Inside multi-disciplinary science and engineering research centers: The impact of organizational climate on invention disclosures and patents

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A B S T R A C T
Much past research on commercialization activities by university scientists and engineers has focused on the role of resources in the extra-organizational commercialization environment, such as the availability of venture capital funding. By contrast, our theoretical and empirical interest was in intra-organizational dynamics impacting the context in which scientists and engineers work. Drawing upon organizational psychology literature on the construct of organizational climate, we posited that researchers working in an intra-organizational climate that supports commercialization and encourages intra-organizational boundary-spanning will be more likely to produce invention disclosures and patents. Our data from 218 respondents at 21 engineering research centers was both multi-method (i.e., qualitative data from interviews, longitudinal archival data, and survey data) and multi-level. Our results showed that an organizational climate characterized by support for commercialization predicted invention disclosures one year later and an organizational climate characterized by boundary-spanning predicted patent awards two years later.

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1. Introduction
Since the early 1980s, US universities have taken an increasing interest in entrepreneurial activities and commercially relevant research that can increase economic growth and promote technological progress. As a result of many factors, such as the Bay–Dole Act, venture capital activity, and major technological advances, many universities are increasingly involved in patenting, licensing, and creating incubators and spin-offs (Rothaermel et al., 2007). A number of scholars have described the growing trend among universities in moving beyond their traditional fundamental research role by engaging in technology commercialization and managing the interface between the university and industry (e.g., Etzkowitz, 2003; Mowery et al., 2004; Siegel et al., 2004).

An exemplar response to this national trend came from the National Science Foundation (NSF) with the formation of the Engineering Research Center (ERC) program in 1985. ERCs are multi-disciplinary university-based research organizations that encourage and facilitate technology commercialization. Past research has provided in-depth case studies mainly of a restricted sample of high-profile institutions such as Stanford (Kenney and Goe, 2004; Powell et al., 2007), University of California, Berkeley (Kenney and Goe, 2004), Johns Hopkins (Feldman and Desrochers, 2004), and MIT (O’Shea et al., 2007). As valuable as those case studies of famous universities are, we found the ERC program appealing as a data collection opportunity because: (1) it is the flagship scheme for federally funded support of engineering research and commercialization in US universities (Perry et al., 2007) and (2) ERCs are located at a broad range of high-profile universities as well as less visible institutions. We believe investigating early stage technology commercialization within heterogeneous ERC settings can inform our understanding of how to best manage and promote commercialization activities among university scientists and engineers.

The ERC program is also a particularly intriguing setting in which to investigate emerging technology commercialization because the NSF has provided large amounts of support for commercialization. Between 1985 and 2006, the NSF funded 41 ERCs, allocating $57 million to those programs (between $1 million and $4 million per ERC per year during 2006 alone). ERC outputs have been substantial. Between 1985 and 2006, ERCs produced 1431 invention disclosures and 528 awarded patents (National Science Foundation, 2007). Because of their unique organizational structure and record of success, ERCs promote highly creative multi-disciplinary research as well as emphasizing commercial applications and technical...
prototypes. Furthermore, ERCs often facilitate multi-disciplinary research and applications by providing organizational structure and infrastructure that supports teams of closely collaborating researchers (Bozeman and Boardman, 2003).

ERC researchers engage in the process of commercialization of a wide range of emerging technologies, such as new human tissues for transplants, sub-surface (below water, ground, or human skin) imaging technologies, and data compression technologies for transmitting digital information. The commercialization “pipeline” begins with a scientific, engineering, or medical discovery that is represented as an invention disclosure. In universities and ERCs alike, it is common for employment contracts of science, engineering, and medical researchers to require inventions to be disclosed to the university for possible intellectual property protection (e.g., patents). Invention disclosure is an early stage of the pipeline most readily controlled by the inventor, whereas a university’s decision to continue to the next stage of the pipeline, filing a patent application, may be influenced by an inventor’s past licensing success or by how favorable the commercial market may appear toward a given technology (Graff et al., 2002). Later stages of the pipeline, including licensing to an existing or spin-off firm, scaled-up product manufacturing, and/or financial liquidity events such as initial public offering or spin-off company sale have increasingly less involvement by academic researchers. For this reason, we focus on the early stages of the pipeline, namely invention disclosure and patenting.

Most research that has examined predictors of invention disclosures and patents has taken an extra-organizational perspective, whereas Rothenberg et al. (2007) called for more research into the intra-organizational processes of entrepreneurial academic units. A number of studies inform our understanding of academic entrepreneurship from the outside-in, examining external factors like the Bayh–Dole Act (Mowery et al., 2004; Shane, 2004), financial support (Coupe, 2003), and university geographical location (Friedman and Silberman, 2003; Powers and McDougall, 2005). But, research on the intra-organizational processes of these academic units is relatively nascent and fragmented. Furthermore, the field may benefit from learning more about flagship units like ERCS, which stand as potential models for universities aiming to straddle the academic-industry divide.

Our work seeks to make a contribution to the technology commercialization and academic entrepreneurship literatures by focusing on the role of organizational climate. Climate is defined as “the shared perceptions of employees concerning the practices, procedures, and kinds of behaviors that get rewarded and supported in a particular setting” (Schneider et al., 1998, p. 151). Although climate is related to the concept of culture, culture refers to a deeply embedded system of shared assumptions, meanings, and values among a group (Schein, 1985), an integrated system of shared social norms (Rappaport, 1999), and a property of the organization (Glisson and James, 2002). In contrast, climate is often viewed as a manifestation of organizational culture, or a perception of the organizational environment through the eyes of the individuals working there (Denison, 1996; Reichers and Schneider, 1990). It has also been suggested that climate is more amenable to empirical summary and testing than culture (Rentsch, 1990). Climate is an important construct for research on invention disclosures and patents because (1) it offers empirical testing of intra-organizational processes that have been described in theory, (2) it can affect the individual performance of scientists and engineers, and (3) it can be directly influenced by managers. Kenney and Goe (2004) called for more research on the specific aspects of climate that influence commercialization.

We propose that a focus on climate can clarify and extend recent work on the social context and intra-organizational processes surrounding university technology commercialization. For example, a scientist’s proximity to commercializing colleagues (Bercovitz and Feldman, 2008; Kenney and Goe, 2004), strength of the university’s technology transfer office (TTO; O’Shea et al., 2007; Siegel et al., 2003, 2004), university support for commercialization activities and information sharing along university-industry or intra-university boundaries (Kenney and Goe, 2004; Siegel et al., 2003, 2004) have all been linked to university commercialization activities. However, we believe this work would benefit from a more cohesive theoretical framework such as that offered by organizational climate. This focus allows us to consider those social context factors through scientist perceptions and empirically examine their relative impact. We also move beyond the TTO’s perspective to consider multiple stakeholders in context (i.e., faculty, industrial liaison officers [ILOs], and administrators). Furthermore, to our knowledge no research has examined these factors in relation to early stages of the commercialization pipeline.

The purpose of the present study was to examine two facets of organizational climate, specifically whether university scientists and engineers are more likely to produce invention disclosures and patents when they perceive support for commercialization and intellectual boundary-spanning. Through interviews with entrepreneurs, scientists, and university administrators, Siegel et al. (2003) found both of these dimensions to be important factors related to university commercialization productivity. Therefore, using both qualitative and quantitative data, we investigated the applicability of these dimensions to ERC productivity. Our theoretical model posits that climate has an influence on disclosures and patents over and above organizational environmental factors. By leveraging multiple data collection methods (i.e., interview, survey, and archival), we were able to garner in-depth understanding of the context and test a relevant, practically useful theoretical model. Interview data highlighted the trends upon which our survey measures were based and provided insight for interpretation of results. Archival data provided a reliable, objective source from which we could empirically test our hypotheses. The survey assessed employee perceptions, which we use as a lens to identify management practices that contribute to commercialization success within ERCS, thereby informing ERC and university administrators alike.

2. Organizational climate perspective on commercialization activity

Organizational climate reflects shared employee perceptions of the organizational context (Schneider et al., 1998). In the organizational climate literature, the basic unit of measurement is the individual whereas the basic unit of analysis is the organizational entity (Joyce and Slocum, 1990). Individual perceptions are empirically aggregated to the organizational-level following the “direct consensus” model (Chan, 1998) in which organizational climate is operationalized as the aggregation of individual-level perceptions as long as those perceptions are shared (Jones and James, 1979). It is important to establish as a threshold that individual perceptions are shared to some extent because climate captures patterns of meaning of organizational features as perceived by employees (Joyce and Slocum, 1990), and within-group agreement of perceptions contributes evidence of construct validity by ensuring we are capturing average perceptions of the group (Ludtke et al., 2007). The justification for within-group agreement can be assessed with established agreement statistics (see Appendix B).

In line with this view, Zohar and Luria (2004) argued that climate is a shared perception in which individuals interpret and make sense of the world around them. Social norms, organizational policies, and procedures provide employees with valuable information about the expectations of role behavior within that particular environment (Zohar and Luria, 2005). Organizational climate can arise when organizational members are exposed to the
same environments, such as when a group of minority employees all endure unjust treatment from a prejudiced supervisor (McKay et al., 2007). Climate can also emerge from social interactions which lead to shared meaning among members (Glick, 1985; Klein et al., 2001).

The organizational climate construct has evolved from a global to a facet-specific construct (Kuenzi and Schminke, 2009), with increasing attention on facet-specific climates, such as climate for innovation (Anderson et al., 1990), climate for service (Schneider et al., 2005), and safety climate (Zohar and Lucia, 2005). Several researchers have argued in favor of the value of facet-specific over global climate as a way to overcome past definitional obstacles associated with global climate (Anderson and West, 1998; Rousseau, 1988; Schneider, 1975). Recent research on corporations has demonstrated the predictive power of facet-specific climates, such as climates for innovation, initiative, and psychological safety, in relation to organizational performance (Baer and Frese, 2003; Jung et al., 2008).

With regard to organizational climate and technology commercialization, Roberts (1991) argued that social norms and university role expectations have a determining influence on the commercialization activity of scientists and engineers. Individual science and engineering researchers, the primary instigators of the technology commercialization pipeline, are likely to act in ways that are influenced by their organization’s norms, policies, and procedures. Those researchers who perceive social norms and policies that promote commercialization are hypothesized to be more motivated to engage in invention disclosure and patenting activity (Roberts, 1991). Indeed, it may be possible that shared individual perceptions, when considered in an organizational climate framework, are more important for the management of commercialization than extra-organizational environmental antecedents, such as the availability of venture capital, because researchers’ perceptions are more proximal causes of their own behavior leading to disclosure and patenting activities. Environmental (e.g., geographical or market) factors, on the other hand, may be more distal causes of researchers’ behaviors.

As a first step in our research, we collected extensive qualitative data, to ensure our grasp of the organizational context of ERCS, their leaders, and researchers. Between January and September 2005, we spent 135 person-hours conducting semi-structured, face-to-face and telephone interviews with 75 ERC leaders and faculty members from 21 ERCS around the U.S. Beyond these interviews, we spent 40 person-days visiting ERCS and attending three annual ERC conferences (in 2004, 2005, and 2006). We observed the heterogeneity of organizational climates in ERCS, which we discuss in detail later. Our theoretical model and hypotheses were derived both from existing research literature and from our observations and interviews. This strategy is based on the discovery-justification-discovery cycle, which combines qualitative and quantitative data (McCall and Bobko, 1990) and which Currall et al. (1999) describe as a process in which “qualitative data contributed to our thinking about the hypothesis, quantitative analyses indicated that the hypothesis needed refinement, and our qualitative data then were used a second time to interpret the analyses” (pp. 29–30).

3. Theoretical model and hypotheses

In the following sections, we elaborate upon two distinct climate facets: namely, intra-organizational (i.e., intra-ERC) commercialization-support climate and intra-organizational boundary-spanning climate, which we identified from the existing literature (Kenney and Goe, 2004; Siegel et al., 2003, 2004) and confirmed in our interviews. We posit that these climate constructs have an influence on invention disclosure and patent activities over and above environmental factors.

3.1. Commercialization-support climate

This climate facet is defined as organizational members’ shared perceptions concerning the organization’s provision of support for commercialization. While similar to climate for innovation (Anderson et al., 1990), commercialization-support climate is a distinct construct. Climate for innovation is defined as “the shared perceptions of location members concerning the practices, procedures, and behaviors that promote the generation, introduction, and realization of new ideas” (Van der Vegt et al., 2005), and it is positively correlated with individual innovative behavior (Scott and Bruce, 1994), general innovativeness of the organization (Ekvall, 1996), demographic diversity (Van der Vegt et al., 2005), and new product development (Cooper et al., 2004). Whereas climate for innovation focuses on the generation of new ideas prior to initiating the commercialization pipeline, we examine a climate that describes the organization’s support for moving an idea toward a viable product by helping researchers engage in the commercialization pipeline, from basic and applied research on an idea to invention disclosure to patenting. Therefore, support for commercialization climate is more proximal to commercialization outcomes than climate for innovation, which is primarily focused on initial idea generation. In this way, we extend previous work on innovative climate (Isaksen and Lauer, 2002; Isaksen et al., 2001; Van der Vegt et al., 2005) to explicate the effect of climate on the commercialization pipeline beyond idea generation.

An institution supportive of commercialization is characterized by top leadership, academic policies, procedures, and normative expectations that encourage the commercialization of innovations (Kenney and Goe, 2004). Siegel et al. (2004) describe university administrators cultivating a climate of support for commercialization by making technology commercialization an organizational objective, monitoring commercialization performance, and incorporating commercialization into standards for promotion and tenure. For example, Roberts (1991) and O’Shea et al. (2007) suggest that MIT is the highest producer of spin-off activity because the university supports commercialization through entrepreneurship programs and rewards for commercialization productivity. By contrast, a university that fails to reward faculty commercialization can inhibit such activity (O’Shea et al., 2008; Stuart and Ding, 2006). Furthermore, support by peers and/or a department chair who actively engage in technology commercialization increases the likelihood of a researcher also participating in technology commercialization and entrepreneurship (Bercovitz and Feldman, 2008; Stuart and Ding, 2006), which scholars explain through the process of social learning (Bandura, 1977).

Our interview data suggested that support for commercialization may come from four sources in the ERC, including the: (1) administrative structure, (2) industrial liaison officer (ILO), (3) affiliated university’s TTO, and (4) affiliated university community (e.g., university incubators and alumni who provide management talent). Table 1 provides illustrative quotes from our interviews for each aspect of the overall commercialization-support climate.

During our site visits to ERCS, we discovered that technology commercialization-support is reflected in the center’s leadership and academic structure. For instance, we observed evidence in favor of Bercovitz and Feldman’s (2008) findings that technology commercialization performance was affected by how often a researcher’s department chair and other departmental members were involved in commercialization activities. Researchers who perceived commercialization support from their laboratory were often more likely to engage in such activities, even if commercialization had not been their priority before joining the ERC (see also
Kassicieh et al., 1996). It was often the case that ERC support personnel helped with the administrative processes required in filing an invention disclosure or patent application.

ERC members also reported receiving commercialization support from their ILO. Research has shown that successful commercialization of academic science and engineering research requires bridging between academia and industry (O’Shea et al., 2008; Roberts, 1991; Thursby and Thursby, 2004); the ILO provides the primary bridge between the ERC and industry. For instance, to encourage increased commercialization, some ILOs hold informative seminars for faculty to discuss the process, share success stories, and seek insight from experts. Furthermore, some ILOs actively seek potential licensees in industry, using marketing campaigns to highlight the portfolio of ERC innovations. In our interviews, many faculty members expressed the benefits of having a supportive ILO.

An ERC’s relationship with its TTO can foster faster processing times or more careful consideration of patent filings. It is typical for TTOs to coordinate the efforts of faculty members who are aiming to commercialize their research (Graff et al., 2002). In our interviews, we found that, when a TTO was perceived as having a customer-service orientation, researchers were more likely to pursue invention disclosure and patent activities. Furthermore, if a TTO is organized, well-funded, and knowledgeable, it is better able to process paperwork and pursue commercialization. Based on their experiences in working with effective versus ineffective TTOs, many of our interviewees emphasized the dramatic impact that an effective TTO can have on the commercialization process.

Finally, there are a number of ERCs in local university communities that provide assistance for commercialization. For instance, a local incubator established by a university in partnership with local entrepreneurs can assist ERC members in establishing start-up companies to license patented technology. University alumni networks can also provide commercialization advice or management talent for spin-offs. ERC researchers who enjoyed these resources appeared more receptive to and involved in commercialization activities than researchers whose university communities offered fewer resources. Thus, we posit that an organizational climate that is supportive of commercialization, embodied in administrative structures, the ILO, the TTO, and the university community, will be associated with faculty engagement in commercialization activities – namely, invention disclosures and patents.

**Hypothesis 1.** A commercialization-supportive climate is positively associated with invention disclosure and patent activities.

### 3.2 Boundary-spanning climate

We define boundary-spanning climate as organizational members’ shared perceptions of the practices, procedures, and behaviors that promote intra-organizational information flow and collaboration. Boundary-spanning theory (Adams, 1976) posits that interactions and communications among parties across inter- and intra-organizational borders allows for information transfer among teams, departments, or functions (Aldrich and Herker, 1977). Boundary-spanners are individuals who serve the primary purposes of promoting interactions and information flow – as well as...
as managing conflicts – across group boundaries (Adams, 1976; Callister and Wall, 2001; Tushman and Scanlan, 1981).

In science and engineering research organizations, boundary-spanning is integral to the development of innovations. Hargadon and Sutton (1997) described how one particular product design company serves as a technology broker, able to navigate boundaries and produce innovations that combine multiple creative ideas. In the same way, individual researchers may serve as boundary-spanners among separate groups of researchers (e.g., across academic disciplines, research institutes, laboratories, or universities) in fostering innovations. In fact, multi-university research teams are the fastest growing type of research collaboration (Jones et al., 2008). The boundaries in an innovation-oriented organization are often quite porous, which allows for a steady flow of information among groups and among internal and external group members. Siegel et al. (2004) emphasized the critical importance of TTO manager boundary spanning between scientists and industry partners for successful commercialization within a university. Finally, according to Owen-Smith and Powell (2003), social networks benefit from more open access to knowledge and information across boundaries.

Our interview data suggested that three aspects of boundary-spanning climate were present to varying degrees in the ERCs: (1) perceptions of the degree of collaboration within an ERC, (2) perceptions of organizational structures that promote collaboration, and (3) perceptions of research spanning multiple academic disciplines. Table 1 provides illustrative quotes from our interviews for each dimension of boundary-spanning climate.

The first dimension refers to the degree of boundary-spanning activity among research thrusts. A “thrust” is a research team with a shared research objective tied to an explicit ERC goal, within which there are numerous specific project groups. Most ERCs have between three and six thrusts that may collaborate primarily through sharing research findings and ideas. We learned from our interviews that student, post-doctoral, and senior faculty researchers are more likely to cross thrust boundaries than tenure-track faculty, lecturers, instructors, or visiting personnel. They may do so for the purposes of idea generation or cross-pollination, obtaining feedback, and/or testing new technologies in multiple research domains.

The second dimension refers to the degree to which the ERC structure encourages collaboration across boundaries. We observed dramatic differences across ERCs in the way research thrusts – and projects within thrusts – were structured. Some ERCs defined thrusts that focused on only one stage of research (e.g., fundamental research versus commercial testbed application of research findings). In those ERCs, collaboration occurred across thrusts as they handed off research deliverables to those involved in the subsequent activities. Other ERCs structured their research thrusts in such a way that the same researchers remained with a project from fundamental research through to its commercial testbed. For these ERCs, collaboration occurred across thrusts only to the extent that content was relevant to multiple research domains. Some ERCs also had formal structural mechanisms in place, such as committees monitoring collaboration or formal mentoring relationships among students, junior faculty, and senior faculty. These structures encouraged increased collaboration by facilitating increased informal information flow across thrust boundaries.

The third aspect of boundary-spanning climate – collaboration across multiple academic disciplines – was a commonly mentioned advantage of working in an ERC. The researchers we interviewed repeatedly mentioned the value of considering ideas and processes from the distinct viewpoints of a variety of disciplines when pursuing highly complex science and engineering research. ERCs are funded by the NSF because they propose research goals that can best be accomplished through multi-disciplinary collaboration. Most ERCs, therefore, were founded as a strategic partnership between two or more universities or departments (e.g., medicine and engineering), representing two or more disciplines.

We posit that all three aspects of boundary-spanning climate influence commercialization activities (i.e., invention disclosures and patenting) similarly – by expanding the breadth of knowledge available to each research team. Bringing together diverse points of view increases the effectiveness of complex problem-solving (van Knippenberg et al., 2004). In addressing highly complex research problems, research teams that cross the boundaries of their own group to gather information from other teams, individuals, and disciplines are likely to benefit from such knowledge transfer and produce relevant research outputs that are well-positioned to progress through the commercialization pipeline.

During our interviews, we found that intra-ERC (i.e., intra-organizational as opposed to inter-organizational) collaboration was most common and most salient in the minds of ERC researchers. ERC members were much more likely to engage in research collaboration with members of their own ERC, whereas collaboration between ERCs was typically more administrative than research-oriented (e.g., consulting with other ERCs on structure or reporting issues). Therefore, we posit that researchers who perceive a strong intra-organizational boundary-spanning climate within their ERC will be better equipped (e.g., with information from colleagues in other research domains) and thus more willing to create, disclose, and patent innovations.

Hypothesis 2. Boundary-spanning climate is positively associated with invention disclosure and patent activities.

3.3. Environmental controls

In line with past research on predictors of commercialization activities by scientists and engineers, we also considered two extra-organizational environmental factors as controls in our model: financial munificence and industry involvement. We included these variables in our model for two reasons. First, past research has emphasized environmental antecedents, so including these variables meant that we could formulate a more comprehensive theoretical model. Second, including environmental factors in our model enabled us to test the possibility that organizational climate dimensions have an impact on invention disclosure and patent outcomes over and above environmental factors.

Financial munificence is the most commonly examined environmental predictor in the commercialization literature (Dess and Beard, 1984; Starbuck, 1976). The availability of funding (e.g., venture capital) for emerging technologies has been linked both to technology success (Kumar and Jant, 2003) and to the likelihood that a patent will be licensed (Shane, 2002). Research has also shown that funding and venture capital resources influence spin-off success (O’Shea et al., 2005, 2008; Shane and Stuart, 2002).

Industry involvement refers to the formal relationships through which industry representatives participate with academic researchers in the research process, either through joint research projects or via an advisory role. Such involvement in university research provides researchers with knowledge of industry standards, customer needs, and competitive products, as well as channels through which to introduce products to commercial markets. Increased collaboration between researchers and potential future licensees and/or end-users increases the relevance and usefulness of new technologies, thereby increasing the probability of successful commercialization. Thursby and Thursby (2004) surveyed 112 firms that engaged in licensing relationships with universities and found that formal and informal faculty–firm collaboration was important to the licensing process.
Relationships with industry have also been shown empirically to improve patent rate (Stuart, 2000), and the existence of social networks among the spin-off founders to predict spin-off success (Shane and Stuart, 2002; Stuart and Ding, 2006).

4. Methods

4.1. Participants

Two hundred and eighteen participants from 21 ERCs, including faculty members, ERC leaders, ILOs, and post-doctoral researchers, completed an online survey in December 2005, representing an overall response rate of 26%. On average, 10 people responded from each ERC (ranging from 5 to 26 respondents per ERC). The sample was 21% female, 74% Caucasian, 21% underrepresented minority (i.e., Asian, Hispanic, and African-American), which was similar — although not identical — to the entire ERC population (26% female; 93% Caucasian, 7% underrepresented minority). Forty percent of respondents were faculty members, while 21% were members of the administrative leadership team (i.e., director, assistant director, ILO, or educational director) and 51% had a research-leadership role, such as testbed, thrust, or project leader. Some respondents fit into more than one category (e.g., faculty and thrust leader).

4.2. Measures

We used ERC annual reports to collect data for invention disclosures and patents awarded in two consecutive years following the survey (2006 and 2007). These organizational-level outcome data were available for 18 ERCs of the 21 in 2006 and for 13 ERCs in 2007 (three and five ERCs graduated from the ERC Program in 2005 and 2006, respectively).

For climate, we surveyed individual-level perceptions in 2005, which were aggregated to create climate constructs. We developed a total of 18 items based on previous literature and our qualitative data from ERCs (see Appendix A for items). We assessed commercialization-support climate by asking respondents about the level of the commercialization-support they received from four sources: the ERC, the ILO in the ERC, the TTO at their employing university, and the university community. Nine items assessed these four dimensions (α = .87). We also assessed three dimensions of boundary-spanning climate using nine items (α = .90). Items used a 7-point response scale, with verbal anchors ranging from “Strongly Disagree” to “Strongly Agree.” We conducted confirmatory factor analyses on both climate measures to establish the factor structure (see Appendix B). See Table 2 for descriptive statistics of the climate items by ERC.

We obtained our control variables using archival ERC annual reports from 2001 through 2005. Financial munificence reflected the level of financial resources garnered from outside the ERC that are available for innovation-related activities. We calculated values for each ERC by totaling the dollar amount received for technology commercialization and industrial collaboration activities divided by 100,000. Sources of such funding included grants, industry affiliate companies, collaborating universities, government agencies (e.g., NSF), and any other entity that contributed to the ERC budget.

We assessed industry involvement across two dimensions. First, “virtual industry involvement,” which reflected the collaboration of industry firms, calculated as the percentage of industry firms formally supporting technology transfer projects or participating through membership on ERC advisory boards. This variable did not, however, include the kind of in-depth, face-to-face collaboration of our second industry involvement dimension: “on-site industry involvement.” This dimension reflected face-to-face collaboration among industry and ERC representatives in ERC research projects. It was calculated as the percentage of industry personnel actually working at the ERC. Because of the substantial variance in the number of industry partners across ERCs, when creating each variable, we controlled for the total number of industry partners (i.e., using percentages of the total number of industry partners).

When examining invention disclosures as the commercialization outcome, we used organizational environment data from 2005, because there is only a relatively short timeframe between a scientific or engineering discovery being made and an invention disclosure being filed. However, when patents were modeled as the commercialization outcome, we used environmental data from 2001 to 2005, because the eventual content of a patent can often be affected by environmental conditions over several years before the patent is awarded.
Although a number of other controls may be relevant to the production of invention disclosures and patents, including research field of an ERC, ERC age, and regional location (e.g., host university in urban city vs. university town), these were not significantly correlated with our dependent variables and they did not change the results when included in the statistical tests. Therefore, in line with Becker’s (2005) recommendations, we did not include them in our empirical model. However, ERC age is discussed later as part of our outlier analysis.

5. Results

Results supporting aggregation of our survey data are presented in Appendix B. Table 3 presents descriptive statistics and correlations. We tested Hypotheses 1 and 2 using negative binomial regression, by examining the relationships between climate variables and disclosure and patent outcomes, while controlling for organizational environment. Negative binomial regression is the appropriate technique for count variables whose distributions are overdispersed and bounded on one end by zero but are not distributed in a strict Poisson distribution (Cameron and Trivedi, 1998). We found that commercialization-support climate assessed in 2005 predicted invention disclosures in 2006 (b = 1.49, p < .01; see Model 2 in Table 4). Similarly, boundary-spanning climate assessed in 2005 predicted patent awards in 2007 (b = 3.42, p < .05; see Model 12 in Table 5). Hypotheses 1 and 2 were partially supported. Fig. 1 provides a summary of our findings.

Because we used negative binomial regression, the impact of each variable is interpreted using incident rate ratios (IRRs), rather than unstandardized regression coefficients (Cameron and Trivedi, 1998). IRRs can be interpreted as follows: as the independent variable increases by one unit (i.e., one Likert-scale increment) controlling for all other predictors, the dependent variable is expected to change by a factor of IRR. Therefore, as commercialization-support climate increases by one unit (e.g., “Agree” to “Strongly Agree”), the number of invention disclosures is expected to increase by a factor of 4.44. Similarly, as boundary-spanning climate increases by one Likert-scale unit (e.g., “Agree” to “Strongly Agree”), the number of patents is expected to increase by a factor of 30.57.

Large IRRs often result from the presence of outliers. We therefore urge caution in interpreting these figures as literal effect sizes. Some ERCs were particularly successful at filing invention disclosures and patents, while others had a notable lack of these outcomes. In the following section, therefore, we supplement our hypothesis tests with qualitative data from our interviews and further quantitative data, in order to suggest what other additional factors may explain why some ERCs are more productive than other ERCs.

5.1. Outlier analysis

We anticipated that two types of outliers may have affected our results: ERC maturity (a within-ERC characteristic) and non-climate characteristics (a between-ERC dynamic). First, ERC maturity (i.e., age since founding) may have influenced how well ERCs performed in terms of invention disclosures and patents. For instance, we expected that, as an ERC matures, its support staff will become more adept at harvesting technology commercialization outcomes such as invention disclosures and patents. This is probably a function of

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1 We also tested the possibility that climate acted as a mediator in the relationship between organizational environment variables and commercialization. However, results demonstrated that none of the environment variables significantly predicted climate, and thus mediation was not supported.
Table 4
Negative binomial results for invention disclosure outcomes.

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<th>Independent variable</th>
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<td></td>
<td>Invention Disclosures 2006</td>
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<td>Model 1</td>
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<td>Environmental controls</td>
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<td>Financial Munificence 2005</td>
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<td>Incident rate ratio</td>
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<td>Virtual industry involvement 2005</td>
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<td>Regression coefficient</td>
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<td>On-site industry involvement 2005</td>
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<tr>
<td>Regression coefficient</td>
<td></td>
</tr>
<tr>
<td>Incident rate ratio</td>
<td>4.44</td>
</tr>
<tr>
<td>Intra-organizational boundary-spanning climate</td>
<td></td>
</tr>
<tr>
<td>Regression coefficient</td>
<td>0.32</td>
</tr>
<tr>
<td>Incident rate ratio</td>
<td>1.38</td>
</tr>
</tbody>
</table>

Note. The incident rate ratios (IRRs) are interpreted as follows: As the independent variable increases 1 unit (i.e., 1 Likert-scale increment) while controlling for all other predictors, the dependent variable is expected to change by a factor of IRR.
N = 18 for Invention Disclosures 2006.
N = 13 for Invention Disclosures 2007.
″ Bonferroni correction p ≤ .01.

We used both our qualitative and our additional quantitative data to further examine these within-ERC and between-ERC factors.

5.1.1. ERC maturity
While age was not statistically significant when we included it as a control in our negative binomial regression models, our impression from our qualitative data was that ERCs evolve and develop over time in ways that may impact these outcomes. To further quantitatively examine a maturity dynamic, we calculated the average within-ERC zero-order correlation for age and each dependent variable. Age was significantly correlated with patents awarded (r = .36, p < .01), but not with invention disclosures (r = .15,

deepling relationships among ERC researchers, ERC support staff, and university technology-transfer professionals. Second, ERCs may possess other characteristics that explain innovation success beyond our hypothesized climate predictors and environmental controls. Specifically, we explored two possibilities. First, perhaps the ILO, who acts as a bridge between technology transfer and researchers, influences disclosure and patent productivity. Second, perhaps the industry emphasis (i.e., an ERC’s host university’s commitment to engaging with industry) may explain why some ERCs are more successful than others at filing disclosures and patenting. Those examinations enabled us to address possible alternative explanations for results from the statistical tests of our hypotheses.

Table 5
Negative binomial results for patent award outcomes.

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 7</td>
</tr>
<tr>
<td>Environmental controls</td>
<td></td>
</tr>
<tr>
<td>Financial Munificence 01–05</td>
<td></td>
</tr>
<tr>
<td>Regression coefficient</td>
<td>0.30′</td>
</tr>
<tr>
<td>Incident rate ratio</td>
<td>1.35</td>
</tr>
<tr>
<td>Virtual industry involvement 01–05</td>
<td></td>
</tr>
<tr>
<td>Regression coefficient</td>
<td>1.42</td>
</tr>
<tr>
<td>Incident rate ratio</td>
<td>4.14</td>
</tr>
<tr>
<td>On-site industry involvement 01–05</td>
<td></td>
</tr>
<tr>
<td>Regression coefficient</td>
<td>−5.06</td>
</tr>
<tr>
<td>Incident rate ratio</td>
<td>0.01</td>
</tr>
<tr>
<td>Climate predictors</td>
<td>Commercialization-support climate</td>
</tr>
<tr>
<td>Regression coefficient</td>
<td></td>
</tr>
<tr>
<td>Incident rate ratio</td>
<td>11.36</td>
</tr>
<tr>
<td>Intra-organizational boundary-spanning climate</td>
<td></td>
</tr>
<tr>
<td>Regression coefficient</td>
<td>1.92</td>
</tr>
<tr>
<td>Incident rate ratio</td>
<td>6.82</td>
</tr>
</tbody>
</table>

Note. The incident rate ratios (IRRs) are interpreted as follows: As the independent variable increases 1 unit (i.e., 1 Likert-scale increment) while controlling for all other predictors, the dependent variable is expected to change by a factor of IRR.
′ p ≤ .05.
ns). The significant correlation for patents was consistent with our qualitative data, which suggested that ERC age does in fact matter. Perhaps this was true with respect to patent productivity because patents take far longer to achieve than do invention disclosures. The process by which patents are awarded often requires more time and numerous interdependencies among universities, researchers, lawyers, and government agencies. Taken together, our qualitative data and quantitative descriptive data suggest that a relationship exists between ERC age and patent productivity, yet not between ERC age and invention disclosures.

The between-ERC dynamic we explored was the possibility that ERC outliers possess non-climate characteristics that were not included in our primary quantitative analyses. In separate outlier analyses we found one outlier ERC for invention disclosures (ERC1 Invention Disclosures: Studentized Residual = 2.44, DFFITS = 2.19, Cook’s D = 1.20) and two outliers ERCs for patents (ERC1 Patents: Studentized Residual = 1.72, DFFITS = 0.56, Cook’s D = 0.12; ERC2 Patents: Studentized Residual = 1.71, DFFITS = 0.59, Cook’s D = 0.14). ERC1 was the same organization for both invention disclosures and patents. The existence of outliers suggests that other between-ERC factors may enable some ERCs to achieve more success than others.

But what was “special” about the outlier ERCs? To explore this further, we returned to our interview data and identified two possible non-climate factors that may have impacted why the outlier ERCs exhibited more success than other ERCs: ILO job behaviors and the ERC’s host university’s industrial emphasis.

5.1.2. ILO job behaviors
We spoke extensively with ILOs from every ERC and observed significant variance in the specific job behaviors, or emphasis, of each ILO. A number of ILOs saw their primary role as building industry relationships. Other ILOs acted primarily as a facilitator between individual ERC researchers and the TTO, making technology commercialization processes seamless for researchers. Although these two approaches may have increased invention disclosures and patents in some ERCs, we posit that a comprehensive approach, emphasizing both sets of behaviors, may have contributed to the higher productivity of the outlier ERCs. In particular, the outlier ERCs’ ILOs positioned themselves as evangelists of the value of technology commercialization and as providers of resources to researchers, the TTO, and industry in order to orchestrate effective collaboration among all participants. One ILO, in noting his role of translator among industry, the TTO, and researchers, stated: “Well, you people in industry, you’re looking for solutions. We in academia have solutions and we’re looking for problems.” Both ILOs proactively forged relationships with other departments in the university, which promoted technology-commercialization processes, garnered resources for these processes, and developed entrepreneurial attitudes among scientists and engineers (e.g., encouraging collaboration with business and law schools). They also comprehensively built relationships with entrepreneurs and organizations, offering entrepreneurial resources and management talent. We believe that this comprehensive and multi-dimensional approach may have been a key ingredient in the recipe for disclosure and patent success exhibited by the outlier ERCs.

5.1.3. Host university’s industrial emphasis
Finally, the ERC’s host university’s industrial emphasis, or the value placed by the host university on linkages with industry, may explain why some ERCs were more successful. When the host university is committed to industrial collaboration, this appears to help ERCs more successfully engage with industrial partners, including potential investors and licensees. Both outlier ERCs in our study,
for instance, made a conscious effort to foster a collaborative tone with industry, which was a reflection of the general emphasis of the university. This university emphasis, in turn, permeated throughout ERC leaders and researchers at all ranks. Examples of efforts by universities and ERCs included open, non-confidential sharing of intellectual property among partner companies and “front door” resources that gave industry a clear avenue for initiating contact with the university and/or the ERC. For instance, one ILO noted that his university’s image was “non-confrontational and more cooperative with industry.”

6. Discussion

Unlike previous research on technology commercialization, which has focused on extra-organizational environmental resources (e.g., availability of venture capital funding and industry support), our results emphasized features of the organization in which scientists and engineers work. Based on our analysis of multi-disciplinary university science and engineering research centers, our findings show promise for future avenues of research on emerging technology commercialization by demonstrating that shared researcher perceptions, in the form of organizational climate, are associated with invention disclosure and patent activity.

Assessment of organizational climate provides information regarding how individuals perceive and process the environment around them, which can influence decisions about what, when, and how often to engage in commercialization activities. In particular, we built on a growing body of literature that examines facet-specific climate dimensions (e.g., Schneider et al., 2005; Zohar and Luria, 2005), by showing that two facets of organizational climate have differential effects on early phases in the commercialization pipeline. We hope our work spawns a new stream of research that further explores how organizational climate drives the commercialization of scientific and engineering discoveries.

We found that climate had a sizeable direct association with disclosure and patent outcomes when controlling for environmental factors. Commercialization-support climate was related to invention disclosures one year later, while boundary-spanning climate was related to patent awards two years later. Inventors were therefore likely to generate more early-stage commercialization outputs when they perceived an atmosphere that was supportive of commercialization and provided opportunities to span the research project, thrust, and boundaries of academic disciplines.

An alternative explanation for our results might be that some ERCs attract faculty who are outstanding in their fields and therefore inclined to commercialize regardless of the climate of the ERC. We believe that explanation is implausible, however, for two reasons. First, our extensive qualitative data, and one co-author’s direct experience as a participant in the process of writing an NSF research center funding proposal, demonstrate that ERC faculty composition is not based on expected commercialization productivity (i.e., invention disclosures and patents). Rather, faculty members are invited to join the proposal-writing process (i.e., become ERC members) based on the relevance of their research activities to the intellectual focus of the proposal.

Second, if our findings were a function of ERCs attracting only the most commercially productive researchers, we would expect that the most productive ERCs in our study would be those based at universities that rank highest nationally in terms of commercialization outputs (for both invention disclosures and patents). To the contrary, the top-performing ERCs in our study were not hosted by the most commercially productive universities, as reflected in the Association of University Technology Managers annual commercialization survey (AUTM, 2007). Indeed, the host universities of the top two highest-performing ERCs in our study were not ranked particularly high in the annual AUTM surveys, while the host universities of other mid- or low-performing ERCs in our study were consistently ranked near the top of the AUTM list. Both our qualitative data and our examination of the AUTM data suggest that our results cannot be explained as a function of ERCs comprising only the most commercially active faculty members.

6.1. Theoretical implications

There are several theoretical reasons why we believe commercialization-support and boundary-spanning climate were differentially related to invention disclosures and patents. Commercialization-support climate was linked to invention disclosures but not patents, which may have been due to the inventor’s extent of control. Inventors have greatest control over the decision to file an invention disclosure at the earliest stage of the commercialization pipeline. Researchers who feel that their organization supports and encourages commercialization (as opposed to only supporting research publications) are more likely to go to the effort of filing a disclosure. Furthermore, academic researchers who have the support of their ILO and TTO will more likely have access to the resources needed to file invention disclosures. Thus, commercialization-support climate had the strongest association with the earliest stage of the commercialization pipeline, which also explains why this effect occurred over the short time-span of only one year that we examined in our study.

Commercialization-support climate may be less likely to relate to patents, since patent awards are much less within the control of the inventor. Even if an inventor perceives support from the ERC, ILO, TTO, and university environment, many other factors influence whether or not a patent is awarded. Examples include novelty of the invention, backlog of patent applications, efficiency and effectiveness of the TTO, and industry trends. Simply supporting an inventor in the patenting process does not guarantee that it will result in a patent award.

Although boundary-spanning climate was not found to have a significant association with invention disclosures, it was linked to patents awarded two years later. Boundary-spanning climate probably related to patent awards because ideas and research that cross project and academic-discipline boundaries may be more novel and thus more likely to receive a patent. Complex problem-solving is more successful when diverse viewpoints are considered (van Knippenberg et al., 2004). Research questions addressed by ERCs are certainly complex and groups that have more information at their disposal may produce a more novel solution. Indeed, novel inventions are more likely to progress down the commercialization pipeline and achieve a patent award (as opposed to rejection of the patent application). However, while boundary spanning may promote more innovative inventions, it probably has little influence on an inventor’s willingness to go through the administrative process required for invention disclosures.

The effects of boundary-spanning may not be all positive, however; transferring knowledge across boundaries has documented difficulties and complexities in terms of syntax, semantics, and pragmatics (Carlile, 2004). Future research should explore the extent to which crossing boundaries may increase process loss. For example, boundary-spanners are often tasked with mediating and translating across multiple academic disciplines, which can complicate the research process and increase the overall time expenditure (Fisher and Atkinson-Grosjean, 2002).

Just as climate affects such organizational outcomes as customer satisfaction and unit sales (Schneider et al., 2005), the technology commercialization literature would benefit from a new focus on the individual attitudes and perceptions involved in organizational cli-
mate. We urge researchers to further explore the impact of climate on commercialization productivity.

6.2. Limitations

Our organizational-level analyses were based on a modest number of observations. Although power need not always be maximized (Scherbaum and Ferreter, 2009), the low statistical power in our regression models may have caused some analyses to fail to reach statistical significance. Under the conditions of low statistical power, however, the fact that we found any statistical significance at all in the models suggests the potential importance of climate in commercialization. Future researchers may wish to continue this research theme with a larger number of organizational observations.

Moreover, despite our longitudinal study design, we are cautious in drawing firm conclusions regarding the causal order of our variables. Although we posit that environmental characteristics and climate predict disclosures and patent awards, the reverse is also possible. An ERC’s previous commercialization success may enhance the supportive nature of the ERC climate, or the anticipation of commercializable products may lead industry to increase their funding of ERC projects or help to build stronger relationships with industry. We encourage future research to explore the possible cyclical nature of commercialization as preceded by and as a precursor of climate and environmental characteristics.

On a related note, the time lags between the predictors and outcomes were one and two years in this study, but we acknowledge that the commercialization process can take longer than two years from start to finish and that timeline will differ for each project and field of study. In a sense, two years is a conservative estimate of the effect of climate on commercialization outcomes and one might expect to see stronger effects given a longer time period. The fact that we found significant results with only two years provides initial support that climate is related to the early stages of commercialization. We also suggest that, to some extent, climate perceptions might be stable over time, and support for commercialization climate and boundary-spanning climate as measured in 2005 may have been similar to the climates experienced a few years earlier when some projects patented in 2007 were beginning to form and move through the pipeline. The stability of climate perceptions may depend upon the stability of environmental factors such as financial munificence and industry involvement as well.

Finally, readers should take care in generalizing these findings beyond the context of ERCs. While the implications can be generalized to some extent to any university setting, particularly multidisciplinary, university research centers (MMURCs; Bozeman and Boardman, 2003), ERCs may have more explicit commercialization goals and more interface with industry partners than traditional universities and MMURCs. ERC support for commercialization climate is likely to be stronger (albeit variable) and invention disclosure and patent rates are likely to be higher than other similar organizations. Universities and MMURCs who desire to increase their commercialization activities can learn much from the ERC model, however. The positive effects of support and boundary-spanning climate may extend beyond patents to other academically relevant outcomes as well, including later outputs in the commercialization pipeline (e.g., licenses and spinoffs) and research publications.

6.3. Practical implications

Our results may also have important implications for managing research organizations, particularly those organizations based in academic settings. Indeed, organizational climate is more readily influenced by management than are extra-organizational environmental factors (e.g., availability of venture capital). Research organizations often face complex management challenges because of their highly educated and professionally committed employees (Wang and Armstrong, 2004). Leaders in such organizations, however, can have a potentially strong influence on the types of climates that are formed, which our study suggests may result in commercialization productivity. For instance, leaders can actively demonstrate support for commercialization by explicitly including commercialization activities in rewards and compensation practices such as promotion and tenure decisions. Leaders might also urge and provide support for science and engineering researchers to collaborate within and beyond traditional organizational boundaries, thereby increasing the novelty and commercial potential of their discoveries.

According to Siegel et al. (2004), one critical issue leaders may face is conflicting motives regarding commercialization. University scientists (especially pre-tenure professors) are driven by the quest for new knowledge as well as recognition within the scientific community (e.g., publications) rather than by the financial profits or competitive advantage provided by commercialization. Representatives of the TTO desire more to protect and market inventions created under the auspices of the university than to promote public scientific knowledge. Finally, firms/entrepreneurs are often motivated by financial gains. The motives of scientists, TTO professionals, and companies are often in conflict, and it is the burden of university administrators and/or TTO officers to reconcile these differences and motivate scientists to engage in disclosing inventions and patenting. Whereas Siegel et al. found that many scientists continue to lack sufficient rewards for engaging in commercialization, scientists within ERCs are more incentivized because one central purpose of an ERC is to encourage relevant, commercializable research that can be used in real-life applications. Building a climate supportive of commercialization and supportive of boundary-spanning may be one way institutional leaders can address these conflicting motives.

Another issue faced by leaders in academic research settings is the traditionally poor track record of universities in commercialization. This is due in part to limited faculty time, limited resources and knowledge for engaging in the commercialization process, and limited interest of many scientific researchers. Because the academic departments of universities involved in ERCs are exceptions to this trend, understanding the role of organizational climate in ERCs, as well as ERC organizational structure, leadership processes, and best practices, may be relevant to university leaders.

Finally, ERCs have the advantage of a built-in organizational architecture within which industry and university partnerships are founded and applied research is conducted and pushed through the commercialization pipeline. One example of a structure of ERCs that may be valuable for leaders of research organizations is the “three-plane framework” that the NSF requires ERCs to use in all strategic planning activities (see Perry et al., 2007). The framework emphasizes the pipeline process of moving basic science to commercial prototype. The orientation of the three-plane framework is fundamentally different from the traditional university research paradigm because it focuses on translational research and engineered system deliverables. We urge leaders of research organizations to draw upon the logic of the NSF’s three-plane framework to create structures, processes, and climates that facilitate the translation of basic science to commercializable products or services.
Acknowledgements

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Appendix A. Survey items

<table>
<thead>
<tr>
<th>Construct</th>
<th>Scales</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercialization-support climate</td>
<td>Perceptions of commercialization-support from ERC</td>
<td>Commercialization of ERC research is encouraged.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>…in my ERC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>…at my university (i.e., where I hold my main employment).</td>
</tr>
<tr>
<td></td>
<td>Perceptions of commercialization-support from ILO</td>
<td>The Industrial Liaison Officer (ILO) in my ERC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>…assists faculty with commercialization processes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>…successfully encourages faculty members to become involved in the process of commercialization.</td>
</tr>
<tr>
<td></td>
<td>Perceptions of commercialization-support from TTO</td>
<td>The Office of Technology Transfer (or licensing) at my university is</td>
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<tr>
<td></td>
<td></td>
<td>…easy to work with in the process of commercialization.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>…effective in carrying out its responsibilities in the process of commercialization.</td>
</tr>
<tr>
<td></td>
<td>Perceptions of commercialization-support from university community</td>
<td>In launching start-up companies, …management talent is available to assist researchers in my ERC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>…incubator services are available to assist researchers in my ERC.</td>
</tr>
<tr>
<td>Intra-organizational</td>
<td>Perceptions of degree of collaboration (e.g., among thrusts)</td>
<td>1. Collaboration (e.g., research, publications) occurs among the projects within each thrust.</td>
</tr>
<tr>
<td>boundary-spanning climate</td>
<td></td>
<td>2. Collaboration (e.g., research, publications) occurs among thrusts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. My involvement with students and/or postdocs increases my collaboration (e.g., research,</td>
</tr>
<tr>
<td></td>
<td>Perceptions of organizational structures promoting collaboration</td>
<td>publications) with people in other thrusts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Collaboration (e.g., research, publications) occurs among project teams that operate on</td>
</tr>
<tr>
<td></td>
<td></td>
<td>different levels of the three-plane framework.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. My ERC has a formal committee or team devoted to promoting collaboration across the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>thrusts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. The thrusts are structured in such a way that requires collaboration across levels of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>three-plane framework.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. The project teams are structured in such a way that requires collaboration across levels of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the three-plane framework.</td>
</tr>
<tr>
<td></td>
<td>Perceptions of multi-disciplinary research</td>
<td>1. Within the thrusts in my ERC multi-disciplinary research is carried out.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. The structure of thrusts has evolved over time in order to remain focused on multidisciplinary research.</td>
</tr>
</tbody>
</table>

a All scales used 7-point response scale, anchored from “Strongly Disagree” to “Strongly Agree.”
b A thrust is a research team with a shared broad research objective, within which there are numerous specific project groups.
Appendix B. Climate measures and justification for aggregation

B.1. Confirmatory factor analysis results

We conducted confirmatory factor analysis (CFA) on the commercialization-support and boundary-spanning climate scales to test their measurement properties. As demonstrated in Appendix A, we expected the commercialization-support climate items to form four factors that loaded onto a broad commercialization-support climate factor and the boundary-spanning climate items to form three factors that loaded onto a broad boundary-spanning climate factor. CFA results supported our hypothesized four-factor structure of commercialization-support climate, including a second-order latent climate factor ($\chi^2 (23, N = 216) = 71.18, p < .01, CFI = .96, TLI = .94, RMSEA = .10, SRMR = .05$). Results also confirmed our three-factor structure of boundary-spanning climate, including a second-order latent climate factor ($\chi^2 (24, N = 218) = 73.86, p < .01, CFI = .95, TLI = .92, RMSEA = .10, SRMR = .05$). We also tested alternative measurement models. The four-factor structure of support climate fit better than alternative one- and three-factor models, and likewise with boundary-spanning climate (two-factor models could not be estimated because they were under-identified). Therefore, given the support of second-order latent climate factors from the 9 items in each scale, we calculated our measures of commercialization-support climate and boundary-spanning climate by averaging the 9 items of each scale.

B.2. Aggregation of individual level survey data

According to our definition of climate (Schneider et al., 1998), climate consists of perceptions that are shared among group members which is empirically assessed by within-group agreement using the $r_{wg}$ statistic (James et al., 1984). Following recommendations by Bliwise (2000), our $r_{wg}$ results for both support (.68) and boundary-spanning (.78; see Table 3) climate exceeded the required threshold of .55 based on 10 respondents per ERC and seven response categories (Ludtke et al., 2007). Therefore, we were justified in aggregating individual survey responses to the ERC level in the form of an ERC average climate score.

References


