The impact of transaction costs on the institutional structuration of collaborative academic research

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Abstract

This paper addresses a crucial question: Which factors explain the choices of institutional structures made by university researchers? The main findings of the study point to the central importance of publication assets, coordination costs, additional funding, and membership in the disciplines of engineering, natural sciences and health sciences as factors affecting the choices of institutional structures university researchers make when they become involved in collaborative research projects. On the other hand, the number of years researchers have been involved in collaborative research, the capture of additional publications linked to involvement in collaborative research, the importance of administrative burdens and the time required to coordinate collaborative research were demonstrated to be unimportant in explaining these choices. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

This paper addresses one crucial question: What factors explain why university researchers choose a given institutional structure? Our main argument, based on a survey of 1566 Canadian university researchers, is that there is a trade off between the capture of benefits measured in terms of additional publications and research funds and the coordinating costs of collaborative research. Thus, contrary to bibliometric studies that primarily stress publications, our paper contributes to knowledge by taking into account cost factors and by shedding new light on researchers' attempts to minimize coordinating costs while maximizing additional publications and research funding.

According to Kyvik and Larsen (1997), collaborative research is 'the strongest form of relationship' between research partners. Such collaborative research can be considered from the standpoint of either the types of structures or the types of partners involved. Structures can be defined as formal or informal, as in the recent Norwegian study by Kyvik and Larsen (1997). As for research partners, they can come from universities, industry or other institutions. In this paper, collaborative research thus refers to exchange relationships in formal research projects undertaken by university researchers and other research partners. More precisely, three categories of partners will be considered: (1) company representa-

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tives, as in university–industry research collaboration; (2) other university researchers, as in the case of collaboration between scientists; and (3) representatives of organizations, as in collaborative projects with government agencies, local governments and organized interest groups.

The world of institutional structures in collaborative research is described as one made up of research institutes, research teams and research conducted outside formal institutional structures. Institutes are defined as research institutes and research centers, but also as all other large-scale research structures irrespective of their particular labels. Research teams are defined as intermediate-scale research structures that include research teams, research groups, study groups, as well as all other types of intermediate-scale research structures. Finally, collaborative research conducted outside formal institutional structures is defined as joint efforts undertaken outside formal institutes or formal teams.

The paper is organized as follows. Section 1 reviews the role of institutional structures in collaborative research. Section 2 presents the transaction cost theoretical framework of our study. Section 3 presents the data. Section 4 introduces a model explaining the institutional structuration of collaborative research. The paper concludes with an assessment of the implications of our results for university researchers, policy makers, university administrators, and further research.

2. The relationships between collaborative research and structures

Prior studies show that the determinants of collaboration vary according to contextual factors and the individual benefits derived by partners. The literature on industry–university collaboration has focused on contextual factors such as institutional arrangements of interaction (Peters and Fusfeld, 1983), services provided to industry (Geisler and Rubenstein, 1989), organizational resources (Bonaccorsi and Piccaluga, 1994), levels of coordination (Bonaccorsi and Piccaluga, 1994; Landry et al., 1996), geographical proximity (Landry et al., 1996), and scientific disciplines (Peters and Fusfeld, 1983; Geisler and Rubenstein, 1989; Landry et al., 1996). Such studies show that the impact of contextual factors is ambiguous.

Nevertheless, when it comes to the benefits derived from collaboration, findings generally indicate that the greater the research funding and the number of publications, the more intense the collaboration (Geisler and Rubenstein, 1989; Peters and Fusfeld, 1983; Baldwin and Green, 1984; Onida and Malerba, 1989; Rebne, 1989; Mitchell and Rebne, 1995; Landry et al., 1996).

Studies on collaboration between scientists focus on contextual factors as well as geographical and cultural proximity. They show that within particular families of scientific disciplines, collaboration increases with geographical and cultural proximity. Moreover, increases in the intensity of collaboration are associated with increases in the number of publications and citations (Frame and Carpenter, 1979; Luukkonen et al., 1992).

The rare studies on university–institution collaboration have found that cultural proximity and a higher number of publications and citations impact positively on the level of collaboration. However, unlike studies on university–industry collaboration and on collaboration between scientists, studies on university–institution collaboration indicate that geographical proximity reduces willingness to collaborate (Landry et al., 1996).

To our knowledge, no prior empirical studies have examined the factors explaining the choice of institutional structures made by university researchers when they engage in collaborative research. Building on earlier research in the field, this paper attempts to shed new light on collaborative research by focusing on the relationship between institutional structuration and (a) the number of publications, (b) the collaborative research context and (c) coordination costs generated by collaborative research.

3. Analyzing the institutional structuration of collaborative research

In this part of the paper, we first try to demonstrate that the institutional structuration of collaborative research matters for both decision-makers and researchers. Second, we attempt to indicate how institutional structures of collaborative research can be analyzed.

3.1. Why the institutional structuration of collaborative research matters

Institutions are devised to solve problems of coordination. They can be either formal or informal (North, 1990). They are formal when governed by rules devised to constrain individual choices, and informal when governed by convention, social norms, and unwritten codes of behavior. Individual choices are always framed by predefined institutional arrangements (Goodin, 1996) that may be more or less efficient.

Policy makers in the Western countries have attempted to increase scientific collaboration—especially between university scientists and between university and industry—in order to foster publications and to improve the quality of training. To this end, they have developed grant programs that provide funding conditional to research projects being conducted within particular institutional arrangements: research teams and research institutes. These policies are based on the assumption that the most efficient way of organizing university research is to structure interactions between researchers into formalized institutional arrangements such as teams and institutes. Indeed, there are many obvious reasons why university researchers should undertake collaborative research within such formal structures. Empirical studies point to the following factors (Geisler and Rubenstein, 1989; Peters and Fusfeld, 1983; Baldwin and Green, 1984; Onida and Malerba, 1989; Rebne, 1989; Mitchell and Rebne, 1995; Landry et al., 1996):

- Additional funding
- Additional equipment and facilities
- Additional information and data
- Additional resources
- Increase in the number of publications
- Increase in the number of innovations
- Improvement in the quality of teaching and training
- Increase in the possibilities of employment for students
- Building networks of collaborators

However, the costs of coordinating negotiations on collaborative research objectives and on choices regarding resources and resource use increase with the size of the structural arrangements, thus limiting the efficiency of larger structures. Transaction cost theory has been developed to study these situations (Williamson, 1975, 1985, 1996).

The transaction cost approach to the institutional structuration of collaborative research attempts to explain why researchers are induced to organize some collaborative research projects in research institutes, and others in research teams or outside formal structures. It explains the various institutional structures under which collaborative research is carried out. The prediction made by this theoretical approach is that collaborative research will be conducted outside formal structures when costs incurred by individuals are relatively higher in research institutes or research teams.

This approach emphasizes the voluntary nature of researcher participation in institutional arrangements: their contribution to an institutional arrangement will depend on the benefits they derive from participating. This approach is appropriate when both the formal and informal institutional arrangements existing in academic research need to be taken into account. Let us now turn our attention to the basic elements comprising this approach.

3.2. The microanalytics of the institutional structuration of collaborative research

The microanalytics of the institutional structuration of collaborative research is presented in three parts. In the first, collaborative research is defined as an exchange of resources corresponding to transactions. In the second, the attributes describing the institutional structures of collaborative research are introduced. In the third, transaction costs and institutional structures are related to derive predictions regarding structures that minimize transaction costs and maximize publications and research grants.

In this paper, transactions include both exchanges and contracts. On the one hand, transactions are understood to involve transfers of resources between research partners; on the other hand, transactions are also perceived as contracts involving promises of future performance. In the case of contracts, promises of future research outputs are exchanged, and investments are made in research activities, the value of

which becomes dependent on the fulfillment of the other researchers' promises.

For the purpose of this paper, transaction costs are more than the costs of finding research partners, assessing the quality of research findings and data, and writing exchange agreements. Like Williamson, we will distinguish between ex ante and ex post costs. Ex ante transaction costs refer to the costs of actions and tasks required establishing a contract. This paper does not deal with the ex ante costs. The paper deals with the ex post transaction costs incurred in subsequently coordinating, monitoring and enforcing the contractual promises of research outputs. In collaborative research, the ex post transaction costs comprise joint decisions made by the researchers regarding research objectives and orientations, preparation of grant proposals, work plans, research design and methodology, use of financial resources, human resources, equipment and data, and preparation of publications.

At the post contract stage, the value of certain resources becomes dependent on the fulfillment of other researchers' promises of research outputs. Under a transaction cost approach, this dependency is assessed in terms of transaction attributes in a context of bounded rationality and opportunism. The assumption of bounded rationality refers to the limited cognitive competence of individuals. In such a context, researchers involved in collaborative research are induced to invest in the creation and maintenance of institutional structures of collaborative research because this generates routine-like decisions that do not require the computation of optimal solutions.

However, the institutional structures of collaborative research cannot be comprehensive to the point of exhausting all possibilities of interaction between researchers. These structures always encompass areas of ambiguity. The impossibility of designing complete contracts creates room for opportunism, an incentive to use incomplete institutional structures to satisfy individual self-interest. This second assumption implies that researchers involved in collaborative research are induced to strategically misrepresent information and intentions to secure more resources for themselves.

As for transaction attributes, we will focus on four of them in this paper: uncertainty, asset specificity, frequency, and measurability. Uncertainty is very important in a context of collaborative research: no one knows what research findings and data will be produced in the future; no one is fully aware of the costs of implementing certain research designs; and, finally, everyone is uncertain about the information and goals of his research partners.

Transactions that are concluded in collaborative research depend on prior specific investments required to realize least cost research outputs. These prior specific investments in assets are specific inasmuch as their degree of redeployment for alternative research uses and by other researchers is costly. According to Williamson (1985), there are four types of asset specificity: site specificity, physical asset specificity, human asset specificity and dedicated asset specificity. Investments in human assets and dedicated assets seem especially important in collaborative research. In a research context, human asset specificity arises from learning by doing. A good indicator of such asset is the number of publications a researcher brings into a transaction. As for dedicated asset specificity, it arises when discrete investments are made that would not have been made had it not been for the purpose of conducting a particular research project. Acquisition of expensive pieces of equipment for particular research projects is a good example of such dedicated assets.

Transaction frequency refers to the frequency at which transactions recur. If they recur on a regular basis, researchers are induced to develop routine-like institutional arrangements that limit the costs of continually renegotiating the agreements between them. Conversely, if transactions occur only rarely, the researchers have no incentive to invest resources in creating specific institutional arrangements because they will be unable to recover the development costs of these institutional arrangements.

The fourth attribute of transactions that will be considered in this paper is measurability. Assets brought into a collaborative project can be easily measured when they have two intrinsic characteristics: a unit of measurement and a number of units. In all other cases, assets are not easily measurable.

The two behavioral assumptions—bounded rationality and opportunism—and the four attributes of transactions—uncertainty, asset specificity, frequency and measurability—will hereafter be used to

derive the transactions costs incurred in collaborative research within three different categories of institutional structures.

The transaction costs involved in exchanging resources to carry out collaborative research are high. In a context of bounded rationality, researchers A and B may agree to support each other's work but their research findings and their data may not be produced simultaneously. Researcher A may produce his results and transfer them to B, but B may be unable to provide his results due to unexpected difficulties. In such circumstances, it is hard for each researcher to judge whether the other's behavior is opportunistic or simply a genuine response to unexpected difficulties inherent in the research process. In this case, an opportunistic researcher would be induced to attempt to secure more resources for him.

Likewise, unlike traders marketing simple economic goods, researchers cannot rely on third-party enforcement of their agreements. This particular context also increases the transaction costs of collaborative research: promises of uncertain research outputs are exchanged without formal enforcement mechanisms.

Therefore, based on the prior assumptions, we can deduce that:

- Transaction costs tend to rise with investments in human asset specificity and dedicated assets;
- Transactions costs tend to decrease with the integration of transactions based on high asset specificity into institutional structures;
- Researchers in disciplines requiring large investments in dedicated assets are more likely than those in other disciplines to conduct collaborative research within formal institutional structures;
- Researchers frequently involved in collaborative research are more likely than others to conduct collaborative research within formal institutional structures.

If transaction costs are zero, choosing to conduct collaborative research within the framework of one institutional structure rather than another has no bearing on efficiency. However, if the transaction costs are non-zero, the choice of research institute, research team, or non-formal institutional structure does affect efficiency. Our analysis is thus conducted with the presumption that the institutional structures of collaborative research are devised by decision-makers and university researchers with the purpose and consequence of economizing on transaction costs and maximizing additional publications and research funds.

How do transaction costs vary from one type of structure to another? The theoretical framework developed so far suggests the following hypotheses:

- Limited cognitive competence (bounded rationality) among researchers is high irrespective of the institutional structures;
- Opportunism increases with the size of the structures because researchers' incentives to misrepresent information and goals to secure more resources for themselves increase with the size of the structures;
- Uncertainty is high irrespective of the structures considered;
- Human asset specificity increases with the size of the structures because specialized learning by doing (division of labor) increases also;
- Dedicated asset specificity increases with the size of the structures because investments in dedicated equipment increase also;
- Frequency increases with the size of the structures;
- The degree of measurability of assets brought into the collaborative research process is high irrespective of the institutional structures.

These assumptions are used to compare the behavioral assumptions and the transactions incurred within and across institutional structures. As Table 1 shows, both incentives for opportunism as well as transaction costs tend to be higher in research institutes than in research teams, and higher in research teams than outside formal institutional structures. Given that no variations are predicted across structures for three of the attributes—namely bounded rationality, uncertainty and degree of measurability—these factors will not be included as explanatory factors in the empirical analysis.

In analyzing how collaborative research is institutionally structured and which factors explain the choices of institutional structures, we are led to consider the variations in efficiency between different structural arrangements.

A structure may be considered more efficient when it produces more benefits per given cost or, alternatively, when it generates less cost per given

Table 1
Predictions regarding the attributes of the institutional structures of collaborative research

Attributes	Institutional structures		
	Outside structures	Teams	Institutes
Behavioral assumptions			
Bounded rationality	+ +	+ +	+ +
Opportunism	0	+	+ +
Transaction dimensionalizing			
Uncertainty	+ +	+ +	+ +
Human asset specificity	0	+	+ +
Dedicated asset spec.	0	+	+ +
Frequency	0	+	+ +
Degree of measurability	0	0	0

0 = Low
+ = Moderately high
+ + = High

benefit. Efficiency can be examined at three levels, depending on the kind of choices considered. It can be examined at the researchers' level, where the alternative cost/benefit ratios of operating within different types of structures are compared (Table 1). The same comparison can be made at the collective structural level for variations in aggregate cost/benefit ratios across different types of structures. Finally, it can be examined at the national level to compare efficiency in funding for collaborative university research structures across public policies. Given that our unit of observation is the individual researcher, our analysis is designed to explain the individual researcher's choices.

The prior assumptions and the hypotheses in Table 1 lead us to suggest that efficiency for individual researcher increases with the size of the institutional structures. This latter hypothesis is derived from the hypotheses stating that as investments in human asset specificity and dedicated asset specificity rise and the frequency of interaction between researchers increases, research benefits (additional publications and funding) also increase.

On one hand, then, transaction costs and incentives for opportunism can be minimized by organizing collaborative research outside formal institutional structures. On the other hand, efficiency at the researchers' level can be maximized by organizing collaborative research within large formal institutional structures such as research centers, but only at the expense of maximizing transaction costs and incentives for opportunism. We could argue that researchers solve this dilemma by making trade off between the logic of transaction cost minimization and the logic of benefit (additional publications and research funding) maximization. To examine the extent of this trade off, we will now turn to empirical evidence gathered about actual choices made by Canadian researchers.

4. Data collection

To collect the data necessary for this study, we designed a questionnaire on collaborative research, institutional structures of collaborative research, research outputs, coordinating actions undertaken in collaborative research, characteristics of the collaborative research context and, finally, the socio-demographic background of the researchers themselves.

At the end of April 1994, a questionnaire containing 47 questions was sent to all faculty members at the 18 Canadian universities located in Quebec. A follow-up letter was sent two weeks later. The questionnaire and the follow-up letter were sent to all faculty members because there is no information on the sub population of faculty members actively involved in research. It is estimated that approximately 50% of Canadian faculty members have research grants and publish scientific articles, so the sub population of active researchers should include approximately 50% of all faculty members.

Our data collecting strategy generated a total of 1566 usable questionnaires. This represents a return rate of nearly 40% of faculty members involved in research activities, a level of representativity confirmed by the fact that only 8.5% of respondents indicated not having published any scientific articles during the five preceding years. To insure the representativeness of our sub-sample, two things were done. First, distributions of faculty members in the sub-sample were constructed regarding institutional affiliation, discipline, and collaborative production. These were then compared with similar distributions from the population of faculty members. No discernable differences were found between the two sets of distributions, implying that the use of the sub-sample is not expected to result in any sample bias.

The data indicate that 55% of the 1566 respondents had been involved in collaborative research over the preceding five years. Within this subset of respondents, 83% had been involved in collaborative research with other academic researchers, 40% in collaborative research with partners from industry and 60% with other institutional partners. Overall, regardless of the partners considered, collaborative research is more frequent within research teams than outside formal structures. As for research institutes, they serve as a framework for collaborative research less often than both the other categories, all disciplines combined. Speaking of disciplines, involvement in collaborative research ranged from 79% for respondents in the humanities to 89% for respondents in engineering. Respondents in arts and literature were alone in falling below this range, with only 61% involved in collaborative research over the preceding five-year period. To sum up, these data indicate that collaborative research is a very important mode of operation, and that preferences regarding structures of collaboration vary between researchers and across disciplines.

The choice of Canada, and more particularly Québec, as the setting for this study is especially appropriate, because both the Canadian and Québec governments have initiated numerous special programs where eligibility for research grants is conditional to collaborative research being conducted within structures such as research institutes and research teams. Given that such special programs have been more prevalent in Canada than in most other countries, Canada constitutes the ideal setting for verifying the efficiency of this type of research policy, as well as for identifying the factors that explain the choice of research structures made by university researchers.

5. The model

The efficiency of the institutional structures of collaborative research is examined using three sets of explanatory variables: (a) publication assets, (b) co-ordinating costs, and (c) characteristics of the collaborative research context. The dependent variable refers to the different types of institutional structures of collaborative research. A categorical variable, it is divided into the three categories identified previously: research institutes, research teams, and research conducted outside formal institutional structures. To study the impact of the explanatory variables on such a qualitative dependent variable, we have developed multinomial logit models. As was also indicated earlier in paper, university researchers can conduct collaborative research with three categories of partners: other university researchers, industry representatives, and institutional representatives. Therefore, three separate models were used to examine the choice of institutional structures.

6. Collaborative research among researchers and regression results

The data regarding the institutional structures of collaborative research were obtained with the following question: ''Can you specify the kind of setting in which you carry out your activities involving other university researchers?''. The respondents had to choose between three possible answers: (1) research group or team; (2) research center or institute; (3) with researchers not affiliated to any group, team, center or institute. In the context of the Canadian universities located in Québec, these labels do not raise any ambiguity. A provincial research council, the Fonds FCAR, has actually a program of research grants dedicated to research centers and another program of research grants reserved for research teams. Furthermore, the labels research centers and research institutes are controlled labels in this sense that in order to have the right to use these labels, research structures have to be formally recognized by university administration after a productivity assessment.

The basic model for collaborative research among university researchers is as follows:

$$\log(P_i/P_j) = b0 + b1ij\text{ASS} + b2ij\text{COOR}$$
$$+ b3ij\text{FREQ} + b4ij\text{MBEN}$$
$$+ b5ij\text{PBEN} + b5ij\text{COST}$$
$$+ b6ij\text{DISCP}$$

where $\log(P_i/P_j) = $ log of the ratio of the probability of choosing an institutional structure from the ith category relative to that of choosing one from the jth category when a researcher is involved in collaborative research. ASS = Assets brought into collaborative research measured in terms of the number of

chapters in scientific books and articles in scientific journals, on a scale ranging from: 1 to 5 publications, 6 to 10 publications, + 10 publications. COOR = coordination costs of the assets brought into collaborative research measured with an index composed of costs in 8 joint decision-making categories: preparation of grant proposals, research objectives and orientations, work plan, research design and methodology, use of financial resources, use of human resources, use of equipment and data and publications. For each decision, the cost is measured on a scale ranging from: 1 = decision never made together; to 7 = decision always made together.

The index of coordination cost is an aggregation of costs incurred for all 8 categories and therefore ranges from 8 to 64. An item analysis on the components of this additive scale was performed by computing the Cronbach's α. This coefficient provides a reliability coefficient for multiple item scales. The Cronbach's $\alpha = 0.84$ for the coordination index. The internal reliability coefficients for the other multiple item scales are summarized in Appendix A: FREQ = frequency of transactions in collaborative research measured in terms of the number of years a researcher has been involved in collaborative research since the beginning of her career. MBEN = monetary benefits derived from collaborative research measured in terms of the importance of addi-

tional funding on a scale ranging from: 1 = not important; to 7 = very important. PBEN = publication benefits derived from collaborative research measured in terms of increase in the number of additional publications resulting from collaborative research on a scale ranging from: 1 = not important; to 7 = very important. COST = costs incurred in collaborative research measured with an index including two items: the importance of the time commitment for project coordination and the importance of the administrative burden. The importance of costs for each item is measured on a scale ranging from: 1 = not important; to 7 = very important. The Cronbach's $\alpha = 0.86$, thus indicating that this cost index is reliable. DISCP = the researcher's scientific discipline, where: 1 = natural sciences, engineering and health sciences; 0 = other disciplines

Results of the regression for collaborative research among researchers are presented in Table 2. The overall model Chi-square statistics is 32.06 with 7 degrees of freedom at the 1% level, which is much higher than its critical value (i.e., 18.47). The MacFadden R^2 is 0.12, which is quite acceptable for such models. The overall model is thus significant at the 1% level. Positive coefficients signify that the structure category indicated by the numerator is chosen over the category mentioned in the denominator. Negative coefficients signify the opposite. For in-

Table 2
Estimated multinomial logit model results of factors affecting institutional structuration of collaborative research among university researchers

	Dependent variables[a]		
	Teams/institutes	Teams/outside structures	Institutes/outside structures
Intercept	0.65 (0.14)	− 0.97 (− 2.40)∗∗∗	− 1.57 (− 3.47)∗∗∗
Publication assets (ASS)	− 0.02 (− 2.49)∗∗∗	0.011 (1.30)∗	0.036 (3.47)∗∗∗
Coordination costs (COOR)	0.035 (0.57)	0.098 (1.84)∗∗	0.053 (0.90)
Frequency of transactions (FREQ)	0.001 (0.15)	0.007 (1.15)	0.006 (0.83)
Additional funding (MBEN)	− 0.003 (− 0.12)	0.063 (2.41)∗∗∗	0.066 (2.17)∗∗
Additional publications (PBEN)	0.014 (0.45)	0.012 (0.42)	− 0.005 (− 0.14)
Costs incurred (COST)	− 0.006 (− 0.38)	− 0.009 (− 0.61)	0.009 (0.05)
Discipline (DISCP)	− 0.25 (− 2.26)∗∗	0.084 (0.84)	0.33 (2.90)∗∗∗

∗∗∗ Means that the variable is significant at 1% level.
∗∗ Means that the variable is significant at 5% level.
∗ Means that the variable is significant at 10% level.
MacFadden $R^2 = 0.12$.
Percentage of Correct Predictions = 58%.
Overall Chi-square statistics (DF) = 32.06 (7).
[a]The T-ratios are in parentheses.

stance, the negative coefficient associated with publication assets in the first column indicates that researchers bring more publication assets into collaborative research when research is conducted within research institutes than within research teams.

The theoretical model developed in the previous section predicts that researchers controlling the greater publication assets are more likely to choose to work within formal institutional structures. The regression results indicate that the researchers bring more publication assets (ASS) when they collaborate within research institutes than within the structures of research teams or outside formal structures. Furthermore, results indicate that researchers bring lower publication assets when they get involve in collaborative research outside formal structures than within research teams.

Coordination costs constitute another factor determining the choice of institutional structures in matters of collaborative research. A transaction cost interpretation model predicts, as indicated earlier, that the coordination costs increase with the size of the institutional structures. The coordination costs can be minimized when collaborators limit their joint decisions to the strategic coordination of research project objectives and orientations. The coordination costs increase when in addition to investing in strategic coordination, researchers invest in organizational coordination by jointly deciding on matters such as preparation of grant proposals, research design and methodology and work plans. Finally, coordination costs increase even further when researchers invest in operational coordination, and implement joint decision making on matters such as use of financial resources, use of human resources, use of equipment and data and preparation of publications. Results show that these coordination costs are higher for researchers collaborating in the framework of research teams than for researchers collaborating outside teams. As for differences in the coordinating costs between institutes and teams, as well as between institutes and researchers outside structures, no statistically significant differences have been observed.

A transaction cost interpretation of collaborative research predicts that researchers are induced to choose institutional structures that are likely to generate the highest additional funding for their own research projects. As we pointed out at the beginning of this paper, Canadian and provincial policy makers have launched many special programs under which eligibility for research funds is conditional to collaboration within institutes and teams. Therefore, we should expect the appropriation of additional monetary benefits to explain the choice of institutional structures in matters of collaborative research. Regression results indicate that, over a five year period, Canadian university researchers who had received additional monetary benefits were more likely to work within institutes and teams than researchers outside these formal structures. Interestingly, results also indicate no significant difference between institutes and teams, thus suggesting that the capture of additional funding is associated to the presence of formal institutional structures, irrespective of their size.

In theory, we might expect researchers in disciplines requiring large investments in dedicated specific assets to be more likely than researchers from other disciplines to conduct their collaborative research within formal institutional structures. According to this rationale, the greater the need for dedicated specific assets, the bigger the institutional structures chosen by the researchers. In turn, this prediction suggests that researchers in engineering, natural sciences and health sciences are more likely to conduct collaborative research projects within formal institutional structures than researchers from the other disciplines. Indeed, results in Table 2 show that the researchers in engineering, natural sciences and health sciences are more likely to work within institutes and teams and are also more likely than researchers from the other disciplines to collaborate within institutes than within teams.

The transaction cost interpretation suggests that collaborative research recurring with the same partners on a regular basis induces researchers to develop formal institutional arrangements that limit the costs of continually renegotiating the agreements that have to be made between them. To capture the impact of this factor on the choices of institutional structures, a frequency variable was constructed by asking the researchers to indicate the number of years they had been actively involved in collaborative research projects since the beginning of their career. Results reported in Table 2 show that, al-

though considered important in Williamson's transaction cost interpretation, this factor does not explain the choices of structures in the area of collaborative research.

Finally, results in Table 2 also show that there is no significant difference between structures regarding the PBEN and COST variables. PBEN refers to the number of additional publications linked to involvement in collaborative research. COST refers to the importance of the additional time commitment required for coordinating collaborative research and the importance of additional administrative burdens collaborative research generates. Contrary to expectations, these two factors do not affect the choice of structures made by researchers.

7. University–industry collaborative research and regression results

A separate model was developed to examine which structures were chosen by university researchers involved in collaborative research projects with industry. The dependent and independent variables are the same as in the model developed to study the choices of structures made by university researchers. The regression results using a multinomial logit model for the structures chosen in the area of university–industry collaborative research are presented in Table

3. The model correctly predicts 54.3% of the choices made by the researchers. The MacFadden R^2 is 0.07, which is quite acceptable for such models. The overall model Chi-square statistics is 13.27 with 7 degrees of freedom at the 10% level. This is higher than its critical value (i.e., 12.02). The model is therefore significant at the 10% level. Positive and negative coefficients have the same interpretations as in the model examining the structures chosen by university researchers.

The results show significant differences for two variables: the publication assets (ASS) and coordination costs (COOR). As indicated in Table 3, researchers involved in university–industry collaborative research bring more publication assets when they collaborate within research institutes than within the framework of research teams or outside formal structures. No significant difference was found between the publication assets for researchers of research teams and researchers conducting university–industry collaborative projects outside formal structures.

As for coordination costs, results indicate that these costs are higher for university–industry collaborative research conducted within institutes and teams than for collaborative projects accomplished outside formal structures. However, the coordination costs incurred by researchers in institutes and teams are

Table 3
Estimated multinomial logit model results of factors affecting institutional structuration of university-Industry collaborative research

	Dependent variables[a]		
	Team/institutes	Teams/outside structures	Institutes/outside structures
Intercept	0.86 (1.03)	−0.81 (−1.16)	−1.61 (−1.99)**
Publication assets (ASS)	−0.019 (−1.38)*	0.009 (0.65)	0.029 (1.92)**
Coordination costs (COOR)	−0.04 (−0.36)	0.11 (1.28)*	0.14 (1.34)*
Frequency of transactions (FREQ)	0.0014 (0.15)	0.0013 (0.14)	−0.0004 (−0.04)
Additional funding (MBEN)	0.007 (0.14)	0.031 (0.72)	0.023 (0.49)
Additional publications (PBEN)	0.009 (0.19)	−0.0022 (−0.046)	−0.012 (−0.22)
Costs incurred (COST)	−0.006 (−0.27)	0.0004 (0.018)	0.0096 (0.37)
Discipline (DISCP)	−0.038 (−0.18)	0.054 (0.27)	0.094 (0.43)

∗ ∗ ∗ Means that the variable is significant at 1% level.
∗ ∗ Means that the variable is significant at 5% level.
∗ Means that the variable is significant at 10% level.
MacFadden $R^2 = 0.07$.
Percentage of Correct Predictions = 54.3%.
Overall Chi-square statistics (DF) = 13.27 (7).
[a]The T-ratios are in parentheses.

not significantly different from a statistical point of view.

No statistically significant differences were observed for the other explanatory variables considered in this model.

8. University–institution collaborative research and regression results

A third model was developed to study which structures were chosen by Canadian university researchers involved in collaborative research with institutional partners such as government agencies and organized interest groups. The dependent and independent variables are as in the two other models. The results using this third model are presented in Table 4. The model correctly predicts 57% of the choices made by the researchers. The MacFadden R^2 is 0.10 and, the model is therefore significant at the 5% level. Results of Table 4 show that the researchers conducting collaborative research projects with institutional partners bring more publication assets (ASS) when such collaborative projects are accomplished within institutes than with teams or outside formal collaborative research structures. No statistically significant difference was found between teams and informal collaboration with respect to publication assets.

As for the MBEN variable, the results indicate, as predicted, that researchers collaborating with institutional partners who have benefited from additional funding are more likely to work within the formal structures of institutes and teams rather than outside such structures. No significant difference is observed between institutes and teams, thus suggesting that the appropriation of additional funding is related to institutional structuration, not to the characteristics of the institutional arrangements of structuration.

When they become involved in collaborative research with institutional partners, researchers in engineering, natural sciences and health sciences are more likely than those in the other disciplines to choose to collaborate within institutes than teams, and to work with teams rather than outside formal structures.

Contrary to expectations, coordination costs (COOR), frequency of transactions (FREQ), additional publications (PBEN) and costs incurred (COST) do not explain the choices of structures made by researchers when they collaborate with institutional partners.

9. Discussion and implications for public policy and future research

Although not entirely unexpected, the main findings of the present study help flesh out reflections

Table 4
Estimated multinomial logit model results of factors affecting institutional structuration of university–institution collaborative research

	Dependent variables[a]		
	Research team/institutions	Research team/informal structure	Institutions/informal structure
Intercept	1.13 (1.73)*	−0.52 (−0.04)	−1.52 (−2.36)***
Publication assets (ASS)	−0.025 (−2.04)**	0.012 (1.05)	0.037 (2.85)***
Coordination costs (COOR)	−0.029 (−0.33)	0.036 (0.48)	0.044 (0.50)
Frequency of transactions (FREQ)	0.0022 (0.25)	0.009 (1.05)	0.006 (0.64)
Additional funding (MBEN)	−0.032 (−0.83)	0.041 (1.29)*	0.069 (1.71)**
Additional publications (PBEN)	0.022 (0.54)	0.026 (0.69)	0.0049 (0.12)
Costs incurred (COST)	−0.0059 (−0.29)	−0.015 (−0.82)	−0.0047 (−0.22)
Discipline (DISCP)	−0.196 (−1.40)*	0.044 (0.35)	0.23 (1.65)**

*** Means that the variable is significant at 1% level.
** Means that the variable is significant at 5% level.
* Means that the variable is significant at 10% level.
MacFadden $R^2 = 0.10$.
Percentage of Correct Predictions = 57%.
Overall Chi-square statistics (DF) = 17.68 (7).
[a]The *T*-ratios are in parentheses.

and generalizations regarding the efficiency of institutional structures for collaborative university research. The results point to the central importance of publication assets, coordination costs, additional funding and membership in the disciplines of engineering, natural sciences and health sciences as factors affecting the choices of institutional structures university researchers make when they become involved in collaborative research projects. On the other hand, the number of years researchers have been involved in collaborative research since the beginning of their career, the capture of additional publications linked to involvement in collaborative research, the importance of administrative burdens and the time required to coordinate collaborative research were all demonstrated to be unimportant in explaining their choices of institutional structures.

The main revelation of the present study is the limited impact of the characteristics of the institutional arrangements of the structures, which is indicated by the absence of significant differences between institutes and teams in matters of coordination costs and appropriation of additional funding. Contrary to the predictions derived from transaction cost theory and, contrary to the expectations of many decision makers, the present findings indicate that what matters most is the presence or absence of formal institutional structures, not the details of their institutional arrangements. However, this finding must be interpreted with caution since our survey measured the coordination costs supported by individual researchers but not the costs of the infrastructures supported by government grants. Recast in this larger context, we can deduce that the coordination costs of institutes are higher than those of teams.

As for the size of the institutional structures of collaborative research, the findings indicate that researchers bring more publication assets when they collaborate within research institutes than within research teams. As expected, the findings of the present study also lend support to the hypothesis that when researchers in engineering, natural sciences and health sciences become involved in collaborative research, they are more likely to work within research institutes than within research teams.

These findings shed new light on the efficiency of collaborative research. In the context of this study, efficiency was conceived as a trade off between an increase in additional publications and additional research funds vs. the minimization of transaction costs. The findings clearly indicate that the capture of additional publications is not related to the structuration of collaborative research. As for the second important benefits category, the appropriation of additional research funding, the findings show that additional monetary benefits can be captured when researchers collaborate within formal structures rather than outside formal structures. In the case of costs, more exactly coordinating costs, the findings show no significant difference between collaborative research within institutes and teams and, in some cases, no difference between institutes, teams and collaboration taking place outside formal structures. From these findings, one may conclude that, from the standpoint of the researchers, collaborative research is more efficient within institutes because it is associated to capture additional research funding at coordinating costs that are equivalent to the coordinating costs found in research teams.

What are the policy implications of these findings for government policy makers and university administrators? The findings of the present study suggest that public policy, government programs and university programs that restrict collaborative research grants to projects carried out within institutes lead to increase in additional research funding. However, given that researchers in engineering, natural sciences and health sciences are more likely to collaborate within institutes than within teams, policies and programs restricting research grants to institutes are biased against researchers in the other disciplines. This bias could be attenuated by devising policies and programs that would encourage researchers in engineering, natural sciences and health sciences to conduct collaborative research within institutes, while encouraging researchers from the other disciplines to collaborate within formal institutional structures, irrespective of their characteristics. Implementation of such changes would lead to more neutral policies and programs while insuring the capture of the additional benefits resulting from collaborative research conducted within formal structures.

Finally, the findings of the present study also suggest that further theoretical and empirical research is needed on the factors explaining the absence of significant differences between the various

types of institutional structures of collaborative research.

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Appendix A. Internal reliability coefficients (Cronbach's α) for variables including multiple item scales

	α	Number of items in scales	Number of cases
Model: collaboration with university researchers			
Coordination	0.84	7	823
Costs	0.86	2	863
Model: collaboration with industry			
Coordination	0.82	7	351
Costs	0.73	2	355
Model: collaboration with institutions			
Coordination	0.86	7	506
Costs	0.66	2	515

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