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A Comparative Analysis of Perceived and Revealed Levels of Competition in The Construction Industry and Its Implications for Technological Change

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Abstract: This work-in-progress is dedicated to identifying the effect of market competition on innovations in the Canadian Construction Industry. Overwhelming competition and low profit margins that preclude construction firms from taking a risk and introduce innovations, are the two popular arguments used by scholars and industry practitioners to explain slow technological change in the construction industry. These claims are usually supported by verbal and analytical models, anecdotal evidence or case studies. However, there is a scarcity of data-supported research in this area. In addition, the existing data-based efforts do not provide a definitive answer as to whether market competition affects innovation in the construction industry and what the nature of such an effect is. In this work, we are using data derived from public tenders conducted in several Provinces of Canada and augmenting that data with surveys of Canadian construction firms. The ongoing survey is being conducted on the sample of companies identified as participants in public tenders between 2011-2018. The tendering data allows us to understand what companies bid on the projects, what projects attract more bids, what the range of bids is, and what bids and companies usually win tenders. The survey data provides insights on firms' performance, managerial practices and innovativeness. Merging these datasets provides a unique perspective on market performance and innovativeness among Canadian construction companies. First, having survey and tendering data for the same set of companies allows for comparisons of self-reported and observed levels of market competition in the industry. Next, it allows for an analysis and comparison of correlation of revealed and perceived levels of competition with the likelihood of innovation, controlling for other economic characteristics of a firm. Finally, it allows for a test of the functional form of such correlation. For example, preliminary analysis of tendering data for the period of 2001-2010 confirms a high degree of seasonality in terms of the number of winning bids as well as their total value. In terms of competitiveness, the highest number of bids per project is usually submitted in the first and second quarters of the year and over 75% of contracts were awarded through tenders with two or less bidders, demonstrating a clear tendency to increase in market competition as project value decreases. Next, we update and merge tendering and survey data; compare perceived and revealed levels of competition and analyze how perceived and revealed levels of competition correlate with innovations.

1 INTRODUCTION

Heavy competition in the Canadian construction sector has been identified in the number of studies as an important factor of slowing down technological change. For example, Waugh, Froese and Sadeghpour (2016) in their survey of infrastructure owners found that in some segments of the Canadian construction industry competition negatively contributes to the quality of the business environment. Specifically, it creates incentives for some participants to exploit project risks and seek success by means that are often incompatible with overall project goals. Such behavior destroys trust between participants and hampers the

development of a cooperative and innovative environment (Zaghloul and Hartman 2003; Drexler and Larson 2000). Earlier, Seaden et al. (2003) analyzed data of the Survey on Innovation, Advanced Technologies and Practices in the Construction and Related Industries. The authors have documented that in the Canadian construction industry, the perceived competitive threat and lack of the customers' and competitors' predictability is negatively correlated with the use of innovative practices among small and medium sized firms. In the United Kingdom, empirical results obtained by Reichstein, Salter and Gann (2005) suggest that the UK's construction industry is much less innovative compared to manufacturing. The authors found that large construction firms appear to perceive little pressure to innovate within the markets they operate in.

While the existing body of knowledge provides some discussion on the effect of competitive pressure on innovation in the construction industry, there are a limited number of data supported studies; there is no conclusive answer to the question of what are the magnitude and the direction of such an effect; and to the best of our knowledge, there is no studies comparing the effect of perceived and observed competition on innovation.

This work represents an intermediate step in our larger data-driven study of the effect of competition on innovation among Canadian construction firms. This paper has several goals. The first is to develop a methodological framework for comparative analysis of perceived and revealed levels of competition and its effect on innovation among Canadian construction companies. The second is to conduct preliminary analysis of historical tendering data and reveal central tendencies of firms' competitive behavior in the public tenderers using sample of tenders conducted in some regions of Canada. The last is to identify further steps to be undertaken in the framework of this project. We organize our work in the following way. In the next section we review the state of the art in the field literature and frame our work into it. In section 3 we develop methodological framework for data collection and analysis of the effect of perceived and revealed levels of competition on innovation of Canadian construction firms. Section 4 provides a description for our data. In section 5, we discuss the preliminary analysis of central tendencies in the tendering data. In section 6, we outline further steps of this study and provide some concluding remarks.

2 LITERATURE REVIEW

The problem of the effect of competition on innovation is neither new nor unique to the construction industry. It has been attracting interest of economists since the publication of "The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle" by Joseph Schumpeter (Schumpeter 1934). However, there is still no conclusive answer as to how competition affects innovation. For example, according to the theoretical framework developed in Mansfield (1963), a large firm with more market power should be more capable to conduct innovation due to abundance of slack resources and lower marginal impact of failed innovations on the firm's performance. A similar conclusion was made in Gilbert and Newbery (1982). However, the authors showed that under the assumptions of their model, larger firms can afford to engage into so-called preemptive innovations and conduct research and development with the purpose of technology confinement to maintain their monopolistic position on the market.

The opposite conclusion has been made in Williamson (1965), where the author finds that larger firms are responsible for the vast majority of innovation, however, smaller firms are responsible for higher proportions of innovations weighted by their market power (as a measured of their market share). It turned out that, marginally smaller firms with less market power are more innovative compared to the larger ones. A conclusion similar to Williamson (1965) is presented in the work of Reinganum (1983), where the author treats innovation as a stochastic result of innovative activities (such as research and development investments). The author shows that in the dynamic equilibrium, firms that enter the market will be more innovative in order to supersede an incumbent firm. This in turn will spur market response from the incumbent and increase overall innovativeness of the economy.

The positive effect of competition on innovation is found in multiple empirical works. For example, Gorodnichenko, Svejnar and Terrell (2010) document a positive effect of perceived competitive pressure from foreign firms on domestics firms' innovation.

A possible solution to the debate on the direction of the competition effect on innovation may be found when this effect is considered through several channels of interaction. To the best of our knowledge, one of the first authors to offer evidence of some optimal level of competition that boosts firms' innovations was Loury (1979). The author found that high competition leads to a higher probability of innovations. However, having an extremely high level of competition may not be optimal. A mathematical model that defines non-liner inverse-U was proposed by (Aghion et al., (2005). According to the model two channels of the effect exist. First, when competition is low, companies have no incentives to innovate, since they enjoy almost monopolistic market power. Second, when competition is too high, firms do not innovate, since they expect that post innovation rent (i.e. the 'economic profit' on top of the 'normal profit' that covers all production and distribution costs, and the entrepreneurs' risk reward) will be immediately removed by competitors who decide to innovate in response, and, therefore, costs associated with innovation will never be recovered.

All the studies discussed above consider competition and innovation in the broad context without discussing their relationship for any specific industries. At best, industry dummies (i.e. binary variables indicating firms belonginess to a specific industry) are used to control for industry specific shocks (Gorodnichenko, Svejnar, and Terrell 2010). However, the construction industry has unique characteristics, such as high degree of fragmentation, complexity and high costs of the final product, products' immobility and long term use, and high degree of regulation (Nam and Tatum 1988, 1989; Hartmann 2006). The limited number of construction specific studies of the link between competition and innovation do not provide a definitive answer about the nature of the effect. By analyzing data from their survey of infrastructure owners, Waugh, Froese and Sadeghpour (2016) found that the primary impediments to innovation in the Canadian construction industry are: the short-term rather than lifecycle decisions, low-bid selection criteria, by-laws, codes and permits. In addition, the authors found that some parts of the industry may suffer from excessive competition that leads participants to practices that are not in line with projects objectives and undermines a trustful and innovative environment. Seaden et al. (2003) analyzed the large scale Survey on Innovation, Advanced Technologies and Practices in the Construction and Related Industries that was collected in 1999 and includes over 1700 Canadian construction firms. The authors found that smaller construction firms are more risk averse and less likely to incorporate innovative practices in their business. They documented a strong negative correlation between innovation and perceived competitive threat among small and medium sized construction firms. In addition, the authors showed that unpredictability of competitors discourages construction firms from innovation.

According to the results of Reichstein, Salter, and Gann (2005), UK construction firms are less likely to innovate, less likely to recognized reasons that restrain them from innovation and more often say they do not perceive enough market pressure to innovate. Globally, the lack of innovation in the construction industry was pointed out by Renz and Solas (2016). As a solution to the problem the authors proposed policies stimulating competition in the construction sector. A model of moderated competition was proposed in Na et al. (2007). The authors consider the case of the Singapore economy, where the government implemented a so-called preferential margin scheme in order to stimulate innovations. According to this procedure, domestic companies and consortiums of domestic and foreign companies (where domestic company holds a substantial share) would be selected as preferred contractors for government funded projects. In such a way Singapore's government attempts to attract foreign firms with superior management practices and business process and create technological spillovers without exposing domestic firms to fierce competition from foreign companies.

In our research we attempt to fill the existing gaps by comparing perceived (self-reported in the survey set up) and revealed (observed competitive behavior in public tenders) levels of competition. We also contribute to the understanding of competition-innovation interaction in the Canadian construction industry by empirically testing the inverse-U relation. Also, we take a quantitative approach to the problem by combining three sources of data: tendering data obtained from one of regional tendering platforms in Canada; data drawn from the ongoing survey conducted by our team using a sample of construction firms participating in public tenders that are accessible through the tendering platform; and performance data acquired from the Mergent Intellect Database(FTSE Russel 2019). In this paper we outline the methodological context of our research, as well as provide a brief descriptive of the analysis of construction firms' competitive behavior observed for public tenders in some Provinces of Canada.

3 METHODOLOGY

The methodology our study is built around empirical testing of the model of competition-innovation interaction mechanism proposed by Aghion et al. (2005) by using several research methods that include survey, comparative analysis, and econometric models.

The model of inverse-U shaped functional form of competition-innovation interaction of Aghion et al. (2005) emerged as an attempt to reconcile contradicting findings of theoretical and empirical works and accommodate for the existence of both positive and negative effects of competition within the same theoretical framework. In addition, the model provides a great vehicle for policy researchers since it allows for the existence of some optimum competition in the economy. The framework mathematically models two mutually exclusive states of the market, as depicted in Figure 1.

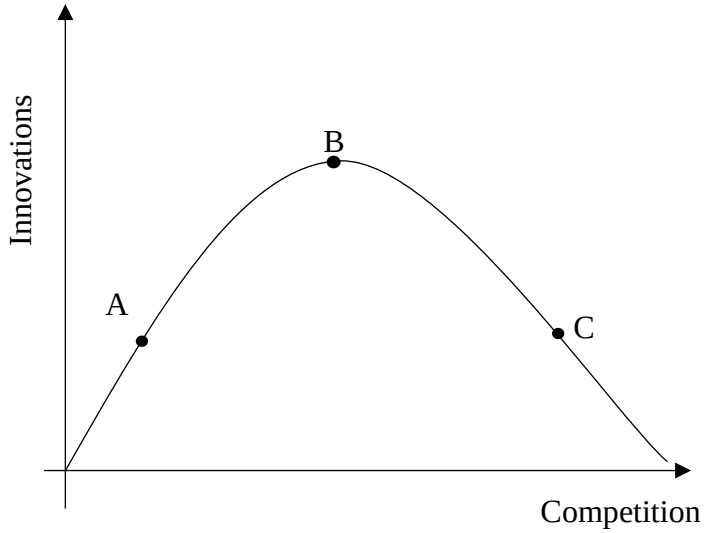

Figure 1 States of the market according to Aghion et al. (2005)

In the sate A (Figure 1), there is overall low level of competition where all firms have approximately the same production technology and no incentives to innovate. No incentives to innovate follows from the fact that firms face no or limited competition and can exhort their market power to extract more profit. At this stage an exogenous increase in competition will stimulate firms to innovate in order to attain a post-innovation monopoly and obtain post-innovation monopolist's rent. An increase in competition will lead to more innovation and therefore a positive effect will be observed. In the state B, there is already a high initial level of competition with technological heterogeneity in the sector induced by technological leaders and followers. However, neither of them has incentives to innovate. The technological leaders already have the best technology in the sector and further improvements will not bring them additional benefits. The technological followers may improve their technology, however, to gain the post-innovation monopolist's rent they have to technologically overcome existing leaders while carrying the costs of improving their technology. However, since there is a high level of competition, the follower expects that the competitors will immediately start improving their technology and their post-innovation rent will be taken off almost immediately by competitors overcoming them too quickly. Therefore, depending on how quickly competitors improve their technology, small post-innovation rent may not be enough to cover the costs of innovation. In this case, the follower is better off by not innovating and a small exogenous decrease in competition will result in more innovations. Therefore, the observed effect of competition will be negative in this case. In our research we are trying to estimate empirical parameters of these interaction for both perceived and revealed levels of competition by employing a tool kit of logistic and ordered logistic regressions (Wooldridge 2010).

As noted, in order to test the model of inverse U-shaped functional dependency of competition and innovation, we use three primary sources of data: historical (2011-2018) data on public tender of construction projects conducted in some Provinces of Canada; basic corporate information (including sales,

number of workers, and corporate structure) reported by Mergent Intellect with nearly census coverage of Canadian companies; a survey of a random sample of construction companies in the selected Provinces of Canada stratified by size, industry and public procurement participation.

Figure 2 outlines the ongoing data collection process. We begin with acquiring tendering data from one of the regional tendering platforms. Next, we match tender participants to the corporate data using company names and a fuzzy matching algorithm (Levenshtein 1966) due to inconsistencies in companies' names spellings across databases. With two data sources secured and matched, we estimate population variances for the firm's size measured by sales and number of workers. Using the estimated variances, we calculate the sample size, such that our sample means would fall within a 5% confidence interval of the population mean. Next, we stratify our sample with respect to firm size (i.e. large, medium, small) and participation in public tenders (participants, non-participants). Finally, we randomly draw a sample of companies preserving proportional representation of each strata.

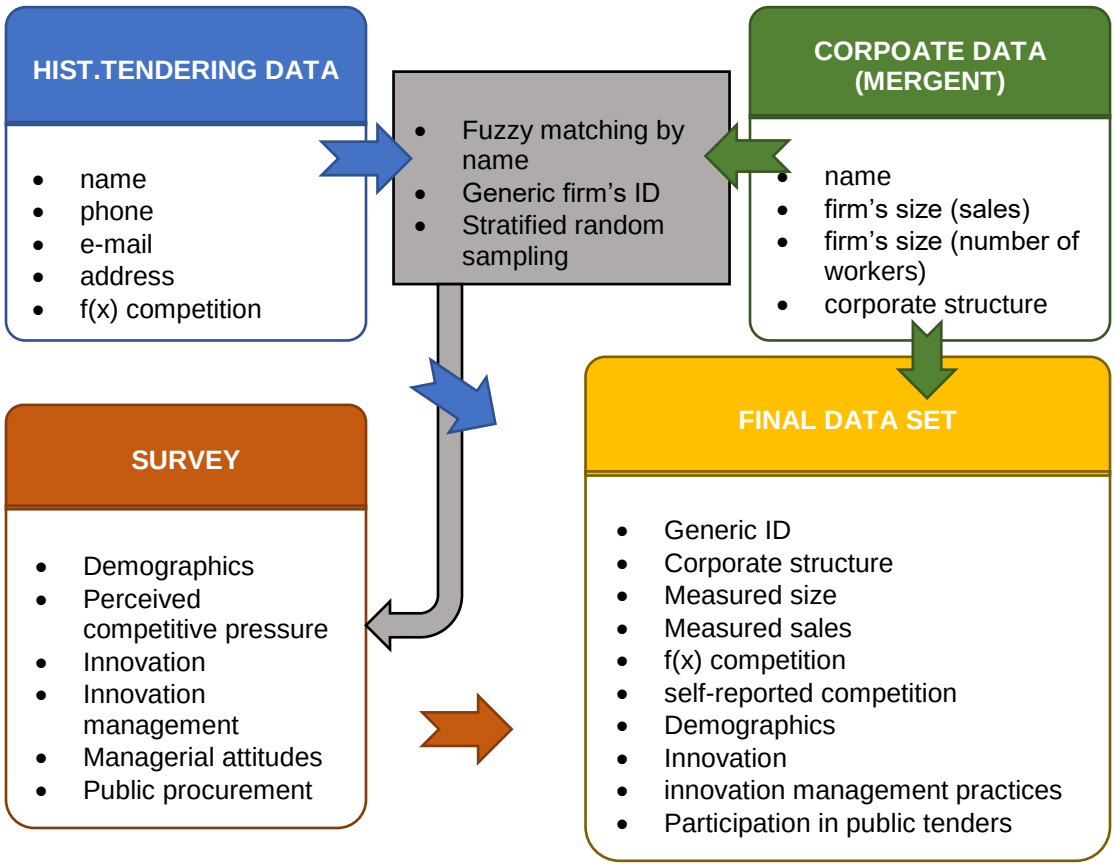

Figure 2 Data collection process

The survey is being conducted anonymously and contains blocks of questions about basic demographic characteristic, perceived competitive pressure and its sources, innovation and innovation management practices, and overall managerial attitudes. The survey being conducted utilizing an online tool with the support of partnering local construction associations.

After the survey is complete and data from all three sources is combined, each company is assigned a generic ID with no correspondence to the firm's name or any other deanonymizing characteristics to preserve anonymity of the survey responses (as depicted in Figure 2).

With all data secured, two pieces of analysis are being conducted (Figure 3). First, we compare distributions of perceived and revealed levels of competition among public tenders' participants to make an inference if the perceived level of competition is matched to what companies actually observe during tendering. Next, the perceived competitive pressure among tender participants and non-participants is compared and differences are tested using a z-test for statistical significance.

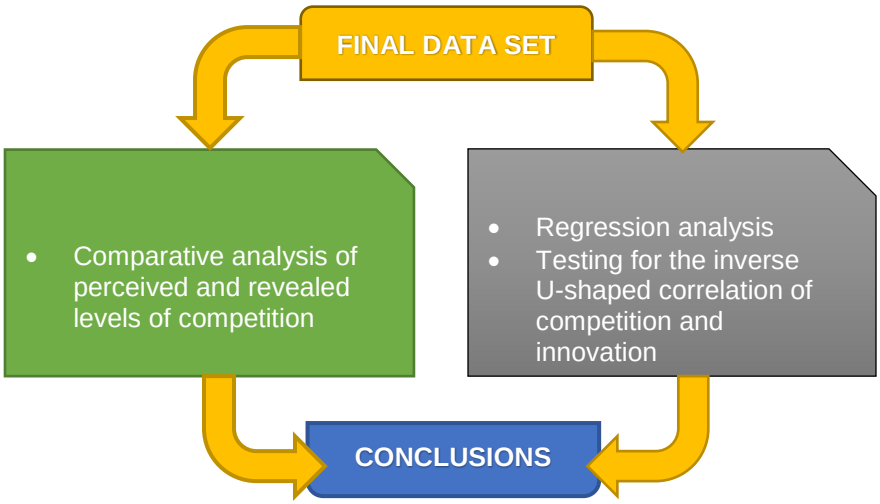

Figure 3 Data analysis process

Next, using the tool kit of econometric analysis, we estimate parameters of the linear and quadratic model specification and compare their performance in terms of coefficient significances and goodness of fit. The results of the empirical analysis are then used to conclude if the inverse-U shaped correlation between innovation and competition exists in the Canadian Construction industry. The results can potentially inform policy.

4 DATA

The data agreement with the partnering association is being processed for the 2011–2018 time period, therefore this section is currently based on a preliminary analysis on tenders conducted for a previous time period.

The database of tenders evolved starting in 1998, therefore, data on the older projects may be fragmented or incomplete. The database provides information on 18,207 projects posted to the system between January1998 and May 2010. Out of that number, some tendering information is available for only 13,283 projects and only in 9,835 cases did the tendering procedure result in a project award. These projects were tendered between July 2001 and May 2010. Most of the owners procuring their projects through the system were publicly funded entities (such as Provincial and Federal governments, port authorities, school boards, etc.). Table 1 provides the frequency distribution of awarded projects across owner types.

In addition, an examination of tendering behavior of private owners reveals that often tenders resulted in no award, an award that is substantially different from the lowest bid or in an award with no bidding information. This is not unexpected as private owners are not legally bound to close tenders with the lowest bidder.

Table 1 Distribution of tenders by types of project owners

Project Owner Category	Freq.
Government	6364
Provincial	1484
Municipal	480
Private	455

Project Owner Category	Freq.
Federal	382
Post-Secondary Academic Institutions	215
School Board	102
Other/Miscellaneous	86
Transportation Authorities	75
Health Authority	52

Project Owner Category	Freq.
Utilities	25
Housing Authority	4
Health Board	2
Port Authority	1
Total	9727

Please note, here and forth we exclude categories with obvious errors in their names, null values or an empty string instead of names. Therefore, the summations (i.e. in Table 1) may mismatch the total number of the projects procured through the system.

5 DISCUSSION

During the period of July 2001 to May 2010, the total value of awarded contracts was around $7.7bn (in prices of 2002). Figure 4 shows the dynamics of contracts value awarded for the period of May 2001 – July 2010.

Figure 4 indicates a clear seasonal pattern of procurement with most tenders awarded in the third quarter of each year. In addition, there is a substantially higher value of contracts awarded in the third quarter of 2009. The number of awarded contracts follows a similar seasonal pattern as their value (see Figure 5). The largest number of contracts is traditionally awarded in the third quarter of each year. The spike in total the value of awards (see Figure 4) somewhat coincides with the number of contracts in the third quarter of 2009. However, the spike is less prominent compared to the awarded contracts' value. This suggests that in the third quarter of 2009 there was a boost in the average value of contracts awarded in 2009.

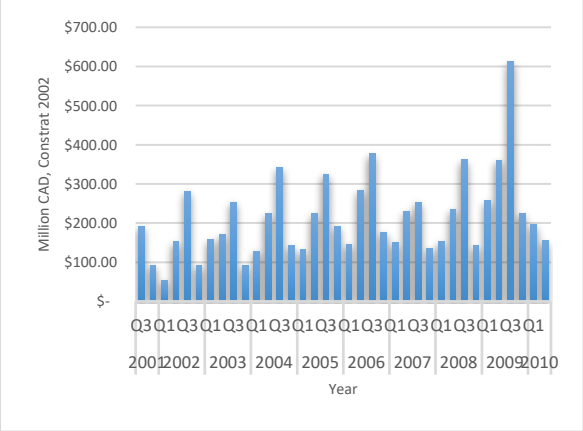

Figure 4 Quarterly values of awarded contracts, 2001-2010

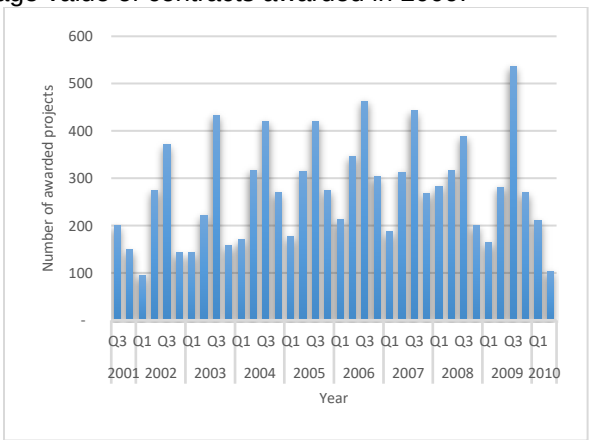

Figure 5 Number of contracts awarded quarterly, 2001-2010

In terms of competitiveness of tenders conducted through the regional construction association, the competitiveness of public procurement tends to increase by the end of 2005. Staring in 2006, there is a seasonal pattern of competitiveness (see Figure 6). It appears that projects awarded in the first and the second quarters of each year are more competitive compared to those awarded in the third and the fourth quarters. Possibly, it is related to the number of the projects awarded in those months or the nature of the work.

More than 75% of contracts were awarded through tenders with two or less bidders, which implies quite low competitiveness in the vast majority of tenders. Figure 7 shows the cumulative distribution of the total worth of contracts awarded across tenders with various number of bidders.

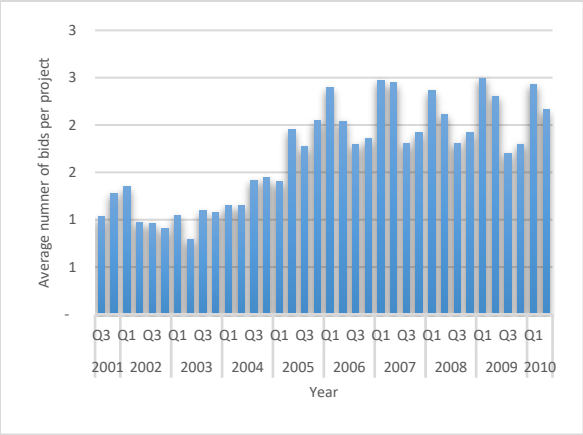

Figure 6 Average number of bids submitted per project, 2001-2010

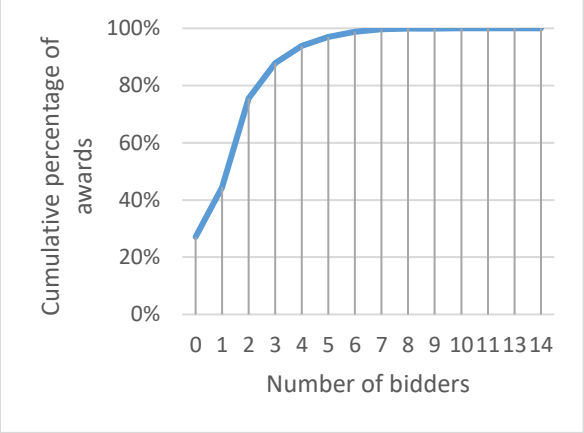

Figure 7 Cumulative distribution of the total value of projects awarded across total number of bids.

It appears that in terms of the project size and competitiveness there is a negative linear tendency (see Figure 8). As the average project value increases the tender's competitiveness drops significantly. Moreover, the variation in average contract value explains 65% of the variation in the number of bidders. This may be explained by the fact that for lower valued projects a greater number of smaller size firms are engaged in competition.

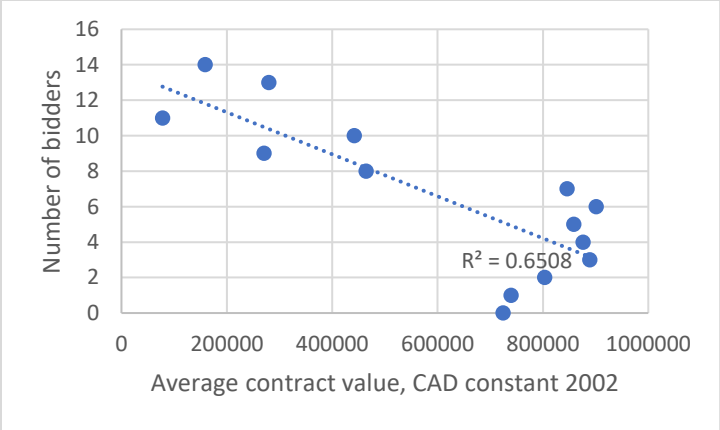

Figure 8 Competitiveness and average warded values of tenders

6 CONCLUSION

With this study we developed a framework for quantitative evaluation and benchmarking of perceived and revealed levels of competition in the Canadian Construction industry. Specifically, we measure perceived competitive pressure by using a survey method and ask companies to state their perception in terms of their estimate of the number of competitors they observe at their primary market of operation. In addition, they are asked to evaluate how competitive pressure affects their decision making. We then compare perceived competition to the competitive behavior and the market environment observed by the same companies at the public tendering platform. When all the data is secured, we estimate empirical parameters of the model of interaction of competition and innovation in the construction industry.

Our preliminary study of the historical tendering data for the period of 2001-2010 provides some quantities insights to the process of public procurement of construction projects at a regional tendering platform. Specifically, we observe a high degree of seasonality of the tenders' awards in terms of the number and their monetary value. In addition, we observe that the vast majority of the projects have been procured in the tenders with two or less bidders, which suggest that the degree of competition in the Canadian construction industry might be overstated. In addition, we document that there is evidence that between 2001 and 2010 there is a negative correlation between a project's size and the level of competition. This implies that the excessive competition might be observed by only the small and medium sized companies.

We have designed and tested the survey questionnaire with several construction companies. The analysis of the responses and willingness to participate reveals the high interest in this study among the industry participants. Further proceedings with the survey are contingent on finalizing our approval for the use of updated tendering data and the proper sampling procedure.

Given the outdated nature of the data set, a similar exercise must be repeated for the modern data in order to corroborate and further investigate the observed tendencies. In addition, with the forthcoming updated tendering and the survey data, the hypothesis of the inverse U-shaped correlation between competition and innovation in the Canadian construction industry will be tested by applying the proposed framework. In addition, we expect that further investigation will be necessary to introduce another metric for the level of rivalry between tender participants for large projects where fewer companies exist in the market for a given project scope.

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