AARHUS UNIVERSITY

Coversheet

This is the accepted manuscript (post-print version) of the article.

Contentwise, the post-print version is identical to the final published version, but there may be differences in typography and layout.

How to cite this publication

Please cite the final published version:

Christensen, E. G., & Nafziger, J. (2016). Packaging of Sin Goods - Commitment or Exploitation? *Journal of Economic Behavior & Organization*, 122(February), 62-74. DOI: 10.1016/j.jebo.2015.11.007

Publication metadata

Title:	Packaging of Sin Goods - Commitment or Exploitation?
Author(s):	Christensen, E. G., & Nafziger, J.
Journal:	<i>Journal of Economic Behavior & Organization</i>
DOI/Link:	10.1016/j.jebo.2015.11.007
Document version:	Accepted manuscript (post-print)

General Rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Packaging of Sin Goods – Commitment or Exploitation?

Else Gry Bro Christensen^a and Julia Nafziger^{b*}

^aUniversity of Munich

^bAarhus University

Abstract

We consider the shopping and consumption decision of an individual with a self-control problem. The consumer believes that restricting the consumption of a sinful product (such as chips) is in his long-run interest. But when facing the actual decision he is tempted to overeat. We ask how firms react to such self-control problems, and possibly exploit them, by offering different package sizes. In a competitive market, either one or three package sizes are offered. In contrast to common intuition, the large, and not the small package might be a commitment device. The latter may serve to exploit the naive consumer.

JEL Classification: D03, D11, D49, D86

Keywords: Quasi-hyperbolic discounting, self-control, consumer behavior, non-linear pricing

*We would like to thank seminar participants at Regensburg and at the Aarhus workshop on self-control for helpful comments. Nafziger acknowledges financial support from the Danish Council for Independent Research — Social Sciences (FSE) under grant 12-124835. ^aUniversity of Munich, Ludwigsstr. 28/02 (Rg), 80539 Munich Germany. Email: else.christensen@econ.lmu.de. ^bDepartment of Economics and Business Economics, Aarhus University, Fuglesangsallée 4, 8210 Aarhus V, Denmark. Email: jnafziger@econ.au.dk.

1 Introduction

Many individuals face self-control problems. The pleasure of the moment seduces them to act against their own long run interests. For example, they are tempted to shirk on unpleasant tasks – such as dieting. And a poor diet contributes to the problem of overweight and obesity. The World Health Organization reports that more than 1.4 billion adults were overweight in 2008, and more than half a billion obese. It estimates that at least 2.8 million people die each year as a result of being overweight or obese. Moreover, globally, 44 percent of diabetes, 23 percent of ischaemic heart disease and 7-41 percent of certain cancers are attributable to overweight and obesity.¹ The associated health costs are large (cf., e.g., Finkelstein et al. 2009).

Chandon and Wansink (2010) discuss how firms influence food intake with their marketing strategies and thereby may contribute to the problem of overeating. Examples of such marketing strategies are food prices and promotion, the food's quality and quantity, marketing, the availability, salience and convenience of food, the type, size and shape of serving containers, or the atmospherics of the purchase and consumption environment.

In this paper, we want to focus on one particular marketing strategy – the packaging of sinful products such as chips. Wertenbroch (1998) argues that consumers engage in pre-commitment by rationing their purchase quantities, i.e., by buying, for example, small packages. Two questions arise from this. First, can the consumer indeed limit his consumption through such a strategy? And second, how do firms react to the consumer's self-control problem? The argument by Wertenbroch (1998) presumes that firms indeed offer small packages as commitment devices. But do they indeed do so or are they trying

¹See <http://www.who.int/features/factfiles/obesity/en/index.html> (last accessed January 2014).

to counteract the consumer's wish for commitment?

To answer these questions, we consider the shopping and consumption decision of a vice, or sinful good (such as chips, cigarettes, or chocolate) of an individual that faces a self-control problem that arises due to time-inconsistent preferences. The individual judges that limiting the amount of, say, chips consumption is in his long-run interest. But once he sits in front of the TV and starts eating chips, the distant health benefits of a healthier life style suddenly do not seem worth the effort of restricting consumption.

The consumer goes shopping when he is not tempted to overeat. For example, when doing his weekly shopping trip, the consumer (self 0) has planned beforehand how much chips to buy and is not hungry. When sitting in front of the TV in the evening, however, the consumer (self 1) is tempted to overeat chips. The consumer can go shopping at this point, but, because of opportunity costs, the costs of such spontaneous shopping trips are higher than those of his weekly, planned shopping trip. We assume that the consumer is either sophisticated or naive, which means that the consumer, when doing his weekly shopping trip, is either fully aware or not at all aware that he faces a self-control problem.

Firms offer the consumer to buy a certain quantity (a "package") for a transfer. In the main model, we consider a competitive market. The sophisticated self 0 perfectly anticipates the shopping and consumption decision of his future self. Firms respond by offering self 0 either full or partial commitment. More precisely, if the shopping costs of self 1 are large, self 0 buys the package that is optimal from his viewpoint. In this case, self 1 is not tempted to go shopping again given the package self 0 bought and so the market can provide full commitment. If, however, self 1 would be tempted to go shopping again if self 0 bought the from his viewpoint optimal package, then only

partial commitment is feasible. That is, firms offer a larger package to self 0 than is optimal from his perspective. Yet, self 0 buys this larger package because he knows that otherwise self 1 would go shopping again to buy a top-up. In contrast to the sophisticated self 0, the naive self 0 does not anticipate the decision of his future self. Hence, he goes shopping and buys the package that is optimal from his point of view. If the shopping costs of self 1 are sufficiently large, then self 1 will not go shopping. So in this case, self 1 will consume the package that is optimal from the point of view of self 0, i.e., the naive consumer receives full commitment. If, however, the shopping costs of self 1 are not sufficiently large, self 1 will go shopping again and buys a “top-up” package. So in this case, commitment breaks down.

The result yields several implications and testable predictions. First, we predict that commitment is easier to achieve if self 1 faces large shopping costs. There is some evidence that supports this result. Hinnosaar (2012) predicts that Sunday sales restriction should decrease weekend consumption of alcohol. When looking at an actual policy change, Bernheim, Meer, and Novarro (2012) however observe no such effect. Currie, Della Vigna, Moretti, and Pathania (2010) observe that a close geographical proximity of a fast food restaurant is associated with higher rates of obesity (of children and pregnant women). Leung et al. (2011) show that the availability of convenience stores within a close distance of residence is correlated with a greater risk of girls becoming overweight or obese. Lee (2012) however finds conflicting evidence regarding the association between distance and overweight.

Second, the result predicts that in the competitive market, if the shopping costs of self 1 are large relative to those of self 0, one package size is offered, which is tailored to the interests of self 0. If the shopping costs at time 1 are relatively small, three different package sizes (a small one, a medium one, and

a large one) are offered, and thus the market does not offer commitment to the naive consumers. Consistent with this result Steenhuis et al. (2010) observe that firms offer different package sizes. In contrast to common intuition, we demonstrate that the small package is not necessarily a commitment device, but can serve to exploit the naive consumer, while the large package may offer commitment to the sophisticated consumers. Indeed, for empirically reasonable values of the self-control problem, the smallest package is always the exploitative.

Third, in a competitive market, the naive consumer may go inefficiently often shopping. He initially buys a relatively small package that is optimal from the point of view of self 0 – believing that he will only consume this package, i.e., not go shopping again. But later, when in the “hot state”, he buys another top-up package. Indeed, Hinnosaar (2012) observes that time-inconsistent consumers go shopping more often than time-consistent consumer. And Vermeer et al. (2011) provide field evidence showing that people having a smaller portion in the lunch cafeteria later are more likely to buy other food.

We contrast the competitive market with a monopolistic one. When facing a naive consumer, the monopolist tailors the package to the preferences of the self from whom he can extract the highest surplus. Thus, if the shopping costs of self 1 are large relative to the shopping costs of self 0, he caters to self 0 and perfect commitment is possible. If not, he caters to the interests of self 1 and offers a relatively large package. The sophisticated self 0 is willing to pay for a smaller commitment-package. The monopolist offers such (partial or full) commitment products to the sophisticated consumer – possibly at a higher price. Thus, in a monopolistic market, small packages are always commitment devices. So overall, our results make clear that a careful

market analysis and assessment of the self-control problem are needed to assess whether small packages are commitment devices or are exploitative. Comparing the monopolistic to the competitive market shows that for the sophisticated consumer only the distribution of rents differs, but the social surplus is the same in both markets. In contrast, the naive individual might be better or worse off in the competitive market. On the one hand, the competitive market provides more often full commitment to the naive consumer than the monopolistic market. However, if he does not receive full commitment, the social surplus in the competitive market can be lower than in the monopolistic market because the naive consumer goes shopping too often in the competitive market. Thus, competition can decrease the social surplus. Finally, we consider some robustness checks and extensions to our main analysis. We show that our results are robust to relaxing some of the more technical assumptions and are robust to allowing for partial naïveté. We also extend the model – allowing for imperfect competition and market entry. In this setting, firms operate on two separate markets: one that caters self 0 and one that caters self 1. This can be seen as reflecting the difference between offering a product in standard supermarkets, or in late night convenience stores.

Related theoretical literature The theme that firms provide commitment to the sophisticated consumer, but exploit the naive consumer is well established in this literature on contracting with time-inconsistent agents. Our paper is distinct by the application and the repeated setting it studies: package sizes in consumer markets with re-shopping possibilities have been underexplored – and some new features arise in such a setting.

DellaVigna and Malmendier (2004) consider a model in which firms offer two-part tariffs consisting of a lump-sum payment and per-unit price to a time-inconsistent consumer. They establish that firms price investment goods below marginal costs, and leisure goods above. Gottlieb (2008) relaxes the assumption of DellaVigna and Malmendier (2004) that a consumer deals exclusively with one firm (for a similar model see also Kőszegi 2005). The assumption of a competitive spot market is more realistic in, e.g., markets for consumption goods such as sinful products. He shows that in this case marginal cost pricing of sinful products arises, i.e., commitment for the sophisticated consumers vanishes. Our paper demonstrates that the market may provide commitment under some circumstances – to both sophisticated and naive consumers. Gottlieb (2008) also shows that competition can decrease the social surplus. In our model, this is the case for the naive, but not for the sophisticated consumer. Heidhues and Kőszegi (2010) consider a competitive credit market. They show that firms exploit naive consumers by offering a cheap baseline repayment, and specifying large penalties for late payments.²

A small literature strand in marketing asks about the package sizes firms provide when consumers face self-control problems. Dobson and Gerstner (2010) show why it can be profitable for firms to offer so-called “super-size” portions, i.e., very large portions which are not much more expensive than

²A number of papers focuses on the question how to screen agents who differ in their degree of sophistication, or in their degree of time-inconsistency (see, e.g., Eliaz and Spiegler 2006, Eliaz and Spiegler 2008, Esteban and Miyagawa 2006, Esteban, Miyagawa, and Shum 2007, Galperti 2012). The theme that relatively sophisticated types receive full commitment, while relatively naive types are exploited re-appears when firms screen agents who differ in their degree of sophistication (see, e.g., Eliaz and Spiegler 2006, Eliaz and Spiegler 2008).

the normal sized portion. Firms employ such a strategy in order to price-discriminate between disciplined and tempted consumers. The former are willing to pay a premium for smaller sized portions. Jain (2012) considers, similar to our setting, the shopping decision of an individual with a present bias. The main difference is that in his framework only self 0 can go shopping, and consumption occurs on two days. The package size and number of package sizes are exogenous in his setting, while it is endogenous in ours. A small package thus is by assumption a commitment device in his model and its introduction increases the social surplus. Firms introduce small packages if the gain from doing so (attracting consumers who would otherwise not buy or buy less) outweighs the loss (some consumers buy less). Jain (2012) also briefly considers naive consumers, but as only self 0 can go shopping, exploitation by firms of naive consumers is not an issue.

Hinnosaar (2012) builds up a model of the behavior of a time-inconsistent consumer related to the one considered here. Her main aim is to identify time-consistent and time-inconsistent consumers from dynamic purchasing behavior, but she does not disentangle naive and sophisticated consumers. And she does not consider firm behavior as we do in this paper.

The paper is organized as follows. We first introduce the model in section 2. The main analysis and results are presented in section 3. In this section, we first consider the competitive market and then the monopolistic one. Section 4 discusses robustness and extensions. Section 5 concludes the paper.

	Type	True preferences	Beliefs about preferences at $\tau = 0$	Actions
$\tau = 0$	Naive	$u(x)$	$u(x)$	Shop $x_0 \geq 0$
	Sophisticates	$u(x)$	$u(x)$	if $x_0 > 0$: incur cost k_0
$\tau = 1$	Naive	$v(x)$	$u(x)$	Shop $x_1 \geq 0$
	Sophisticates	$v(x)$	$v(x)$	if $x_1 > 0$: incur cost k_1 consume $x_0 + x_1$

Table 1: Overview of types, preferences, beliefs and actions

2 Model

There is a continuum of firms who operate in a competitive market and a continuum of consumers (with unit mass one).³ In each period $\tau \in \{0, 1\}$, firms offer the consumer a schedule, i.e., a quantity-transfer pair (x_τ, t_τ) that specifies for every quantity $x_\tau \in \mathbb{R}_0^+$, a (possibly negative) transfer $t_\tau \in \mathbb{R}$ from the consumer to the firm. Firms make these offers in a given period simultaneously. In each period, firms observe which contracts have been offered previously. A firm's cost of producing x units is cx . The profits of the firm are $\Pi(x_0, x_1, t_0, t_1) = t_0 + t_1 - c(x_0 + x_1)$.

In period 0, the consumer has the opportunity to go shopping. In period 1, the consumer can go shopping again and consumption takes place. Shopping

³The assumption that there is a continuum of consumers is not crucial for the baseline model, but ensures that models in which the distribution of types of consumers play a role (see section 4) can easily be build on top of the existing framework.

trips are costly. The consumer incurs a monetary cost k_τ for a shopping trip in period τ . We assume that $k_1 \geq k_0 = 0$. The timing and consumers' beliefs are summarized in table 1.

The consumer faces a self-control problem, i.e., the consumer's preferences regarding consumption change between periods 0 and 1. The date 0 incarnation of the consumer will be called self 0, and the date 1 incarnation will be called self 1. In period 0, the consumer's utility from consuming some quantity x is $u(x)$, while in period 1 the preferences have changed to $v(x)$. The consumer has quasi-linear preferences over consumption and the transfer/shopping costs. That is, self 0's utility function (if self 1 incurs positive shopping costs) is given by $U(x_0, x_1, t_0, t_1, k_1) = u(x_0 + x_1) - t_0 - t_1 - k_1$ and the one of self 1 (if he incurs positive shopping costs) is $V(x_0, x_1, t_1, k_1) = v(x_0 + x_1) - t_1 - k_1$. Both $u(x)$ and $v(x)$ are strictly increasing and concave functions, implying $u'(x), v'(x) > 0$ and $u''(x), v''(x) < 0$. Further, $v(0) = u(0) = 0$. If the consumer does not consume, he receives the reservation utility $\bar{u} = 0$.⁴ ⁵

From the perspective of self 0, let the surplus maximizing quantity⁶ be given by: $x_0^* = \arg \max_x u(x) - cx$, and from the perspective of self 1: $x_1^* = \arg \max_x v(x) - cx$.

We are interested in the case where the good is a harmful vice good, such as chips, or cigarettes. Self 0 prefers a lower consumption than self 1. Assuming

⁴Allowing for $\bar{u} > 0$, or $k_0 > 0$ does not change results. What matters is the difference between $\bar{u} + k_1$ and $\bar{u} + k_0$.

⁵These preferences capture in a stylized way present biased preferences (Laibson 1997, O'Donoghue and Rabin 1999). For example, the consumption of x units of the good causes immediate benefits of $b(x)$ and delayed costs of $\kappa(x)$. Self 0 weighs these costs equally, i.e., $u(x) = b(x) - \kappa(x)$. Self 1 attaches, due to his present bias, $\beta \in (0, 1)$, a larger relative weight to the current benefits than to the delayed costs, i.e., $v(x) = b(x) - \beta \kappa(x)$.

⁶That is, the quantity that maximizes $U(x_0, x_1, t_0, t_1, k_1) + \Pi(x_0, x_1, t_0, t_1)$.

$v(x) > u(x) \forall x$ and $v'(x) > u'(x) \forall x$ implies $x_1^* > x_0^*$, i.e., there is a conflict of interest between self 0 and self 1.

Consumers can be either naive or sophisticated about their future preferences. The consumer believes that his future preferences are captured by the utility function $\hat{v}(x)$. If $\hat{v}(x) = v(x)$ the consumer is fully sophisticated and if $\hat{v}(x) = u(x)$ he is fully naive. Partial naïveté does not change the main insights and is briefly discussed in section 4).

We assume that firms know $u(x)$, $v(x)$ and $\hat{v}(x)$. Relaxing the assumption that firms know the degree of sophistication does not change our results as we discuss in section 4. Furthermore, we assume that gains from trade are positive, i.e., $v(x_1^*) - c x_1^* - k_1 > 0$ and $u(x_0^*) - c x_0^* > 0$.

The setup captures the idea that in period 0 the individual does his (weekly) shopping trip. At this date, he is in a cold state and not tempted to overeat the harmful product (such as chips). In period 1, when sitting in front of the TV, he is in a hot state, and prefers to eat more chips than is optimal from the long run perspective. He can go shopping at this date, but at this point in time the opportunity costs of a shopping trip are higher than for the weekly shopping trip. For example, buying chips in the shop around the corner just before the movie starts causes higher costs than buying them along with other goods on a planned, weekly shopping trip.⁷

Competitive equilibrium As usual in the literature, we define the competitive equilibrium in terms of the contracts that survive competitive pressure. A contract is a quantity-transfer pair. Consumers apply for at most one contract and if their participation constraint is satisfied, they choose the

⁷The assumption that costs are higher in period 1 than in period 0 could also reflect psychological costs, such as a bad conscience for an additional shopping trip.

contract that yields the highest utility to them (if indifferent they randomize 50-50). In each period, they can choose a different contract from a different firm. Each equilibrium contract earns zero expected profits, and there exists no profitable deviation in any period that is accepted by a consumer and that yields strictly positive expected profits. Each contract offered is purchased by some consumers. We assume that firms produce on the spot. Thus, firms can react to a deviation of a firm in the current period in later periods. In section 4, we discuss the robustness of the results to this assumption.

3 Analysis

We start by analyzing the case of naive consumers and then sophisticated consumers in a setting of perfect competition before contrasting these results to the case of a monopoly.

3.1 Naive consumers

Suppose self 0 bought some quantity x_0 . Self 1 has to decide whether he is satisfied with this quantity, or whether he wants to incur the costs of an additional shopping trip and pay the transfer to get the additional quantity x_1 . So he goes shopping whenever the following participation constraint is satisfied:

$$v(x_0 + x_1) - k_1 - t_1 \geq v(x_0). \quad (PC_1)$$

Since it will often be of interest when the participation constraint of self 1 is not satisfied, we will use the notation (NPC_1) when referring to the constraint that self 1 will not go shopping. The naive self 0 believes that his consumption plan coincides with the one of self 1. This means that self 0 does not anticipate that self 1 will possibly go shopping. Hence, the naive self

0 goes shopping whenever the following participation constraint is satisfied:

$$u(x_0) - t_0 \geq 0. \quad (PC_0^N)$$

Contract for self 1 A firm's problem in period 1 is to maximize its profits subject to the participation constraint of the consumer.

$$\max_{t_1, x_1} t_1 - c x_1 \quad \text{s.t. } (PC_1) \quad v(x_0 + x_1) - k_1 - t_1 \geq \max\{v(x_0), \bar{v}^*\}. \quad (3)$$

Competition affects the outside option of the consumer. If he does not buy from a specific firm, he can buy from another firm. Thus, in a competitive market, the outside option is determined endogenously. Specifically, utility level $\bar{v}^*$ is the perceived utility from the (equilibrium) contract. Since we are in a competitive setting, the maximized profit of each firm must be zero, i.e., $t_1 = c x_1$. In the optimization problem the level $\bar{v}^*$ ensures that this zero profit condition holds: $v^* = v(x_0 + x_1) - k_1 - t_1 = v(x_0 + x_1) - k_1 - c x_1$ for the equilibrium quantity x_1 .

In the appendix, we show that the solution to this problem is to sell $x_1 = x_1^* - x_0$ at $t_1 = c(x_1^* - x_0)$, whenever $v(x_1^*) - c x_1^* - k_1 \geq v(x_0) - c x_0$, and 0 otherwise. When selling $x_1 = x_1^* - x_0$ to self 1, he will consume his preferred quantity $x_0 + x_1 = x_1^*$. That is, the utility of self 1 is maximized. The transfer insures that firms make zero profits. The condition $v(x_1^*) - c x_1^* - k_1 \geq v(x_0) - c x_0$ is satisfied whenever self 1 finds it optimal to buy the equilibrium quantity at the respective transfer.

Contract for the naive self 0 We first argue that in any competitive equilibrium the naive self 0 goes shopping. If this were not the case, a firm had an incentive to deviate and offer self 0, say, x_0^* defined by $u'(x_0^*) = c$ for a transfer $t_0 = u(x_0^*)$. The naive self 0, who is not aware that self 1 shall

possibly go shopping, accepts such an offer and the offer yields strictly positive profits for a firm. Thus, in a competitive equilibrium, the participation constraint of the naive self 0 cannot be violated and the period-0 contract for the naive consumer solves

$$\max_{t_0, x_0} \quad t_0 - c x_0 \quad \text{s.t.} \quad (PC_0^N) \quad u(x_0) - t_0 \geq \bar{u}^*. \quad (4)$$

Again, utility level $\bar{u}^*$ is the perceived utility from the equilibrium contract. The solution is to offer $(x_0^*, c x_0^*)$ in period 0.⁸ The naive self 0 accepts this offer.

3.2 Sophisticated consumers

In contrast to the naive, the sophisticated self 0 perfectly anticipates the consumption and shopping decision of his future self. We hence use a backward induction approach to derive the participation constraints. Suppose self 0 does not go shopping in period 0. Then self 1 would accept (x_1, t_1) if $v(x_1) - k_1 - t_1 \geq 0$. More generally, the participation constraint of sophisticated and naive consumers coincide at date 1, i.e., (PC_1) is also the relevant constraint for the sophisticated self 1.

Contract (x_1, t_1) yields utility $u(x_1) - t_1 - k_1$ to self 0. Hence, the sophisticated self 0 accepts contracts which satisfy the following participation constraint

$$u(x_0) - t_0 \geq u(x_1) - t_1 - k_1, \quad (PC_0^S)$$

where (x_1, t_1) must be such that the participation constraint of self 1, (PC_1) (with $x_0 = 0$) holds and where x_0 must be such that self 1 does not go

⁸To see this solve the binding participation constraint for t_0 , plug t_0 in the objective function and differentiate with respect to x_0 , yielding the first order condition $u'(x_0^*) = c$. The transfer is determined by the zero profit condition.

shopping. This means that for any profitable (x'_1, t'_1) it must hold that

$$v(x_0) \geq v(x_0 + x'_1) - k_1 - t'_1. \quad (NPC_1)$$

The intuition is as follows: The sophisticated consumer will know of the change in preferences, and therefore never buy a quantity x_0 so small, that there exists a quantity-transfer pair (x'_1, t'_1) such that self 1 will go shopping. Such a behavior would yield additional shopping costs which the sophisticated self 0 could avoid by buying the total desired quantity immediately. Thus, (NPC_1) cannot be violated. But at the same time self 0 will never buy a quantity x_0 if he would have a higher utility from the expected equilibrium contract at date 1. This is what (PC_0^S) states.

Contract for self 1 While in equilibrium the sophisticated self 1 will never go shopping, we have to specify which contract firms offered him if he, off the equilibrium-path, were to go shopping. As the participation constraint for the naive and sophisticated consumer coincide in period 1, the optimization problem of a firm for a sophisticated consumer is identical to the one for the naive consumer, i.e., to (3). Again the solution to this problem is to sell $x_1 = x_1^* - x_0$ at $t_1 = c(x_1^* - x_0)$, whenever $v(x_1^*) - c x_1^* - k_1 \geq v(x_0) - c x_0$, and 0 otherwise.

Contract for the sophisticated self 0 Self 0 anticipates that if self 1 went shopping, he would consume x_1^* in total. Selling self 0 such a low quantity that self 1 goes shopping could not, however, be a competitive equilibrium. As the shopping costs of self 0 are lower than those of self 1, firms could increase profits by selling the desired quantity to self 0 rather than to self 1. Thus, in any competitive equilibrium, only the sophisticated self 0, not self 1 goes shopping. So the competitive equilibrium is characterized by

the solution to the following optimization problem:

$$\begin{aligned}
& \max_{t_0, x_0} && t_0 - c x_0 && (7) \\
& \text{s.t.} && (PC_0^S) && u(x_0) - t_0 \geq \bar{u}^*, \\
& \text{s.t.} && (NPC_1) && v(x_0) \geq v(x_1^*) - c(x_1^* - x_0) - k_1.
\end{aligned}$$

Utility level $\bar{u}^*$ is the perceived utility from the equilibrium contract. Suppose first that $v(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$. Then self 1 would never go shopping when self 0 bought x_0^* , and hence the solution to the above problem is x_0^* , defined by $u'(x_0^*) = c$, $t_0 = c x_0^*$. Suppose next that self 1 would go shopping if self 0 bought only x_0^* . Then the “no-shopping” constraint, (NPC_1^S) , has to be binding. Otherwise a firm had an incentive to deviate and lower x_0 by an ε . The lower offer is more attractive for self 0, and self 1 would, for ε small, still not go shopping. Hence, the optimal solution x_0^S is defined by $v(x_0^S) - c x_0^S = v(x_1^*) - c x_1^* - k_1$, and $t_0 = c x_0^S$. So overall, firms offer (partial) commitment to the sophisticated self 0. Specifically, selling self 0 the quantity desired by self 1, x_1^* for $t_1 = c x_1^*$, cannot be a competitive equilibrium. Suppose it were. Then a firm could deviate and offer self 0 some quantity $x_0 \in [x_0^*, x_1^*)$ and a transfer t_0 , such that $u(x_0) - t_0 \geq u(x_1^*) - c x_1^*$. Such an offer raises the utility of self 0 if the quantity is such that self 1 would not go shopping in period 1. Consider, e.g., $x_0 = x_1^* - \varepsilon$ and note that $v(x_1^*) > v(x_1^*) - t_1 - k_1$. Offering $x_0 = x_1^* - \varepsilon$ implies that, by continuity, $v(x_1^* - \varepsilon) > v(x_1^*) - t_1 - k_1$.

Proposition 1

1. *The competitive equilibrium contract for the naive individual is $(x_0^*, c x_0^*)$, which he buys in period 0. If, in addition, PC_1 is satisfied: $v(x_1^*) - c x_1^* - k_1 \geq v(x_0^*) - c x_0^*$, then firms offer contract $(x_1^* - x_0^*, c(x_1^* - x_0^*))$, which self 1 buys in period 1.*

2. *The competitive equilibrium contract for the sophisticated individual is $(x_0^S, c x_0^S)$, where $x_0^S \in [x_0^*, x_1^*)$ is defined by $v(x_0^S) - c x_0^S = v(x_1^*) - c x_1^* - k_1$, which he buys in period 0. If $v(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$, then $x_0^S = x_0^*$.*

In the competitive market, either 1 or 3 different package sizes are offered. If $v(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$, then both the naive and the sophisticated consumers receive full commitment and only a package of size x_0^* is offered. If this does not hold, then 3 packages are offered: a large package, a medium package and a small package. In the appendix, we provide some details on the ranking of the packages sizes. We demonstrate that for empirical reasonable values of the self-control problem the ranking is in contrast to common intuition. Specifically, for such values the largest package is x_1^S , i.e., the package that offers commitment to the sophisticated consumer. The small package is $x_0^* - x_1^*$ and thus not a commitment device, but serves to exploit the naive consumer. The naive consumer initially does not buy the biggest package (x_1^S) but the medium one x_0^* – believing that he will stick to this quantity. But later, when in the “hot state” he buys a small top-up ($x_0^* - x_1^*$). This results in inefficiently high shopping costs.

3.3 Monopolist

The monopolist maximizes his profits, $t_0 + t_1 - c(x_0 + x_1)$ subject to the respective participation constraints. For the sophisticated consumer, optimization problem (7) is unchanged, except for the reservation utility of self 0. Thus, as in the competitive market, self 0 receives either full or partial commitment. What changes is the transfer, which is given by $t_0 = u(x_0) - u(x_1^*) + v(x_1^*) \equiv$

$$u(x_0) - \bar{u}^S, x_0 \in \{x_0^*, x_0^S\}.$$
⁹

Consider next the naive consumer. Unlike firms in the competitive market, the monopolist can commit to sell to only one of the selves. He maximizes profits subject to the participation constraint of self 0 and/or self 1. As we show in the appendix, the monopolist never finds it optimal to sell a positive quantity to both selves. That is, he either caters to self 0 (by selling x_0^*), or self 1 (by selling x_1^*). Whether it is optimal to cater to the interest of self 0 or self 1 depends on whether $v(x_1^*) - cx_1^* - k_1$ is smaller or larger than $u(x_0^*) - cx_0^*$. While the sophisticated self 0 always does all the shopping, the naive self 0 never buys x_1^* and thus self 1 does the shopping in case it is optimal for the monopolist to cater self 1. This is due to the naïveté of the consumer. Self 0 does not anticipate that self 1 will buy x_1^* . Thus, at time 0, he will not buy x_1^* even if that could save him the higher shopping costs k_1 at time 1. Thus, in this case, naïveté results in inefficiently high shopping costs.

Proposition 2

1. If $v(x_1^*) - cx_1^* - k_1 \geq u(x_0^*) - cx_0^*$ the monopolist offers contract (x_1^*, t_1^*) , with $t_1^* = v(x_1^*) - k_1$ to the naive consumer, who goes shopping in period 1.
1. If $u(x_0^*) - cx_0^* \geq v(x_1^*) - cx_1^* - k_1$ the monopolist offers contract (x_0^*, t_0^*) , $t_0^* = u(x_0^*)$ to the naive consumer, who goes shopping in period 0.

⁹Consider the subgame following a rejection of self 0 in period 0. In this subgame, the monopolist maximizes his profits by offering quantity x_1^* at transfer $t_1 = v(x_1^*) - k_1$. Self 1 accepts such an offer. This yields utility $u(x_1^*) - v(x_1^*)$ to self 0. Thus, self 0 accepts contracts with $u(x_0) - t_0 \geq u(x_1^*) - v(x_1^*) \Leftrightarrow u(x_0) - u(x_1^*) + v(x_1^*) \geq t_0$ given that $v(x_0) \geq v(x_1^*) - c(x_1^* - x_0) - k_1$.

2. If $v(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$ the monopolist offers contract (x_0^*, t_0^S) , $t_0^S = u(x_0^*) - \bar{u}^S$ to the sophisticated consumer. Otherwise he offers (x_0^S, t_0^S) , $t_0^S = u(x_0^S) - \bar{u}^S$ and x_0^S defined by $v(x_0^S) - c x_0^S = v(x_1^*) - c x_1^* - k_1$.

Hence, the monopolist either offers one package size (x_0^*) , which provides perfect commitment to both types of consumers. Such perfect commitment is possible if the shopping costs of self 1 are large. Or he offers a small and a large package (either the pair (x_0^*, x_1^*) or the pair (x_0^S, x_1^*) depending on whether or not perfect commitment for the sophisticated consumer is possible). Thus, in a monopolistic market, small packages are always commitment devices for sophisticated consumers.

The solution for the sophisticated consumer is identical in the monopolistic and competitive market. Only the distribution of rents differs. Thus, the social surplus is the same. What about the naive consumer? He receives full commitment more often in the competitive market than in the monopolistic market. If, however, $v(x_1^*) - c x_1^* - k_1 \geq v(x_0^*) - c x_0^*$, so that not only self 0, but also self 1 goes shopping in the competitive market, then the total quantity consumed is equal in the monopolistic and the competitive market, but total shopping costs are higher in the competitive market. Thus, the social surplus is lower in the competitive than in the monopolistic market as the naive consumer goes shopping too often in the competitive market.¹⁰

¹⁰Comparing the sophisticated and the naive consumer in the monopolistic market shows that the social surplus generated from the sophisticated consumer is larger than the one for the naive self 0. The monopolist offers full commitment to the sophisticated self 0 whenever $v(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$ and partial commitment otherwise. In contrast, the naive individual receives full commitment whenever $u(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$, i.e., as $v(x_0^*) - c x_0^* > u(x_0^*) - c x_0^*$, less often than the sophisticated individual.

4 Extensions and robustness

In the following section we wish to explore what happens if the model is extended in different ways. First, we discuss robustness to relaxing the assumptions of an observable degree of sophistication, on-the-spot-production and to allowing for partial naïveté. We do so for the competitive market.¹¹ Then we will look at market entry and the degree of competition.

4.1 Relaxing the assumption of observable degree of sophistication

The assumption that firms in the competitive market can distinguish between the naive and the sophisticated consumer is not crucial. Suppose three packages are offered. The commitment quantity x_0^S at the given transfer is not attractive for the naive consumer as he does not demand commitment. And $x_1^* - x_0^*$ and x_0^* are not attractive for the sophisticated consumer as they would induce overconsumption. If one package size (x_0^*) is offered, then it is offered at the same transfer to the sophisticated and naive consumer.

4.2 Relaxing the assumption of on-the-spot-production

The assumption that firms produce on the spot and can thus react to a period-0-deviation in period 1 neither drives the results for the sophisticated consumer if perfect commitment is feasible, nor for the naive consumer. In all these cases, no firm had an incentive to deviate – independent of what will happen in period 1. If however the sophisticated consumer receives only

¹¹For the monopolistic market, we discuss the robustness of the results to the assumption that firms know the degree of sophistication and on-the-spot-production in the appendix. The arguments for the former case are more involved, but the main insights are robust.

partial commitment, i.e., x_0^S , the assumption matters. Self 0 would prefer to buy a lower quantity than x_0^S – but only if he knew that self 1 would not go shopping. In the model with on-the-spot-production, firms can, in reaction to a period-0-deviation of some firm to say some lower quantity than x_0^S , offer self 1 a quantity that makes a shopping trip attractive. Anticipating this, self 0 would not buy the lower quantity and a deviation would not pay off.

If however firms could not react in period 1, the threat to sell self 1 some quantity might not be credible anymore. And if self 0 knew that self 1 would not go shopping, then he would buy the lower quantity from the deviating firm. But even if firms could not react to the deviation by tailoring a package for self 1, self 1 might still go shopping and buy one of the other available packages ($x_1^* - x_0^*$, x_0^* , or x_0^S). Anticipating this self 0 would not buy from the deviating firm. So if there exists no $x_0^* \leq x_0 < x_0^S$, such that $v(x_0) > \max\{v(x_0 + x_0^*) - c x_0^*, v(x_0 + x_0^S) - c x_0^S, v(x_0 + x_1^* - x_0^*) - c(x_1^* - x_0^*)\} - k_1$, offering package x_0^S is still a competitive equilibrium. If this condition fails to hold, a firm has an incentive to deviate, and no competitive equilibrium exists.

4.3 Partial naïveté

In the main model we assume that there are two types of consumers: perfectly naïve, and perfectly sophisticated consumers, implying $\hat{v}(x) \in \{u(x), v(x)\}$. In this section, we wish to explore if our main findings are robust to allow for partial naïveté. To do this we will assume $\hat{v}(x)$ can be anything between $u(x)$ and $v(x)$. The details can be found in the appendix. The implication is that consumers are aware of their self-control problem, but all except the perfectly sophisticated consumers underestimate the severity. This means

that consumers are willing to pay for commitment, as we have shown in the baseline model. As in the baseline model, if x_0^* is sufficient to prevent perfectly naive consumers from shopping at time 1, all consumers receive full commitment. This is an intuitive extension of the baseline model. If x_0^* is sufficient to prevent the fully naive consumer from shopping at time 1, then the quantity also prevents partially naive consumers from shopping. If, on the other hand, x_0^* is not sufficiently big, then partially naive consumers do not buy a sufficiently large quantity to avoid shopping at time 1. Therefore, the consumers ends up consuming x_1^* but having paid more than $v(x_1^*) - k_1$, making them worse off than even the perfectly naive consumers. In fact, the closer to perfectly sophisticated, the greater the exploitation.

Thus, the result of (partially) naive consumers' too frequent shopping goes through. Yet, if there is a continuum of possible degrees of naïveté, then firms offer a continuum of quantities. Introducing a (plausible) fixed cost of offering a quantity-transfer pair into the model restores however a finite number of packages.¹²

4.4 Circle model

We now look at what happens if we change the competitive setting and allow for imperfect competition and market entry. To do this we will use the circular city model first presented by Salop (1979). In this setting, consumers

¹²Details are available upon request. Specifically, if we maintain the assumption of perfect competition, the number of offers will be such that the the marginal consumer of a quantity will be indifferent between buying and not entering the market, that is, even with perfect competition, the marginal consumer will not be left with any rents. In this setting, there will exist some level of sophistication such that all consumers at least as sophisticated as the cutoff will receive at least partial commitment, that is, the marginally naive will no longer be the most exploited.

are distributed uniformly along a circle where firms, when entering, choose a locations. This setting alters the nature of consumers' shopping costs in that the shopping costs now not only depend on the parameter k_τ but also on the distance θ to a firm. We assume that firms occur some fixed cost of entry into the market. Details can be found in the appendix.

Since we now have a fixed cost of entry, each firm must in either period serve a fraction of consumers and not just one individual for entry to be profitable. Hence if a type of consumers constitutes too small a fraction of consumers, it is no longer possible to target them. If we abstract from this case, the results of the main model goes through: sophisticated consumers always receive at least partial commitment, and naive consumers are sometimes offered commitment, but only if x_0^* is sufficient to prevent shopping at time 1. The new aspect in this model is entry. Generally the fixed cost of entry along with free entry will drive prices up even if no firm makes positive profits, and in equilibrium entry is above the socially optimal level. This is not specific to our setting, but is a general result from the circle model.

What is specific about this setting is that each firm compete over consumers in either of the two periods. That is, firms operate on two separate markets: the one at time 0 and the one at time 1. This can be seen as reflecting the difference between offering a product in standard supermarkets, or in late night convenience stores.

5 Conclusion

The paper considers the shopping and consumption decision of an individual who faces a self-control problem. It asks how firms react to consumers' self-control problems, and possibly exploit them, by offering different package

sizes. In a monopolistic market, small packages are commitment devices. In a competitive market, small packages may not be commitment devices, but, quite to the contrary, can serve to exploit naive consumers, who go (unexpectedly) frequently shopping. Further, the paper shows that while the sophisticated consumer receives the same commitment in the monopolistic and competitive market, the social surplus from the naive consumer can be lower in the competitive market because the naive consumer goes shopping more often in competitive markets.

Our model is consistent with recent results in the literature that suggest positive welfare effects of restricting sales times or locations of sinful products (see, e.g., Beshears, Choi, Laibson, and Madrian 2006, Hinnosaar 2012). Such policies increase k_1 and therefore make commitment easier to achieve, i.e., firms are less likely to offer products that cater the interests of the short-run self. Care should however be taken when restricting package sizes or subsidizing small packages. Depending on the market environment and the extend of the consumers' self-control problem, a large package can either be a commitment device or can serve the interests of the short-run self. Thus, a careful market analysis would be needed to decide which one is the case.

Appendix

Relaxing the assumption of observable degree of sophistication (monopolistic case)

In the main text, we assumed that the monopolist can distinguish between the naive and the sophisticated consumer. We now discuss what happens if we relax this assumption. Suppose first that the monopolist caters to the naive self 1 by offering (x_1^*, t_1^*) . Then $v(x_1^*) - c x_1^* - k_1 \geq u(x_0^*) - c x_0^*$.

The sophisticated consumer pays transfer $u(x_0^*) - u(x_1^*) + v(x_1^*)$ for x_0^* . Similarly, he would pay $u(x_0^S) - u(x_1^*) + v(x_1^*)$ for x_0^S . The naive consumer has no willingness to pay for commitment. Thus, the naive self 0 would not choose x_0^* or x_0^S as the associated transfer (which extracts the sophisticated consumer's willingness to pay for commitment) is too high. But the sophisticated consumer would prefer buying (x_1^*, t_1^*) over buying x_0^* or x_0^S . The transfers for these quantities are constructed such that the sophisticated consumer is indifferent between buying at time 0 and buying x_1^* at time 1. Therefore, the sophisticated consumer is paying to avoid the higher shopping cost k_1 . If the sophisticated consumer can not be identified, and hence can buy x_1^* at time 0, the consumer can avoid the shopping cost k_1 and hence keep rents from the transaction. In order to avoid the sophisticated consumer imitating the naive, the monopolist will either have to subtract k_1 from the time 0 transfer to again make the sophisticated consumers indifferent, offer the same bundle to all consumers, or exclude the naive consumers.

Suppose next the monopolist caters to the naive self 0. Then $u(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$. Note that then $v(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$ also holds. Hence, the sophisticated consumer also receives x_0^* . But since the monopolist

prefers to offer x_0^* at a higher transfer to the sophisticated consumer than to the naive consumer the monopolist either offers only (x_0^*, t_0^S) and serves only the sophisticated consumers or offers (x_0^*, t_0^*) and serves both types or offers both $(x_0^*, t_0^S - k_1)$ and (x_1^*, t_1^*) again offering both types. What is optimal depends on the share of naive and sophisticated consumers, and the shopping cost k_1 . If, for example, the share of sophisticated consumers is large, he prefers to offer x_0^* at the higher transfer and not serve the naive consumers. If the share is small he prefers serving everyone the same quantity-transfer pair, but there may exist an intermediate share where it is optimal to serve sophisticated consumers $(x_0^*, t_0^S - k_1)$, and the naive (x_1^*, t_1^*) . In this case the loss in profits from subtracting the shopping cost k_1 to make the sophisticated consumers indifferent, is smaller than the gain in profits from serving naive consumers at time 1.

Suppose $u(x_0^*) - c x_0^* \leq v(x_1^*) - c x_1^* - k_1$, then the monopolist will either exclude naive consumers and serve sophisticated consumers (x_0^*, t_0^S) or (x_0^S, t_0^S) , or serve sophisticated consumers $(x_0^*, t_0^S - k_1)$ or $(x_0^S, t_0^S - k_1)$ and serve the naive consumers (x_1^*, t_1^*) .

Proposition 3 *Suppose the monopolist cannot distinguish naive and sophisticated consumers.*

1. *Suppose $u(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$. Then*
 - (a) *For large shares of naive consumers the monopolist will offer (x_0^*, t_0^*) to all consumers.*
 - (b) *For small shares of naive consumers (x_0^*, t_0^S) to sophisticated consumers, excluding naive consumers.*
 - (c) *For intermediate share of naive consumers potentially offer $(x_0^*, t_0^S - k_1)$ to sophisticated consumers and (x_1^*, t_0^*) to naive consumers.*

2. Suppose $v(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1 \geq u(x_0^*) - c x_0^*$. Then

(a) For large shares of naive consumers the monopolist will offer $(x_0^*, t_0^S - k_1)$ to sophisticated consumers and (x_1^*, t_1^*) to naive consumers.

(b) For small shares of naive consumers the monopolist will offer (x_0^*, t_0^S) to sophisticated consumers and exclude naive consumers.

3. Suppose $v(x_1^*) - c x_1^* - k_1 \geq v(x_0^*) - c x_0^*$. Then

(a) For large shares of naive consumers the monopolist will offer $(x_0^S, t_0^S - k_1)$ to sophisticated consumers and (x_1^*, t_1^*) to naive consumers.

(b) For small shares of naive consumers the monopolist will offer (x_0^S, t_0^S) to sophisticated consumers and exclude naive consumers.

Proof.

Assume λ is the share of naive consumers, and $u(x_0^*) - c x_0^* \geq v(x_1^*) - c x_1^* - k_1$. Then the firms options are: serve everyone at time 0, $(x_0, t_0) = (x_0^*, u(x_0^*))$, only serve sophisticated, $(x_0, t_0) = (x_0^*, u(x_0^*) + v(x_1^*) - u(x_1^*))$, or serve sophisticated at time 0 and naive at time 1, $(x_0, t_0) = (x_0^*, u(x_0^*) + v(x_1^*) - u(x_1^*) - k_1)$, $(x_1, t_1) = (x_1^*, v(x_1^*))$. This gives the following profits for the firm respectively:

Pooling: $u(x_0^*) - c x_0^*$

Sophisticated: $(1 - \lambda)(u(x_0^*) + v(x_1^*) - u(x_1^*) - c x_0^*)$

Split: $\lambda(v(x_1^*) - c x_1^*) + (1 - \lambda)(u(x_0^*) + v(x_1^*) - u(x_1^*) - k_1 - c x_0^*)$

Comparing these profits pairwise yields the following cutoffs:

Split equilibrium over pooling:

$$\lambda \leq \frac{v(x_1^*) - u(x_1^*) - k_1}{u(x_0^*) - c x_0^* - (u(x_1^*) - c x_1^*)}.$$

Sophisticated over pooling:

$$\lambda \leq \frac{v(x_1^*) - u(x_1^*)}{u(x_0^*) - c x_0^* + v(x_1^*) - u(x_1^*)}.$$

Split equilibrium over sophisticated:

$$\lambda \geq \frac{k_1}{v(x_1^*) - c x_1^*}.$$

From this we have that there exists a $\lambda \in (0, 1)$ such that the monopolist is indifferent between only serving sophisticated and serving the two types at separate times. We also have that $\lambda \in (0, 1)$ such that the monopolist is indifferent between serving types at different times and serving everyone at time 0. But it might always be preferred to serve everyone at time 0 over splitting the consumers. If:

$$\frac{v(x_1^*) - u(x_1^*) - k_1}{u(x_0^*) - c x_0^* - (u(x_1^*) - c x_1^*)} \in (0, 1).$$

The monopolist will only serve sophisticated if:

$$\lambda \leq \frac{k_1}{v(x_1^*) - c x_1^*}.$$

The monopolist will serve types at different times if:

$$\frac{k_1}{v(x_1^*) - c x_1^*} \leq \lambda \leq \frac{v(x_1^*) - u(x_1^*) - k_1}{u(x_0^*) - c x_0^* - (u(x_1^*) - c x_1^*)}.$$

And serve everyone at time 0 if:

$$\lambda \geq \frac{v(x_1^*) - u(x_1^*) - k_1}{u(x_0^*) - c x_0^* - (u(x_1^*) - c x_1^*)}.$$

If:

$$\frac{v(x_1^*) - u(x_1^*) - k_1}{u(x_0^*) - c x_0^* - (u(x_1^*) - c x_1^*)} \notin (0, 1)$$

the monopolist will serve sophisticated if:

$$\lambda \leq \frac{v(x_1^*) - u(x_1^*)}{u(x_0^*) - c x_0^* + v(x_1^*) - u(x_1^*)}.$$

And serve everyone at time 0 if:

$$\lambda \geq \frac{v(x_1^*) - u(x_1^*)}{u(x_0^*) - c x_0^* + v(x_1^*) - u(x_1^*)}.$$

Assume $u(x_0^*) - c x_0^* \leq v(x_1^*) - c x_1^* - k_1$. Then the pooling equilibrium becomes $(x_1^*, v(x_1^*) - k_1)$, the split equilibrium only changes in that sophisticated consumers now demand $x_0^S \geq x_0^*$. Comparing the profits of pooling and split equilibrium shows that split is always preferred over pooling. Hence there will only be one cutoff, where the monopolist is indifferent between only serving sophisticated consumers, and serving sophisticated at time 0 and naive at time 1. The cutoff is unchanged from before, and hence for:

$$\lambda \geq \frac{k_1}{v(x_1^*) - c x_1^*}$$

the monopolist will only serve sophisticated, and otherwise serve consumers at different times. ■

Relaxing the assumption of on-the-spot-production (monopolistic case)

The solution for the naive consumer in the monopolistic market does not rely on the assumption that on-the-spot-production is feasible. So consider the sophisticated consumer. If the monopolist cannot produce on the spot, then, when facing a sophisticated consumer, he maximizes his profits subject to the participation constraint of self 0 and/or self 1. The solution coincides with the solution for the naive consumer. So the monopolist does not offer partial commitment to self 0 any longer.

Proof of the contract for self 1 in a competitive market

Suppose first that PC_1 binds. Rewrite it to get $t_1 = v(x_0 + x_1) - k_1 - \max\{v(x_0), \bar{v}^*\}$ and plug t_1 into the objective function. Then we can write the problem of the firm as $\max_{x_1} v(x_0 + x_1) - c x_1 - k_1 - \max\{v(x_0), \bar{v}^*\}$. The first order condition is $v'(x_0 + x_1) = c$. Hence, by the definition of x_1^* it follows that $x_0 + x_1 = x_1^*$, i.e., $x_1 = x_1^* - x_0$. Thus, $v^* = v(x_1^*) - k_1 - c(x_1^* - x_0)$ and $t_1 = c(x_1^* - x_0)$. Finally, note that $\max\{v(x_0), \bar{v}^*\} = v^*$ whenever $v(x_1^*) - c x_1^* - k_1 \geq v(x_0) - c x_0$.

Package sizes

In the competitive equilibrium, there are either one or three package sizes as described in the main text. For the equilibrium with three quantities (x_0^* , x_0^S and $x_1^* - x_0^*$), we ask how these relate to one another in size. We can rewrite the condition of optimal choice of x_0^S as:

$$k_1 = v(x_1^*) - v(x_0^S) - c(x_1^* - x_0^S)$$

For $k_1 > 0$ we have that $x_0^S \in (x_0^*, x_1^*)$. From this we can see that for k_1 small enough we can get x_0^S arbitrarily close to x_1^* , though $x_0^S < x_1^*$. Since we have assumed three quantities we have $x_0^S > x_0^*$, though for k_1 high enough we can get arbitrarily close to x_0^* .

The question is then how $x_1^* - x_0^*$ relate to the other two quantities. If $x_1^* < 2x_0^*$ implying the consumer will want to consume less than twice the amount when present biased compared to when not, the top-up quantity $x_1^* - x_0^*$ is smaller than x_0^* and hence the top-up quantity is the smallest in the market.

When does this arise? Suppose, using the present-bias formulation outlined in footnote 5, that $u(x) = b(x) - \kappa(x)$ and $v(x) = b(x) - \beta \kappa(x)$. Intuitively,

the larger β , i.e., the less severe the self-control problem, and thus the closer x_1^* is to x_0^* (for $\beta = 1$, $x_1^* = x_0^*$) and thus, the more likely $x_1^* < 2x_0^*$ holds. Assuming, e.g., a linear delayed cost function ($k(x) = \kappa x$) and a quadratic or logarithmic immediate benefit function ($b(x) = \ln x$ or $b(x) = \sqrt{x}$) shows that $x_1^* < 2x_0^*$ arises for all $\beta > \frac{1}{2}$ (and possibly for all $\beta \in (0, 1)$, depending on κ and c). For a linear current benefit function ($b(x) = bx$) and a quadratic delayed cost function ($\kappa(x) = \frac{x^2}{2}$), $x_1^* < 2x_0^*$ arises for $\beta > \frac{1}{2}$. Using a real effort task, Augenblick, Niederle and Sprenger (2013) estimate a β around 0.9. That is, $\beta > \frac{1}{2}$ seems the empirical plausible size of the present bias.

If on the other hand $x_1^* > 2x_0^*$ the quantity x_0^* is smaller, and since we can find a k_1 so that x_0^S is arbitrarily close to x_0^* , it is even possible that the top up quantity is the biggest in the market. This will happen if the present bias is severe, so that $x_1^* \gg x_0^*$ and k_1 is large such that $x_0^S - x_0^*$ is small.

Proof Proposition 2

The proof for the sophisticated consumer is in the text. So consider the naive consumer. Suppose it is optimal to sell some quantity $x_0 > 0$ to self 0 and $x_1 > 0$ to self 1. Then it follows from the participation constraint of self 0 that $t_0 = u(x_0)$. And from the participation constraint of self 1 it follows that $t_1 = v(x_0 + x_1) - k_1 - v(x_0)$. Thus, the monopolist maximizes $v(x_0 + x_1) - v(x_0) + u(x_0) - c(x_0 + x_1)$ over x_0 and x_1 . The first order conditions are:

$$x_0 : \quad v'(x_0 + x_1) - v'(x_0) + u'(x_0) \leq c \quad \text{with equality if } x_0 > 0,$$

$$x_1 : \quad v'(x_0 + x_1) \leq c \quad \text{with equality if } x_1 > 0.$$

The two first order conditions cannot hold with equality at the same time. Hence, either $x_0 > 0$ and $x_1 = 0$, or $x_0 = 0$ and $x_1 > 0$. In the former case

the optimal transfer and quantity are determined by:

$$u'(x_0^*) = c \quad \text{and} \quad t_0^* = u(x_0^*).$$

In the latter case, the optimal transfer and quantity are determined by:

$$v'(x_1^*) = c \quad \text{and} \quad t_1^* = v(x_1^*) - k_1$$

Whether it is optimal to cater to the interest of self 0 or self 1 depends on whether $v(x_1^*) - c x_1^* - k_1$ is smaller or larger than $u(x_0^*) - c x_0^*$.

Partial naïveté

Let $\hat{v}(x) = v_\theta(x) = (1 - \theta)u(x) + \theta v(x)$. Where $\theta \in (0, 1)$ is a parameter capturing the severity of naivety.¹³ Then if:

$$\nu(x_0^*) - c x_0^* > \nu(x_1^*) - c x_1^* - k_1,$$

even perfectly sophisticated consumers will chose x_0^* since this is sufficient to prevent self 1 from shopping. In this case, firms offer full commitment for all consumers. If:

$$\nu(x_0^*) - c x_0^* \geq \nu_\theta(x_1^*) - c x_1^* - k_1,$$

where $x_1^* \equiv \arg \max_x \nu_\theta(x) - c x$, self 1 is not willing to buy any $x > x_0^*$. But he is if:

$$\nu(x_0^*) - c x_0^* \leq \nu(x_1^*) - c x_1^* - k_1.$$

Partially naive consumers will purchase x_0^* at $\tau = 0$, believing that this will be sufficient to overcome self-control problems, but at $\tau = 1$ self 1's preferences

¹³If $\nu(x) = b(x) - \beta\kappa(x)$ and $u(x) = b(x) - \kappa(x)$ then θ is a measure of the consumer's belief, $\hat{\beta}$, about β . Such that $\theta = 0$ corresponds to $\hat{\beta} = 1$ and $\theta = 1$ corresponds to $\hat{\beta} = \beta$.

have changed more than self 0 anticipated, and it is now optimal for self 1 to go shopping. This means, that partially naive consumer will act like naive consumers, and go shopping. If:

$$\nu(x_0^*) - c x_0^* \leq \nu_\theta(x_\theta^*) - c x_\theta^* - k_1,$$

self 0 will demand a quantity $x_\theta^S \in [x_0^*, x_\theta^*)$ $x_\theta^S < x_0^S$ such that:

$$\nu(x_\theta^S) - c x_\theta^S = \nu_\theta(x_\theta^*) - c x_\theta^* - k_1.$$

But per definition of x_0^S , x_θ^S will not be sufficiently big to prevent self 1 from shopping. With partial naïveté, firms will offer the same packaging sizes as in the baseline model, but with introduction of the sizes x_θ^S and $x_1^* - x_\theta^S$. If the consumers in the market have continuous levels of naïveté we will have that competitive firms offer a continuous range of packaging sizes.

Circle Model with monopolistic competition

We assume a fraction λ of consumers are naive, and a fraction $1 - \lambda$ are sophisticated. Consumers are distributed uniformly along a unit circle. Firms have costs $c x + h$ of offering a quantity.

Suppose that n firms have entered the market. In a symmetric equilibrium, firms locate at equal distance along the circle. Consider a consumer located at $\theta \in (0, \frac{1}{n})$ on the circle. Suppose firm i locates at location 0 and firm $i + 1$ at location $\frac{1}{n}$. The utility specifications of the consumers in this setting are at time 0 if he buys from firm i $u(x_0) - k_0 (\frac{1}{2} + \theta) - t_0$, and at time 1: $\nu(x_1) - (\frac{1}{2} + \theta) k_1 - t_1$. The $(\frac{1}{2} + \theta)$ formulation instead of just θ is to ensure at least partial commitment is possible. If $\theta = 0$ and no other fixed shopping cost exists, a self 0 would never be able to prevent a self 1 consumer from shopping, hence the inclusion of a $\frac{k_0}{2}$. If he buys from firm $i + 1$ his utility at time 0 is $u(x_0) - k_0 (\frac{n+2}{2n} - \theta) - t_0$ (analogue for time 1).

Analysis With n firms, making zero profit and x_0^* being sufficient for commitment, the transfers will be:

$$\frac{1}{n}(t_0 - c x_0^*) - h = 0 \quad \Leftrightarrow \quad t = c x_0^* + n h.$$

In order to find the level of entry, we need to identify the consumer indifferent between shopping at either of two firms:

$$\begin{aligned} u(x_0) - k_0 \left(\theta + \frac{1}{2} \right) - t' &= u(x_0) - k_0 \left(\frac{n+2}{2n} - \theta \right) - t'' \\ \Leftrightarrow \quad \theta_n &= \frac{t'' - t'}{2k_0} + \frac{1}{2n}. \end{aligned}$$

Since the firm will offer the same transfer to all consumers, the profit maximization problem for pricing an offered variety becomes:

$$\max_{t'} (t' - c x_0^*) \theta_n.$$

This gives the following first order condition:

$$-\frac{t' - c x_0^*}{2k_0} + \left(\frac{t'' - t'}{2k_0} + \frac{1}{2n} \right) = 0.$$

Assuming symmetric strategies $t' = t''$ and we get $t' = t'' = c x_0^* + \frac{k_0}{n}$. Using the zero profit condition yields the following level of entry at time 1:

$$\frac{1}{n} \left(c x_0^* + \frac{k_0}{n} - c x_0^* \right) - h = 0 \quad \Leftrightarrow \quad \left\lfloor \sqrt{\frac{k_0}{h}} \right\rfloor = n_0.$$

In this case, all consumers receive full commitment. If x_0^* is not sufficient for commitment, naive consumers will still demand x_0^* at time 0, and as usual we have, that at time 1, the optimal quantity to offer is $x_1^* - x_0^*$. The difference now being, that naive consumers only constitute a fraction λ of the population. This means that the profit and transfer for a firm serving naive consumers is:

$$\frac{\lambda}{n}(t_0 - c x_0^*) - h = 0 \quad \Leftrightarrow \quad t = c x_0^* + \frac{n h}{\lambda}.$$

By analogous argument as before, the equilibrium level of entry at time 0 will be $\left\lfloor \sqrt{\frac{\lambda k_0}{h}} \right\rfloor = n_0$, and at time 1: $\left\lfloor \sqrt{\frac{\lambda k_1}{h}} \right\rfloor = n_1$. Sophisticated consumers will demand a quantity larger than x_0^* . Assuming sophisticated consumers are uncertain about the location of firms at time 1, the sophisticated consumers will demand the quantity that for sure will make them not go shopping at time 1. Since temptation is decreasing in distance from a firm's location, each consumer will assume a firm's location will coincide with the consumer's location. Denoting this commitment quantity x_{0S}^S , the sophisticated consumers will be offered partial commitment at a transfer $t_{0S} = c x_{0S}^S - \frac{nh}{1-\lambda}$, and by same argument as for naives, the level of entry serving sophisticated consumers will be: $\left\lfloor \sqrt{\frac{(1-\lambda)k_0}{h}} \right\rfloor = n_{0S}$.

References

- AUGENBLICK, N., NIEDERLE, AND C. SPRENGER (2013): “Working over Time: Dynamic Inconsistency in Real Effort Tasks,” Discussion Paper, National Bureau of Economic Research.
- BERNHEIM, B. D., J. MEER, AND N. K. NOVARRO (2012): “Do Consumers Exploit Precommitment Opportunities? Evidence from Natural Experiments Involving Liquor Consumption,” Discussion paper, National Bureau of Economic Research.
- BESHEARS, J., J. J. CHOI, D. LAIBSON, AND B. MADRIAN (2006): “Early decisions: A regulatory framework,” Discussion paper, National Bureau of Economic Research.
- CHANDON, P., AND B. WANSINK (2010): “Is food marketing making us fat? A multi-disciplinary review,” *Foundations and Trends® in Marketing*, 5(3), 113–196.
- CURRIE, J., S. DELLA VIGNA, E. MORETTI, AND V. PATHANIA (2010): “The effect of fast food restaurants on obesity and weight gain,” *American Economic Journal: Economic Policy*, pp. 32–63.
- DELLAVIGNA, S., AND U. MALMENDIER (2004): “Contract design and self-control: theory and evidence,” *Quarterly Journal of Economics*, 119(2), 353–402.
- DOBSON, P. W., AND E. GERSTNER (2010): “For a few cents more: Why supersize unhealthy food?,” *Marketing Science*, 29(4), 770–778.
- ELIAZ, K., AND R. SPIEGLER (2006): “Contracting with diversely naive agents,” *The Review of Economic Studies*, 73(3), 689–714.

- (2008): “Consumer optimism and price discrimination,” *Theoretical Economics*, 3(4), 459–497.
- ESTEBAN, S., AND E. MIYAGAWA (2006): “Temptation, self-control, and competitive nonlinear pricing,” *Economics Letters*, 90(3), 348–355.
- ESTEBAN, S., E. MIYAGAWA, AND M. SHUM (2007): “Nonlinear pricing with self-control preferences,” *Journal of Economic Theory*, 135(1), 306–338.
- FINKELSTEIN, E. A., J. G. TROGDON, J. W. COHEN, AND W. DIETZ (2009): “Annual medical spending attributable to obesity: payer-and service-specific estimates,” *Health affairs*, 28(5), 822–831.
- GALPERTI, S. (2012): “Commitment, flexibility, and optimal screening of time inconsistency,” mimeo, UC San Diego.
- GOTTLIEB, D. (2008): “Competition overtime-inconsistent consumers,” *Journal of Public Economic Theory*, 10(4), 673–684.
- HEIDHUES, P., AND B. KŐSZEGI (2010): “Exploiting naïveté about self-control in the credit market,” *The American Economic Review*, 2279–2303.
- HINNOSAAR, M. (2012): “Time inconsistency and alcohol sales restrictions,” mimeo, Northwestern University.
- JAIN, S. (2012): “Marketing of vice goods: A strategic analysis of the package size decision,” *Marketing Science*, 31(1), 36–51.
- KŐSZEGI, B. (2005): “On the feasibility of market solutions to self-control problems,” *Swedish Economic Policy Review*, 12(2), 65.

- LAIBSON, D. (1997): “Golden eggs and hyperbolic discounting,” *Quarterly Journal of Economics*, 112(2), 443–477.
- LEE, H. (2012): “The role of local food availability in explaining obesity risk among young school-aged children,” *Social Science & Medicine*, 74(8), 1193–1203.
- LEUNG, C. W., B. A. LARAIA, M. KELLY, D. NICKLEACH, N. E. ADLER, L. H. KUSHI, AND I. H. YEN (2011): “The influence of neighborhood food stores on change in young girls’ body mass index,” *American journal of preventive medicine*, 41(1), 43–51.
- O’DONOGHUE, T., AND M. RABIN (1999): “Doing it now or later,” *American Economic Review*, 89(1), 103–124.
- SALOP, S. (1979): “Monopolistic Competition with Outside Goods,” *The Bell Journal of Economics*, 10(1), 141–156.
- STEENHUIS, I. H., F. H. LEEUWIS, AND W. M. VERMEER (2010): “Small, medium, large or supersize: trends in food portion sizes in The Netherlands,” *Public health nutrition*, 13(06), 852–857.
- VERMEER, W., I. STEENHUIS, F. LEEUWIS, M. HEYMANS, AND J. SEIDELL (2011): “Small portion sizes in worksite cafeterias: do they help consumers to reduce their food intake&quest,” *International Journal of Obesity*, 35(9), 1200–1207.
- WERTENBROCH, K. (1998): “Consumption self-control by rationing purchase quantities of virtue and vice,” *Marketing Science*, 17(4), 317–337.