Nonlinear Pricing Under Regulation: Comparing Portion Cap Rules and Taxes in the Laboratory

Jose G. Nuno-Ledesma* Steven Y. Wu† Joseph V. Balagtas†

August 14, 2020

Link to most recent version

Abstract

We report a laboratory experiment designed to test the economic impacts of two regulations: specific taxes and portion cap rules (caps). Caps have been accused of reducing consumers' choice and well-being. In our experiment, single-product sellers face demand from two types of privately-informed buyers. We manipulate the policy environment across treatments. With regulations, we aim to reduce the size of the large option by an amount close to half the original quantity. With a tax, subjects are less likely to offer menus with two alternatives, suggesting that taxes reduce the choice set for buyers. We also find that consumer surplus remains unaffected under a cap rule, while buyers with high willingness to pay for the product see their surplus diminished by the tax. These results have implications for food policy where the assumption that caps reduce consumer choice and negatively impact buyers' surplus largely drives public debate.

Keywords: experiment, nonlinear pricing, quantity cap, specific tax

JEL classification: C9, D04, D82, I18

*jnuno@uoguelph.ca. Assistant Professor. University of Guelph. Department of Food, Agricultural & Resource Economics. J.D. MacLachlan Building. 50 Stone Road East. Guelph, Ontario, Canada N1G 2W1.

†{sywu, balagtas}@purdue.edu. Associate Professors. Purdue University. Department of Agricultural Economics. 403 W. State Street West Lafayette, IN 47907.

The authors benefited greatly from comments from Sven Anders, Timothy Cason, Alejandrina Salcedo, Stephen Hamilton, seminar participants at the AAEA, CAES WAEA, Purdue University, Universidad de Guadalajara, University of Guelph, and Banco de México. We thank Tim Cason for providing access to Purdue Universtiy's Vernon Smith Experimental Economics Laboratory. Financial support from USDA-NIFA grant award no. 2014-67023-21852 is gratefully acknowledged.

We report a laboratory experiment designed to contrast the impacts of taxes and portion cap rules (caps, also known as portion size restrictions) in a single-product market whit discrete privately-informed buyers. Holding the quantity-reduction goal for the largest option constant in the regulated treatments, we manipulate the policy environment across treatments to observe i) the seller's segmentation strategies, ii) changes in consumed quantities, and iii) impacts on payoffs, with an especial emphasis on consumer's information rents.

Contrasting caps and taxes is important in light of an increased public interest in regulations aimed at combating obesity. Sugar consumption has been linked to increased risk of obesity and there is a growing, if still fluid, body of evidence suggesting that added sugars in sugar-sweetened beverages (SSBs) are uniquely harmful [Stanhope (2015); Malik et al. (2010)]. Thus, much of the debate surrounding obesity has focused on reducing consumption of SSBs. For example, Lustig et al. (2012) advocate for restrictions on sales of sugary foods using a public health argument that draws a parallel between sugar and tobacco/alcohol.

Taxes are among the most common policy instrument aiming to curb consumption of high calorie foods such as SSBs.[1] Their effects are examined in a large and growing economic literature. Less studied and much more controversial than taxes, cap rules are limits on the maximum default size at which can offer a food product.[2] In light of a number of studies linking larger portion sizes to increased consumption, caps have arisen as a possible instrument to curb the consumption of unhealthy foods [Rolls et al. (2006); Ledikwe et al.

[1]For example, in 2015 Berkeley became the first locality within the US to enact a tax specifically targeting SSBs. In the years to come, multiple localities, -including San Francisco, Oakland, Boulder, Colorado, Seattle, and Philadelphia- adopted similar levies.

[2]The so-called New York City's "soda ban" is a prominent example. Originally proposed to take effect in New York City by 2013, the plan intended to prohibit the sale of SSBs in containers exceeding 16 ounces. "Small", and "large" sizes typically found in American fast-food restaurants contain around 16, and 32 ounces correspondingly. The proposal was struck down in court (New York Statewide Coalition of Hispanic Chambers of Commerce v. New York City Department of Health and Mental Hygiene, 2014).

(2005); Flood et al. (2006); Young and Nestle (2002)]. Opponents to caps argue that these are disproportionately harmful to consumers and reduce choice. The implication is that diminishing default sizes will result in smaller choice sets and lower consumer welfare. These assumptions are already shaping public policy.[3] These concerns are rarely raised when discussing the application of specific taxes to discourage consumption of large portions.

In a setting where sellers segment demand with differently-sized alternatives and nonlinear prices, our aim is to compare taxes and caps designed to reduce the large option of a product by the same amount and observe which regulation hurts consumers the most. The adoption of a nonlinear pricing schedule by the seller is an important feature of our research. Results derived from a standard supply and demand microeconomic model with perfect information would be insufficient to predict how a price-dsicriminating seller would endogenously modify her pricing scheme following an intervention. Moreover, the different nature of the alternative regulations may result in the adoption of distinct pricing policies by the seller, which in turn would translate into different surplus distributions. The importance of taking strategic responses from sellers when evaluating food policy has been highlighted by Bonnet and Réquillart (2013).

In our experiment, we manipulate the policy environment across treatments holding the reduction goal for the large option constant in the regulated groups. To contrast the policies, we submit that if one policy is more likely to cause our sellers to offer less options compared to our baseline, we argue that the policy reduces the consumer choice set above and beyond the goal of the intervention. Similarly, if a policy has a larger negative effect on consumer

[3] In the United States, for example, Mississippi's Bill 2687 (2013) interdicts against future restrictions of food sales within the state based upon the product's nutrition information or upon its bundling with other items.

surplus, we conclude it hurts consumers more than the alternative.[4]

In our experiment, the parameter values are chosen such that separation of types is optimal regardless of the regulation context. Compared to a regulation-free baseline, the data suggest that subjects are as likely to offer two-alternatives menus with cap rule, but less likely to offer them under taxation. Moreover, we find that information rents are, in general, reduced when a tax is implemented, but not when a cap rule is enforced. These findings are important because the claims of a negative impact on both consumer choice and surplus are often made to disregard portion cap rules but scantly raised against taxes.

We remain agnostic about the effectiveness of either taxes or caps to fight obesity. We do not advocate for the implementation of either regulatory alternative. Our objective is to use an economic experiment, informed by a stylized model, to find out whether the ills of reduced choice sets and diminished information rents, often used to dismiss cap rules, can also be the result of taxes. The experimental evidence illuminates the way price-discriminating vendors endogenously adapt their strategies under different policy environments. To the degree that retailers of SSBs and other foods adopt nonlinear pricing, and a main concern of authorities is the protection of consumer surplus, the present study can inform food policy design.

The contribution of this document is twofold. First, we expand the model presented by Bourquard and Wu (2020) who leverage nonlinear pricing theory to theoretically study the effects of cap rules on consumer information rents. They find that, absent a severe restriction, consumer rents remain unaffected by the cap because the seller has an incentive to keep information rents unchanged to continue segmenting demand. We take their basic model and incorporate taxation. Our second contribution is the empirical comparison of

[4] In this document, information rents and consumer surplus are used interchangeably.

taxes and caps in a laboratory market.

Our treatment comparison relies on the premise that both taxes and caps have an impact on quantities. There is evidence showing that taxes do result in reduced consumption of sugary drinks [Grogger (2017); Silver et al. (2017), and Colchero et al. (2017)]. Most of these studies, however are silent about the mechanism driving the outcomes. We complement this literature by concentrating on studying the way in which the seller, as opposed to the buyer, reacts to the policy and by comparing the consumption and welfare impacts caused by taxes to the effects of caps.

Regarding studies analyzing the effects of portion cap rules, Wilson et al. (2013) conducted a behavioral study to determine how restrictions in cup sizes might affect SSB consumption. In a non-incentive-compatible experiment, human subjects are asked to declare hypothetical purchases. There are two conditions: baseline-menu with small and large options, and a restricted-menu without large options. Their key finding is that buyer purchase more soda in the restricted condition. While interesting, this result seem counter-intuitive as it suggests that sales could be increased by offering only small servings. In practice, most food retailers offer differentiated price-quantity options in their menus. John et al. (2017) conducted a similar study but included an incentive-compatible design and a budget constraint. They find that a restricted menu does reduce consumption.

Even though there are experimental studies evaluating the theory of adverse selection (for example, **?**). To the best of our knowledge, we present the first empirical study comparing per-unit taxes and portion cap rules in a market with heterogeneous buyers.

The rest of the document is organized as follows. We the proceed to introduce the model used to aid the experimental design. In the following part, we show our experimental design and list the testable hypotheses. We use the following section to provide a general overview of the experimental. In the next section, we present the main results. This is followed by conclusions.

Theory

In this section we describe the model from which we derive our hypotheses. We show the characterization of the seller's optimal separating pricing strategies in three policy environments: an unregulated baseline scenario; an environment with a moderate portion cap, and a third setting where a tax is enforced.[5] The baseline and cap subsections rely on the work by Bourquard and Wu (2020), where proofs and details can be found. We dedicate relatively more time to discuss the taxed scenario.

We primarily focus on consumer welfare from consumption and do not account for potential health benefits from reduced consumption. This is for three reasons. First, much of the opposition against SSB regulations focuses on how these might hurt consumers via reduced choice and consumption. Second, incorporating health benefits in a model is fraught with arbitrary assumptions and it would be easy for us to generate nearly any conclusion by strategically choosing our assumptions. Our approach allows us to focus on the claim that regulation would reduce consumer welfare from consumption. Third, omitting health benefits makes our results robust to substitution effects in that, even if consumers shift to other unhealthy beverages, we do not run the danger of over-estimating consumer benefits.[6]

[5] For completeness, we show the characterization of single-package schemes in the appendix A. We also discuss the issue of segmentation policy-switching in appendix B

[6] Indeed, one way to interpret our findings is how consumers might be impacted even if the regulations yield little to no health benefits.

Model Baseline Without Regulations in Effect

We begin by establishing a benchmark for the retailer's pricing behavior in the absence of regulation. This allows us to make subsequent comparisons with respect to the impact of regulation on serving sizes, expected profit and consumer welfare.

The seller offers a menu of different price-size combinations of a product to a privately informed buyer. There are two types of buyers. With probability $\beta \in [0,\, 1]$, the buyer is a low-type (L-type). With probability $(1-\beta)$, the buyer is a high-type (H-type). The types are characterized by a taste parameter θ_i for $i = H,\, L$ such that $\theta_H > \theta_L$. At a given price, H-types consume more than L-types because the former have higher willingness to pay.

When an i-type purchases a package with q_i units of the good (e.g. q_i number of ounces in the cup) and pays a price $p_i \equiv p(q_i)$, he earns surplus $U_i = \theta_i u(q) - p_i$, where $u(\cdot)$ is a well-behaved utility function.[7] Note that price p_i refers to the serving price, as opposed to per-unit (e.g. per ounce) price. Seller and buyer have reservation values of zero. We assume that the seller's cost $c(q) = cq$, where $c'(q) = c > 0$ is a constant. The seller maximizes her expected profit subject to incentive-compatibility (IC) and participation (PC) constraints:

$$
\begin{aligned}
&\underset{(p_H, q_H, p_L, q_L)}{\text{maximize}} \quad \mathbb{E}[\pi] = (1-\beta)\big[p_H - cq_H\big] + \beta\big[p_L - cq_L\big] \\
&\text{subject to:} \\
&\text{PC: } \theta_L u(q_L) - p_L \geq 0 \\
&\text{IC: } \theta_H u(q_H) - p_H \geq \theta_H u(q_L) - p_L \\
&q_i \geq 0, \;\; i = H,\, L
\end{aligned}
\tag{1}
$$

[7] Throughout the paper, we use the words "cup", "serving" and "package" interchangeably.

The seller's objective function weights the profit contribution of serving a given buyer type by the probability of the customer she faces being of either type. As we will show, taxes and caps modify the optimization program in different ways: taxes distort profit contributions, while caps reduce the seller's choice space.

Because the IC and PC restrictions play an important role on the outcomes of the interventions, we briefly discuss them. PC ensures that all buyer types are at least indifferent between not participating or purchasing one of the packages offered by the seller. To serve both consumer types, only the participation constraint of the lower type is relevant because its satisfaction automatically implies that the H-type finds the menu of options to be individually rational.

The IC restriction plays an essential role. We say a menu of two packages is incentive-compatible if the i-type buyer prefers package (p_i, q_i) over the alternative (p_j, q_j) $i \neq j$. In an incentive-compatible mechanism, the quantity increases with the value of the taste parameter θ_i, satisfying the monotonicity condition $q_H > q_L$.

Depending on how prevalent L-types are in the population and how large the taste dispersion $(\theta_H - \theta_L)$ is, there are occasions where single-package strategies are preferable to separating schemes. Conditions where single-packages are preferable with and without a size restriction are discussed in Bourquard and Wu (2020). In the main text, we discuss only the separating strategy.

The quantities that satisfy the first order conditions are the following:[8]

[8] We use superscripts throughout the theory section to denote solutions to endogenous variables as follows. The stars refer to the policy environment: one star (*) refers to the baseline, two to the market with a cap, and three to the taxed environment. The numbers correspond to the segmentation strategy: number one (1) marks the separating scheme; number two labels the pooling scheme outcomes (when the seller offers one option to serve both types), and the number three denotes results when the seller adopts an exclusive strategy (an option designed to serve H-types only, excluding L-types from participation).

$$\text{Baseline-separating-quantities} \begin{cases} \theta_H u'(q_H^{*1}) = c \\ \\ \theta_L u'(q_L^{*1}) = \dfrac{c}{\left[1-\left(\frac{1-\beta}{\beta}\right)\left(\frac{\theta_H-\theta_L}{\theta_L}\right)\right]} \end{cases} \tag{2}$$

With these quantities, the L-type buyer is held at reservation value receiving no surplus ($U_L = 0$). While the High-type buyer receives positive surplus $U_H^{*1} = (\theta_H - \theta_L)u(q_L^{*1})$. The sellers' expected profit is $\mathbb{E}[\pi^{*1}] = \beta[\theta_L u(q_L^{*1}) - cq_L^{*1}] + (1-\beta)[\theta_H u(q_H^{*1}) - (\theta_H - \theta_L)u(q_L^{*1}) - cq_H^{*1}]$. Therefore, total surplus is $T.S. = \mathbb{E}[\pi^{*1}] + U_H$. In short, the profit-maximizing schedule allocates larger quantities to the buyer with higher willingness to pay, grants positive surplus to the H-type, while it does not grant information rents to the L-type consumer. The resulting separating schedule allocates to the H-type his first best quantity where this type's marginal willingness to pay equates marginal cost of production. Quantity is downward-distorted and the L-type buyer receives less than his first-best quantity.

Model With Portion Cap Rule

With a cap limiting the maximum quantity to an arbitrary level $\hat{q}$, such that $q_L^{*1} \leq \hat{q} \leq q_H^{*1}$, the seller's problem is still 1, but with an additional portion cap rule (PCR):

$$\text{(PCR)}: q_i \leq \hat{q} \quad \text{for} \quad i = L,\, H \tag{3}$$

We consider this range of regulations because only restrictions where $\hat{q} \leq q_H^{*1}$ are of economic interest. We assume that the regulation is set at a level larger than or equal to the unregulated small size, i.e. $q_L^{*1} \leq \hat{q}$. Our analysis is consistent with moderate restrictions that do not set the limit below the quantity contained in the small alternative when there is no regulation enacted. The quantities satisfy:

$$\text{Cap-separating-quantities} \begin{cases} \theta_H u'(q_H^{**1}) \geq c, \text{ where } q_H^{**1} = \hat{q} \\ \theta_L u'(q_L^{**1}) = \frac{c}{\left[1 - \left(\frac{1-\beta}{\beta}\right)\left(\frac{\theta_H - \theta_L}{\theta_L}\right)\right]} \end{cases} \tag{4}$$

With a menu of two packages, the L-type buyer gains no information rents. The H-type consumers earn $U_H^{**1} = (\theta_H - \theta_L)u(q_L^{**1})$. The expected profit is $\mathbb{E}[\pi^{**1}] = \beta[\theta_L u(q_L^{**1}) - cq_L^{**1}] + (1-\beta)[\theta_H u(\hat{q}) - (\theta_H - \theta_L)u(q_L^{**1}) - c\hat{q}]$. Total surplus is $\beta[\theta_L u(q_L^{**1}) - cq_L^{**1}] + (1 - \beta)[\theta_H u(\hat{q}) - (\theta_H - \theta_L)u(\hat{q}) - c\hat{q}] + (\theta_H - \theta_L)u(\hat{q})$.

In brief, if the size restriction limits the H-type's serving but not the L-type's. There is no impact on consumer surplus. Profit is negatively impacted. This measure will not affect the portion size served to the L-type. Intuitively, as the regulation moves the size of the large package down, the seller adjusts the price of the large package accordingly in an effort to keep separating the demand.

Incorporating Taxation into the Model

We expect a SSB tax to have two major effects. First, it could directly impact cup sizes and prices. Second, it may indirectly cause the retailer to change her segmentation strategy (separating, pooling or exclusive). We start by analyzing the direct effects.

Let us define a tax regime (τ_s, τ_v) as any mixture of specific ($\tau_s \geq 0$) and *ad valorem* ($\tau_v \in [0, 1)$) taxes, such that both of them are not zero at the same time. To avoid divisions by zero later on, we excluded combinations where $\tau_v = 1$. Note that $(\tau_s, \tau_v) = (0, 0)$ denotes the event of no taxation. Specific taxes modify the objective function in a way akin to a change in the cost function. *Ad valorem* taxes alter the objective function in two ways: by modifying the cost function and scaling down expected profit. With taxation and solving for prices, the seller's problem is:

$$\max_{q_L, q_H} \ \mathbb{E}\left[\pi\right] = (1-\tau_v)\Big\{(\beta)\big[\theta_L u(q_L) - \Psi_L\big] + (1-\beta)\big[\theta_H u(q_H) - (\theta_H - \theta_L)u(q_L) - \Psi_H\big]\Big\} \quad (5)$$

where $\Psi_i \equiv (\tau_s q_i + c q_i) \div (1-\tau_v)$ is the effective cost function. Let $\psi \equiv \frac{d\Psi_i}{dq_i} = (\tau_s + c) \div (1-\tau_v)$ denote effective marginal cost. First order conditions are:

$$\begin{aligned} &\text{FOC}[q_H] : \frac{\partial\, \mathbb{E}\left[\pi\right]}{\partial q_H} = (1-\tau_v)(1-\beta)[\theta_H u'(q_H) - \psi] \leq 0 \\ &\text{where} \quad q_H \geq 0 \quad \text{and} \quad \frac{\partial\, \mathbb{E}\left[\pi\right]}{\partial q_H} \cdot q_H = 0 \end{aligned} \quad (6)$$

$$\begin{aligned} &\text{FOC}[q_L] : \frac{\partial\, \mathbb{E}\left[\pi\right]}{\partial q_L} = (1-\tau_v)\big\{\beta(\theta_L u'(q_L) - \psi) + (1-\beta)[-(\theta_H - \theta_L)v'(q_L)]\big\} \leq 0 \\ &\text{where} \quad q_L \geq 0 \quad \text{and} \quad \frac{\partial\, \mathbb{E}\left[\pi\right]}{\partial q_L} \cdot q_L = 0 \end{aligned} \quad (7)$$

Separating Pricing Strategy with Taxation

Both buyer types are offered options such that $q_i > 0$, $i = H, L$. Thus, equations 6 and 7 hold with equality:

$$\text{Tax-separating-quantities} \begin{cases} \theta_H u'(q_H) = \psi \\ \\ \theta_L u'(q_L) = \psi + \left(\frac{1-\beta}{\beta}\right)(\theta_H - \theta_L)u'(q_L) \end{cases} \tag{8}$$

The *effective* marginal cost of supplying a large cup equals the H-type's marginal utility of consumption. Thus, while there is distortion relative to the untaxed case, there is "no distortion at the top" relative to the effective marginal cost. The seller continues to distort the size of the L-type package. Relative to the baseline, both buyer types get less than their first-best optimal quantities because the effective marginal cost is altered by the tax so that $\psi > c$. The price rules associated with this case are $p_L^{***1} = \theta_L u(q_L^{***1})$, and $p_H^{***1} = \theta_H u(q_H^{***1}) - (\theta_H - \theta_L)u(q_L^{***1})$.Earnings are:

$$\text{Tax-separating-information rents} \begin{cases} U_L^{***1} = 0 \\ \\ U_H^{***1} = (\theta_H - \theta_L)u(q_L^{***1}) \end{cases} \tag{9}$$

$$\pi^{***1} = (1-\tau_v)\Big\{(\beta)[\theta_L u(q_L^{***1}) - \psi q_L^{***1}] + (1-\beta)\big\{[\theta_H u(q_H^{***1}) - (\theta_H - \theta_L)u(q_L^{***1})] - \psi q_H^{***1}\big\}\Big\} \tag{10}$$

In sum and compared to the unregulated benchmark, the size of both packages is smaller. H-type consumers still receive information rents, although these are smaller so there is welfare loss. L-types are held at their reservation values, and the seller sees her expected profit unambiguously diminished. While it may seem counter-intuitive that serving prices are lower after a tax, keep in mind that we focus on serving size prices as opposed to per-unit prices (e.g. price per-ounce).[9]

Pooling Strategy with Taxation

We now consider the case where the seller offers one option to serve both consumer types with a one-size-fits-all type of strategy. The retailer's optimization problem can be written as follows:

$$
\begin{aligned}
&\max_{p,q}\ \mathbb{E}\left[\pi\right] = (1-\tau_v)t_L - (\tau_s + c)q_L \\
&\text{subject to:} \\
&\text{IRL} : \theta_L u(q) - t_L \geq 0
\end{aligned}
\tag{11}
$$

The optimization conditions imply:

$$
\text{Tax-pooling-quantity} \left\{ \theta_L u'(q^{***2}) = \psi \right. \tag{12}
$$

While equation 12 implies marginal benefits are equal to the effective marginal cost, recall that ψ is the effective marginal cost post-tax. Thus, the L-type does not get his first-best level of consumption. The value functions for the seller and buyers are:

$$
\text{Tax-pooling-payoffs} \left\{
\begin{aligned}
&\pi^{***2} = (1-\tau_v)[\theta_L u(q^{***2}) - \psi \cdot q^{***2}] \\
&U_L^{***2} = 0 \\
&U_H^{***2} = (\theta_H - \theta_L)u(q^{***2})
\end{aligned}
\right. \tag{13}
$$

[9] In the standard textbook problem, a tax causes the demand function to shift downward and lead to a higher uniform price for all units. However, in the nonlinear pricing problem that we study, a serving size price is designed to extract as much consumer surplus as possible. As such, the implicit unit price may vary across different units.

Claim 1. *The separating strategy is more profitable than the pooling scheme if and only if* $\beta \geq \underline{\beta}_O = \frac{(\theta_H-\theta_L)u(q_L^{***1})+\theta_L u(q^{***2})-\psi q^{***2}-[\theta_H u(q_H^{***1})-\psi q_H^{***1}]}{\theta_H u(q_L^{***1})-\psi q_L^{***1}-[\theta_H u(q_H^{***1})-\psi q_H^{***1}]}$

All proofs are in the appendix. The above claim pins down the minimum threshold ($\underline{\beta}_O$) that β must exceed for the separating strategy to remain more profitable than the one-size-fits-all strategy.

Proposition 1. *Suppose that a tax regime* (τ_s, τ_v) *comes into effect. Then,* $\underline{\beta}_O$ *decreases. This increases the range of* β *for which the separating strategy is more profitable than the pooling scheme.*

Proposition 1 suggests that a tax makes it *less* likely that the seller will switch from a separating strategy to a one-size-fits-all scheme. The intuition is that the single option has to be priced reasonably low to ensure that the L-type participates. Thus, it is a relatively low profit margin strategy that relies on the already low margins. The key point is that if the retailer chooses the separating strategy pre-tax, then the retailer will not switch to a pooling pricing scheme post-tax.

Exclusive Strategy with Taxation

We now consider the case where the seller serves only H-type buyers. This scheme implies that $FOC[q_L]$ in 7 does not bind with equality. Using $FOC[q_H]$ from 6, pricing rule $p_H = \theta_H u(q_H) - (\theta_H - \theta_L)u(q_L)$, and the normalizing assumption $u(0) = 0$, we obtain:

$$\text{Tax-exclusive-quantity} \begin{cases} \theta_H u'(q^{***3}) = \psi \end{cases} \tag{14}$$

L-type buyers drop out of the market because they would earn negative utility given the price. H-types are held at their reservation value. Expected earnings are:

$$\text{Tax-exclusive-payoffs} \begin{cases} \pi^{***3} = (1-\tau_v)(1-\beta)[\theta_H v(q^{***3}) - \psi q^{***3}] \\ \\ U_i^{***3} = 0 \text{ for } i = H,\, L \end{cases} \tag{15}$$

Claim 2. *The separating pricing strategy is more profitable than excluding the L-type buyer to serve the H-type if and only if* $\beta \geq \underline{\beta}_E = \frac{(\theta_H - \theta_L)u(q_L^{***1})}{\theta_H u(q_L^{***1}) - c q_L^{***1})}$

The above claim pins down a threshold ($\underline{\beta}_E$) that β must exceed for the separating strategy to be more profitable than an exclusive scheme.

Proposition 2. *Assume that a tax regime* $(\tau_s,\, \tau_v)$ *comes into effect. Then,* $\underline{\beta}_E$ *increases. This reduces the range of* β *for which the separating strategy is more profitable than serving H-types exclusively.*

Because a tax reduces the range of β for which the separating strategy is more profitable than the H-exclusive scheme, it increases the possibility that retailers might endogenously switch to the H-exclusive strategy.

Experimental Design and Hypotheses

We conduct our experiment with university students taking the role of sellers in our experiment. Three main reasons support the choice of such subject pool. First, college students follow abstract instructions more precisely relative to field professionals [Cooper et al. (1999); Alatas et al. (2008)]. The last two reasons are discussed by Cason and Wu (2019). We are interested in testing predictions derived from economic theory. College student are relatively more homogeneous than professionals and other populations, this allows the experimenters to exert more control in the laboratory. As a result, students are an appropriate subject pool when addressing research questions closely tied to theory. Finally, their homogeneity is a feature that facilitates statistical estimations. Inference is easier when nuisance variation across treatments stemming from factors irrelevant to the main question is minimized.

Table 1 shows the parameters used in the experiment. We choose specific parameter values to evaluate the impacts of reducing the quantity of the large option from 31 units to 17. It is to the advantage of the sellers to offer a menu with two incentive-compatible packages in all treatments. We chose the intervention levels (cap and tax) to be equivalent by the theoretical impact they would have on the size of the large unregulated package. We use a per-unit tax because it is the most common way of taxing SSBs.[10]

[Table 1 about here]

There are three treatments. In our *Baseline*, there is no intervention; in treatment *Cap*, there is a limit on the maximum quantity sellers were allowed to offer per package, and in treatment *Tax*, a per-unit fee was charged to sellers. In theory, sellers can engage in the three segmentation strategies already discussed. Because the choice of quantities and prices was restricted to integer numbers, it is possible that more than one screening contract could result in the same expected profit. Thus, it is possible that more than one contract could maximize expected profit for a given segmentation strategy. Table 2 presents figures describing the contracts that result in the maximum expected profit for a given segmentation strategy.

[Table 2 about here]

[10] All six localities within the U.S. with a "soda tax" enacted by the end of 2019, levied a per volume excise tax. This form of taxation is prevalent in other jurisdictions as well, for example, Mexico implemented a specific tax of one peso per litter in 2014.

The purported objective of caps is to restrict the largest option available with the hope of diminishing consumption. Translated to our experimental setting, a cap rule ought to limit the size of the largest option available when sellers price discriminate. The quantity limit in *Cap* is set to 17 units, which is close to half the size of the large option in the *Baseline* treatment (about 31 units). The per-unit tax in the *Tax* treatment was set at a level such that, in theory, it would cause sellers to reduce the quantity of the large option in the menu from about 31 to about 17 units.[11]

Hypotheses

With the chosen parameters, we expect subjects to offer menus with two packages frequently across all three treatments. However, an interpretation of propositions 1 and 2 imply that the proportion of two-option menus should not decrease with a cap, and decrease with a tax in favor for H-exclusive offers.

Hypothesis 1 - Separation of types: We expect two-packages menus to be more common than single-item offers in all treatments. The proportion of two-option menus should not decrease in the *Cap* treatment, and decrease in *Tax* in favor of offers excluding L-type buyers.

Hypotheses 2 and 3 refer to the impacts on serving sizes and payoffs comparing separating offers. These are our main hypotheses because we expect subjects to favor separating

[11] An alternative design would have been to match the restriction by the portion cap rule to the reduction in size induced by current levels of taxes. Current taxes on SSBs are small, thus the cap needed to equate their effect on portions would have been barely noticeable. Because one of our results is that taxes hurt consumers more than caps, we decided to implement a severe portion cap rule. It is reasonable to deduce that if the impact on consumer surplus is null with a very restrictive cap, it would also be absent in more lenient cases.

schemes.

Hypothesis 2 - Effect on quantities when the seller separates demand: When two-package menus are offered, the cap rule only reduces the size of the large package, while the specific tax results in smaller serving sizes for both small and large alternatives.

Hypothesis 3 - Impact on payoffs when the seller separates demand: When two-package menus are offered, the L-type buyer is held at reservation value thus his payoff is not impacted. On the other hand, the H-type's surplus is diminished by the tax only. Lastly, expected profit is lower in both regulated groups.

When the seller offers menus, reductions in welfare under the cap rule are entirely explained by reductions in expected profit. On the other hand, the tax negatively impact both seller and buyers.

For completeness we also look at the impacts on quantities and payoffs under single-item strategies. The testable hypotheses for these offers are listed below.

Hypothesis 4 - Effect on quantities when the seller pools demand: When one-size-fits-all options are offered, the size of the package is smaller only with a tax. It remains unchanged with a cap.

Hypothesis 5 - Impact on payoffs when the seller pools demand: When one-size-fits-all options are offered, the L-type buyer is held at reservation value thus his payoff is not impacted. On the other hand, the H-type's surplus is reduced by the tax but unaffected by the cap. Expected profit is lower under both regulations.

Hypothesis 6 - Effect on quantities when the seller adopts a H-exclusive scheme: When a single option is offered which excludes the L-type, the portion size is smaller under both regulations compared to the baseline.

Hypothesis 7 - Impact on payoffs when the seller adopts a H-exclusive scheme: When a single option is offered which excludes the L-type, the H-type buyer is held at reservation value thus his payoff is not impacted. The seller's sees her expected profit diminished by the interventions.

Procedures and the Experimental Task

Three sessions per treatment were conducted at a large American public university. Each session had twelve participants drawn from a subject pool managed with ORSEE (Greiner, 2015). Participants were university students. In total, 108 subjects participated in the experimental sessions. Subjects did participate in more than one session. The experimental interface was implemented using oTree (Chen et al., 2016). The structure of all sessions was the same: first, subjects answered a pre-experimental quiz to make sure they understood the instructions; then, there were six non-paying trading periods for subjects to become familiar with the computer interface; afterwards, there were twelve paying trading rounds; lastly, the subjects were ask to answer a post-experimental survey.[12]

All human subjects took on the role of a seller and interacted exclusively with their assigned computer. A computer program mimicked the role of a rational buyer. Earnings for both seller and buyer were denominated in an experimental currency called "points". At the end of the session, points were converted into cash at the rate of 100 points per US dollar. Seller and buyer earned points during trading periods. All trading periods went as follows: the seller first decided whether to offer one, two or no packages; in a subsequent

[12] For a copy of the instructions, please contact the corresponding author.

decision screen, she specified price and quantity for each of the packages to offer; then, the buyer was privately assigned a type and proceeded to purchase the package that maximized his payoff; lastly, the seller observed a screen displaying the characteristics (quantities and prices) submitted, the buyer's purchase decision, period and accumulated earnings. For every trading period, the buyer taste parameter was randomly assigned to be θ_L or θ_H with equal probability. This assignment was not revealed to the seller. The buyer would reject any package resulting in negative surplus. In the event of rejection of the entire menu, zero points were earned by both seller and buyer. If the buyer was presented with two options resulting in the same non-negative payoff, then the purchase decision is random with both options equally likely. If the seller decides not to offer a package, then seller and buyer earn zero points. Sellers started the session with a balance of 500 points in the *Tax* treatment, and had no starting balance in the other treatments. Average earnings in U.S. dollars, including a $5.00 participation fee, were 28.03, 25.72, and 23.17 in the *Baseline*, *Cap*, and *Tax* treatments correspondingly.

The buyer's role is automated to minimize the chance of two possible distortions. Firstly, an automated buyer eliminates possible uncertainty the seller could have regarding the buyer's decision process. Because the seller knows that the buyer is programmed to purchase the package that maximizes his payoff contingent on his type, the seller can be sure that the computer program does not commit mistakes, is memory-less, and his decisions are not explained by any strategic behavior beyond utility maximization. Thus, the laboratory conditions are such that the seller can explore with different screening strategies without worrying about the possible interpretations that a human buyer could give to her decisions. Secondly, we eliminate the confounding effect of inequity aversion. This is the regularity observed in several economic experiments wherein participants in laboratory economies give up some of their own payoff to avoid inequitable outcomes (Fehr and Schmidt, 1999). [13]

Results: Impacts on the number of options

Subjects offer two-option menus more often than single-package offers. Table 3 presents descriptive figures from within treatment outcomes.[14] The top rows in the table show the number of two-packages (menu) and single-package (single) offers submitted by the sellers; and average prices and quantities. We find that the majority of offers submitted by sellers in the laboratory, are two-package menus. To the degree that our subjects' objective of offering two packages is to segment demand, they do so with success. The majority of large packages are bought by H-type customers, while small packages are regularly acquired by L-types. Moreover, comparing the prices and quantities, we note that average price and quantities of small and large packages closely resemble the average prices and quantities of the packages actually purchased by low and high-type buyers.

[Table 3 about here]

In table 4, we present the results from a logistic model where we estimate the probability of subjects offering two-package menus, and the likelihood of subjects submitting H-exclusive

[13] The final original database contains 1296 observations. We made the following modifications: 1) When the subject submitted two packages, but these had identical prices and quantities, we consider this offer to be a single-option offer. In total, we re-classified 7 offers in this way; 4 from *Baseline*, 1 from *Cap*, and 2 from *Tax*. 2) In 23 trading periods, subjects incurred in losses, that is the cost of the purchased package exceeded its price. The median loss was 2600 points ($26.00 usd). We removed the observations of any subject that incurred in a loss of at least 2600 points. In total, the observations of 5 subjects were removed; 2 from *Baseline*, 2 from *Cap*, and 1 from *Tax*. After trimming these, we are left with 1236 observations.

[14] To classify packages as either small or large, we look at quantities. If a seller offered a menu, the option with larger quantity is assigned to be the large package. If the two options have the same quantity, then the alternative with larger price is assigned to be the large package.

offers. An offer is classified as exclusive if it satisfies the H-type's participation constraint, but not the L-type's. We observe that subjects are 17% less likely to submit menus in the *Tax* treatment compared to the baseline. Likewise, subjects in the taxed group are 15% more likely to offer H-exclusive packages. The effects are statistically significant. This is in accordance to what we expected.

Result 1 - *In alignment to hypothesis 1, the majority of offers submitted by our subjects are two-option menus. In the* Cap *treatment, subjects are not statistically less likely to offer two alternatives. On the other hand, in the* Tax *group, subjects are statistically less likely to submit two-options menus and more likely to submit H-exclusive offers.*

[Table 4 about here]

One of the arguments usually raised against portion cap rules is that they reduce consumer choice. However, our data suggests that buyers are offered two options in the *Cap* treatment at, on average, the same rate that they are offered menus in the *Baseline*. On the other hand, sellers are less likely to offer menus with two alternatives in the *Tax* group.

Results: Impacts when sellers adopt two-package strategies

We proceed now to discuss impacts of the regulations when subjects submitted menus with two packages. Table 5 shows econometric estimates of the impacts on the quantities consumed by each buyer type (q_H and q_L), per-period expected profit ($\mathbb{E}[\pi]$), consumer utility per type (U_H and U_L), and total surplus (including tax revenue when appropriate).

[Table 5 about here]

We start by looking at the effects on purchased sizes. The coefficients on both treatment dummy variables are negative and significant. This is the case for both buyer types. We include a time trend (period) and interact it with the treatment dummy variables to control for possibly different rates of learning. In the case of quantities, if the coefficient on the time trend is positive and significant, it would imply that subjects offer larger quantities as the session progresses. A significant coefficient on the interaction between a given active treatment and the trend would imply that. To the degree that learning was present in the baseline, the rate at which subjects learned differed in the regulated treatment and is more pronounced in the capped treatment.

Result 2 - Impacts on serving sizes (Menu): *In accordance to hypothesis 2, the average purchased quantity of the large alternative is smaller in both regulated treatments. Unlike what we expected, the size of the small serving size is smaller, not only in the* Tax *group, but with the* Cap *as well.*

Moving to effects on per-period payoffs. The cap rule does not impact consumer surplus, while the tax reduces the earnings accruing to the H-type buyer. The cap rule seems not to reduce expected profit sensibly. For completeness, we look at the impacts on total surplus. Total surplus is negatively affected by both interventions.

Result 3 - Impacts on payoffs (Menu): *According to hypothesis 3, when sellers offer two-package menus, the H-type's consumer surplus is negatively impacted in treatment* Tax. *Expected profit is affected only with a* Tax.

An explanation of why expected profit does not change in the capped case, is that sellers adjusted their prices in such a way that the profit contributions made by selling large and small packages remained equal across unregulated and quantity-limited treatments. Evidence supporting this explanation is presented in the appendix.

Results: Impacts when sellers adopt single-package strategies

We classify single-package offers as either pooling or exclusive according to the following heuristic: if the offer satisfies the low-type participation constraint, we consider it to be a pooling offer; whereas, if the offer satisfies only the participation restriction of the high-type buyer, then we consider it to be exclusive.

Regarding pooling offers, we expected only the tax to reduce the serving size. According to the experimental data, both regulations reduce the quantity purchased by consumers.

Result 4 - Impacts on serving sizes (Pooling): *According to 4, the* Tax *reduces the size of the serving portion. However, we observe that the offers in* Cap *treatment are also smaller.*

According to what we expected, the portion cap rule does not impact consumer surplus, while the tax does affect the rents earned by the H-type. Expected profit is lower only with a tax.

Result 5 - Impacts on payoffs (Pooling): *According to 5, the* Tax *affects the surplus earned by the H-type buyers, while the* Cap *does not impact consumer surplus. However, we observe that expected profit is smaller only with a Tax.*

Both interventions reduce the serving size sold when sellers adopt an H-exclusive scheme. Additionally, and as we expected it, the surplus earned by the H-type buyer is not affected.

Result 6 - Impacts on serving sizes (Exclusive): *According to 6, both interventions* *reduce the quantity of the exclusive offers.*

Result 7 - Impacts on payoffs (Exclusive): *According to 7, neither intervention affects the surplus earned by the H-type. Moreover, both regulations reduce profit and the* Tax *has a larger impact.*

1 Conclusion

In this document, we report a laboratory experiment on nonlinear pricing with contracting restrictions. We compare two interventions that have been proposed as alternatives to restrict the consumption of foods judged to have deleterious effects on human health, particularly sugar-sweetened beverages (SSB). Our goal is not to advocate for or against cap rules or taxes. We are agnostic about whether regulating the consumption of SSB will have a significant impact on the population's health and weight. We outline the economic effects of both regulations in a controlled environment and contrast them.

Our findings largely corroborate the theoretical predictions. Our main finding is that, in general, the portion cap rule does not reduce buyers' consumer surplus regardless of the pricing scheme adopted by the seller. On the other hand, the tax reduces consumer surplus when the seller implements either a separating or a pooling strategy.

We find evidence suggesting that taxes reduce the likelihood with which sellers offer two-package menus. Subjects are as likely to offer two-package menus with a cap rule as they are in the baseline. With a tax, subjects are less likely to offer two-item menus, and more likely to submit H-exclusive offers. In the context of food policy design, this finding is notable and highlights an effect produced by per-unit taxes that is not often discussed in public debates. It implies that, for a given quantity-reduction goal, taxes are more likely to reduce the consumers' choice set and caps do not seem to have a negative impact in the number of options offered by the seller.

We would like to mention potential limitations of our study. Addressing some of them could produce interesting research agendas. First, this is a laboratory experiment and thus its limited external validity is limited. The laboratory context is appropriate for our purpose of testing predictions form a highly stylized theoretical model. This is the first step from pure theory to the field. Future studies that gradually incorporate specific attributes of given industries will aid to the understanding of soda seller's behavior under different policy contexts.

Lastly, behavioral theories of consumer choice and psychological theories of food consumption do not inform our design. We compare the impacts of the regulation relying on utility theory. As a first empirical study comparing taxes and caps in a setting with heterogeneous buyers, this is beneficial, rather than detrimental, to our work. We provide an early study based on classical and orthodox assumptions and principles. This can serve as a baseline foundation for researchers interested in extending the design to better fit the particular needs of their field of interest.

Tables

Table 1: Parameter values used in the experiment

Variable or function	Value or form	Description
β	0.5	Probability of the buyer being high type.
p	$[0, 1, \ldots, 25000]$	range of possible prices.
q	$[0, 1, \ldots, 90]$	range of possible quantities.
c	240	Unitary cost of production.
$v(q)$	$q^{0.95}$	Buyer's unscaled utility of consumption.
θ_H	300	High-type buyer's taste parameter.
θ_L	290	Low-type buyer's taste parameter.
$\hat{q}$	17	Maximum size allowed under portion cap rule.
t_s	7.35	Per-unit fee active under taxation.

Table 2: Description of screening contracts that maximize seller's expected profit

		Menu			Pooling			Exclusive		
Variable	Treatment	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Large quantity	Baseline	30.88	30	32	15.5	15	16	31.78	30	34
	Cap	17	17	17	15.5	15	16	17	17	17
	Tax	17.2	16	18	9	9	9	17	17	17
Large price	Baseline	7727.25	7509	7999	3919	3799	4039	8018.11	7591	8551
	Cap	4353.33	4345	4362	3919	3799	4039	4426	4426	4426
	Tax	4410.8	4114	4609	2338	2338	2338	4426	4426	4426
Small quantity	Baseline	8.13	7	9						
	Cap	8	7	9						
	Tax	7	7	7						
Small Price	Baseline	2120.5	1840	2338						
	Cap	2089.67	1841	2338						
	Tax	1841	1841	1841						
U_H	Baseline	75.38	64.53	83.76	135.39	131.14	139.64	0.9	0.08	1.76
	Cap	73.04	64.37	81.37	135.39	131.14	139.64	0.37	0.37	0.37
	Tax	64.82	64.37	65.37	81.09	81.09	81.09	0.37	0.37	0.37
U_L	Baseline	0.96	0.45	1.90	0.24	0.13	0.35	0	0	0
	Size-cap	0.72	0.45	0.90	0.24	0.13	0.35	0	0	0
	Tax	0.79	0.79	0.79	0.45	0.45	0.45	0	0	0
$\mathbb{E}[\pi]$	Baseline	244	244	244	199	199	199	196	196	196
	Size-cap	222	222	222	199	199	199	173	173	173
	Tax	133	133	133	112	112	112	111	111	111

In *Baseline*, 32 two-package menus maximize seller's expected payoff; 2 offers result in the maximum expected payoff from pooling; 9 offers render the maximum expected payoff possible for exclusive contracts. In *Cap*, 3 menus maximize seller's expected profit; 2 offers render the maximum expected payoff for pooling strategies; 1 offer results in the maximum expected profit possible for exclusive schemes. In *Tax*, 5 two-options menus produce the maximum expected profit; 1 offer achieves the maximum expected seller's payoff for pooling strategies; 1 offer results in the maximum payoff for exclusive strategies.

Table 3: Submitted offers and consumption decisions by buyer type

	Baseline		Cap		Tax	
	Menu	Single	Menu	Single	Menu	Single
Offers submitted:						
# Obs/Total (%)	277/408 (67.9)	131/408 (32.1)	254/408 (62.2)*	154/408 (37.7)	221/420 (52.6)***	197/420 (46.9)
Mean large quantity	29.685	21.305	14.956***	14.402***	19.131***	12.781***
Mean large price	7379.407	5341.167	4155.440***	4334.551***	4990.936***	3464.604***
Mean small quantity	14.104		10.771***		9.986***	
Mean small price	3587.909		3007.763***		2895.280***	
High type:						
Buy large offer	223/277 (80.5)	130/131(99.2)	190/254 (74.8)	138/154 (89.6)***	125/221 (56.6)***	185/197 (93.9)***
Buy small offer	51/277 (18.4)		56/254 (22.1)		83/221 (37.6)	
Reject	3/277 (1.1)	1/131 (0.8)	8/254 (3.1)*	16/154 (10.4)***	13/221 (5.9)***	12/197 (6.1)**
Mean consumed quantity	26.350	21.430	14.536***	15.260***	13.418***	11.367***
Mean paid price	6536.372	5370.715	3662.528***	3853.775***	3414.701***	2942.037***
Low type:						
Buy large offer	26/277 (9.4)	90/131 (68.7)	88/254 (34.6)***	115/154 (74.7)	13/221 (5.9)***	97/197 (49.2)***
Buy small offer	215/277 (77.6)		143/254 (56.3)***		157/221 (71.0)*	
Reject	36/277 (13.0)	41/131 (31.3)	23/254 (9.1)	39/154 (25.3)	51/221 (23.1)***	100/197 (50.8)***
Mean consumed quantity	14.286	16.866	12.545***	15.147	8.882***	8.226***
Mean paid price	3594.958	4215.077	3166.844***	3814.478	2268.500***	2132.958***

The stars indicate whether there are significant difference (* at the 10%, ** at the 5%, and *** at the 1%) between the relevant treatment and the baseline. Differences between ratios tested with χ^2 independence tests. Differences between averages of quantities and prices tested with Mann-Whitney tests.

Table 4: Probability of submitting two-package and exclusive offers

Dependent variable:	Two-options menu		H-exclusive offer	
	Model	Marginal effect	Model	Marginal effect
Cap	-1.116	-0.078	1.009	0.005
	(0.760)	(0.063)	(0.998)	(0.049)
Tax	-2.071**	-0.170*	2.820***	0.150***
	(0.893)	(0.087)	(0.798)	(0.051)
Period	-0.086*	-0.005***	0.080	-0.000
	(0.047)	(0.002)	(0.052)	(0.002)
Cap*Period	0.043		-0.144***	
	(0.055)		(0.054)	
Tax*Period	0.045		-0.105	
	(0.065)		(0.099)	
Constant	2.748***		-5.008***	
	(0.798)		(0.688)	
N	1236	1236	1236	1236

$*$ Pr $<$ 0.1, $**$ Pr $<$ 0.05, $***$ Pr $<$ 0.01. Robust standard errors clustered at the session level in parentheses. Marginal effects: standard errors estimated with delta method in parentheses.

Table 5: Impacts of the regulations on quantity and per-period payoffs - Menus

	Dependent variable					
	q_H	q_L	$\mathbb{E}[\pi]$	U_H	U_L	Total Surplus
Cap	-9.366***	-2.657***	-38.521	3.238	30.548	-44.294*
	(1.259)	(0.678)	(26.110)	(32.294)	(26.293)	(25.660)
Tax	-11.119***	-5.790***	-97.378***	-53.176***	8.782	-37.897*
	(1.051)	(0.680)	(16.283)	(14.457)	(12.035)	(19.756)
Period	0.341***	-0.056	1.085***	-0.662	0.157	1.217***
	(0.040)	(0.043)	(0.206)	(1.066)	(0.339)	(0.265)
Cap*Period	-0.238***	0.107**	1.773	-1.662	-3.461	1.539
	(0.080)	(0.051)	(2.268)	(3.110)	(2.978)	(2.126)
Tax*Period	-0.094	0.063	-0.241	-0.624	-0.508	0.167
	(0.102)	(0.047)	(0.349)	(1.363)	(0.552)	(0.680)
Constant	23.220***	14.920***	165.234***	157.963***	19.635***	182.857***
	(0.689)	(0.233)	(13.773)	(2.436)	(6.694)	(14.321)
N	728	642	752	752	752	752

$*$ Pr $<$ 0.1, $**$ Pr $<$ 0.05, $***$ Pr $<$ 0.01. Robust standard errors clustered at the session level in parentheses. Marginal effects: standard errors estimated with delta method in parentheses.

Table 6: Impacts of the regulations on quantity and per-period payoffs - Pooling

	Dependent variable				
	q	$\mathbb{E}[\pi]$	U_H	U_L	Total Surplus
Cap	-4.920*	-31.527	-7.851	36.240	-36.557
	(2.562)	(27.810)	(20.783)	(26.304)	(29.002)
Tax	-8.506***	-71.579***	-83.510***	-13.467	-5.997
	(2.634)	(4.938)	(16.320)	(9.368)	(11.581)
Period	-0.109	1.308***	-1.562***	-0.662**	1.189***
	(0.079)	(0.396)	(0.333)	(0.296)	(0.310)
Cap*Period	0.249***	1.298***	0.643	-1.386***	1.562***
	(0.080)	(0.494)	(0.630)	(0.465)	(0.424)
Tax*Period	-0.023	-0.739	0.041	0.292	-1.822***
	(0.109)	(0.494)	(0.917)	(0.364)	(0.584)
Constant	18.375***	164.302***	177.446***	19.139**	182.693***
	(2.327)	(4.744)	(10.601)	(8.997)	(6.432)
N	302	302	302	302	302

$*$ Pr $<$ 0.1, $**$ Pr $<$ 0.05, $***$ Pr $<$ 0.01. Robust standard errors clustered at the session level in parentheses. Marginal effects: standard errors estimated with delta method in parentheses.

Table 7: Impacts of the regulations on quantity and per-period payoffs - Exclusive

	Dependent variable				
	q	$\mathbb{E}[\pi]$	U_H	U_L	Total Surplus
Cap	-20.403***	-60.784***	-7.464	-	-74.336***
	(5.585)	(20.903)	(17.628)	-	(23.964)
Tax	-22.125***	-80.296***	-8.411	-	-56.184***
	(5.755)	(8.666)	(12.367)	-	(14.235)
Period	-0.533	2.474***	-3.196**	-	2.323***
	(0.407)	(0.733)	(1.468)	-	(0.798)
Cap*Period	0.565	-2.362***	4.924**	-	1.974**
	(0.407)	(0.741)	(1.902)	-	(0.870)
Tax*Period	0.797	-0.683	3.090*	-	1.662
	(0.498)	(0.866)	(1.696)	-	(1.328)
Constant	36.043***	141.557***	39.311***	-	158.698***
	(5.551)	(8.590)	(1.775)	-	(11.333)
N	151	180	180	-	180

$*$ Pr $<$ 0.1, $**$ Pr $<$ 0.05, $***$ Pr $<$ 0.01. Robust standard errors clustered at the session level in parentheses. Marginal effects: standard errors estimated with delta method in parentheses.

References

Alatas, V., L. Cameron, A. Chaudhuri, N. Erkal, and L. Gangadharan (2008, July). Subject pool effects in a corruption experiment: A comparison of Indonesian public servants and Indonesian students. *Experimental Economics 12*(1), 113–132.

Bonnet, C. and V. Réquillart (2013, October). Tax incidence with strategic firms in the soft drink market. *Journal of Public Economics 106*, 77–88.

Bourquard, B. A. and S. Y. Wu (2020, January). An analysis of beverage size restrictions. *American Journal of Agricultural Economics 102*(1), 169–185.

Cason, T. N. and S. Y. Wu (2019, September). Subject Pools and Deception in Agricultural and Resource Economics Experiments. *Environmental and Resource Economics 73*(3), 743–758.

Chen, D. L., M. Schonger, and C. Wickens (2016, March). oTree-An open-source platform for laboratory, online, and field experiments. *Journal of Behavioral and Experimental Finance 9*, 88–97.

Colchero, M. A., J. Rivera-Dommarco, B. M. Popkin, and S. W. Ng (2017, March). In mexico, evidence of sustained consumer response two years after implementing a sugar-sweetened beverage tax. *Health Affairs 36*(3), 564–571.

Cooper, D. J., J. H. Kagel, W. Lo, and Q. L. Gu (1999, September). Gaming Against Managers in Incentive Systems: Experimental Results with Chinese Students and Chinese Managers. *American Economic Review 89*(4), 781–804.

Fehr, E. and K. M. Schmidt (1999, August). A Theory of Fairness, Competition, and Cooperation. *The Quarterly Journal of Economics 114*(3), 817–868.

Flood, J. E., L. S. Roe, and B. J. Rolls (2006, December). The Effect of Increased Beverage Portion Size on Energy Intake at a Meal. *Journal of the American Dietetic Association 106*(12), 1984–1990.

Greiner, B. (2015, May). Subject pool recruitment procedures: organizing experiments with ORSEE. *Journal of the Economic Science Association 1*(1), 114–125.

Grogger, J. (2017). Soda taxes and the prices of sodas and other drinks: Evidence from Mexico. *American Journal of Agricultural Economics 99*(2), 481.

John, L. K., G. E. Donnelly, and C. A. Roberto (2017, March). Psychologically informed implementations of sugary-drink portion limits. *Psychological Science 28*(5), 620–629.

Ledikwe, J. H., J. A. Ello-Martin, and B. J. Rolls (2005, April). Portion Sizes and the Obesity Epidemic. *The Journal of Nutrition 135*(4), 905–909.

Lustig, R. H., L. A. Schmidt, and C. D. Brindis (2012). The toxic truth about sugar. *Nature 482*(7383), 27–29.

Malik, V. S., B. M. Popkin, G. A. Bray, J.-P. Despres, W. C. Willett, and F. B. Hu (2010, August). Sugar-Sweetened Beverages and Risk of Metabolic Syndrome and Type 2 Diabetes: A meta-analysis. *Diabetes Care 33*(11), 2477–2483.

New York Statewide Coalition of Hispanic Chambers of Commerce v. New York City Department of Health and Mental Hygiene (2014, N.Y.). 16 N.E. 3d 538.

Rolls, B. J., L. S. Roe, and J. S. Meengs (2006, April). Larger Portion Sizes Lead to a Sustained Increase in Energy Intake Over 2 Days. *Journal of the American Dietetic Association 106*(4), 543–549.

Silver, L. D., S. W. Ng, S. Ryan-Ibarra, L. S. Taillie, M. Induni, D. R. Miles, J. M. Poti, and B. M. Popkin (2017, April). Changes in prices, sales, consumer spending, and beverage consumption one year after a tax on sugar-sweetened beverages in berkeley, california, US: A before-and-after study. *PLoS Medicine 14*(4), e1002283.

Stanhope, K. L. (2015, September). Sugar consumption, metabolic disease and obesity: The state of the controversy. *Critical Reviews in Clinical Laboratory Sciences 53*(1), 52–67.

Wilson, B. M., S. Stolarz-Fantino, and E. Fantino (2013, April). Regulating the Way to Obesity: Unintended Consequences of Limiting Sugary Drink Sizes. *PLoS ONE 8*(4), e61081.

Young, L. R. and M. Nestle (2002, February). The Contribution of Expanding Portion Sizes to the US Obesity Epidemic. *American Journal of Public Health 92*(2), 246–249.

Appendix for online publication

Proof of Claim 1

Proof. We will show that $\mathbb{E}[\pi^{***1}] \geq \mathbb{E}[\pi^{***2}]$ is equivalent to

$\beta \geq \underline{\beta}_O = \frac{[\theta_H-\theta_L]u(q_L^{***1})+\theta_L u(q^{***2})-\psi q^{***2}-[\theta_H u(q_H^{***1})-\psi q_H^{***1}]}{\theta_H u(q_L^{***1})-\psi q_L^{***1}-[\theta_H u(q_H^{***1})-\psi q_H^{***1}]}$. .

Using the profit expressions under the taxed separating and one-size-fits-all strategies, note that $\pi^{***1} \geq \pi^{***2}$ can be expressed as

$(1-\tau_v)\Big\{(\beta)[\theta_L u(q_L^{***1}) - \psi q_L^{***1}] + (1-\beta)\big\{[\theta_H u(q_H^{***1}) - (\theta_H - \theta_L)u(q_L^{***1})] - \psi q_H^{***1}\big\}$

$\geq (1-\tau_v)[\theta_L u(q^{***2}) - \psi q^{***2}]$

Solving for β yields $\beta \geq \frac{[\theta_H-\theta_L]u(q_L^{***1})+\theta_L u(q^{***2})-\psi q^{***2}-[\theta_H u(q_H^{***1})-\psi q_H^{***1}]}{\theta_H u(q_L^{***1})-\psi q_L^{***1}-[\theta_H u(q_H^{***1})-\psi q_H^{***1}]} = \underline{\beta}_O$ $\square$

Proof of Proposition 1

Proof. Recall that $\psi \equiv \frac{d\Psi_i}{dq_i} = (\tau_s + c) \div (1-\tau_v)$. The no taxation case is nested within ψ when $\tau_s = \tau_v = 0$. When there is no tax, $\psi = c$ but if either τ_s or $\tau_v > 0$, then $\psi > c$. Thus, taxation effectively increases marginal cost.

By Claim 1, $\frac{[\theta_H-\theta_L]u(q_L^{***1})+\theta_L u(q^{***2})-\psi q^{***2}-[\theta_H u(q_H^{***1})-\psi q_H^{***1}]}{\theta_H u(q_L^{***1})-\psi q_L^{***1}-[\theta_H u(q_H^{***1})-\psi q_H^{***1}]} = \underline{\beta}_O$.

Applying the quotient rule, we have $\frac{\partial \underline{\beta}_O}{\partial \psi} = \frac{q_L^{***1}-q^{***2}}{\theta_H u(q_L^{***1})-\psi q_L^{***1}-[\theta_H v(q_H^{***1})-\psi q_H^{***1}]}$. Note that the denominator is squared and therefore must be positive. To sign the numerator, comparing the first order conditions characterizing quantities, it is obvious that $q^{***2} > q_L^{***1}$. Hence, $\frac{\partial \underline{\beta}_O}{\partial \psi} < 0$. $\square$

Proof of Claim 2

Proof. We will show that $\mathbb{E}[\pi^{***1}] \geq \mathbb{E}[\pi^{***3}]$ is equivalent to $\beta \geq \frac{[\theta_H-\theta_L]u(q_L^{***1})}{\theta_H u(q_L^{***1})-\psi q_L^{***1}} = \underline{\beta}_E$.

Using the profit expressions under the taxed separating and H-exclusive strategies, note that $\pi^{***1} \geq \pi^{***3}$ can be expressed as $(1-\tau_v)\Big\{(\beta)[\theta_L u(q_L^{***1}) - \psi q_L^{***1}] + (1-\beta)\big\{[\theta_H u(q_H^{***1}) - (\theta_H - \theta_L)u(q_L^{***1})] - \psi q_H^{***1}\Big\} \geq (1-\tau_v)(1-\beta)[\theta_H u(q^{***3}) - \psi q^{***3}]$. Using the fact that the H-type first order conditions are identical, we have $q_H^{***1} = q^{***3}$. This allows us to simplify the inequality to obtain $\beta[\theta_H u(q_L^{***1}) - \psi q_L^{***1}] \geq [\theta_H - \theta_L]u(q_L^{***1})$. Solving for β yields $\beta \geq \frac{[\theta_H - \theta_L]u(q_L^{***1})}{\theta_H u(q_L^{***1}) - \psi q_L^{***1}}$ □

Proof of Proposition 2

Proof. Recall that $\psi \equiv \frac{d\Psi_i}{dq_i} = (\tau_s + c) \div (1-\tau_v)$. The no taxation case is nested within ψ when $\tau_s = \tau_v = 0$. When there is no tax, $\psi = c$ but if either τ_s or $\tau_v > 0$, then $\psi > c$. Since c is the lower bound of ψ, it follows that any positive tax implies an increase in ψ. One can easily see from $\beta_E = \frac{[\theta_H - \theta_L]u(q_L^{***1})}{\theta_H u(q_L^{***1}) - \psi q_L^{***1}}$ that an increase in ψ implies an increase in β_E. □

What are the effects of taxation holding the pricing strategy constant?

Here we show the work that results in our testable hypotheses. We concentrate first on the impacts of taxation.

Proposition 3. Suppose that a tax regime (τ_s, τ_v) is implemented. Then, serving sizes for both types of consumers decline.

Proof. Suppose that a tax a tax regime (τ_s, τ_v) is implemented. A simple comparison can show that $q_H^{*1} > q_H^{***1}$ and $q_H^{*1} > q^{***3}$. Therefore, regardless of whether the retailer continues with the separating strategy or switches to the H-exclusive strategy, the H-type serving will decline.

Also, $q_L^{*1} > q_L^{***1}$ so the L-type serving size declines if the retailer continuous with the separating strategy post tax. If the retailer switches to the H-exclusive strategy, then by proposition 3, L-type consumers are excluded so that serving size trivially declines to zero. In either case, L-type serving size declines. □

Proposition 4. Suppose that a tax regime (τ_s, τ_v) is implemented. Then consumer surplus for H-types declines. Consumer surplus for L-types is unaffected.

Proof. Suppose that a tax regime (τ_s, τ_v) is implemented. Smaller quantities with regulations imply $U_H^{*1} > U_H^{***3}$. Therefore, the H-type buyer's surplus declines.

Also, the L-type buyer is always held at his reservation utility. Thus, a tax does not affect the L-type's consumer surplus as his utility remains at the reservation both pre and post-tax. □

Intuitively, if a tax does not cause the retailer to switch away from a separating strategy, the tax still causes the L-type serving size to drop, which lowers the H-type information rent. Thus, H-type consumer welfare decreases.

Proposition 5. Suppose that a tax regime (τ_s, τ_v) is implemented. Then, retailer surplus unambiguously declines.

Proof. Suppose that a tax regime (τ_s, τ_v) is implemented. If the retailer continues to use the segmentation strategy post-tax, then by proposition 2, $\pi^{*1} > \pi^{***3}$.

If instead, the retailer switches to a the H-exclusive strategy, then the retailer's post-tax value function is $\pi^{***3} = (1 - \tau_v)(1 - \beta)[\theta_H v(q^{***3}) - \psi q^{***3}]$. Note that if the retailer had adopted a H-exclusive strategy pre-tax, then the retailer's value function would be

$\pi^{*3} = (1-\beta)[\theta_H u(q^{*3}) - \psi q^{*3}]$ where q^{*3} is the optimal H-type serving size in the absence of a tax. This would be determined by the first order condition $\theta_H u'(q^{*3}) = c$. However, note that Taxed Case Exclusive that the same condition for the post-tax H-exclusive strategy is $\theta_H u'(q^{***3}) = \psi$. Because $\psi > c$, it follows that $q^{***3} < q^{*3}$ and therefore $\pi^{*3} > \pi^{***3}$. However, we know that, by assumption, the retailer adopts a separating strategy pre-tax so it must be the case that $\pi^{*1} > \pi^{*3}$. Hence, by transitivity, $\pi^{*1} > \pi^{***3}$. $\square$

Proposition 6. *Assume that the government enforces a tax regime (τ_s, τ_v) with at least one type of tax strictly positive. Suppose that the retailer decides to offer one single cup size designed to serve H-type buyers solely. Then:*

1. $\theta_H u'(q^{***3}) = \psi > c$. *There is a tax induced reduction in q^{***3} below first best. Thus, $q^{***3} < q_H^{*1}$*

2. *L-type buyers are excluded and do not engage in trade.*

3. *The serving price is $p^{***3} = \theta_H v(q^{***3})$ which does not include an information rent.*

4. *Expected profit is lower.*

5. *Both buyer types are held at their reservation values; i.e. $U_H = U_L = 0$.*

The proof is just a straightforward comparison so we exclude it.

Proposition 7. *Assume the government enforces a tax regime (τ_s, τ_v) with at least one type of tax strictly positive. If the retailer decides not to screen the market and offers a one-size-fits-all package designed to serve both types of buyers, then:*

1. *$\theta_L u'(q_L^{***2}) = \psi$ so that buyers are provided with a quantity, q_L^{***2}, that is smaller than the L-type first best.*

2. *The price per serving is $p^{***2} = \theta_L u(q^{***2})$.*

3. *The seller's value function is reduced.*

4. *The L-type consumer value function is $U_L^{***2} = 0$.*

5. *The H-type consumer value function is $U_H^{***2} = (\theta_H - \theta_L)u(q^{***2}) > 0$.*

The proof is straightforward and therefore excluded. Note that H-type buyers still earn excess rents though this is not due to screening driven information rents.

What are the effects of the size cap holding the pricing strategy constant?

We present the work that results in the comparison between cap rule and the baseline just for completeness. For more details and a longer exposition, we direct the reader to Bourquard and Wu (2020).

Consider the set of possible discrete pricing strategies:

- Case ib: Sell to both types of consumers with a menu of differentiated H-type and L-type price-size options.

- Case iib: Sell exclusively to H-types.

- Case iiib: Sell to all types using one-size-fits-all pricing.

Case ib: Sell to both types with a menu of H-type and L-type options.

Assuming that the size-restriction only caps the H-type serving so that the restriction has an upper corner solution, $0 \leq q_H \leq \hat{q}$, then the K-T conditions are

$$\theta_H u'(q_H) \geq c \quad where \quad q_H = \hat{q} \tag{16}$$

$$\beta\left[\theta_L u'(q_L) - c\right] + (1-\beta)\left[-(\theta_H - \theta_L)u'(q_L)\right] \leq 0 \quad where \quad q_L \geq 0 \quad \& \quad \frac{\partial \pi}{\partial q_L} q_L = 0 \tag{17}$$

These conditions imply that $q_H = \hat{q}$ and $\theta_L u'(q_L) = c + \frac{(1-\beta)}{\beta}\left[\theta_H - \theta_L\right] u'(q_L)$. But the latter is identical to the unregulated case. so that a beverage size-restriction would have no impact on q_L if the separating strategy is used post-regulation.

Furthermore, because $\tilde{q}_L$ is unchanged, and q_H^* decreases to $\hat{q}$, this suggests that p_H drops but p_L remains the same.

Lemma 1 - Suppose that there is a size-restriction $q_H \leq \hat{q}$ such that the retailer continues to use a separating pricing strategy where $0 < q_L < q_H = \hat{q}$. Then

1. The H-type's serving size declines to $q_H = \hat{q} < q_H^*$ and p_H drops from $t_H = \theta_H u(q_H^*) - (\theta_H - \theta_L)u(\tilde{q}_L) - \overline{u}$ to $\hat{t}_H = \theta_H u(\hat{q}) - (\theta_H - \theta_L)u(\tilde{q}_L) - \overline{u}$,

2. The L-type's serving size, $\tilde{q}_L$, and price, p_L, remain unchanged.

3. The retailer's profit declines to: $\Pi_{ib} = \beta\left[\theta_L u(\tilde{q}_L) - c\tilde{q}_L - \overline{u}\right] +$

   $(1-\beta)\left[\theta_H u(\hat{q}) - c\hat{q} - (\theta_H - \theta_L)u(\tilde{q}_L) - \overline{u}\right]$

4. The H-type's welfare (utility) remains unchanged at $U_{Hib} = \overline{u} + [\theta_H - \theta_L]u(\tilde{q}_L)$ (earns information rents).

5. The L-type's welfare remains unchanged at $U_{Lib} = \overline{u}$ (earns no excess surplus).

Proof of Lemma 1

Proof. The proof for part (1) follows from the binding size-restriction, which yields K-T condition 16 and thus, $q_H = \hat{q}$. Also, p_H drops because q_H^* is replaced with the smaller $\hat{q}$ in the the optimal price function. Since the price function is a function of $p(q_H)$ and $p(q_H)$ is increasing in q_H $\forall$ $q_H < q_H^*$, it must be true that the new price $\hat{t}_H < t_H$ since $\hat{q} < q_H^*$.

Part (2) follows from the first order condition for q_L (17), which is unchanged from the unregulated case. Hence, the retailer will still offer the same $\tilde{q}_L$ as the unregulated case. Serving price p_L is unchanged because the L-type price is a function of only q_L (and not q_H).

The proofs for parts (3), (4), and (5) are easy to show by substituting the optimal prices and quantities into the objective functions of the retailers and consumers. $\square$

Case iib: Sell to only high types with $q_L = 0$

Here, the seller only serves H-type consumers because it is too costly in terms of information rents to also serve L-types. Neither 16 nor 17 hold with strict equality so $q_H^* = \hat{q}$ and $\tilde{q}_L = 0$. Because the size-restriction causes q_H^* to drop to $\hat{q}$, $p_H^* = \theta_H u(q_H^*) - \overline{u}$ (from case ii) drops to $\hat{p}_H = \theta_H u(\hat{q}) - \overline{u}$.

Lemma 2 - Suppose that there is a regulatory restriction of the form $q_H \leq \hat{q}$ and the retailer serves only H-type consumers. Then

1. The H-type's serving size declines to $q_H = \hat{q} < q_H^*$ and p_H drops from $p_H^* = \theta_H u(q_H^*) - \overline{u}$ to $\hat{p}_H = \theta_H u(\hat{q}) - \overline{u}$.

2. The retailer's profit declines to: $\Pi_{iib} = (1-\beta)[\theta_H u(\hat{q}) - c\hat{q} - \overline{u}]$

3. The H-type's consumer welfare is: $U_{Hiib} = \overline{u}$ (no excess rents).

Proof of Lemma 2

Proof. Part (1) follows from the assumption of a binding restriction, $\hat{q}$, which yields K-T condition 16 so $q_H = \hat{q}$. The serving price, p_H, drops because q_H^* is replaced with the smaller $\hat{q}$ in the the optimal price function. Since the price function is a function of $u(q_H)$ and $u(q_H)$ is increasing in q_H $\forall$ $q_H < q_H^*$, it follow that $\hat{p}_H < p_H$ since $\hat{q} < q_H^*$.

The proofs for parts (2) and (3) follow from substituting the optimal prices and quantities into the objective functions for the retailer and consumers. □

Case iiib: Sell to both types with a one-sized fits all package

The optimal one-size-fits-all strategy under a size restriction is generated by solving:

$$\max_{p,q} \, [p - cq] \quad s.t. \tag{18}$$

$$\theta_L u(q) - p \geq \overline{u} \tag{19}$$

$$0 \leq q \leq \hat{q} \tag{20}$$

Because $\theta_L < \theta_H$, the H-type participation constraint is always satisfied so long as L-type constraint is satisfied. The binding participation constraint 19 can be substituted into the objective function to get:

$$\max_{q}] \, [\theta_L u(q) - cq - \overline{u}] \tag{21}$$

$$0 \le q \le \hat{q} \tag{22}$$

which yields the Kuhn-Tucker conditions:

$$\theta_L u'(q) \ge c \quad \& \quad q \le \hat{q} \quad \& \quad \frac{\partial \pi}{\partial q}(\hat{q} - q) = 0 \tag{23}$$

Solving the K-T conditions yields the following proposition.

Lemma 3 - Suppose that there is a restriction of the form $q \le \hat{q}$ and the retailer uses a one-size-fits-all strategy for both types of consumers. Then

1. The quantity offered to both types of consumers is $q = min\{q_L^*, \hat{q}\}$ where q_L^* is the first-best quantity for the L-type consumer.

2. The price is $p = \theta_L u(q) - \overline{u}$.

3. The retailer's profit is: $\Pi_{iiib} = \theta_L u(q) - cq - \overline{u}$.

4. The H-type's consumer welfare is: $U_{Hiiib} = \overline{u} + [\theta_H - \theta_L]u(\hat{q})$ (excess rents).

5. The L-type's consumer welfare is: $U_{Liiib} = \overline{u}$ (no excess rents).

Proof of Lemma 3

Proof. Part (1) follows from K-T condition 23. That is, if the size-constraint is not binding so that $q < \hat{q}$, then the first order is $\theta_L u'(q) = c'(q)$ so the solution to 23 is clearly equal to the first best level of quantity for L-types, q_L^*. If the size constraint is binding, then, $\hat{q} \le q_L^*$ in which case $q = \hat{q}$. Hence, $q = min\{q_L^*, \hat{q}\}$

Part (2) follows easily from the optimal q and the binding participation constraint.

Parts (3)-(5) follow from substituting the optimal q and t into the objective functions of the retailer, and consumers. □

Impacts to profit contributions

In result 3, we mention that the observed effect on the seller's expected earnings in the *Tax* treatment aligns with our hypothesis. However we observe no change in expected earnings in *Cap* treatment. An explanation of why expected profit does not change in this case, is that sellers adjusted their prices in such a way that the profit contributions made by selling large and small packages remained equal across the unregulated and quantity-limited treatments. The profit contribution of a sold package is the difference between its price and its cost of production. In the table below, we present econometric estimates of the impact of regulations on the profit contributions of large and small options and their sum. Profit contributions of both types of packages decreased in *Tax*. In *Cap*, the fall in profit contributions made by the large packages is barely significant; while the contributions of small options are statistically equivalent to the baseline. This suggests that under a portion cap, sellers adjust both quantity and prices so that the sum of profit contributions remains unchanged compared to the *Baseline* treatment.

We find similar patterns when looking at profit contributions in single-package offers, as can been seen in the second table below.

Estimated Impacts of the Regulations on Profit Contributions - Menus

	Dependent variable: Profit contribution		
	Large Package	Small Package	Sum of Profit Contributions
Cap	-48.252*	-33.096	-78.960
	(28.259)	(28.359)	(56.654)
Tax	-108.643***	-93.318***	-202.278***
	(14.140)	(17.299)	(35.894)
Period	2.315***	0.068	2.220***
	(0.769)	(0.315)	(0.127)
Cap*Period	1.396	3.396	4.987
	(2.296)	(2.840)	(5.228)
Tax*Period	0.062	0.241	-0.814
	(1.012)	(0.600)	(1.206)
Constant	188.588***	162.509***	347.589***
	(12.835)	(14.541)	(28.258)
N	728	642	642

$*$ Pr $<$ 0.1, $**$ Pr $<$ 0.05, $***$ Pr $<$ 0.01. Robust standard errors clustered at the session level in parentheses. Marginal effects: standard errors estimated with delta method in parentheses.

Estimated Impacts of the Regulations on Profit Contributions - Single option

	Dependent variable: Profit contribution	
	Pooling	Exclusive
Cap	-31.527	-40.954
	(27.810)	(25.118)
Tax	-71.579***	-170.800***
	(4.938)	(17.467)
Period	1.308***	4.411***
	(0.396)	(1.433)
Cap*Period	1.298***	-6.179***
	(0.494)	(2.012)
Tax*Period	-0.739	-2.382
	(0.494)	(1.595)
Constant	164.302	317.186***
	(4.744)	(16.520)
	302	151

$*$ Pr $<$ 0.1, $**$ Pr $<$ 0.05, $***$ Pr $<$ 0.01. Robust standard errors clustered at the session level in parentheses. Marginal effects: standard errors estimated with delta method in parentheses.

Pre-experimental quiz

Question 1: Suppose that you did not make an offer during the trading phase. How many points do you earn for this period?

Question 2: Suppose that you offer a single package of size 16 at a price of 3920 points. The buyer accepts your offer. How many points did you earn for this period? You can use the calculator at the bottom of this page.

Question 3: Suppose that you offer a menu of two packages. The first package is size 15 at a prize of 9000, and the second package is size 9 at a price of 2200 points. The buyer accepts the smaller package. How many points did you make this period? You can use the calculator at the bottom of this page.

Question 4: Suppose that the buyer is a low-valuation buyer and the buyer rejected the seller's offer. How many points did you make for this period?

Question 5: Suppose that for this period, the buyer is a high-valuation buyer and decided to accept your offer of a package size of 10 at a price of 2500 points. How many points did the buyer make this period? You can use the calculator at the bottom of this page.

Question 6: Suppose that for this period, the buyer is a low-valuation buyer and you offered a menu of two packages. The first package is size 16 at a price of 6200 points. The second package is size 9 at a price of 2100. Which package yields the highest amount of points to the buyer? You can use the calculator at the bottom of this page. **Options**: The first (larger) package, The second (smaller) package.

Question 7: Suppose that trading periods are about to start. What is the probability of your buyer being assigned to be a high-valuation buyer for the first period? (Express the probability in percentage, i.e. a number between 0 and 100).

Question 8: The type of the buyer (high-valuation or low-valuation) is randomly assigned every period. Select one. **Options**: True, False.

Question 9: You will not be informed about the type of buyer (high-valuation or low-valuation) you are trading with. Select one. **Options**: True, False.

Post-experimental survey

- Please, mark your gender. Options: Female, Male, Prefer not to disclose.
- Please type your major field of study.
- Please indicate the range within your cumulative GPA falls. Options: 0 - 2.70, 2.71 - 2.90, 2.91 - 3.10, 3.11 - 3.30, 3.31 - 3.50, 3.51 - 3.70, 3.71 - 3.90, 3.91 - 4.00, Prefer not to disclose.
- Did you primarily offer a single price/size package or a menu of two packages? Why?
- How did you decide on your prices?
- How did you decide on the size of the package(s) you offered?
- Did you ever decide not to make an offer? Why?
- Did the fact that you did not know the buyer's type with certainty affect your pricing and package size strategies?

Experimental Instructions

This experiment is about how people sell goods. A clear understanding of the instructions will help you make better decisions and increase your chances of earning more money that will be paid to you in cash at the end of the experiment. During the experiment, you will earn points. **Points will convert to cash at the end of the experiment at the rate of 100.00 points = 1.00 US Dollar**. You are entitled to a $5.00 USD participation fee which will be paid to you in cash at the end of the experiment.

It is important that you don't talk or look at other people's work. If you have any questions, or need any assistance of any kind, please raise your hand. All written information is for your private use only. **Do not pass over any information to other participants**. During the experimental session **you are not allowed to talk, laugh or exclaim out loud**. Be sure to **keep your eyes on your screen only**. Please, **turn off your electronic devices (such as phones, tablets, etc.)** and put them away during the experiment. **Violations of these rules may force us to stop the experiment**. Anybody that violates any of these rules will be asked to leave the laboratory and **will not be paid**. We appreciate your cooperation.

Agenda

1. First, we will go over the instructions.
2. Next, there will be a quiz with 9 questions to make sure that everybody understands the experimental instructions. **You can earn money for each question that you answer correctly.**
    - All 9 questions will be displayed on your computer's screen.
    - You will be asked to answer all of them and then proceed to the next page. You will have only one chance to answer the questions.
    - You earn 25 points for each correct answer. So you can earn up to 225 points if you answer all the questions correctly.
    - Answers for each question will be displayed in the page following the quiz. You should briefly study the questions you got wrong because it might help improve your performance during the experiment.
3. After the quiz, the experiment will begin. The experiment is about how people sell goods.
    - First, there will be a set of non-paying trading periods that will allow you to trade without incurring financial risk.
    - Next, there will be a set of paying trading periods. Your performance in these periods will determine your final earnings.
    - Finally, you will be asked to answer a post-experimental survey.

Description of the Experiment

A Brief Overview

In this experiment every subject in the room is assigned to the role of a seller. You **will not** interact with any other human subject participating in the experiment. You will only interact with a computerized buyer.

To make a trade, a seller will specify a price for a certain size package of an abstract good. The computer will receive your offer and decide whether to buy or not. The price and size of the package agreed upon will determine how much money you make. Trades will occur within a **trading period**. There will be many trading periods throughout the course of this experiment so you will make many trades.

In general, the seller's cost of producing the good is increasing in size. The buyer's payoff is also increasing in size. Moreover, the seller's payoff will be increasing in the price while the buyer's payoff will be decreasing in price. *In short, the buyer benefits from large size at low prices while the seller benefits from high prices at low production cost.*

Also, there are two types of buyers in the marketplace. The **high valuation** type buyer values the good highly. The **low valuation** type buyer still values the good but not as much as the high valuation type does. The seller will not know for certain what type of buyer he/she is trading with.

Specific Trading Instructions

All trades will occur via the computer. Each period is divided into the following phases:

1. **Pricing/packaging phase**. You will observe a screen that allows you to determine the price and size of the package to offer to the computerized buyer.
   - Menu choice: You will be asked to choose whether to offer one package, two packages, or not to offer any package for the period. Note: if two-packages are offered, then the buyer will choose **one** of the packages. Thus, you are offering the buyer a "menu" of choices.
   - Size - Price choice: After selecting the number of packages to offer, you will be asked to set price and size for each of the packages. The size can be any integer number between 0 and 17. The price can be any integer number between 0 and 25000 points. If you decided not to offer a package for the period, this sub-phase will be skipped.
2. **Purchase phase**. If the seller decides to offer at least one package, the computer will be presented with the price and size of each option and **it will choose the option that maximizes its payoff. The buyer will also reject any package that results in the buyer making a negative payoff**. The computerized buyer has the following alternatives:
   - If offered a single package: Either accept or reject reject the package.
   - If offered a menu of two packages: Either accept package 1, accept package 2, or reject both. The buyer cannot purchase both packages. **If both packages offer the buyer the same positive payoff, then the buyer will randomly select one of the packages.**

At the end of the period, the points you earned will be displayed on the screen. Both the earnings for the period as well as the accumulated earnings from all previous paying periods will be displayed.

You should also document your performance in the paysheet provided to keep track of your past strategies and performance.

Additional Important Information

How many trading periods will there be? The experiment will be divided into two halves:

1. **First half**: There will be 6 **non-paying training periods**. This part provides 6 trading opportunities for you to become familiar with the trading screens and to develop strategies without financial consequences. You should still document your performance on the paysheet to help you learn to improve your strategies.
2. **Second half**: The second half begins following the non-paying periods. There will be 12 paying periods. All periods after the first 6 non-paying periods are **paying periods**. Thus, the points that you earn will be converted into cash at the end of the experiment.

The decisions you make do not affect in any form the decisions or results of other participants in the room. You will be a seller throughout all of the non-paying and paying trading periods.

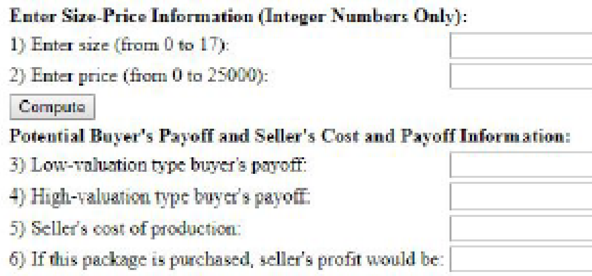
How is the buyer type assigned to the computer? Whether the buyer is a high or a low valuation type in each period will be randomly determined. There is an equal 50-50 chance that the buyer will be a high or low type in each period (similar to a coin-flip). *You will not know for certain what type of buyer you are trading with. You will only know that the computer takes on the role of a high valuation or a low valuation type with 50% probability each.* The computer will behave like a buyer who knows his/her own type. Note: buyer types are not fixed across periods.

How are payoffs calculated?

In each period, if you decide not to make an offer or if the computer rejects your offer, then you earn 0 points for that period.

Prior to making an offer, you will have access to an on-screen calculator where you can compute, for a given size-price combination, the following: the payoff that each type of buyer would gain; the seller's cost of production, and the payoff that the seller would obtain if the package were purchased. This calculator appears during the price/package phase. So you can try different package sizes before submitting an offer. The following is how the calculator would appear on-screen:

Figure 1: On-screen Calculator



If you are curious as to how payoffs are affected by size and price, keep in mind the following: *In general, seller payoffs are increasing in price and decreasing in size. This is because it costs more to produce a larger size. Buyer payoffs are increasing in size and decreasing in price.* Also, the buyer would earn zero points if no offer is made or the offer is rejected.

Additionally, for a given package size, High-type buyers will have higher payoffs than Low-type buyers.

For those of you interested in even more details of the equations behind the calculator, below are the equations:

$$\text{High-Type Buyer's payoff} = 300 size^{0.95} - price \tag{1}$$

$$\text{Low-Type Buyer's payoff} = 290 size^{0.95} - price \tag{2}$$

Note from the above that the high-type buyer has a much higher valuation ($300 size^{0.95}$ versus $290 size^{0.95}$)

$$\text{Seller's payoff} = price - 240 \times size \tag{3}$$

Notice that "Cost" is determined by the last term $240 \times size$. This means that the larger the size, the larger the cost. If the payoff contains decimals, the computer will round it to the nearest integer.

Initial point balances

During the paying periods, you can make decisions that can earn more points or cause a loss of points.