Research Statement

September 12, 2017

My primary area of research is empirical industrial organization. My research projects typically use new data, a new modeling framework or a new econometric method to understand the functioning of specific markets and to assess the impact of policies and regulations.

My research agenda has three main parts with significant interdependence between them. The first part is devoted to the study of public procurement markets which account for a significant fraction of aggregate economic activity and government spending. My research is focused on understanding the economic mechanisms governing the operation of these markets, such as the endogeneity of participation and subcontracting decisions, and on using this knowledge to evaluate the impact of government policies. The second part of my agenda is focused on the analysis of online auction markets which have emerged over the last decade as a major platform for industry procurement. The data generated by online markets possess a number of unique features that have required me to develop a set of techniques that enable the empirical study of these markets. In the third part of my research agenda I study important non-procurement markets that are among those at the forefront of public policy debates, such as the operation and regulation of private pension (social security) systems and the market for auto insurance. As discussed in more detail below, my research on these markets is greatly facilitated by the ability to leverage insights from my other research areas.

My applied research isolates different channels through which new or existing policies affect the market and assesses their overall impact. The methodological contributions of my research address some of the key challenges at the heart of such analysis. They include recognizing and modeling features of the environment salient to the assessment, establishing identification, i.e., the theoretical mapping between the data and the model components (primitives), and designing an estimation strategy which allows one to obtain consistent estimates of the model primitives from the available data that are often imperfect and limited in various ways. In several papers I also develop computational algorithms needed to solve and estimate the model.

In what follows I describe my research contributions to date and my current projects. Given the significant interdependence between the parts of my research agenda, I have structured the discussion on the basis of shared methodological insights across my research papers.

1 Unobserved Auction Heterogeneity, Entry, and Two-stage Game of Competition

Identification of Auction Model with Unobserved Heterogeneity. Auction participation is of long standing interest to researchers analyzing auction markets. This interest was motivated in part by the theoretical finding that increased participation has a large impact on auction revenue or procurement costs. Moreover, participation in auctions reflects firms' strategic decisions which means that participation-related variables, such as the number of bidders, may be endogenous in a statistical sense. In order to obtain unbiased estimates of the primitives a researcher has to take this endogenity into account in the empirical analysis. Yet, a methodological framework necessary for the structural analysis of auction models with endogenous participation had not been developed at the time when I started my research career. Such a framework needs to incorporate an auction-level unobservable which influences firms' participation decisions, but it was not clear whether such models can be identified from standard data. The contribution of my research in [1], which stems from my Ph.D. dissertation, is to propose a constructive identification strategy to recover primitives of the model with unobserved auction heterogeneity. This identification strategy is further translated into the estimation strategy which is shown to produce uniformly consistent estimates of the distribution of costs. I apply this estimation strategy to data from the US highway procurement market in order to assess the importance of private information about contractors' costs and thus the magnitude of informational rents that may arise in these markets. I also demonstrate that the estimates of the distribution of contractors' costs may be significantly biased if unobserved project heterogeneity is not taken into account. This paper has been quite influential in prompting empirical researchers to account for unobserved auction heterogeneity in studies of related markets. It has also motivated further methodological research extending my results to more general settings. For example, my own work in [2] extends the analysis to a setting with multi-dimensional unobserved auction heterogeneity.

The Bid Preference Program and Entry into Auction. In [3] I study the impact of affirmative action on the public procurement market while emphasizing participation adjustments induced by such a policy. This policy, a bid preference, allows contractors from some groups which are identified as disadvantaged[1] to win projects even when they do not submit the lowest bid. The key question about this policy is its impact on procurement costs. While these programs have been the focus of extensive research, the existing studies did not take participation effects into account. For example, theoretical studies indicate that such discriminating policies may help to exert additional competitive pressure on non-disadvantaged businesses, which tend

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[1]These are small businesses or minority-owned businesses which are likely to have high-costs either due to lack of experience, small scale, or lack of integration within the business community. The preference is given with the objective to enable entry and subsequent growth of such businesses which would ultimately contribute to increased competitiveness of the marketplace.

to have low costs, and thus bring the overall cost of procurement down. However, these studies did not account for the fact that the low profitability of auctions where bid preference is implemented makes them unattractive to non-disadvantaged businesses. Reduced participation by such firms may result in higher procurement costs since it eliminates strong low-cost competitors, and the "competitive pressure" effect is not realized when the non-disadvantaged businesses do not participate. Our empirical results confirm the importance of this mechanism and imply that the program should be tailored to take into account local economic conditions.

This paper also makes a methodological contribution by proposing a framework to incorporate the endogeneity of participation decisions. Specifically, we allow the distribution of bidders' costs to depend on observed and unobserved auction characteristics. This generates statistical endogeneity of strategic participation decisions. Further, we model the auction as a two stage game where in the first stage the potential auction participants decide whether they want to participate or not, and then in the second stage they decide on their bids (prices). Such modeling directly incorporates the dependence of pricing strategies, and thus the firm's profitability, on the realized set of participants which in turn correctly informs potential participants about the implication of their own and competitors' participation decisions. This was a novel feature in the empirical auction literature and also more broadly in the empirical literature studying market participation. Indeed, existing empirical studies of participation in general markets relied on the reduced form representation of profits which did not include prices. Our approach allowed us to verify whether a given model is capable of simultaneously rationalizing pricing and participation decisions (in other words, whether observed participation is consistent with subsequent pricing and thus profitability).

Privatized Pension Systems. The importance of linking firms' competitive choices with subsequent realized pricing and thus profitability also underlies my work in [4].[2] This paper studies the privatized pension system implemented in Chile. One of the main policy goals in designing such systems is ensuring that sufficient funds can be accumulated by the time an individual retires and specifically protecting pension accounts from large losses. Existing proposals for the design of such systems frequently involve some form of a minimal return regulation. The Chilean version of this regulation required the industry to provide a guaranteed minimum return to their consumers which was tied to average industry performance. Such a policy partially protects consumers from downside risk, and it is expected to discipline industry portfolio choices by placing the financial burden of this protection on the industry. We study the effect of this regulation on the decisions by firms in the industry of what portfolios to offer and what fees to charge.

We model the competition in this market as a two-stage game where firms first simultaneously decide on the riskiness of their portfolios and then simultaneously choose fees taking into account the set of portfolios offered in the market. We account for the fact that the profitability of a

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[2]This paper considers firms' positioning (rather than participation) decisions, i.e., decisions concerning which products to offer and links them to subsequent profitability associated with different choices.

given portfolio (given the set of portfolios offered in the market) depends on the type and the number of consumers this portfolio attracts. Indeed, the fee revenue in this market is tied to a consumer's contribution and thus his income, whereas the regulatory cost of serving a given consumer is proportional to the balance he carries in his pension account. Further, a consumer's decision of which firm should manage his pension accumulation is driven, in addition to the size of his balance and income, by his attitude towards risk and by his preferences for higher retirement income versus higher current disposable income.

We find that, contrary to expectation, this regulation results in firms offering riskier portfolios and charging higher fees. This effect arises because the regulation makes consumers prefer riskier portfolios. Further, everything else equal, the safest portfolio in the market has the highest likelihood of falling below the threshold imposed by the minimum return regulation. The need to cover expected regulatory costs results in higher fees. In the setting where the safe portfolios find it difficult to cover costs by means of fee revenue, the profitability considerations incentivize firms to try to "escape" regulatory costs by offering riskier portfolios (relative to their competitors). This creates strategic complementarities which ultimately result in a riskier set of portfolios offered in the market relative to the case without regulation.

This paper remains one of the very few studies to analyze the supply side of the privatized pension market. It is a very challenging problem both conceptually and methodologically. The theoretical characterization of the solution to such models is yet to be developed. At the same time, despite the Chilean government's efforts to collect extensive data for this market, the analysis is complicated by the fact that the market is highly regulated with several conflicting regulatory rules in place. This makes it difficult to recover underlying primitives as well as to isolate the impact of various features of the Chilean economy on the operation of this industry.

2 Online Auctions

The last decade has seen a dramatic change in the service marketplace. Specifically, the Internet enabled the provision of many services, particularly, professional services, by providers who are no longer restricted by a joint location with the buyer. These transactions are facilitated by intermediaries that provide a platform for the buyers and providers to meet. The design of such online marketplaces varies, but the typical format involves buyers posting a description of the desired service (project) and then running an auction to select a provider among those who expressed interest in the job. As is common in industry procurement, the auction mechanism which is used (usually referred to as multi-attribute auction) allows a buyer to select a provider based on the value of the submitted bid as well as other considerations, such as the expected quality of the provider. The emerging organization of trade in professional services through online auctions suggests that the insights developed in the auction literature could be used to study how these markets function and to develop policies tailored to their design. However, the specific features of these settings and the nature of the available data often differ from those studied in the traditional empirical auction literature and thus require new methodological tools. In a

series of papers, I developed a conceptual and methodological framework which enables structural analysis of online procurement markets. My work in this area is based on a unique and very rich dataset which covers a leading online procurement market for programming services. I use these data and methods to assess the welfare implications of the globalization of service markets, to analyze international trade in markets for services, and to measure the impact of policies that restrict action formats used in public procurement by contrasting those pricing mechanisms to a more flexible one used in online markets.

Unobserved Provider Heterogeneity. Descriptive analysis of the data reveals that observable provider characteristics (including indicators of past performance) explain only a small part of the variation in the seller-specific outcomes and that buyers tend to choose providers who charge higher prices, everything else equal. This suggests that some characteristics observed and valued by buyers, such as provider quality, are not recorded in the data. A potential selection of providers on unobservables should thus be of a foremost concern in any positive or normative analysis of such markets.

In [5] I develop a methodology which allows researchers to take unobserved provider heterogeneity into account. This analysis addresses a set of novel methodological challenges which arise in the context of online procurement markets. Specifically, in contrast to other discrete choice settings, it is impractical to capture unobserved provider quality by provider-specific fixed effects. The two main difficulties are that market shares of individual sellers can be very small in some auctions and that very few auctions feature the same set of sellers. The first issue is problematic both for MLE and GMM methods because their accuracy suffers when the choice probabilities are close to zero. The second issue gives rise to a problem in the context of GMM estimation because the probability of choice conditional on choice set – the basis for GMM estimation in the analysis of differentiated products markets – cannot be precisely estimated.[3] While one could have hoped to be able to resolve these issues by some straightforward extension of the existing methods, in reality such extensions are far from obvious and, on a close examination, tend to run into identification, performance, and robustness issues.

In the differentiated products setting, the first issue is often addressed by aggregating the products to the level where market shares become of reasonable size (for example, by treating all the models from the same car family within a producer as one product). Our approach is based on the same logic but is designed to tackle the issue that there is no obvious way to similarly group individual providers in the market we study – so that the members of the group are roughly interchangeable from the buyer's point of view – because providers are not related to each other in any way. Thus, the first methodological contribution of the paper is to propose a basis for aggregation over providers and over the choice sets under which the model primitives are identified and which enables robust performance of the estimation procedure given the available data structure. Specifically, we derive pairwise inequality restrictions which link providers' relative performance to the ordering of their qualities. This property allows us, in

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[3]I provide a more detailed discussion on why a new estimation procedure is needed in [**?**].

the first step, to subdivide the population of sellers into groups of equal quality through the testing procedure which does not require specific knowledge of model primitives. Once this group structure is recovered, we use it in the second step to estimate other primitives of the model through a GMM procedure based on a novel set of moments that aggregate over choice sets to overcome the second issue.

This methodology also addresses another challenge which arises due to the high turnover of market participants. It has been long recognized in the traditional procurement literature that transitory participants ("fringe bidders") cannot be simply excluded from the analysis because of the significant competitive pressure they exert.[4] However, the literature has maintained the assumption that fringe bidders are homogeneous, an assumption that seems implausible in our market with highly heterogeneous service providers. Unobserved heterogeneity of such transitory providers cannot be captured by fixed effects since a researcher only has a very small number of observations per such provider within the context of a non-linear model. Thus transitory providers' qualities have to be modeled as random effects correlated with prices and other characteristics. In short, transitory providers introduce mixture components into the estimation. An important insight which emerges from this paper is that, in the presence of permanent (long-term) providers, whose unobserved type could be identified from the data, the mixture components associated with transitory providers can be identified utilizing the variation in permanent provider bids combined with the variation in the set of competitors and conditional on permanent providers' types. This insight has broad implication and can be used in other settings. For example, I use it in [14] to measure learning-by-doing in highway procurement markets.

Applying this methodology to the data, we recover buyers' preferences for sellers' attributes including quality and price, assign quality levels to the long-run sellers, and recover the distribution of quality levels among the transitory sellers. This allows us to evaluate the benefit to the buyers brought about by the Internet, i.e. the gain in welfare that buyers in this market obtain relative to the outside option (offline market). We find that the gains are quite large (close to 70% of the project value).

In [9] I compare the multi-attribute auction mechanism preferred in industry procurement to the standard auction mechanism used in public procurement. The starting point of the analysis is that an auctioneer, both in the public and industry setting, cares about non-price seller characteristics (e.g., quality). Industry procurement directly incorporates this preference into the award rule allowing for the auctioneer to discriminate among bidders on the basis of non-price characteristics. In contrast, public procurement usually incorporates a certification stage at which low quality providers are excluded from participation. In our analysis we specifically consider the impact of the auction mechanism on the competitiveness of the resulting pricing and on the composition of the set of participants in terms of the features needed by buyer.

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[4]This is in contrast to the studies of differentiated products which tend to drop unsuccessful products from consideration. This is feasible in their context, because all unsuccessful products combined account for a very small market share and constitute a tiny part of any buyer's choice set. However, in our market, often more than half of the choices in any buyer's choice set consists of transitory sellers, and the probability that any given buyer will choose a transitory seller is quite large (0.38).

Despite the concern that the auction mechanism used in public procurement is restricted for accountability reasons, we find that this restriction does not lead to significantly suboptimal outcomes of public procurement.

Classification Methods. The key step of grouping providers in [5] is an application of a more general econometric theory developed in [7]. In this paper I introduce a testing-based classification procedure which delivers consistent estimates of the underlying group structure associated with unobserved agent heterogeneity. The procedure extends to a large number of settings where the analysis of unobserved agent heterogeneity is very difficult, e.g., settings where agents are strategically interdependent and may be sparsely common across markets. It also allows for a very general set of data generating processes including the case where the number of agents in the population grows with the number of observations. The procedure is computationally feasible and robust to many realistic features which frequently complicate analysis of settings with strategic interdependence of agents.

International Trade in Online Markets. The analysis in [5] focuses on the demand side of the market. It incorporates the standard model of entry where potential bidders consider one auction at a time, and its contribution is to develop a methodology to recover sellers' unobserved heterogeneity and the distribution of buyers' preferences. In [8] I complement this analysis by developing a model of the supply side which is capable of rationalizing sorting into participation across multiple auctions. I then bring the two methodologies together to deliver a comprehensive equilibrium analysis of the market where multiple projects are auctioned at the same time. The explicit micro-founded model of both demand and supply in [8] then allows for the simultaneous rationalization of pricing and entry patterns in the market.

Clear evidence of sorting in the data emerges along the international trade dimension. The buyers and sellers in the online market I study come from a large number of different countries with buyers awarding 80% of all projects to sellers located in countries different from their own. As in the case of trade in goods, I observe significant clustering of trade flows, with buyers from a given country disproportionally awarding contracts to sellers from specific countries.

Motivated by these observations, I consider a model which allows for the volume of transaction between any two countries to be shaped by the decisions of the supply side as well as the demand side participants. Specifically, the shares of trade between buyers and sellers from various countries reflects not only the preferences of the buyers but also the selection of bidders from the various seller countries in the auctions run by these buyers. These participation decisions by the sellers are determined by their expectations about the profitability of various types of auctions.

This framework reflects the regularity that, in these markets, multiple projects are offered for bidding at the same time forcing sellers to decide which auctions to enter. This implies that the set of participants, bids quoted, the service received, and the price paid by the buyer depend on the overall set of projects offered and on the overall set of providers present in the market at a given time. These outcomes will thus change under alternative configurations of

these sets induced, for example, by changes in policy. In other words, changes in policy may induce re-sorting of sellers across projects with potentially important consequences for economic outcomes.

The model estimated in this paper closely matches the endogenous sorting of buyers and providers reflected in the clustering of trade observed in the data. Importantly, we find that sellers' participation decisions significantly contribute to the observed clustering of trade. In fact, counterfactually shutting down the participation channel in the estimated model eliminates 70% of the clustering. We then use this model to study the impact of several economic policies and find the crucial role of re-sorting which arises as a by-product of these policies in policy evaluation.

3   Endogeneity of Agents' Private Types

The standard framework for the analysis of the setting with private information assumes that the distribution of private types is fixed and is exogenously given. Recently, however, researchers have started to become increasingly aware of the fact that in many settings economic agents have a degree of control over their private types. Taking endogenity of their type into account is then essential to obtain unbiased estimates of the economic primitives and an accurate assessment of the impact of economic policies since the agents may respond to changes in policy by adjusting their types. An important part of my research agenda is devoted to understanding different mechanisms through which agents' types may be adjusted and their economic consequences.

Moral Hazard.   In [10] I assess the importance of this issue in the context of the auto insurance market. Specifically, I study the implications of drivers' ability to modify their risks (the probability of having an accident) in response to economic incentives. It is intuitively clear that such ability arises because individual risk depends, in part, on how often and in what conditions he drives, factors which are under an individual's control. Presence of moral hazard is also evident from the data which indicate that individuals who are labeled by the industry as less risky tend to have more accidents than those labeled as more risky. This apparent contradiction can be resolved once it is taken into account that those drivers who are classified as risky are subject to harsher penalties for any future accidents than their less risky counterparts.

The analysis is based on a dynamic model of individual choice of insurance contract and risk level which incorporates individual heterogeneity in the cost of effort and risk aversion. The first application of the estimated model is to re-assess the importance of private information about individuals' riskiness while taking into account the fact that risk in this market is endogenous and reflects the incentives faced by the driver. In contrast to prior literature, we find a high degree of private information about the individual's cost of effort and risk aversion which translates into a substantial private heterogeneity in individuals' risk. We also find that failing to account for moral hazard in estimation may lead the researcher to underestimate private heterogeneity in

realized risk, overestimate private heterogeneity in risk aversion, and to erroneously infer that risk and risk aversion are positively correlated.

The conceptual framework which incorporates moral hazard also allows us to shed some light on the design of contracts used in this market. Specifically, an integral component of pricing in this market is experience rating which links the premium an individual pays for the insurance contract to the recent realizations of their risk (accidents). While the industry may use experience rating to screen individuals on risk (and thus price individual risk more precisely), we find that experience rating is ineffective as a screening tool. It is, however, highly effective at incentivizing risk reduction. In contrast, contracts with varying degree of coverage are a very effective screening mechanism. In fact, early theoretical literature suggests that the industry should offer a menu of contracts in order to overcome inefficiency issues associated with private information about idiosyncratic risks. In practice, however, we find that the menu of contracts tends to separate individuals primarily on observables with pricing designed in such a way that extended coverage is an economically viable alternative only for individuals with expensive cars. This is likely to reflect concerns for risk expansion which arise in the presence of moral hazard as well as the industry's ability to control the risk through the incentives embedded in contract pricing.

Finally, we evaluate the consequences of the mandatory liability insurance regulations in the presence of moral hazard. We find that these regulations increase the probability of accidents. Instead, alternative regulations that allow for partial liability insurance can significantly reduce the number of accidents by providing incentives for risk reduction associated with exposing drivers to higher risk on the margin.

Subcontracting. In [12] and [13] I study the implications of the ability of primary bidders to modify their private costs through subcontracting. Subcontracting plays important role in procurement markets, e.g. in highway procurement 30% of the work is subcontracted on average. Yet, this feature is little studied in the literature in part due to the data limitations. My work in this area is based on a unique dataset which I, with the help of coauthors, put together over the years. This dataset provides for each project the full list of tasks that need to be completed and, for each contractor who submitted a bid for this project, a subset of tasks that contractor subcontracts, identities of subcontractors, and the prices paid to each subcontractor. The descriptive analysis of these data indicates that within contractor the same task is subcontracted for some projects and is performed in-house for others. In other words, contractors frequently subcontract tasks that they are capable of completing in-house. This suggests that subcontracting is used to modify the contractor's costs and thus to increase the contractor's competitiveness in a given auction.

In [12] I investigate the implications of subcontracting in the market where capacity constraints are important. Subcontracting allows a firm to modify the size of the project it takes on to optimally suit the firm's current capacity utilization and the market conditions. It also enables firms to eliminate high cost draws in general. In the model, contractors decide whether

to participate in the auction or not and, conditional on participation, they decide which fraction of work to subcontract and what bid to submit. We calibrate this model using data from the California highway procurement market. We find that availability of subcontracting reduces the cost of the procurement by 14% and increases the volume of work completed in this market by 20%. We also demonstrate that the estimates of the model parameters may be substantially biased if subcontracting is ignored in estimation (which is the case for most studies). For example, the parameter capturing the impact of capacity utilization on costs would be underestimated by 50%.

The objective of my current work in [13] is to develop a framework which incorporates the economic and informational links between primary auction bidders that arise due to the participation in subcontracting market. Indeed, primary contractors are approached by the same set of subcontractors. As a result, they obtain signals about competitors' costs even if they do not hire the same subcontractors. Further, quite frequently the same subcontractor appears on the bid documents of multiple primary bidders for the same project. In addition, in imperfectly competitive subcontracting markets, subcontractors price their services strategically taking into account the impact they have on the main contractor's probability of winning the project. The decision to subcontract at a given price by primary contractors, and the decision of subcontractors which prices to quote are endogenous and depend on the market conditions at the time of the auction. These decisions shape the joint distribution of contractors costs. We explore implications of the endogeneity of the distribution of costs for the estimation of primitives and for the policy analysis. We also resolve a number of methodological issues associated with identification of the model primitives given the structure of the available data.

The Impact of Learning-by-Doing on Costs. In an ongoing project [14] I study learning as a source of cost modification. This paper is motivated in part by my earlier work on bid preference programs. The stated objective of these programs is to help disadvantaged contractors lower their costs through learning by working on a project. This, in turn, is expected to help businesses survive and make the procurement marketplace more competitive. Indeed, it has been shown by my Ph.D. student, Lucia Tiererova, that contractors who won more projects have more advantageous cost distributions. However, to measure the effect of learning it is important to distinguish it from selection whereby inherently lower cost contractors are more likely to win projects and, also, survive longer. This information, even though embedded in their bids, is misinterpreted by a model which does not allow for the heterogeneity of contractors. In this new paper I allow for unobserved contractor heterogeneity and use the methodological insights developed in my work on online auctions in [5] and [7] to estimate the distribution of contractors' costs and the adjustment of the cost distribution associated with learning-by-doing conditional on type. Specifically, I exploit variation in the bids of established contractors and in the competitive structure across auctions to identify these primitives.

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