Sequential Procurement through Contractual and Observational Learning

We consider the problem of a firm which repeatedly demands a product or service from a provider. In many cases, the quality of the delivered product or service is stochastic over time periods and unknown in advance. Moreover, especially in services, the delivered quality is often not (objectively) ex post verifiable, in the sense that at each period the firm and the provider may disagree on the quality that was just delivered. Therefore it is not clear how the firm can implement a procurement mechanism with quality-dependent transactions; this makes it critical for the firm to design and implement learning mechanisms which extract value as well as information from each transaction with the service provider. We study the performance and the market dynamics that emerge in this environment when the firm aims to learn the intrinsic quality of candidate providers while maximizing its long-run payoff and when providers strategically react to the learning mechanism to maximize their own long-run payoff.

Model. We study a dynamic game of incomplete information that models the interactions between a Principal (“Buyer”), who demands the same good or service repeatedly over time, and an Agent (“Seller”), who can produce the good at a marginal cost and an average quality that are his private information.

The distinctive features of our setting are that (i) neither the Buyer nor the Seller can credibly commit to future terms of trade so the parties must agree to terms in each period that an exchange occurs, and (ii) in each round, transaction terms must be set ex ante, and cannot depend on the quality realization in that round. (Notably, this formulation captures a particularly difficult learning environment for the Buyer because she has very limited ability to separate types through the contract offers.)
In each period, the Buyer can either use her outside option or make a price offer to the Seller in exchange for one unit of product. The Seller then decides to either accept or reject the offer. If the offer is rejected, the Buyer must use her outside option and receive a known payoff, and the Seller receives no payoff. If the offer is accepted, the Seller delivers a product with stochastic quality, conditional on his type. In periods that her offer is accepted, the Buyer’s payoff equals the realized quality of the delivered product less the price she paid. The Seller’s payoff in turn equals the price less the marginal cost of production.

Results. We identify two forms of learning that may take place in equilibrium, and through which the Buyer may update her belief regarding the Seller’s type. First, in each period she learns from the Seller’s response to the offered price. For example, if the Buyer offers a price that a lower type is more likely to accept than higher types, and the offer is accepted by the Seller, the Buyer learns that the Seller is more likely to be a lower type. We refer to this form of learning as *contractual learning*.

When the Seller accepts an offer and the Buyer purchases a product, the Buyer also updates her belief about the Seller’s type based on the quality observation she collects. For example, after observing a product that is delivered with a low quality, the Buyer updates her beliefs to reflect that it is more likely that the Seller is a lower type. We refer to this as *observational learning*.

Using Perfect Bayesian Equilibrium as a solution concept, we characterize the Buyer-optimal mechanism, under the assumption that there are two types of Sellers: high and low. We identify two primary parametric regimes which are characterized by different structures of the Buyer’s optimal learning dynamics.
**Pure Observational Learning Regime:** When the low-type Seller is less efficient than the Buyer’s outside option, the Buyer makes offers that either both types accept or both types reject. Thus, the Buyer only learns in periods in which an exchange occurs, by observing the realized quality of the product. We establish that in this regime, the Buyer’s optimal price offer in each period can be determined using a Gittins index policy.

**Mixed Observational and Contractual Learning Regime:** When the low type is more efficient than the Buyer’s outside option, the Buyer may incorporate both types of learning, depending on her beliefs. If the Buyer believes the Seller is likely to be a high type, the Buyer will purchase from both Seller types at a relatively high price and learn by observing the realized quality. For lower beliefs, the Buyer will offer a low price which will be rejected by the high type and accepted with a positive probability by the low type. Thus, the equilibrium path may include periods in which the Buyer applies contractual learning and periods in which she applies observational learning.

We also identify a subset of this regime where the Buyer engages in what we refer to as *strong contractual learning* by making a price offer that fully separates the two types of Sellers, and reveals the Seller’s type with certainty. When the low-type agent is sufficiently more efficient than her outside option, *strong contractual learning* is optimal for an interval of moderate beliefs.