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ENTRE-U: An entrepreneurial orientation scale for universities

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ABSTRACT

The development of a new scale, ENTRE-U, that measures the entrepreneurial orientation of university departments is described. Governments, industry, and funding organizations challenge universities to become more "entrepreneurial", often in the context of increasing the commercialization outcomes of publicly funded research. The extant literature on corporate entrepreneurial orientation (EO) suggests this orientation is beneficial when organizations face dynamic or hostile environments. However, the EO concept and related empirical research focus on firms in competitive markets. Little is known about the nature of EO in other organizational contexts. ENTRE-U was developed to facilitate empirical research on EO within public universities. Interviews and a follow-up focus group with faculty members from departments in computer science, health science, and engineering at Canadian Universities elicited items for the new scale. A survey of university department heads provided data for statistical development of the scale. ENTRE-U consists of four dimensions – research mobilization, unconventionality, industry collaboration, and perception of university policies – that successfully predict department involvement in commercialization activities. Implications of the findings and opportunities for research using the ENTRE-U scale are discussed.

1. Introduction

The prominence of knowledge as a valuable resource for economic advantage has prompted a shift in expectations of universities to include commercialization of research alongside the traditional activities of teaching and basic research (National Governors Association, 2000a, 2000b; Association of Universities and Colleges of Canada, 1995; Chiesa and Piccaluga, 2000; Macho-Stadler et al., 2008). Consequently, universities are encouraged to become more "entrepreneurial" (Mowery and Shane, 2002), requiring changes in their culture, governance, and administration (Association of Universities and Colleges of Canada, 1995; Rip, 2002). Despite expanding research on commercialization activities within universities, little is known about the entrepreneurial orientation (EO) of academic departments, and how such an orientation might foster commercialization activity.

Making corporations more entrepreneurial is the central focus of literature on corporate entrepreneurship (Kuratko and Goldsby, 2004). However, the extent to which the conclusions of this literature can be extrapolated to alternative organizational contexts like universities is unknown. Much of the empirical literature uses ENTRESCALE to measure the EO of private sector firms (Covin and Slevin, 1989; Knight, 1997). Several studies conclude that ENTRESCALE predicts firm performance, especially in hostile environments (Becherer and Maurer, 1997; Chow, 2006; Covin and Slevin, 1989; Knight, 1997; Moreno and Casillas, 2008). However, ENTRESCALE has limited applicability in the public or non-profit sectors, and what it means to be "entrepreneurially oriented" within public or non-profit sectors is just beginning to be explored (Box, 1999; Caruana et al., 2002; Mentoor and Friedrich, 2007; Morris and Jones, 1999; O'Shea et al., 2005, 2007). Differences in the objectives, structure, and governance of universities may influence the relevant dimensions of what constitutes an entrepreneurial orientation.

This paper reports the systematic development of a scale that measures EO within university departments. This scale, called ENTRE-U, has potential to support university administration efforts to evaluate the culture of university departments, and develop conditions more conducive to commercialization outcomes such as spinouts, patenting, and licensing. ENTRE-U exhibits acceptable psychometric properties and shows promise for use in future research as it correlates strongly with the commercialization activities of university departments.

The following section briefly reviews the extant research on the entrepreneurial orientation construct, and current research on university-based entrepreneurship and commercialization. Next, the processes of generating scale items, and item purification are discussed. Section 4 describes the collection of data from a sample of department heads at Canadian universities and statistical

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assessment of the scale. The final section discusses the implications of the scale for use in future research and within universities to assess the entrepreneurial orientation of departments.

2. Literature review

2.1. The entrepreneurial orientation construct

A focused stream of research on the concept of "entrepreneurial orientation" clearly establishes that large organizations can benefit from doing things in an entrepreneurial manner. The study of EO has its roots in the field of strategy research, especially the writings of Mintzberg (1973) and Miles and Snow (1978). Mintzberg identified three strategy types, entrepreneurial, planning, and adaptive, while Miles and Snow (1978) wrote about "prospector firms" and the role that an entrepreneurial approach to strategy plays when firms are faced with decision such as what products to offer or markets to enter. Building on these early references to an entrepreneurial approach to strategy, Miller (1983) was one of the first to describe the components of the approach. He defined an entrepreneurial firm as one that "engages in product marketing innovation, undertakes somewhat risky ventures, and is first to come up with proactive innovations (p. 771)." Later, Morris and Paul (1987) refined this definition: EO is the "… inclination of top management to take calculated risks, to be innovative, and to demonstrate proactiveness (p. 41)."

Empirical contributions to this literature frequently use ENTRESCALE to assess the entrepreneurial orientation of an organization. This scale originates with the work of Khandwalla (1977), and subsequent development by Miller and Friesen (1978). The latter authors identified eleven strategy-making process dimensions, including adaptiveness, analysis, integration, risk-taking, and product–market innovation. Later Miller (1983) provided the first explicit operationalization of the EO construct, based on the three dimensions innovation, risk-taking, and proactiveness. Miller's operationalization is the basis of scales used in numerous studies (Table 1). The EO construct is typically treated as a latent variable composed of three highly correlated dimensions, though Lumpkin and Dess (1996) supplemented the original dimensions with "propensity to act autonomously" and a "tendency to be aggressive towards competitors."

Although there is considerable agreement on the fundamental dimensions of an entrepreneurial orientation in the context of large commercial organizations, application of the concept in other organizational contexts remains an underexplored area.

Table 1
Researchers using ENTRESCALE.

Authors (Year)	Scale origin
Lumpkin and Dess (2001)	Covin and Covin, (1990), Covin and Slevin (1986, 1989), Khandwalla (1977), Miller (1983)
Wiklund (1999)	Miller and Friesen (1982)
Becherer and Maurer (1997)	Covin and Slevin (1989)
Miles and Arnold (1991)	Covin and Slevin (1989)
Covin and Slevin (1989)	Khandwalla (1977), Miller and Friesen (1982)
Khandwalla (1985)	Pioneering innovative scale (newly developed)
Ginsberg (1985)	Khandwalla (1977), Miller and Friesen (1982)
Miles and Snow (1978)	Khandwalla (1977)
Miller and Friesen (1978)	Khandwalla (1977)

The scale is not identified by the name "ENTRESCALE" in all of the papers cited in the table. However, the items are the same ones that constitute this scale.

The objectives that guide strategy formulation, characteristics of organization structure and governance, and external market conditions all vary significantly between organizational types. While behaving "entrepreneurially" is frequently cited as an approach to finding innovative solutions to a myriad of problems experienced by public sector organizations, such organizations are also clearly different from those in the private sector. The literature contains evidence that even within the private sector the dimensions of EO can vary in their importance and relationship to each other in complex ways (Richard et al., 2004). For example, Kropp et al. (2008) found that the decision to start an international new venture is positively related to the proactiveness and risk-taking components of EO, while the innovativeness component is not an important factor. Naldi et al. (2007) found that the three dimensions differentially impact the performance of family owned firms. In particular, family firms take fewer risks than do non-family firms. (Indeed, Naldi's findings show that risk-taking in family firms is negatively related to their performance). Coulthard (2007) reviewed four Australian industry studies and found positive correlations between performance and the dimensions of innovativeness and proactiveness, while dimensions of competitive aggression, risk-taking, and autonomy varied in their importance between sectors and over time. These studies and others suggest that the influence of EO is contextual. In addition, the original ENTRESCALE was developed using a relatively small sample of large U.S. and Canadian corporations. Thus, it is prudent to question use of this scale in different organizational contexts, especially ones as distinctive as public universities.

2.2. Entrepreneurial orientation in universities

Declines in per-student government funding, calls for increased accountability, and a focus by governments on the commercialization of research, are forces influencing many public universities to seek more innovative and "entrepreneurial" approaches to diversify revenue and contain costs (Box, 1999). Calls for increased commercialization of university research have become louder, even from within the university sector (Agrawal, 2001; Association of Universities and Colleges of Canada, 1998, 2001R 3150; Conceicao et al., 1998; Expert Panel on the Commercialization of University Research, 1999). Likewise, collaborative efforts between academia, government, and industry are seen as vital for the regional technology development (Johnson, 2008). Commercialization and technology transfer are seen as a way to increase the benefits of universities to the public (Expert Panel on the Commercialization of University Research, 1999), and to help fill the funding gap left by reduced government funding (Association of Universities and Colleges of Canada, 2001). This gap is often supplemented through revenue sharing with inventors, or patent-based royalties (Baldini, 2010).

Historically, technology transfer by Canadian universities was almost exclusively through the patenting and licensing the results of university research (Association of Universities and Colleges of Canada, 2001; Association of University Technology Managers, 2000; Bonaccorsi and Piccaluga, 1994; Johnson and Tilley, 1999). However, more recently universities have played a direct role in venture start-ups (Bray and Lee, 2000; Steffensen et al., 2000), establishing business incubators (Mian, 1994, 1996, 1997; Stevenson and Thomas, 2001), and encouraging university-based consulting (Rainsford, 1992). The Canadian government continues to emphasize and support commercialization efforts of Canadian universities (Rasmussen, 2008). Researchers who collaborate with practitioners are found to have significantly superior research performance compared to researchers who do not engage in such collaboration (Abramo et al., 2009). Some universities combine these activities with their education efforts, resulting in more

applied education programs (Mallick and Chaudhury, 2000; Solomon and Fernald, 1991).

Today there is wide acceptance of the growing importance of university spin-off activity and technology transfer (Bathelt et al., 2010; Hoye and Pries, 2009; Hussler et al., 2010; Linton, 2009; Prodan and Drnovsek, 2010). Although the role of universities is increasingly recognized by governments (Rasmussen, 2008) and perhaps less so by business media (Linton, 2010), changes at public universities still occur relatively slowly.

Much of the existing research in this area examines the interaction between the university and industry, or research commercialization at the university level. Researchers have observed an existence of differentiated tools indentified for technology transfer at the regional level (Hussler et al., 2010), as well as a variety of business models available to transfer an innovation from the academic world to the practitioner realm (Pries and Guild, in press). Some researchers focus on the academic inventor, their intentions (Prodan and Drnovsek, 2010), or their propensity to re-engage in commercialization (Hoye and Pries, 2009). Others focus on the implementation process (Linton, 2002), management team processes, and access to capital (Braunschweig, 2001; Gurdon and Samsom, 2010; Macho-Stadler et al., 2008).

There is a paucity of research examining cultural differences between university departments and their influence on commercialization activities. Cultural differences between universities and commercial entities have also been identified as factors that affect technology transfer (Liyanage and Mitchell, 1994; Samsom and Gurdon, 1993; Todorovic and Suntornpithug, 2008). van Geenhuizen and Soetanto (2009) find that the characteristics of a new venture, and therefore the organizational culture, change with the age of the startup. They discovered that the ability of most academic startups to remain flexible and overcome obstacles decreases significantly about the age of four years. Liyanage and Mitchell (1994) and Samsom and Gurdon (1993) point to the clash of cultures as innovations move from the academic to the practitioner realm. Specifically, Liyanage and Mitchell (1994) indentify the conflict they term the "ideology of production" (p. 643), a state where commercial entities "tend to safeguard available technology" while scientists "advocate introduction of new technology" (p. 643). Likewise, Samsom and Gurdon (1993) indentify a similar clash of business and scientific cultures, which can impede or even dissolve academic-commercial partnerships.

While performance/reward structures and other policies that can incent or discourage entrepreneurial behaviors are typically university-wide, their interpretation and implementation can differ substantially between faculties and departments. Indeed, university departments have a significant influence on the culture, and activities, of their faculty members.

Etzkowitz (2003) characterized university responses to the changing environment in terms of two academic "revolutions". The first revolution involved the introduction of research in addition to the traditional task of teaching in the late 19th-century (Etzkowitz, 1998, 2003, 2000). A second academic revolution occurred recently, adding economic and enterprise development to teaching and research (Etzkowitz, 2003). Etzkowitz (2003) argues that since universities are slow-changing bureaucracies, evidence of the second revolution occurred first at the department level, especially the phenomenon of department based "quasi-firms". Etzkowitz (2003) defines quasi-firms as a "series of research groups that have firm-like qualities (p. 109)", which allow them to function in a more commercial manner. Research groups, institutes, and centers are partly responsible for the heterogeneity in commercial activity observed between departments. Other recent research focused on the role of university culture in commercialization outcomes includes Braunerhjelm (2007) and Arianna et al. (2008). Both identify university culture, weak incentive structures, and badly managed support facilities as barriers to commercialization success, while noting that some departments are better able to overcome these. Similarly, van Burg et al. (2008) recommend that universities "shape a university culture that reinforces academic entrepreneurship by creating norms and exemplars that motivate entrepreneurial behavior", and Hsu et al. (2007) argue that MIT was successful in part because "the culture within MIT faculty encourages entrepreneurship" (p. 1).

3. Developing the ENTRE-U scale

This section reports the development of the ENTRE-U scale to measure the entrepreneurial orientation of university departments. The scale development process follows the steps described by Churchill (1979), with modifications as recommended by Flynn and Pearcy (2001) and Stratman and Roth (2002).

3.1. Generating the items

To generate items for the scale, we interviewed forty faculty members from the disciplines of computer sciences, health sciences, and engineering at four universities in southern Ontario (the University of Waterloo, the University of Guelph, the University of Western Ontario, and McMaster University). Data gathered by the Association of University Technology Managers (2004) show these disciplines are the most likely to commercialize their research in the form of patents/licensing or spinouts. Participants were selected from university websites using the stratified convenience sample approach described by Creswell (1994). Approximately 40% of the participants were heads of a department or research institute/center. The sample included a high proportion of department heads to ensure representation of participants with a thorough knowledge of their organizational context. Participants were asked, "If someone stated that a particular university department is very entrepreneurial, what would that observation mean to you?" Other questions in the survey probed for the perceived advantages and disadvantages of being an "entrepreneurial" department. Interviews were audio recorded and subsequently transcribed and then analyzed using QSR NVivo 6. Todorovic et al. (2005) report the results of the interviews in detail.

3.2. Item generation and purification

Analysis of the interviews yielded 368 codes extracted from the transcripts through *in vivo* coding. As a first step to reduce the number of items, we omitted those with fewer than three text units. This frequency-based approach retained 84 potential items. The interviewees were contacted again to complete an online survey in which they rated the 84 items on their effectiveness in "differentiating university departments that are very entrepreneurial from those that are less so." We also discussed the list of items with 12 heads of a department in a focus group held at the University of Waterloo. At the beginning of the focus group, participants had 10 minutes to rate the items in terms of their ability to distinguish between an entrepreneurial department and one that is less so. Afterward, participants took part in a discussion of each item in terms of suitability, uniqueness, and ability to convey the intended meaning.

Insights gained from the survey of interviewees and the focus group helped to further reduce the number of items and rephrase some items. An issue raised within the focus group was that a number of the items related to university level policies and incentives (e.g., the annual review of faculty members' performance). While we described our intention to focus on the department level, the group recommended retaining these items. University-wide policies can be important incentives or barriers

to the development of an entrepreneurial orientation, and many institutions have some latitude in how policies are interpreted and applied between departments. Appendix A shows the final list of 47 potential items, including those related to university policies. In addition to the potential measures of entrepreneurial orientation, we added an item to test validity ("Our department is very entrepreneurial"), and two measures of potential commercial outcomes of an entrepreneurial orientation (patents and spinouts). Although there are many possible outcomes of an entrepreneurial orientation, we chose to focus on these two metrics of commercialization activity as they are used in previous studies (e.g., Henderson et al., 1998; Jaffe and Lerner, 2001; Zucker et al., 2002). It would be desirable to measure these outcomes from secondary data to avoid concern for biases that could arise in self-reported measures. However, this was not possible because (1) the ethics approval process required us to offer anonymity to respondents, and (2) universities rarely report information on commercialization activity at the department level.

3.3. National survey

To gather data for the statistical analysis of the scale, we conducted an online survey of English-speaking department heads and institute/center directors in the disciplines of computer sciences, health sciences, and engineering at Canadian universities. Targeting department heads is appropriate since the survey concerns department level (rather than individual) variables. Department heads or center/institute directors are analogous to middle managers in the private sector. The use of middle managers (or executive officers) as single informants is common practice in organization research (Allen and McCluskey, 1990; Kwaku, 1996; Nahavand and Chestech, 1988; Pearce et al., 1997; Ruppel and Harrington, 2000). Hambrick (1981) showed that CEOs' and managers' perceptions were closer to a set of objective measures of the same phenomenon than were those of observers with other positions within the organization. Similarly, university department heads (or directors) are likely to have more knowledge about issues affecting the department and the aggregate activities of department members, than is the typical faculty member. Respondents were asked to rate the extent to which the entrepreneurial orientation items described their department on a seven-point Likert scale.

The survey was administered through the Web because of the geographic dispersion of respondents, and to benefit from speed, ease of access, and reasonable cost (Ilieva et al., 2002). The target population consisted of 544 individuals: 290 from health sciences, 79 from computer sciences, and 175 from engineering. Of these, 86 could not be reached by e-mail or telephone. We received 208 responses, representing 45.4% of those contacted. Due to problems with the software, 21 responses were lost, leaving 187 cases for analysis. Based on an examination of the descriptive statistics and distribution of each variable, we eliminated the item "We give faculty members significant freedom to pursue their career goals". A strong negative skew, along with a high mean and small variance (relative to the other items) indicated little difference between university departments in the autonomy afforded faculty members. Several of the items are reverse coded, so we inverted the ratings before including them in the analysis. Appendix A lists all of the items included in the questionnaire, indicates which items are reverse coded, and identifies those items retained in the final scale.

Wave analysis, which assumes that those who return the survey later in the survey process are most like non-respondents, was used to evaluate potential non-response bias (Creswell, 1994). The means of the earliest 25% of responses were compared to the means of latest 25% for all of the variables. In no case were the means significantly different at $p=0.05$, suggesting that both early and late responders belong to the same population. For the analyses reported in the following sections, we tested that the data are missing completely at random, and then replaced the missing values with the mean for the variable.

4. Statistical assessment of the scale

4.1. Exploratory factor analysis

The first step in the statistical assessment of a new scale is typically exploratory factor analysis (EFA) to identify items that share significant variance. However, sample size was a potential problem, especially as we also wished to test factorial validity by dividing the data randomly into a set for exploration and one for confirmatory analysis. With 46 variables remaining after the initial screening, an optimal sample would be considerably larger (e.g., around 300 using the traditional guidance offered by Thompson, 2004). However, Guadagnoli and Velicer (1988) argued that there is no theoretical or empirical rationale for a particular sample size, and their Monte Carlo analysis showed that even small samples could produce stable results if the factor loadings are sufficiently large. Thus, instead of only focusing on sample size, they recommend careful attention to selecting variables that are "heavily saturated with the factors." For reasons related to theory rather than statistical estimation, Churchill (1979, p. 68) cautions against immediately conducting a factor analysis, arguing that correlations between items should first be explored to identify the variables most central to the domain. Thus, we pursued a multiple-step approach to reducing the number of measurement items with the objective of both increasing the ratio of cases to variables, and identifying the set of variables that are most closely associated with each other.

First, we randomly assigned cases to an exploratory (93 cases) and a confirmatory (94 cases) set of data. Using the exploratory data set, corrected item-total correlations were calculated for the 45 potential measures of university entrepreneurial orientation using the exploratory data set. We retained the 23 items with an item-total correlation that rounded to at least 0.5. While it is desirable to have inter-correlation between the variables as a requisite condition for factor analysis, overly strong correlation between two or more variables can lead to the problem of multicollinearity. To check for this, we examined the matrix of bivariate correlations to make sure that none was in excess of 0.9 as recommended by Field (2005).

The 23 items were then subjected to a principal axis factor analysis with oblique rotation. Barlett's Test of Sphericity was statistically significant (1073.57, df=256, $p<0.000$), and the Kaiser-Meyer-Olkin index of 0.82 was "meritorious" (using the thresholds proposed by Kaiser, 1974). Floyd and Widaman (1995, p. 291) summarize the arguments for using principal axis factoring (common factor analysis), especially in the context of developing a reflective scale. An oblique (Promax) rotation allows factors to share variance, which is appropriate in this case, as we anticipated the factors are likely sub-dimensions of a common construct. If the factors are truly uncorrelated, then an oblique or orthogonal rotation will produce essentially the same result, but, to the extent that the factors are correlated, an orthogonal rotation results in a loss of information (Costello and Osborne, 2005).

The analysis identified four factors with Eigenvalues greater than 1.0, and accounting for 54.39% of the variance. The "elbow" in the Scree Plot, and "principle of parsimony" (Handfield and Melnyk, 1998) suggested retaining three factors. However, we decided to favor theoretical richness by retaining all four factors since a large number of items were eliminated in the first stage. The four factor solution also retained the items relating to department perception

of university policies (which loaded together on the fourth factor), and the focus group suggested that this is an important component of university entrepreneurial orientation. Table 2 reports the structure matrix, which shows the correlations between the items and the factors. These coefficients reflect all paths from a variable to a factor, since the factors are themselves correlated. In contrast, the coefficients in a pattern matrix (not shown) are analogous to standardized regression coefficients, and show only the direct path from factor to a variable. In naming the variables and interpreting the factors, we examined both matrices.

4.2. Naming the ENTRE-U dimensions

The exploratory factor analysis suggested that university entrepreneurial orientation consists of four dimensions, measured by six, eight, five, and four items. The first dimension is dominant, accounting for 33.23% of the variance, while the others account for 10.51%, 5.97%, and 4.68%. Table 3 shows that the first three factors are significantly correlated, while the fourth is correlated with Factor 2, but not with Factors 1 and 3. Correlating the *F*-scores of the three factors with the validity check item "Our department is very entrepreneurial" (EO Validity) results in statistically significant positive correlations for all four factors, but the size of the correlation is smaller for the fourth factor. The first three factors also correlate significantly with the two commercialization outcome variables – patents and spinouts – while the fourth factor does not.

Factor 1—Research Mobilization (RM)

Six items correlate strongly with the first factor. The majority of items relate to research—involving external partners in research, and making sure that research outcomes are valued, useful, and shared with industry or other stakeholder groups. We discuss the rational for calling this factor "Research Mobilization" in Section 5.

Factor 2—Unconventionality (UC)

Eight items loaded on the second factor. The associated items relate to identifying opportunities, taking unconventional approaches (to funding, problems, and working with partners), and working outside the traditional university environment.

Table 2
Factor loadings from exploratory factor analysis (structure matrix).

	Factor			
	1	2	3	4
RM1 We encourage our graduate students to engage in research with significant implications for industry or society	**.812**	.417	.519	.017
RM2 We encourage students to seek practical applications for their research	**.777**	.294	.411	.123
RM3 Faculty members in our department emphasize applied research	**.768**	.391	.455	.014
RM4 Compared to other similar departments in our province, our department has a reputation for its contribution to industry or society	**.707**	.675	.524	.238
RM5 Many of our faculty members conduct research in partnership with non-academic professionals	**.699**	.644	.520	−.110
RM6 Our faculty members are expected to make substantial contributions to industry or society	**.534**	.348	.330	.178
UC1 Cooperation with organizations outside the university significantly improves our research activities	.612	**.704**	.446	.173
UC2 Our faculty members often seek research opportunities outside the traditional university environment	.440	**.671**	.428	.016
UC3 We seek significant funding from sources other than the Tri-councils	.280	**.662**	.157	.378
UC4 Compared to other similar departments in our province, our faculty members are known as very efficient and productive researchers	.157	**.648**	.247	.437
UC5 We try to generate off-campus benefits from research projects	.620	**.645**	.309	.074
UC6 Compared to other similar departments in this province, we are good at identifying new opportunities	.238	**.611**	.282	.490
UC7 We support our faculty members collaborating with non-academic professionals	.576	**.577**	.447	-.021
UC8 When we come upon an unconventional new idea, we usually let someone else try it and see what happens (reverse coded)	.216	**.519**	.222	.211
IC1 We encourage industry involvement in the research activities of our faculty members	.543	.330	**.838**	.009
IC2 Our department is highly regarded by industry	.436	.447	**.815**	.097
IC3 We are recognized by industry or society for our flexibility and innovativeness	.505	.604	**.784**	.172
IC4 We believe that our department should build relationships with private or public sector organizations	.494	.395	**.664**	.025
IC5 Our graduate students often secure high quality industry positions	.324	.184	**.637**	.092
UP1 We feel that university-wide policies at this university contribute substantially towards our department achieving its goals and objectives	.138	.344	.199	**.806**
UP2 Our university policies are best described as developed "bottom-up" using feedback from all levels of the university	.153	.244	.112	**.788**
UP3 Compared to most other universities, our university is very responsive to new ideas and innovative approaches	.330	.395	.468	**.613**
UP4 Our department is given significant latitude when evaluating faculty members performance	−.079	.200	−.168	**.455**
Variance explained	33.23%	10.51%	5.97%	4.68%

Extraction method: Principal axis factoring. Rotation method: Promax with Kaiser normalization.

Table 3
Correlations between factor scores and other key variables.

	Factor 1	Factor 2	Factor 3	Factor 4	EOVALIDITY	Patents	Spinouts
Factor 1 (Research Mobilization)	1	.610[a]	.649[a]	.048	.500[a]	.191[b]	.378[a]
Factor 2 (Unconventionality)	.610[a]	1	.536[a]	.323[a]	.597[a]	.374[a]	.531[a]
Factor 3 (Industry Collaboration)	.649[a]	.536[a]	1	.110	.525[a]	.242[b]	.569[a]
Factor 4 (University Policies)	.048	.323[a]	.110	1	.247[a]	.145	.126
EOVALIDITY	.500[a]	.597[a]	.525[a]	.247[a]	1	.320[a]	.438[a]
Patents	.191[b]	.374[a]	.242[b]	.145	.320[a]	1	.561[a]
Spinouts	.378[a]	.531[a]	.569[a]	.126	.438[a]	.561[a]	1

[a] Correlation is significant at the 0.01 level (1-tailed).
[b] Correlation is significant at the 0.05 level (1-tailed).

Factor 3—Industry Collaboration (IC)

This factor consists of five items, all of which relate to cooperation with industry. Items suggest both faculty and student involvement, as well as department level industry cooperation.

Factor 4—University Policies (UP)

Four items loaded on the fourth factor. These items relate to departmental perception of university policies and the extent to which they support departmental aspirations, and incent or impede innovation and unconventionality.

4.3. Confirmatory factor analysis

The pattern of correlation between the four factors suggests considerable common variance between Research Mobilization, Unconventionality, and Industry Collaboration, but less between these three factors and University Policies. Thus, the next step was to use the confirmatory sample and conduct a confirmatory factor analysis (CFA) to test the factorial validity of the EFA results. We used AMOS version 18 to fit a hierarchical series of confirmatory factor analyses as suggested by Koufteros et al. (2009). Table 4 reports the results. In the first model, ENTRE-U is posited to be a single factor with 23 measurement items. Alternative models are compared using a selection of goodness-of-fit measures for each model. Model 4 (second-order CFA model) is a special case of Model 3 (first-order CFA model with four correlated dimensions), with the added restriction of structure imposed on the pattern of correlations among the first-order factors (Byrne, 2010, p. 143). The benefit of characterizing ENTRE-U as a single second-order factor is two-fold: (1) it provides a higher level of abstraction, allowing researchers to focus on the "general construct" (Chen et al., 2006, p. 90), and (2) controls multicollinearity problems that could arise if the four first-order factors are used in a structural model (Koufteros et al., 2009, p. 645). The difference between Models 1 and 4 is of particular interest, for as Widaman (1985) shows; a statistically significant difference demonstrates the discriminant validity of the factorial structure. In this case, the chi-square difference test (described by Mueller, 1996) is significant ($\Delta\chi^2 = 191.56$, df = 4, $p < 0.000$).

Table 5 reports the standardized regression coefficients (or weights) for the individual items, along with two measures of reliability (construct reliability (CR), and Cronbach's alpha (α)), and the average variance extracted (AVE) for each first order factor. The recommended threshold for both CR and α is 0.7 (Hair et al., 2006), and 0.45 for AVE (Netemeyer et al., 2003). The regression coefficients should also be greater than 0.5 and statistically significant. One item is a problem – UP4 "Our department is given significant latitude when evaluating faculty members performance". The standardized regression coefficient for this item is small, and removing the item from the factor results in a substantial increase in CR, α, and AVE. Thus, the final version of the scale omits UP4, resulting in a three item measure of university policies.

Table 4
Differences in fit for alternative CFA models.

	Model 1—one first order factor	Model 2—four first order factors (uncorrelated)	Model 3—four first order factors (correlated)	Model 4—four first order and one second order factor
Chi-square (df)	646.18 (230)	557.75 (230)	448.16 (224)	454.62 (226)
Chi-square/df	2.81	2.43	2.00	2.01
NFI	.50	.57	.65	.65
PNFI	.45	.52	.58	.58
CFI	.60	.68	.78	.78
RMSEA	.14	.12	.10	.10

$\Delta\chi^2$ (Model 4, Model 1) = 191.56, df = 4, $p < 0.000$.

Table 5
CFA reliability analysis.

	Standardized regression coefficient	Measures of reliability
Research Mobilization		CR=.752; AVE=.793; α=.859
RM1	.771[a]	
RM2	.679[a]	
RM3	.738[a]	
RM4	.793[a]	
RM5	.717[a]	
RM6	.565[a]	
Unconventionality		CR=.695; AVE=.752; α=.835
UC1	.648[a]	
UC2	.496[a]	
UC3	.541[a]	
UC4	.646[a]	
UC5	.752[a]	
UC6	.604[a]	
UC7	.685[a]	
UC8	.635[a]	
Industry Collaboration		CR=.782; AVE=.816; α=.859
IC1	.801[a]	
IC2	.812[a]	
IC3	.799[a]	
IC4	.679[a]	
IC5	.624[a]	
University Policy		CR=.594; AVE=.668; α=.745
UP1	.894[a]	
UP2	.693[a]	
UP3	.735[a]	
UP4	.351[b]	CR=.729; AVE=.774; α=.808[c]

[a] Regression weight is significant at the 0.01 level.
[b] Regression weight is significant at the 0.05 level.
[c] CR, AVE and α after removing UP4.

4.4. Predictive validity

The final step in the development of ENTRE-U is to test its predictive validity with respect to commercialization outcomes. To test the relationship, we fit two structural models, each with ENTRE-U as the independent variable and patenting or spinout activity as the dependent variable. Fig. 1 describes the general form of the structural model. Table 6 reports the results. Overall model fit is similar to that of the CFI as this analysis only adds one measured variable. The important observation is that for both dependent variables the standardized regression coefficient is statistically significant, and substantial from a practical point of view. The relationship is much stronger in the case of spinouts, with ENTRE-U explaining 37.4% of the variance, compared to 12.0% for patenting activity.

5. Discussion

While EO is a well-recognized theoretical construct in the literature on corporate entrepreneurship, little is known about the appropriateness of generalizing the construct to other organizational contexts. It is intuitive that what it means to be "entrepreneurial" likely varies between industries and organizational forms. This is especially so when an industry is characterized by a unique organizational form like universities. The research reported in this paper provides support for this assertion, and develops a new scale, ENTRE-U, that successfully predicts spinout and patenting activity in university departments.

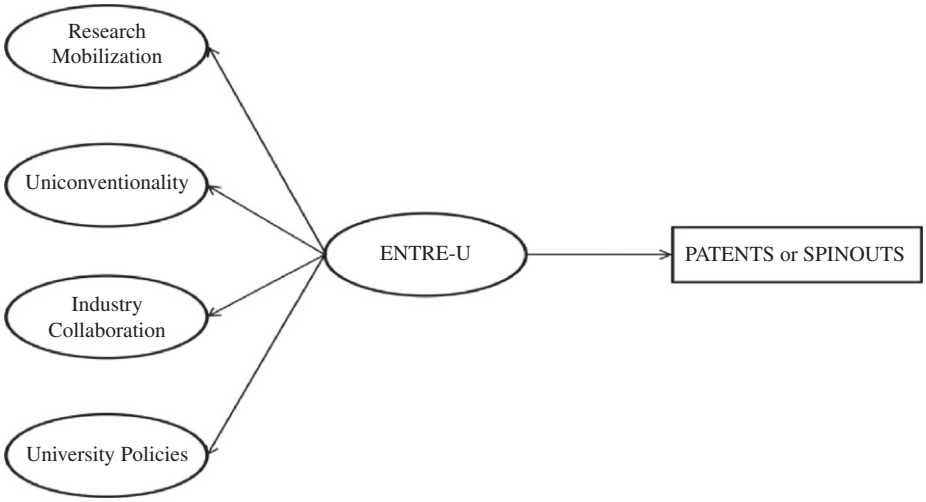

Fig. 1. Structural model.

Table 6
Standardized regression weights for structural model.

	Patents as dependent	Spinouts as dependent
Entre-U– > Industry standardized regression weight	.720[a]	.776[a]
Entre-U– > Unconventional standardized regression weight	.905[a]	.881[a]
Entre-U– > Applied standardized regression weight	.882[a]	.854[a]
Entre-U– > Policy standardized regression weight	.405[a]	.397[a]
Entre-U– > Patents or spinouts standardized regression weight (R^2)	.346[a] (.120)	.612[a] (.374)
Chi-square (df)	481.538 (248)	498.76 (248)
Chi-square/df	1.942	2.011
NFI	.637	.635
PNFI	.527	.525
CFI	.773	.765
RMSEA	.101	.105

[a] Regression weight is significant at the 0.01 level.

Interviews and a confirmatory survey provide data for the statistical development of ENTRE-U. The results suggest that entrepreneurially oriented departments are distinguished from those that are less so by the extent of their research mobilization activities, unconventionality, industry collaboration, and perception of university policies. We chose to call the first dimension "Research Mobilization" in reference to a concept promoted by the Social Sciences and Humanities Research Council (SSHRC), one of Canada's three federally funded granting agencies. SSHRC uses the term to refer to an emerging paradigm for the research process in which researchers engage external stakeholders at all stages of the research process, especially in making sure that research outcomes are communicated to multiple audiences in ways that are easily understood, so the results are more readily transferred and applied by stakeholders. (See Levin, 2008 for a review.) We think this term, while not yet widely used, captures both the research focus and the orientation toward external parties that pervade the items loading heavily on this factor.

Research mobilization fits within the broader concept of "knowledge mobilization" about which there is a developing literature. A review of this literature is beyond the scope of this paper, but Hasan and Crawford (2007) provide a recent overview, arguing that the mobilization concept represents a "shift from the traditional sense of [knowledge] management, to the new concept of enabling people to 'apply their sense-making' (p. 237)." It implies a shift from systems that support knowledge creation and innovation at the level of the individual, to groups, organizations, or communities. This is consistent with the orientation toward stakeholders outside of the academy that pervades the items in this factor, and to a certain extent, Industry Collaboration as well.

The second dimension, which we call "Unconventionality", also focuses on research, especially looking for new opportunities and making sure research is useful and benefits stakeholders. However, the items also suggest doing things that are unconventional, and/or innovative. The items do not directly refer to sources of risk (or what is at risk, for example, reputation, resources, or career advancement). Thus, we chose to call this factor "Unconventionality", rather than retaining the "risk-taking" label used in ENTRESCALE. Many of the items suggest unconventional activities such as seeking research-funding sources other than the Tri-councils, or collaborating with non-academic professionals. (One item includes the word "unconventional", and one includes the phrase "outside the traditional".) To use the scale outside of the Canadian context, researchers should substitute the most common form of research funding in their country for "Tri-councils".

Industry collaboration, the third dimension, refers to the department, faculty, and student engagement with the related industry. Abramo et al. (2009, p. 498) found that "university researchers who collaborate with those in the private sector show research performance that is superior to that of colleagues who are not involved in such collaboration." Further, it is reasonable to assume that departments with closer industry relationships are likely to have lower cultural divergence than those that are not so (Liyanage and Mitchell, 1994; Samsom and Gurdon, 1993).

The fourth factor, department perception of "university policies" also appears to have a role in encouraging university entrepreneurial orientation. The key items relate to the general culture of the university, especially being "responsive to new ideas and innovative approaches", having a "bottom-up" approach to policy development, and good fit between university policies and department objectives.

ENTRE-U successfully predicts department level commercialization activity in terms of both generating spinouts and filing patents. However, ENTRE-U is more strongly related to spinout activity. This difference is not unexpected as creation of a spinout venture and patenting are very different processes and represent different stages (or even types) of commercialization. Table 3 shows that while patenting and spinout activity are significantly

correlated, they only share about 31.5% of their variance. Creating a spinout is more likely to be considered an "entrepreneurial" activity than is filing a patent, so it is logical that this activity would be more strongly related to an entrepreneurial orientation.

5.1. Implications

There is a growing literature about entrepreneurial activity and commercialization within universities (e.g., Agrawal, 2001; Association of Universities and Colleges of Canada, 1998; 2001R 3150; Conceicao et al., 1998; Expert Panel on the Commercialization of University Research, 1999). However, few studies focus on the culture or orientation that facilitates such outcomes, and how this might be developed at the department level. Our results point to the importance of an entrepreneurial orientation as a partial explanation for the heterogeneity between departments, even within the same university, in commercialization outcomes. The implication is two-fold. First, we demonstrate the university entrepreneurial orientation is different from EO in large private corporations. The availability of the ENTRE-U scale may spur additional empirical research on the role of EO in facilitating commercialization and other entrepreneurial outcomes in university departments. This scale may also serve as a starting point for the development of additional scales specific to other organizational contexts, especially in the public sector.

ENTRE-U can be used alongside traditional measures of research and commercialization outcomes to assess the environment for entrepreneurship within a university. The recognition of EO as a second order construct with four inter-related first order dimensions has implications for practical attempts to make universities more entrepreneurial. The observation that the dimensions are separate and, at the same time related, implies that administrators must focus on each of the individual dimensions and encourage their development. Facilitating only one dimension (for example, research mobilization) while discouraging another (for example, unconventionality) will likely lead to an unsuccessful implementation of EO. The finding with regard to department perception of university policies suggests that central administration can influence EO at the department level through policies that facilitate rather than discourage the other dimensions of ENTRE-U.

Table A1
Original scale items.

Items in ENTRE-U
RM1 We encourage our graduate students to engage in research with significant implications for industry or society
RM2 We encourage students to seek practical applications for their research
RM3 Faculty members in our department emphasize applied research
RM4 Compared to other similar departments in our province, our department has a reputation for its contribution to industry or society
RM5 Many of our faculty members conduct research in partnership with non-academic professionals
RM6 Our faculty members are expected to make substantial contributions to industry or society
UC1 Compared to other similar departments in this province, we are good at identifying new opportunities
UC2 We support our faculty members collaborating with non-academic professionals
UC3 We try to generate off-campus benefits from research projects
UC4 We seek significant funding from sources other than the Tri-councils
UC5 Cooperation with organizations outside the university significantly improves our research activities
UC6 Our faculty members often seek research opportunities outside the traditional university environment
UC7 Compared to other similar departments in our province, our faculty members are known as very efficient and productive researchers
UC8 When we come upon an unconventional new idea, we usually let someone else try it and see what happens (reverse coded)
IC1 We are recognized by industry or society for our flexibility and innovativeness
IC2 Our graduate students often secure high quality industry positions
IC3 Our department is highly regarded by industry
IC4 We encourage industry involvement in the research activities of our faculty members
IC5 We believe that our department should build relationships with private or public sector organizations
UP1 We feel that university-wide policies at this university contribute substantially towards our department achieving its goals and objectives
UP2 Compared to most other universities, our university is very responsive to new ideas and innovative approaches
UP3 Our university policies are best described as developed "bottom-up" using feedback from all levels of the university
UP4 Our department is given significant latitude when evaluating faculty members performance. (This item was omitted in the final stage to improve reliability.)
Omitted items
The performance review of our faculty members includes off-campus activities in addition to research, teaching, and service to the university
Our performance review discourages faculty members from co-operating closely with the private sector (reverse coded)
Our university has a department (or group) dedicated to industry/university liaison activities
The proportion of faculty research, teaching, and service contributions can be altered significantly to suit the specific situation of the individual faculty member
We do not encourage industry involvement in our graduate student training (reverse coded)
Our faculty members rarely set up their own companies or professional practices (reverse coded)
Faculty members in our department are very competitive with each other
Our faculty members feel they benefit financially from their research efforts (in addition to their university salary)
We give faculty members significant freedom to pursue their career goals
Decisions made in this department are often made slowly and carefully (reverse coded)
Compared to other similar departments in this province, we act quickly in response to new opportunities
We are often the first to introduce new methods of teaching, courses, or degrees that other universities subsequently adopt
When evaluating the progress of our department, we tend to put more emphasis on external standards rather than internal standards
We believe that partnership with the private sector has potential to reduce the "impartiality and social consciousness" of a university department (reverse coded)
Faculty members in our department are discouraged from setting up their own companies to commercialize research (reverse coded)
In the last 3 years we have made major changes to our course offerings and curriculum
When dealing with challenges, our philosophy is best described as a "live-and-let-live" attitude
In the last 3 years we have introduced no new programs or degrees (reverse coded)
In our department we know the rules and know how to break the rules
Our university rewards faculty members for their entrepreneurial attempts
Our faculty performance evaluation system appears better at penalizing failure than recognizing successes (reverse coded)
When facing a decision that carries some risk, we tend to adopt a "wait-and-see" approach (reverse coded)
Our department encourages "thinking outside the box" even at the risk of failure
Our faculty members are willing to take unconventional approaches when working on research problems

6. Conclusions and future research

Universities are adjusting to recent changes in the economic environment, and expectations for their contribution to innovation and economic development. As government funding becomes scarcer, universities are forced to diversify their revenue sources, become more efficient, and shift resources towards greater commercialization of knowledge. As a response, universities are encouraged to become more "entrepreneurial". The literature on corporate entrepreneurial orientation suggests this strategic approach may benefit universities (as EO correlates with firm performance, especially in hostile environments). Our research provides a definition of what it means to be "entrepreneurial" in the context of a university department, and a scale to measure this orientation.

We show that ENTRE-U successfully predicts commercialization outcomes from computer science, health sciences, and engineering departments. However, the wording of the scale items is not unique to these disciplines, and future research may investigate the entrepreneurial orientation of departments in other disciplines, and other types of outcomes. Similarly, this research can extend to universities in other countries, especially the U.S., and to differences between universities with different governance structures, mandates, or funding levels.

In sum, this study provides a reliable and valid instrument to evaluate entrepreneurial orientation in public universities. Being able to measure the EO of university departments enables research to improve understanding of university organizational culture and the antecedents to commercialization outcomes. By understanding our institutions of higher learning, society will be able to better appreciate, support, and benefit from the resources they bring to the knowledge economy.

Appendix A

See Table A1.

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