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Identification of participation constraints in contracts

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HIGHLIGHTS

- In a contractual relationship, the agent forgoes outside opportunities to engage in a transaction with the principal.
- We study the nonparametric identification of contract models with participation constraints.
- We employ a cost shifter as an exclusion restriction, which changes marginal cost but not the agent type distribution.

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ABSTRACT

In a contractual relationship, the agent forgoes outside opportunities to engage in a transaction with the principal. This paper studies the nonparametric identification of contract models with participation constraints. We employ a cost shifter as an exclusion restriction, which changes marginal cost but not the agent type distribution. First, the distribution of agent heterogeneity is identified from markets where production is highly efficient or inefficient. Second, the utility function and participation constraints are identified from agent and principal optimality conditions, respectively.

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1. Introduction

Standard contract models assume that informational rent is monotonic in agent type, which guarantees that individual rationality (IR) constraints hold everywhere as long as it holds for the lowest type. See, e.g., Baron and Myerson (1982) and Maskin and Riley (1984). However, agents may forego opportunities to engage in a contractual relationship with the principal. For instance, an agent may obtain a reservation utility from competing offers when there are multiple principals. As a result, there would exist a flexible relationship between the type and value of outside opportunities. In this case, the monotonicity assumption regarding informational rents may fail. Jullien (2000) proposes a general adverse selection model where an agent obtains a reservation utility level if he/she does not contract with the principal. In this paper, we study nonparametric identification of this model.

In a standard model without participation constraints, the IR constraint binds only at the lowest type, which significantly simplifies the tradeoff between extracting surplus from an agent type and leaving enough informational rent for all higher types. Luo et al. (2018) establish nonparametric identification of the standard adverse selection model by exploiting both principal and agent optimality conditions. In a general model with participation constraints, IR constraints may bind on any subset of types. As a result, the shadow value of the IR constraint is *a priori* unknown, which obscures identification from data on supply and demand of a single market. Attanasio and Pastorino (2018) study a nonlinear pricing model with budget constraints, which is equivalent to one with participation constraints. They sidestep this identification issue by parameterizing the shadow value function.

We establish nonparametric identification of the Jullien (2000) adverse selection model by exploiting a cost shifter that changes the marginal cost but does not change the agent type distribution. First, the type distribution is identified from markets where production is highly efficient or inefficient. In such markets, IR binds at the lowest type or the highest type. Therefore, reservation utility disappears from the equilibrium conditions; the identification problem reduces to that of Luo et al. (2018). Second, the utility function and participation constraints are identified from agent and principal optimality conditions, respectively. In particular, identification of participation constraints builds on the fact

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that the shadow value of the IR constraint vanishes when it does not bind. Rewriting the principal's optimality condition gives a representation of this shadow value in terms of observables and the agent type distribution. As a result, whenever the shadow value is positive, the reservation utility equals agent surplus, which is identified from the agent's optimality condition.

The rest of the paper is organized as follows. Section 2 introduces the model and its equilibrium under several regularity conditions. Section 3 studies the nonparametric identification of model primitives. Section 4 concludes.

2. The model

This section introduces the model. Each agent has private information on her own willingness to pay θ. If a type-θ agent purchases q from the principal, she obtains utility

$$\theta u(q) - T(q),$$

where $u(\cdot)$ is the base utility function and $T(\cdot)$ is the tariff function. Otherwise, she obtains a reservation utility $\widehat{u}(\theta)$. The agent type parameter θ is continuously distributed on $[\underline{\theta}, \overline{\theta}]$ with CDF $F(\cdot)$ and PDF $f(\cdot)$. $u(\cdot)$ is strictly increasing and concave.

If the agent purchases q, the principal's payoff is

$$T(q) - cq,$$

where we assume a linear cost function for simplicity. The principal knows $F(\cdot)$ and designs tariff $T(\cdot)$ in order to maximize its expected payoff. From the revelation principle, the problem is equivalent to designing $\{t(\theta), q(\theta), x(\theta)\}$ such that the agent reports her true type (i.e., IC constraint) and she receives utility that is at least above $\widehat{u}(\theta)$ (i.e., IR constraint).

Denote total surplus as $s(\theta, q) = \theta u(q) - cq$. The principal's problem becomes

$$\max_{u,q,x} \int_{\Theta} x(\theta)[s(\theta, q(\theta)) - v(\theta)]f(\theta)d\theta,$$

such that

$$(IR) : v(\theta) \geq \widehat{u}(\theta)$$
$$(IC) : v(\theta) \geq v(\tau) + (\theta - \tau)u(q(\tau)), \text{ if } x(\tau) = 1$$
$$(EX) : v(\theta) = \widehat{u}(\theta), \text{ if } x(\theta) = 0$$

where $v(\theta) = \theta u(q(\theta)) - t(\theta)$ represents type-θ agent surplus, and $x(\theta) = 1, 0$ is an indicator for type-θ participating or taking the reservation utility, respectively. (EX) imposes that the outside option provides the reservation utility.

Before deriving equilibrium conditions, Jullien (2000) introduces three regularity conditions. Define $\sigma(\gamma, \theta) = H(\gamma, \theta)u(q) - cq$, where $H(\gamma, \theta) \equiv [\theta - \frac{\gamma - F(\theta)}{f(\theta)}]$. Maximizing σ with respect to q leads to

$$\ell(\gamma, \theta) = u'^{-1}(\frac{c}{H(\gamma, \theta)}),$$

which is decreasing with respect to c because u is concave.

Assumption 1 (*Potential Separation*)**.** For all $\gamma \in [0, 1]$, $\ell(\gamma, \theta)$ is a nondecreasing function of θ.

Assumption 2 (*Homogeneity*)**.** There exists a quantity profile $\widehat{q}(\theta)$ such that the allocation with full participation $\{\widehat{u}, \widehat{q}\}$ is implementable, i.e., $\widehat{u}'(\theta) = u(\widehat{q}(\theta))$.

We assume that the reservation utility is convex. Therefore, this quantity profile $\widehat{q}(\theta) = u^{-1}[\widehat{u}'(\theta)]$ is nondecreasing.

Assumption 3 (*Full Participation*)**.** The optimal contract induces full participation.

Under Assumptions 1–3, Jullien (2000) shows that there exists a unique optimal allocation. In particular, the agent and the principal's first-order conditions are

$$T'(q) = \theta u'(q), \quad (1)$$
$$c = u'(q)H(\Gamma(\theta), \theta), \quad (2)$$

respectively, where $\Gamma(\cdot)$ is a distribution function that satisfies:

$$\int [v(\theta) - \widehat{u}(\theta)]d\Gamma(\theta) = 0, \quad q(\theta) = \ell(\Gamma(\theta), \theta).$$

Discussion

In a standard adverse selection model, such as Maskin and Riley (1984), $\Gamma(\cdot)$ is replaced by a constant of 1 in the principal's first-order condition. $\frac{1-F(\theta)}{f(\theta)}$ represents distortion due to asymmetric information. To induce quantity q at θ, the principal needs to leave all higher types a rent of $u(q)$. The total rent is $f(\theta)s(\theta, q)$ for the type-θ agent and $(1 - F(\theta))u(q)$ for all higher types. Since $\frac{1-F(\theta)}{f(\theta)} > 0$, there is underproduction except at the maximum $\overline{\theta}$.

In the general case, $\Gamma(\cdot)$ represents the shadow value associated with a marginal reduction of the reservation utility for all types in $[\underline{\theta}, \theta]$. Since $v(\theta) \geq \widehat{u}(\theta)$, $\Gamma(\cdot)$ must be constant whenever the inequality is strict, i.e., when IR is not binding. As a result, $\{\theta \in \Theta : \Gamma'(\theta) > 0\} \subset \{\theta \in \Theta : v(\theta) = \widehat{u}(\theta)\}$. Moreover, overproduction occurs when $\Gamma(\theta) < F(\theta)$, and underproduction occurs when $\Gamma(\theta) > F(\theta)$. Lastly, $\Gamma(\overline{\theta}) = 1$. Intuitively, if the reservation utility function is reduced by 1 unit on its support, it is optimal to reduce the agent's surplus by a unit while keeping quantities unchanged.

3. Identification

This section studies nonparametric identification of the primitives $\{u(\cdot), F(\cdot), c, \widehat{u}(\cdot)\}$. The observables are $\{T(\cdot), G(\cdot)\}$, where $T(\cdot)$ is the tariff function and $G(\cdot)$ is the distribution of consumption.

Following Luo et al. (2018), we use the fact that the mapping from agent type θ to choice q is strictly monotone and rewrite first-order conditions (1) and (2) in terms of quantiles[1]:

$$T'(q(\alpha)) = \theta(\alpha)u'(q(\alpha)),$$
$$c = u'(q(\alpha))H(\Gamma(\theta(\alpha)), \theta(\alpha)),$$

where $\alpha \in [0, 1]$. $\theta(\alpha)$ and $q(\alpha)$ are α-quantiles of the agent's type and choice, respectively. In other words, $\theta(\alpha) = F^{-1}(\alpha)$ and $q(\alpha) = G^{-1}(\alpha)$.

Replacing $u'(q(\alpha))$ with $T'(q(\alpha))/\theta(\alpha)$ in the principal's FOC, we obtain our key identification equation:

$$\frac{T'(q(\alpha)) - c}{T'(q(\alpha))} = \frac{\theta'(\alpha)}{\theta(\alpha)}[\Gamma(\theta(\alpha)) - \alpha], \quad (3)$$

where both $\theta(\cdot)$ and $\Gamma(\cdot)$ are unknown.

Despite having a simple form in many cases,[2] $\Gamma(\cdot)$ being unknown brings complications. In particular, since it is endogeneous, the shape of $\Gamma(\cdot)$ is unknown unless one has some prior knowledge of the model primitives. This implies that point identification fails in a single market with only the observed tariff $T(\cdot)$ and the distribution of consumption $G(\cdot)$. This demands a general identification approach that allows a flexible $\Gamma(\cdot)$.

[1] Empirical auction literature has studied quantile-based methods extensively. See, e.g., Guerre et al. (2009), Marmer and Shneyerov (2012), and Liu and Luo (2017).

[2] Its functional form is determined by how IR binds. For instance, when $\widehat{u}$ is highly convex, IR binds at both $\underline{\theta}$ and $\overline{\theta}$. In this case, $\Gamma(\cdot)$ is constant on $[\underline{\theta}, \overline{\theta}]$. See Jullien (2000) for further details.

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