I am a microeconomic theorist who studies the role of information in markets. A main focus of my research is to develop and study models of markets with multi-product sellers. My work has characterized optimal selling strategies and explored the welfare consequences of market segmentation in multi-product settings. A second interest of mine is in modeling markets for information, where I have developed models of the certification industry, the use of samples in auctions, and data cooperatives. Outside of these two interests, I have also studied other questions pertaining to economic theory. Methodologically, my work develops new approaches for mechanism design including settings with multi-dimensional heterogeneity.

1 Markets with multi-product sellers

Many markets involve sellers with multiple products. To analyze these markets, it is important to understand optimal selling strategies for such sellers. Some of my papers find conditions under which we can characterize a seller’s optimal strategy and develop computational tools when closed-form characterizations are unknown. Some of my other papers apply these results and tools to explore the welfare implications of market segmentation in multi-product settings, combining second- and third-degree price discrimination.

Pure bundling. Should a multi-product monopolist sell products separately or offer discounts for buying them as bundles? If bundling is profitable, which products should be bundled and at what prices? A large theoretical literature that studies this problem highlights that the solution may be complex. The seller may find it optimal to offer a very large menu of bundles and may even benefit from randomization.

In “When is Pure Bundling Optimal?” (Review of Economic Studies) joint with Jason Hartline, we find conditions under which pure bundling, i.e., selling only the grand bundle of all products, is optimal. The main insight is that the optimality of pure bundling depends on the degree of consumers’ perceived complementarity between products. In particular, this strategy is optimal when more price-sensitive consumers (e.g., those who have less money) consider the products to be more complementary. For instance, this could happen in the context of streaming services if price-sensitive consumers have more leisure time, so they have a higher added value for watching more movies or shows. Methodologically, this work
makes progress towards solving multi-dimensional screening problems in which buyer types cannot be ranked. We solve the problem by developing an orthogonalization approach that decomposes the problem into simpler ones.

**Pareto improving segmentation.** In “[Pareto Improving Segmentation of Multi-product Markets](#)” (forthcoming in *Journal of Political Economy*) joint with Ron Siegel, we highlight the welfare-enhancing potential of market segmentation in a multi-product setting. We study a multi-product seller who serves a market of consumers. If the market is not segmented, then the seller has to offer the same menu of products and bundles to all consumers. But if the market is segmented, then the seller can offer different menus to different segments. Can every inefficient market be segmented in a way that benefits all consumers and the seller? The answer, perhaps surprisingly, is generically affirmative. We give a construction of such Pareto improving segmentations. This construction is based on understanding what drives inefficiency: the only reason a seller serves some consumer, say consumer 1, inefficiently is to be able to charge more from some other consumer, say consumer 2. Based on this observation, we construct a segment in which the seller serves consumer 1 efficiently, thereby increasing consumer 2’s surplus. This result speaks to ongoing debates on the regulation of consumer data and what kind of information sellers should have access to. Appropriate regulation of sellers’ access to consumer data can lead to unambiguous improvements in the sense that benefiting the seller or some consumers does not necessarily mean that other consumers must be harmed.

**Consumer optimal segmentation.** Given the welfare-enhancing potential of market segmentation, we next turn to understanding “the best” market segmentations. In “[The Limits of Multi-product Price Discrimination](#)” (forthcoming in *American Economic Review: Insights*) joint with Ron Siegel, we study what segmentations maximize average consumer surplus. In particular, we ask if there is a segmentation in which the consumers’ “first best” payoff benchmark is achieved. The first best benchmark is an upper bound on the consumers’ payoff in any segmentation and is equal to the surplus of the efficient allocation minus the seller’s payoff in the original, unsegmented market. Achievability of this benchmark is closely

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1 An inefficient market is one where the the profit-maximizing allocation of some consumer is inefficient. Otherwise, if the allocation of all consumers is efficient, then total surplus is already maximized so there is no room for improvement.
related to the conditions of my earlier paper, “When is Pure Bundling Optimal?” In particular, this benchmark is achievable if and only if the conditions in the earlier paper are satisfied so the seller always finds it optimal to use pure bundling.

Dynamic mechanisms. In [“Sequential Mechanisms with ex-post Individual Rationality”] (forthcoming in Operations Research) joint with Itai Ashlagi and Costis Daskalakis, we study how a multi-product monopolist screens a buyer dynamically. In our setting, the buyer receives information about the values of products over time. So unlike many other dynamic screening settings, products do not arrive over time (nor do they perish). It is the information about them that arrives over time. This allows the seller in our setting to use a wide range of mechanisms, some of which are static (e.g., wait until all the uncertainty is resolved and then offer a menu) and some of which are dynamic (offer prices that adjust over time). Thus our model nests the classical static multi-product monopoly problem.

We provide an algorithm that computes the optimal mechanism. We use this algorithm to obtain conditions under which the seller benefits from screening the consumer over time, as opposed to using a static mechanism. A main insight is that the optimality of static mechanisms depends on the order in which the buyer learns the values for the products: static mechanisms are sub-optimal if the buyer learns the values for ex-ant more valuable products first.

Multi-unit demands. Many screening problems involve multiple units of products. For example, a cellphone service provider sells multiple units of calls and data, and a cloud service platform sells multiple units of service on virtual machines. Often, these units are sold using price schedules that specify how much a buyer needs to pay for any given quantity of usage. In “Optimal Multi-unit Mechanisms with Private Demands” (Games and Economic Behavior) joint with Nikhil Devanur and Alex Psomas, we study when such strategies are optimal, even if the seller can use more complex strategies such as randomization. We study a model in which buyers are heterogeneous both in their marginal values for products and their “demand”, i.e., how many units they wish to consume. We show that deterministic price schedules are optimal if for any given quantity, the revenue curve for selling only that quantity (as a function of different prices) is concave. This observation has computational implications; under the concavity condition, we develop an algorithm to compute optimal price schedules.
Computation. Even though there are some multi-product settings in which we can characterize optimal mechanisms (including the ones I discuss above), a general closed-form characterization is not known. In “Efficient Computation of Optimal Auctions via Reduced Forms” (Mathematics of Operations Research) joint with Saeed Alaei, Hu Fu, Jason Hartline, and Azarakhsh Malekian, we develop computational tools to calculate optimal mechanisms. A challenge is that even describing a mechanism may require exponentially many bits because the auction needs to specify an outcome for any (exponentially many) profile of bids. So it is necessary to find a succinct representation of a mechanism that can be used in our optimization problem. We formulate and characterize a “reduced form” representation of mechanisms, and use this reduced form to develop algorithms to compute optimal auctions. Several of my other papers from my PhD study computational aspects of optimal mechanisms and are published in peer-reviewed conference proceedings or journals.\footnote{These include “The Simple Economics of Approximately Optimal Auctions” in Foundations of Computer Science, “Optimal Auctions with Positive Network Externalities” in ACM Transactions on Economics and Computation, “Revenue Maximization with Nonexcludable Goods” in Transactions on Economics and Computation, and “Equilibrium Pricing with Positive Externalities” in Theoretical Computer Science.}

2 Data markets

What is traded in markets is often not just goods and services but information about those goods and services. Sellers often collect and disclose information about their products by acquiring certificates or displaying reviews from past purchases, or obtain information about consumers’ tastes with or without their consent. I have an ongoing research agenda to better understand these data markets.

Selling information. I study markets for hard information in “How to Sell Hard Information” (Quarterly Journal of Economics) joint with S. Nageeb Ali, Ron Siegel, and Xiao Lin. We study a seller who has an asset to sell in a competitive market. The value of the asset is unknown, but an intermediary (e.g., a testing agency) offers the seller a test that provides verifiable information that the seller can reveal to the market. Importantly, testing the asset is optional for the seller and not observable by the market. After testing the asset, the seller may simply conceal the result and pretend to not have taken the test.

We study how the intermediary optimally designs and prices such a test to maximize
profit. Even though testing is optional for the seller, the intermediary can extract significant profit by designing a test that is “irresistible.” In particular, the intermediary chooses prices that are low enough to tempt the seller to always take the test because of its option value. Since the market expects this, it interprets the lack of a test result as bad news. This in turn further increases the seller’s willingness to pay to disclose the test results, which allows the intermediary to charge more for such disclosure.

**Auctions with samples.** The standard Bayesian theory of auctions takes the distribution of buyers’ valuations as given, and does not address how these distributions are formed. Very often, sellers form these distributions based on data about buyers that they collect or purchase. In “Full Surplus Extraction from Samples” (Journal of Economic Theory) joint with Hu Fu, Jason Hartline, and Robert Kleinberg, we study a seller who only knows that the distribution of values belongs to a finite set, and observes “samples” (independent draws) from the true distribution. Even though the seller doesn’t know the true distribution, we show that she can extract the full surplus (buyers’ willingness to pay for the product) with a finite number of samples. If there are only two possible distributions, a single sample suffices. The key insight is that the seller should use the samples not for statistical inference but to design contingent payments. These payments extract each buyer’s surplus in expectation for each possible distribution in the set.

**Cooperative segmentation.** Market segmentation is often thought to be controlled by sellers. Motivated by the ongoing debates about consumers’ control of their own data, I develop a model to understand what segmentations arise if consumers control them. I do this in “A Cooperative Theory of Market Segmentation by Consumers” (work in progress) joint with Ron Siegel. In this setting, consumers first form coalitions where each coalition represents a segment. The seller then offers uniform prices to all consumers in each segment. This gives rise to a novel cooperative game between consumers in which the surplus of each consumer depends on the coalition to which this consumer belongs.

We characterize segmentations that are stable. A segmentation is stable if for each possible objection by a coalition, there is a counter-objection by a coalition in the original segmentation. This means that if existing coalitions have the power to veto a proposed deviation, then any deviation is vetoed. We show that stable segmentations exist. They need not maximize average consumer surplus, and segmentations that maximize average
consumer surplus need not be stable. In fact, we construct examples where the average consumer surplus of a stable segmentation may be arbitrarily bad. This observation suggests that simply giving the power to consumer to form segments may not be good for them, and points at desirable measures to ensure good outcomes for consumers.

3 Spending public money

Groups of individuals often have to decide how to spend their public money. High level executives at a firm, members of a city council, and adult members of a household decide what products and services to buy with their collective money. I develop a model in “Selling to a Group” (work in progress) to study public money, joint with Aditya Kuvalakar and Elliot Lipnowski. The group members in our setting have heterogeneous opinions about how much a good is worth in terms of the public money. They want to choose a mechanism that maximizes the (weighted) sum of their surplus, taking the incentives of each group member into account.

The optimal mechanism for the group is a weighted voting mechanism with a simple implementation. Each group member submits a bid and the group pays the sum of all the bids to the seller. The bid of each agent is then transformed to a vote, and the good is bought if the sum of the votes is above the cost. Interestingly, it is optimal for the group to sometimes pay the seller a price higher than the cost of the good, even though the group knows precisely how much the cost is! If the group only pays the cost, then an individual group member can veto the purchase if they think the product is worth less than the cost, even if all other members think the product is worth the money. Paying the seller a variable amount allows each member to express the intensity of their preferences.

References


