlations between 0.30 and 0.50.

After this data screening, and to identify the underlying dimensions assessed by this measuring instrument of service offerings, we firstly performed an exploratory factor analysis (EFA) with a principal axis factoring with the entire set of services listed in the measurement instrument. This EFA permitted to discard three variables that were weakly correlated with the overall set of variables (i.e., those whose communalities are lower than 0.50), namely, *Help firms to access government subsidies and R&D credits linked to the development of new or improved products and processes* (0.297); *Help firms to recruit qualified managers* (0.346); and *Help firms to recruit students and qualified employees via internships, fellowships, and other programs and activities where students or employees are involved with industry* (0.401).

Then, a second exploratory factor analysis with the remaining 21 items was conducted using the same extraction method. The accuracy of using the factorial model with our data was assessed using two tests: the Kaiser-Meyer-Olkin (KMO) test, and Bartlett’s sphericity test<sup>1</sup>. The results of these two tests reported at the bottom of Table 1 confirm the appropriateness of using a factor analysis in this study.

Table 1 shows the results of this second EFA with a Varimax rotation method. Factors with an eigenvalue greater than 1.0 were retained and the cut-off of factors loading was greater than 0.5. These results reveal five distinctive factors underlying the stages of service offerings by KTTOs to private firms that we labelled as follows: 1) exploration of knowledge-based opportunities (4 items); 2) technical validation of knowledge-based opportunities (5 items); 3) legal issues linked to exploitation of knowledge-based opportunities (3 items); 4) issues regarding access to capital linked to exploitation of knowledge-based opportunities (3 items); and 5) commercialization issues linked to exploitation of knowledge-based opportunities (6 items). These five factors explain 72.11% of the original variance of the studied phenomenon. We also assessed the statistical reliability of these five factors. As can be seen at the bottom of Table 1, the Cronbach’s alphas range from .662 for the legal issues factor, to .886 for the commercialization factor, indicating that the items forming each factor are reliable.

**Table 1. PFA Results Underlying Stages of Service Offerings**

	Factors				
	1	2	3	4	5
<b>Exploration of knowledge-based opportunities</b>					
• Help firms to specify their needs related to technologies, production equipment and patents	.595				
• Help firms to specify their needs related to research	.795				
• Help firms to access ideas and information on relevant technologies, equipment and patents	.815				
• Help firms to access pertinent research	.832				
<b>Technical validation of knowledge-based opportunities</b>					
• Help firms with prototype design and tests of technical feasibility (product testing)		.561			
• Help firms with product and process safety certification		.606			
• Help businesses to scale up their manufacturing practices, processes and technology		.698			

<sup>1</sup> The Kaiser-Meyer-Olkin measure of sampling adequacy tests whether the partial correlations among variables are small. Bartlett’s test of sphericity tests whether the correlation matrix is an identity matrix, which would indicate that the factor model is inappropriate (See Hutcheson and Sofroniou, 1999, p. 224-225 for more details).

• Help businesses to access specialized equipment or facilities to scale up production (e.g., testing specialized equipments, etc.)			.700		
• Help businesses to access expertise to scale up production (e.g., student interns, engineers, faculty, experts of the industry, etc.)			.644		
<b>Exploitation of knowledge-based opportunities: Legal issues</b>					
• Help firms to prepare patent applications			.800		
• Help to create spin-offs in order to exploit inventions			.550		
• Help firms regarding negotiation and management of contractual agreements			.681		
<b>Exploitation of knowledge-based opportunities: Access to capital</b>					
• Help firms to access commercial bank loans linked to the development of new or improved products and processes				.579	
• Help firms to access angel investors or angel networks linked to the development of new or improved products and processes				.802	
• Help firms to access venture capital linked to the development of new or improved products and processes				.839	
<b>Exploitation of knowledge-based opportunities: Commercialization</b>					
• Provide assistance related to product positioning (first on the market, creating a niche, etc.)					.682
• Help firms to develop a business case					.557
• Help firms in the design and implementation of business processes (customer needs assessment service, inventory management)					.609
• Help firms regarding advertising and promotion of new products					.831
• Help client firms access markets/distribution channels					.839
• Help client firms access international markets/distribution channels					.761
<b>Eigenvalue</b>	2.783	1.525	1.074	1.258	7.22
<b>Variance Explained</b>	14.254	9.261	7.113	6.088	35.393
<b>Cronbach's Alpha</b>	.812	.776	.662	.859	.886
(a) Total Variance Extracted by the five factors: 72.11%; KMO = 0.870; Bartlett's Test = 2261.3 ( <i>p-value</i> = 0.000)					
(b) Extraction Method: Principal Components					
(c) Rotation Method: Varimax with Kaiser Normalization.					

The factors underlying the stages of service offerings by KTTOs to private firms will be used as dependent variables in our econometric models. More precisely, we used the weighted sum of items corresponding to each factor to construct an index. Therefore, the mean scores of a particular stage of service offerings can take on non-integer values from 1 to 5. On this matter, Thornhill and White (2007, p. 556) mentioned that the use of the sum of items “did not give qualitatively different results from employing factor scores.”

### 3.2.2. Independent variables

The explanatory variables considered in this study were regrouped in seven categories that capture: (1) customer value proposition (i.e., non-customized solutions, mixed solutions, customized solutions), (2) market segment (i.e., size of private firms that received services), (3) revenue generation mechanisms (i.e., importance of revenue from sales of services in the total budget of KTTOs), (4) positioning within the value network (i.e., the strength of ties between the KTTOs' and their clients), (5) strategies (i.e., market strategies, knowledge-management strategies, promotion of services strategies), (6) key resources (i.e., technical resources, knowledge resources), (7) control variables (i.e., size of organization, size of urban agglomeration where organization is located, types of organization). The operational definitions and descriptive statistics of these explanatory variables are presented in Table 2.

## 4. Analytical plan

The analytical plan is structured in three sequential steps. Firstly, we used *Mplus* 3.13 — structural equation-modeling package by Muthén and Muthén (1998-2004) — to estimate a saturated path model which allows to simultaneously estimate five OLS regressions to explore the correlates of the stages of service offerings previously identified with the exploratory factor analysis, namely, Exploration of knowledge-based opportunities (EXPLOR), Technical validation of knowledge-based opportunities (TECVALID), and the three sub-stages of exploitation of knowledge-based opportunities: legal issues (LEGAL), access to capital (ACCESSK) and commercialization (COMMER).

This path model was fitted to the data using a maximum likelihood (ML) of a multivariate normal density function, as all dependent variables considered in this study are continuous and normally distributed. Technical details about the ML estimator are provided in Muthén (1998-2004, p. 17-20) and in Golob (2003, p. 8-9). Each dependent variable, which corresponds to a specific stage (or sub-stage in the case of exploitation of knowledge-based opportunities), was measured by a construct of which the unidimensionality and the reliability were assessed using, respectively, a principal components factor analysis (PCFA) on the construct scales and Cronbach's alpha coefficient (See section 3.2.1).

The path model used in this study is similar to five separate OLS regressions, except that it applies to five simultaneously estimated equations with free error-term covariances. It allows for jointly estimating several equations while controlling for the existence of mutual covariances between their disturbances (Galia & Legros, 2004; Amara et al., 2008). The major issue raised from the use of separate models is related to the possibility of getting inefficient estimators if some equations' disturbances are correlated (Belderbos, Carree, Diederer & Lokshin, 2004).

Therefore, for each of the five dependent variables, we developed the following ordinary least squares model:

$$Y_i = \beta X_i + \varepsilon_i$$

**Table 2. Definitions of independent variables**

<i>Independent variables</i>	Measure	Sub-items	Mean (SD)	Percentage (Nombre)	Cronbach's alpha
<b>Continuous variables</b>					
Strength of ties [LnTIES]	Measured as an index on a 5-point Likert scale (1 = <i>Very close: practically like being in the same work group</i> ; 2= <i>Somewhat close: like discussing and solving problems together</i> ; 3= <i>Somewhat distant: like with people that you do not know well</i> ; 4= <i>Distant: like a working group with which you can only have a quick exchange of information</i> ; 5= <i>Very distant: practically like with people that you do not know at all</i> ) describing the working relationship between organizations and their clients in the following sectors. The strength of ties index is thus the sum of the scores of the items corresponding to the researcher's responses. The respondents' scores, which initially ranged from 4 to 20, were weighted in order to take into account "does not apply" answers. Thus, for each respondent, the sum of the scores was divided by the number of applicable item(s). Even though the initial index ranges from 1 to 5, once weighted, it can take on non-integer values. This variable was matched with the normal distribution using a logarithmic transformation	<ul style="list-style-type: none"> <li>• Industry</li> <li>• Public sector organizations, government departments / agencies</li> <li>• Universities</li> <li>• Colleges</li> </ul>	1.82 (.54)		.692

Market strategies [MARKET]	Measured as a weighted index on a Likert scale of frequency ranging from 1 = <i>Never</i> to 5 = <i>Very often</i> of the engagement of the organization, over the last three years preceding the survey, in the following four activities in order to provide services to private firms:	<ul style="list-style-type: none"> <li>• Seeking new geographic markets for your services</li> <li>• Extending your current services to new categories of clients</li> <li>• Developing new services</li> <li>• Developing and exploiting niches or specialized markets</li> </ul>	2.94 (.93)	.772
Knowledge management strategies [KNOWMNG]	Measured as a weighted index on a Likert scale of frequency ranging from 1 = <i>Never</i> to 5 = <i>Very often</i> of the engagement of the organization, over the last three years preceding the survey, in the following four activities in order to provide services to private firms:	<ul style="list-style-type: none"> <li>• Using and updating scientific information databases</li> <li>• Developing measures favoring knowledge sharing between your employees</li> <li>• Capturing and using knowledge obtained from other industry sources (e.g., industry associations, competitors, clients and suppliers)</li> <li>• Capturing and using knowledge obtained from public research institutions including universities and government laboratories</li> </ul>	3.40 (.91)	.793
Promotion of service strategies [PROMO]	Measured as a weighted index on a Likert scale of frequency ranging from 1 = <i>Never</i> to 5 = <i>Very often</i> of the engagement of the organization, over the last three years preceding the survey, in the following three activities in order to provide services to private firms:	<ul style="list-style-type: none"> <li>• Promoting your services through advertising (<i>advertising campaign, websites, etc.</i>)</li> <li>• Promoting your services through direct marketing (<i>prospectus, email marketing, technical reports, etc.</i>)</li> <li>• Promoting your services through public relations (<i>seminars, press conferences, etc.</i>)</li> </ul>	2.91 (.95)	.719
Generation & Finding of knowledge [GENFIND]	Measured as a weighted index on a Likert scale of frequency ranging from 1 = <i>Never</i> to 5 = <i>Very often</i> of the use by the organizations, over the last three years preceding the survey, of the following five tools for the development and improvement of their services offered to private firms:	<ul style="list-style-type: none"> <li>• Data mining/ text retrieval software</li> <li>• Expert or decision support software</li> <li>• Automatic e-mail alerts</li> <li>• Intelligent agent or artificial intelligence</li> <li>• Mind/knowledge mapping software</li> </ul>	2.28 (.98)	.770

**Table 2 (Continued). Definitions of independent variables**

Storing & Spreading of knowledge [STOSPRES]	Measured as a weighted index on a Likert scale of frequency ranging from 1 = <i>Never</i> to 5 = <i>Very often</i> of the use by the organizations, over the last three years preceding the survey, of the following four tools for the development and improvement of their services offered to private firms:	<ul style="list-style-type: none"> <li>• Content/document management software</li> <li>• Intranet or enterprise information portal</li> <li>• Knowledge repository or digital archive</li> <li>• Workflow/process management software</li> </ul>	2.86 (.98)	.738
Market segment [SEGMENT]	<ul style="list-style-type: none"> <li>• Measured as the percentage of private firms with less than 10 employees that received services from the KTTO</li> </ul>		39.90 (28.29)	
Size [LnSIZE]	<ul style="list-style-type: none"> <li>• Measured by the total number of full-time employees (equivalent full time) in 2008. This variable was matched with the normal distribution using a logarithmic transformation</li> </ul>		46.57 (85.68)	
Scientific employees [LnSCENGIN]	<ul style="list-style-type: none"> <li>• Measured as number of employees with scientific or engineering training. This variable was matched with the normal distribution using a logarithmic transformation</li> </ul>		26.19 (55.27)	
Management employees [LnMNG]	<ul style="list-style-type: none"> <li>• Measured as number of employees with management training. This variable was matched with the normal distribution using a logarithmic transformation</li> </ul>		4.87 (8.47)	
<b>Categorical Variables</b>				

<b>Customer value proposition</b>	Three dichotomous variables constructed with respect to the responses of the organization to the following question: <i>Which of the following statements best describes the services you offered to private firms over the last three years?</i>	
	<ul style="list-style-type: none"> <li>• Non-customized solutions (NOCUSTOM): (<i>Mainly basic research &amp; Almost only basic research=1; Else=0</i>)</li> <li>• Mixed solutions (MIXED): (<i>Half customized solutions and half basic research=1; Else=0</i>)</li> <li>• Customized solutions (CUSTOM): (<i>Almost only customized solutions &amp; Mainly customized solutions=1; Else=0</i>)</li> </ul>	<p>19.3%</p> <p>38.7%</p> <p>42.0%</p>
	CUSTOM is the reference category.	
<b>Revenue generation mechanisms</b>	Three dichotomous variables constructed with respect to the responses of the organization to the following question: <i>Please estimate (as best you can) the percentage of sale of services in your organization's total budget over the last three years?</i>	
	<ul style="list-style-type: none"> <li>• Non-revenue from sale of services (NOREV): (<i>0% of organization's total budget from sale of services=1; Else=0</i>)</li> <li>• Moderate revenue from sale of services (MODREV): (<i>from 1% to 25% of organization's total budget from sale of services=1; Else=0</i>)</li> <li>• Important revenue from sale of services (IMPOREV): (<i>more than 25% of organization's total budget from sale of services=1; Else=0</i>)</li> </ul>	<p>47.6%</p> <p>24.1%</p> <p>28.3%</p>
	IMPOREV is the reference category.	
<b>Size of urban agglomerations</b>	A series of dichotomous variables defined as follows:	
	<ul style="list-style-type: none"> <li>- Large agglomerations [LARGE] is a binary variable coded 1 if the organization is based in an agglomeration of more than 1 million people, and coded 0 otherwise.</li> <li>- Medium agglomerations [MEDIUM] is a binary variable coded 1 if the organization is based in an agglomeration between 100 000 and 1 million people, and coded 0 otherwise.</li> <li>- Small agglomerations [SMALL] is a binary variable coded 1 if the organization is based in an agglomeration of less than 100 000 people, and coded 0 otherwise.</li> </ul>	<p>30.7%</p> <p>42.9%</p> <p>26.4%</p>
	The reference category is Large agglomerations.	
<b>Types of organizations</b>	A series of dichotomous variables indicating the types of organization. The organizations are regrouped in four types:	
	<ul style="list-style-type: none"> <li>- Nonprofit organization (NPO)</li> <li>- College technological transfer office (CTTO)</li> <li>- University technological transfer office (UTTO)</li> <li>- Public research organization (PRO)</li> </ul>	<p>36.3%</p> <p>25.5%</p> <p>19.8%</p> <p>18.4%</p>
	The reference category is Public Research Organization (PRO).	

where  $Y_i$  is the dependent variable referring to the stage of service offerings for organization  $i$ ,  $X_i$  is the vector of  $K$  explanatory variables for organization  $i$ ,  $\beta$  is a vector of parameters to be estimated for organization  $i$ , and  $\varepsilon_i$  is the error term for organization  $i$ .

Secondly, as the fit of the saturated path model estimated in the first stage cannot be assessed<sup>2</sup>, the same model was estimated, but by fixing insignificant parameters (i.e., those with  $p > 0.10$ , two-tailed) at 0. This second unsaturated path model can be assessed for model fit as its degree of freedom is different from 0. As mentioned in Ouimet, Amara, Landry and Lavis (2007), Golob and Regan recommend fixing insignificant parameters, as “saturated models are difficult to interpret, because statistically significant effects can be diminished due to multicollinearity with insignificant effects” (2002, p. 217).

Thirdly, we also estimated the same unsaturated path model, but with the covariances between the equations' error-terms fixed at 0. The comparison of this constrained unsaturated path model with the unsaturated one with free error-terms permits to assess if the simultaneous estimation of the five OLS regressions is more appropriate than the use of separate regression models. If this is the case, the free error-term covariances will serve as proxies of the complementarity, substitution or independence effects between the stages of service offerings.

## 5. Results

<sup>2</sup> Saturated models always fit perfectly as they typically have 0 degree of freedom.

The results of the unsaturated path models (which take into account only the significant coefficients) are summarized in Table 3. The results of the comparison of the constrained unsaturated path model to the unsaturated one with free error-terms are also reported in the lower part of Table 3.

### **5.1. Overall model fit, R-squares and error-term covariances**

As mentioned in section 4, the saturated path model estimated in the first step could not be assessed for model fit as it typically has zero degree of freedom. We therefore only present the fit of the unsaturated model (Table 3), which excludes the insignificant parameters found in the saturated model estimated in step 1. The unsaturated path model had 44 degrees of freedom and an insignificant Chi-square statistic of 33.719 ( $p$ -value = 0.869). The insignificant Chi-square indicates that the final unsaturated path model has a very good fit. The  $R^2$  estimates reported in Tables 3 show that access to capital (ACCESSK) and commercialization (COMMER) are the stages of service offerings that are the most effectively explained.

The estimates of the error-term covariances of the five regression equations are listed at the bottom of Table 3. All of these covariances are significant and positive, except for the covariance between service offerings linked to exploration of knowledge-based opportunities and service offerings linked to access to capital. These last two stages of service offerings seem to be independent from each other, as indicated by the corresponding insignificant covariances between the estimated disturbances. Overall, these results support the hypothesis of interdependence between the different stages of service offerings. However, some covariances between pairs of stages of service offerings are higher than others, suggesting the presence of higher complementarities between some pairs of stages of service offerings than others. More specifically, the lower part of Table 3 shows that the highest covariances are between service offerings linked to access to capital and service offerings linked to commercialization (0.262), and service offerings linked to technical validation of knowledge-based opportunities and service offerings linked to legal issues (0.251). At the other extreme, the lowest covariances are between service offerings linked to exploration of knowledge-based opportunities and service offerings linked to legal issues (0.100), and service offerings linked to exploration of knowledge-based opportunities and service offerings linked to commercialization (0.101). Hence, service offerings linked to exploration of knowledge-based opportunities appear to be more related to the service offerings linked to technical validation of knowledge-opportunities than to any of the other three stages of service offerings.

### **5.2. Effects of explanatory variables of stages of service offerings**

As for the extent to which explanatory variables explain the various stages of service offerings, results show that anywhere from nine to twelve variables are significant at levels varying from 1% to 10% in each of the five equations. Let us first consider the capacity of the different variables to explain stages of service offerings. Developing mixed solutions for client firms (MIXED) (*half customized solutions and half basic research*) rather than customized solutions (CUSTOM) (*almost only customized solutions and mainly customized solutions*) had a significant and positive impact on three stages of service offerings, namely exploration of knowledge-based opportunities, technical validation of knowledge-based opportunities, and commercialization. Conversely, developing non-customized solutions for client firms (NOCUSTOM) (*mainly basic research and almost only basic research*) had a negative and significant impact in all the five stages of service offerings. Likewise, the market segment, as measured by the percentage of private firms with less than 10 employees that were targeted by

KTTOs' services (SEGMENT), is significantly and positively related to all stages of service offerings, except exploration of knowledge-based opportunities. Moreover, the KTTOs that generated no revenues (NOREV) or moderate revenues (MODREV) from sale of services were more present in services linked to exploration of knowledge-based opportunities than those that generated important revenues (IMPOREV) from the sale of services. However, the KTTOs that generated no revenues from the sale of services were more present in services regarding legal issues linked to exploitation of knowledge-based opportunities than those that generated important revenues from the sale of services. The strength of ties between the KTTOs and their clients (TIES) had a significant and negative impact on three stages of service offerings: exploration of knowledge-based opportunities, access to capital, and commercialization. More precisely, for these three stages, an increase in the index of strength of ties, which means an increase in the distance between KTTOs and their clients, decreases the capacity of the KTTOs to offer the services related to these stages. With regard to the three indices measuring the KTTOs' strategies, market strategies (MARKET) was found to have a significant impact on the services linked to the technical validation and legal issues stages. Knowledge management strategies (KNOWMNG) had a significant and positive impact on service offerings regarding exploration and commercialization. Finally, strategies regarding the promotion of services (PROMO) exerted a positive impact on three stages of service offerings: exploration, access to capital, and commercialization. Likewise, the index measuring the frequency of use by the KTTO of technical tools for generating and finding knowledge (GENFIND) had a positive impact on three stages of service offerings, namely, technical validation, access to capital, and commercialization.

However, the index measuring the frequency of use by the KTTO of technical tools regarding the storing and spreading of knowledge (STOSPRE) exerted a negative impact on services linked to access to capital and commercialization. With regard to knowledge resources embodied in employees of KTTOs, the number of employees with scientific or engineering training (LnSCENGIN) is found significant and exerting a negative impact on the services linked to the access to capital stage, whereas the number of employees with business training (LnMNG) is found significant and exerting a positive impact on the services linked to access to capital and commercialization, and exerting a negative impact on services regarding the technical validation stage of the value chain.

As for the control variables considered in this study, the number of employees (LnSIZE) is found to have a positive and significant effect in three stages of service offerings: exploration, technical validation, and legal issues. With regard to the location effect, the results show that being located in small agglomerations (SMALL), instead of being located in large agglomerations (LARGE), exerted a negative impact on all stages of service offerings except the technical validation stage. Being located in medium agglomerations (MEDIUM), instead of being located in large agglomerations, had a negative impact on the services linked to access to capital. Likewise, with regard to types of KTTOs, the results show that the University Technology Transfer Offices (UTTOS) were more active than Public Research Offices (PROs) in the offering of services at all stages of the value chain, except for the commercialization stage. Moreover, Community College Technological Transfer Offices (CTTOs) were more active than PROs in the offering of services at all stages of the value chain, except for the exploration stage. Finally, Nonprofit Organizations (NPOs) were more active than PROs in the offering of services related to the technical validation stage.

## 6. Discussion and conclusion

This study pointed out at the beginning that there is a large diversity of knowledge and technology intermediaries involved in the provision of services aiming to help firms to develop or improve their products and production processes. This study focuses its attention on knowledge and technology transfer organizations (KTTOs). Contrary to most studies which deal with university technology transfer offices (UTTOs) and public research organizations (PROs) while focusing on services linked to patenting, licensing, spin-off formation and contract research, this study includes two other types of KTTOs, the community college technology transfer organizations (CTTOs) and the nonprofit knowledge and technology transfer organizations (NPOs), while taking into account 21 services provided by KTTOs in order to help firms to develop or improve their products and production processes. Such an approach was likely to contribute to shed light on more proactive roles played by KTTOs in the innovation process of firms, while providing new evidence on the differences between the services provided to firms by different types of organizations.

Looking simultaneously at 21 services would have prevented us from considering the innovation process of firms as a whole. To avoid this pitfall, we classified the services in reference to their contribution at three generic stages of the firm's knowledge value chain: the exploration of knowledge-based opportunities (4 services), the validation of knowledge-based opportunities (5 services), and the exploitation of knowledge-based opportunities. A factor analysis led us to subdivide the third stage into three sub-stages: services linked to legal issues (3 services), access to capital (4 services) and commercialization (6 services). This approach to analyze the service offerings of KTTOs to firms provides new evidence on the similarities and differences that exist between the four types of organizations considered in this study.

Independent variables	Exploration of knowledge-based opportunities		Technical validation of knowledge-based opportunities		Exploitation of knowledge-based opportunities: Legal issues	
	Coeff. ( $\beta$ )	T statistics	Coeff. ( $\beta$ )	T statistics	Coeff. ( $\beta$ )	T statistics
Intercept	2.240***	6.858	.592**	2.332	.700***	2.778
<b>Customer value proposition:</b>						
☑ Mixed solutions (MIXED) <sup>a</sup>	.154*	1.779			.133**	1.980
☑ Non-Customized solutions (NOCUSTOM) <sup>a</sup>	-.358**	-2.449	-.270**	-2.055	-.355**	-2.435
<b>Market segment:</b>						
☑ Percentage of private firms with less than 10 employees that received services (SEGMENT)			.003*	1.777	.005**	2.392
<b>Revenue generation mechanisms:</b>						
☑ No revenues from sale of services (NOREV) <sup>b</sup>	-.264**	-2.160			.271***	3.046
☑ Moderate revenues from sale of services (MODREV) <sup>b</sup>	-.300**	-2.275				
<b>Positioning within the value network:</b>						
☑ Strength of ties (TIES)	-.377**	-2.134				
<b>Strategies:</b>						
☑ Market strategies (MARKET)			.235***	4.567	.150**	2.729
☑ Knowledge management strategies (KNOWMNG)	.300***	5.185				
☑ Promotion of service strategies (PROMO)	.134**	2.384				
<b>Key resources:</b>						
<i>Technical resources</i>						
☑ Generation & Finding of knowledge (GENFIND)			.110**	2.091		
☑ Storing & Spreading of knowledge (STOSPRES)						
<i>Knowledge resources</i>						
☑ Number of employees with scientific or engineering training (LnSCENGIN) <sup>c</sup>						

<input checked="" type="checkbox"/> Number of employees with management training (LnMNG) <sup>c</sup> <b>Control variables:</b> <input checked="" type="checkbox"/> Size (LnSIZE) <sup>c</sup> <b>Size of urban Agglomerations</b> <input checked="" type="checkbox"/> Small (SMALL) <sup>d</sup> <input checked="" type="checkbox"/> Medium (MEDIUM) <sup>d</sup> <b>Types of organizations</b> <input checked="" type="checkbox"/> Nonprofit organization (NPO) <sup>e</sup> <input checked="" type="checkbox"/> College technological transfer office (CTTO) <sup>e</sup> <input checked="" type="checkbox"/> University technological transfer office (UTTO) <sup>e</sup>						
	.124***	3.295	.233***	5.225	.141***	3.894
	-210**	-1.971			-189*	-1.720
			.783***	5.103		
			.548***	3.655	.464***	3.770
	.082*	1.824	.549***	3.120	.865***	5.847
<b>Covariances between disturbances</b>	$\varepsilon_1$		$\varepsilon_2$		$\varepsilon_3$	
$\varepsilon_2$	0.203 ***					
$\varepsilon_3$	0.100 ***		0.251 ***			
$\varepsilon_4$	0.007		0.117 ***		0.145 ***	
$\varepsilon_5$	0.101 ***		0.188 ***		0.207 ***	
Number of observations	212					
R-Square	0.306		0.289		0.271	
Unsaturated path model with free error-terms	$\chi^2(44) = 33.72, p\text{-value} = 0.869$					
Constrained unsaturated path model with error-terms fixed at 0.:	$\chi^2(54) = 207.93, p\text{-value} = 0.000$					
<p>*, ** and *** indicate that the coefficient is significant, respectively, at the 10%, 5% and 1% thresholds.  <sup>a</sup> The reference category is Customized Solutions (CUSTOM).  <sup>b</sup> The reference category is Important Revenues from Sale of Services (IMPOREV).  <sup>c</sup> Ln indicates a logarithmic transformation.  <sup>d</sup> The reference category is Computer System Designs Services (COMPU).  <sup>e</sup> The reference category is Large urban agglomerations.  <sup>f</sup> The reference category is Public Research Organization (PRO).</p>						

<b>Table 3 (Continued). Unsaturated Multivariate Path Model Results Explaining the Stages of Service Offerings</b>				
	Exploitation of knowledge-based opportunities: Access to capital		Exploitation of knowledge-based opportunities: Commercialization	
	Coeff. ( $\beta$ )	T statistics	Coeff. ( $\beta$ )	T statistics
Intercept				
<b>Customer value proposition:</b>	.938***	2.823	.860***	2.904
<input checked="" type="checkbox"/> Mixed solutions (MIXED) <sup>a</sup>				
<input checked="" type="checkbox"/> Non-Customized solutions (NOCUSTOM) <sup>a</sup>			.069*	1.769
<b>Market segment:</b>	-373***	-2.975	-377**	-2.527
<input checked="" type="checkbox"/> Percentage of private firms with less than 10 employees that received services (SEGMENT)				
<b>Revenue generation mechanisms:</b>	.006***	3.120	.006***	3.044
<input checked="" type="checkbox"/> No revenues from sale of services (NOREV) <sup>b</sup>				
<input checked="" type="checkbox"/> Moderate revenues from sale of services (MODREV) <sup>b</sup>				
<b>Positioning within the value network:</b>				
<input checked="" type="checkbox"/> Strength of ties (TIES)				
<b>Strategies:</b>	-347**	-1.899	-167*	-2.197
<input checked="" type="checkbox"/> Market strategies (MARKET)				
<input checked="" type="checkbox"/> Knowledge management strategies (KNOWMNG)				
<input checked="" type="checkbox"/> Promotion of service strategies (PROMO)			.143**	2.431
<b>Key resources:</b>	.169***	3.019	.231***	4.257
<b>Technical resources</b>				
<input checked="" type="checkbox"/> Generation & Finding of knowledge (GENFIND)				
<input checked="" type="checkbox"/> Storing & Spreading of knowledge (STOSPRES)	.142**	1.959	.186**	2.584
<b>Knowledge resources</b>	-076**	-2.054	-160**	-2.470
<input checked="" type="checkbox"/> Number of employees with scientific or engineering training (LnSCENGIN) <sup>c</sup>				

Number of employees with management training (LnMNG) <sup>c</sup>	-0.068**	-2.719		
<b>Control variables:</b>				
Size (LnSIZE) <sup>c</sup>	.153**	2.267	.075*	1.875
<b>Size of urban Agglomerations</b>				
Small (SMALL) <sup>d</sup>				
Medium (MEDIUM) <sup>d</sup>	-.290**	-2.118	-.223**	-1.955
<b>Types of organizations</b>				
Nonprofit organization (NPO) <sup>e</sup>				
College technological transfer office (CTTO) <sup>e</sup>				
University technological transfer office (UTTO) <sup>e</sup>	.677***	5.213	.307**	2.546
Intercept	.371***	2.793		
<b>Covariances between disturbances</b>		$\epsilon_4$		
$\epsilon_2$				
$\epsilon_3$				
$\epsilon_4$				
$\epsilon_5$		0.262***		
Number of observations				
R-Square	0.376		0.333	
nsaturated path model with free error-terms	$\chi^2(44) = 33.72, p\text{-value} = 0.869$			
Constrained unsaturated path model with error-terms fixed at 0.:	$\chi^2(54) = 207.93, p\text{-value} = 0.000$			
* , ** and *** indicate that the coefficient is significant, respectively, at the 10%, 5% and 1% thresholds.				
<sup>a</sup> The reference category is Customized Solutions (CUSTOM).				
<sup>b</sup> The reference category is Important Revenues from Sale of Services (IMPOREV).				
<sup>d</sup> Ln indicates a logarithmic transformation.				
<sup>c</sup> The reference category is Computer System Designs Services (COMPU).				
<sup>d</sup> The reference category is Large urban agglomerations.				
<sup>e</sup> The reference category is Public Research Organization (PRO).				

Hence, contrary to our expectations, the results of this study show that the involvement of UTTOs, CTTOs, PROs and NPOs does not differ in the provision of services at the exploratory stage of the value chain. We were expecting to observe higher levels of service offering from research-intensive organizations such as UTTOs and PROs than from CCTOs and NPOs which are much less research-intensive organizations. This result suggests that KTTOs, regardless of their type, achieve a similar role in the innovation process of firms at the exploratory stage of the value chain. Furthermore, the results of this study show that NPOs and CTTOs are more involved than UTTOs and PROs regarding the services offered at the validation stage of the value chain. It suggests that less research-intensive organizations (CTTOs and NPOs) are more involved in the innovation process of firms at the validation stage of the value chain than UTTOs and PROs. Finally, the tests of differences suggest that NPOs are generally more involved in the provision of services linked to the exploitation stage of the value chain than PROs and UTTOs. Overall, these descriptive results suggest that each type of KTTO selectively emphasizes its service offering at different stages of the value chain. In themselves, these simple descriptive results suggest that public policies aimed at fostering innovation should take into account the differentiated roles performed by different types of knowledge and technology transfer organizations in the innovation process of firms. More specifically, the results of this study suggest that policy makers should pay more attention to the roles performed by NPOs at the exploitation stage of the value chain.

By looking simultaneously at the five packages of services linked to the different stages of the value chain, the statistical approach used in this study also provides new evidence on complementarity effects that exist between the services offered at the different stages of the

value chain. The results suggest different patterns of complementarities between many packages of service offerings. Hence, the complementarities between the services provided at the exploration and validation stages are higher than the complementarities between the services offered at the exploration and exploitation stages. Furthermore, the services offered at the validation stage exhibit higher degrees of complementarity with those offered at the exploitation stage than between the services provided at the exploration and exploitation stages. The highest degrees of complementarity were found between the exploitation services linked to access to capital and the exploitation services linked to commercialization of knowledge-based opportunities. These results carry important implications. Hence, they suggest that certain services might become the base upon which other services may build, and that the provision of services at certain stages of the value chain may generate a leverage effect on the provision of services at other stages of the value chain. Thus, failing to recognize complementarities between services linked to access to capital and commercialization may lead to the under-exploitation of synergies and therefore KTTOs' revenues and performance. Similarly, a failure to recognize complementarities between services offered at the validation stage and services linked to the legal issues of the exploitation stage may lead to the under-exploitation of synergies and therefore KTTOs' revenues and performance. Hence, managers of KTTOS and public policy supporting KTTOs should attempt to take into account how different services reinforce each other, instead of attempting to prevent the entry of KTTOs in the provision of complementary services.

Let us consider the different elements of the business models developed by the KTTOs. First, what are the characteristics of the value proposition offered to client firms? The results of the statistical analysis show that developing non-customized rather than customized solutions for client firms decreases the level of service offering to firms at all stages in the value chain. Interestingly, developing mixed solutions (half customized solutions and half basic research) rather than customized solutions increases the level of service offering at the exploration stage, and at two sub-stages of the exploitation stage: services linked to legal issues and services linked to commercialization issues. These results suggest that KTTOs transform research knowledge and technology into customized or semi-customized solutions for client firms. Hence, the business model implemented by KTTOs tends to create value for client firms by providing customized and semi-customized solutions that satisfy specific customers' needs.

Second, what is the market segment targeted by the KTTOs? The results show that the higher the propensity of KTTOs to serve firms of less than 10 employees, the higher their level of service offering at the validation and exploitation stages of the value chain. These results suggest that KTTOs which offer higher levels of services at these stages tend to serve a distinct customer group with different characteristics: the very small firms. Hence, the KTTOs' business model tends to target very small firms at the validation and exploitation stages of the value chain.

Third, how do KTTOs earn their revenues? The results show that generating low or moderate revenues from the sale of services to firms is associated with a higher level of service offering at the exploration stage of the value chain. Moreover, the absence of revenues from the sale of services is associated with higher levels of legal services linked to the exploitation stage. Furthermore, revenues from sales of services are not associated with the provision of services for the validation stage and for the sub-stages of access to capital and commercialization of the value chain. These results might suggest that the KTTOs' business model does not primarily depend on revenues from the sale of services but that it relies on government subsidies to finance the

development and delivery of their services. As a consequence, it means that KTTOs are highly vulnerable to changes in the innovation policies of their governmental sponsors.

Fourth, what is the positioning of the KTTOs within their value network? More precisely, how do KTTOs work with their partners? The results of the statistical analysis show that increases in the strength between the KTTOs and their partners in industry, government agencies, universities and community colleges are associated with the provision of a higher level of services at the exploration stage, and at the services linked to access to capital and commercialization of the exploitation stage. These results suggest that close relationships may facilitate the production and delivery of services at these stages of the value chain, but not at the validation stage and for the legal services surrounding the exploitation stage. In spite of these mixed results, one might nevertheless conclude that the KTTOs' business model relies more on strong ties than on weak ties.

Fifth, what are the strategies devised by KTTOs? Three types of strategies were considered in this study: market strategies, knowledge management strategies and promotion strategies. Overall, the results suggest that KTTOs rely on different strategies for the different stages of the value chain. Hence, the KTTOs' business model depends on many different and perhaps complementary strategies in order to compete on the market of knowledge-intensive business services.

Sixth, what are the key resources used by KTTOs to make their business model work? We hypothesized that the KTTOs' business model is largely built on the knowledge resources embodied in employees. The results show that increases in the number of scientists and engineers are associated with decreases in the helping of firms to access to capital, while increases in the number of employees with a business training decreases the level of services at the validation stage. However, increases in the number of employees with a business training are associated with increases in services aimed at helping firms to access to capital and commercialization. These results suggest that KTTOs must dispose of different types of human resources for different stages of the value chain to make their business model work: having only scientists and engineers is necessary but not sufficient, as well as having only employees with a business training is necessary but not sufficient.

Overall, with a few exceptions, these results suggest that the KTTOs' business model is built around the following building blocks: they offer mixed or customized solutions to their clients, target very small firms, do not primarily depend on revenues from the sale of services, develop strong ties with their partners and clients, formulate differentiated strategies for the different stages of the value chain, and dispose of differentiated types of human resources for different stages of the value chain.

What do these results suggest for the management of KTTOs and public policy supporting them? Managers of KTTOS could improve their business model in increasing the value created for their clients by increasing the degree of customization of the solutions offered to their clients, and in increasing the revenues they generate from sales of services in order to reduce their vulnerability to reductions in government subsidies. Policy makers should recognize the existence of complementarities between the services provided at the different stages of the value chain, and thus refrain from attempting to rely on a concept of KTTOs that would specialize in the provision of services at only one or two stages of the value chain.

Understanding how KTTOs help firms to develop or improve their products and production processes is a complex issue that will require further research. Hence, this paper adopted a supply side perspective that should be complemented by a demand side perspective focusing on

the use and appreciation of the services acquired by firms. Furthermore, there are, as we pointed out at the beginning of this paper, many other categories of intermediaries who provide services to help firms to improve their innovation process, and other studies should focus their attention on additional categories of knowledge and technology intermediaries. Finally, this study focused its attention on Canadian KTTOs. The results of this study could potentially reflect peculiarities of the Canadian institutional infrastructure of organizations that supports the innovation process of firms. This potential shortcoming could be compensated by multi-country studies that would attempt to neutralize the impact of national peculiarities.

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