8-2018

Take all You Want, but Eat all You Take: Effectiveness of a Financial Incentive on Individual Food Waste

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TAKE ALL YOU WANT, BUT EAT ALL YOU TAKE: EFFECTIVENESS OF A FINANCIAL INCENTIVE ON INDIVIDUAL FOOD WASTE

by

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A Thesis

Submitted to the Faculty of Purdue University

In Partial Fulfillment of the Requirements for the degree of

Master of Science

Department of Agricultural Economics

West Lafayette, Indiana

August 2018

THE PURDUE UNIVERSITY GRADUATE SCHOOL
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To my family.

ACKNOWLEDGMENTS

I would like to thank Dr. Bhagyashree Katare for her guidance and constant support throughout this project and for teaching me about the research process. My thankfulness extends to my committee members, Dr. Michael Wetzstein for providing invaluable advices and for reviewing this work, and Dr. Jiong Sun for his feedback and for agreeing to be a part of my committee.

I would like to thank Jim and Neta Hicks for providing funds for this research project (Jim and Neta Hicks Graduate Student Small Grant). I would like to recognize Greg Minner, Mary Jo Zeiser, and Sally Baugues from Purdue Dining & Catering for their help with realizing this research project.

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ABSTRACT

Author: Jovanovic, Nina. MS
Institution: Purdue University
Degree Received: August 2018
Title: Take all You Want, but Eat all You Take: Effectiveness of a Financial Incentive on Individual Food Waste
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This study investigates the effect of a fixed financial incentive on students' food consumption and food wastage behavior. We hypothesize that students will change their behavior under financial incentive with respect to the (1) amount of food taken and (2) associated plate waste. To test our hypothesis, we conduct a randomized control trial experiment at an all-you-can-eat university dining hall, and employ digital photography method to collect daily consumption and waste data for each student. We estimate the amount of food taken on the plate and the amount of plate waste to the nearest 10%. The results indicate the financial incentive was instrumental in increasing the likelihood of students cleaning their plates (reduction in waste). However, we find no significant decrease of the amount of food taken on the plate by the students. These results are encouraging as they provide a foundation for policymakers implementing and evaluating policies to reduce food waste.

CHAPTER 1. INTRODUCTION

During World War II there was the slogan "take all you want, but eat all you take" (Take/Eat) in U.S. military mess halls. The objective was to discourage food waste at a time of food shortages. Currently, almost one-third of food for human consumption is wasted or lost (Gustavsson et al., 2011). At the household level, approximately 21% of the total food available for U.S. consumption is wasted (Buzby et al., 2011). U.S. consumers throw away 25% of the food purchased, with an estimated annual cost of $1365 to $2275 per household (Gunders, 2012). Dining halls, food courts, and fast food restaurants are possible points of intervention as they are major sources of individual level food waste. For instance, annually university dining halls account for nearly 540,000 million tons of food waste (Whitehair et al., 2013). Such waste generates external costs in the form of groundwater contamination, overuse of natural resources, greenhouse gas emissions, and food insecurity (Coleman-Jensen et al., 2014; Grizzetti et al., 2013; Hall et al., 2009; Hamm & Bellows, 2003; Venkat, 2011; FAO, 2013).

With the current heightened concern surrounding food waste nonpecuniary costs, a resurgence is occurring in reducing institutional-cafeteria (dining hall) food waste. Availability of extensive food choice and large portion size are possible explanations of dining hall plate waste (Gunders, 2012). In an effort to mitigate food waste, dining halls have donated uneaten food to foodbanks, served lunch after recess, created longer lunch periods, removed food trays, and placed signs promoting waste reduction (Bergman et al., 2004; Getlinger et al., 1996; Kantor et al., 1997; Kuo & Shih, 2016; Thiagarajah & Getty, 2013). However, there is little if any research dedicated to studying the effect of economic incentives on food waste reduction at the individual level.

This study attempts to fill the literature gap by theoretically and empirically investigating the effect of an economic incentive in a university dining hall setting. Specifically, this study investigates a Take/Eat economic incentive where university all-you-can-eat dining hall patrons (students) are provided a monetary reward for consuming all the food on their plates (zero plate waste). This study also provides a theoretical framework to study the influence of a Take/Eat incentive on the amount of food taken (take all you want, Take) and the associated plate waste (but eat all you take, Eat). We hypothesize that students are responsive to a Take/Eat incentive with respect to the food taken and the amount of associated plate waste. We test this hypothesis through a randomized controlled experiment, with a financial incentive intended to reduce individual level plate food waste at an all-you-can-eat university dining hall. The intervention offers students a fixed financial incentive to eat all they have taken on their lunch plate. We find our fixed financial incentive has a positive and statistically significant effect on zero plate waste. In contrast, we find no evidence of a reduction in food taken by the students. Our results are comparable to previous research indicating a reduction in the fixed price at an all-you-can-eat restaurant leads to less waste (Just & Wansink, 2011). The study was conducted with approval from the Institutional Review Board at Purdue university.

1.1 Background

Our efforts contribute to the theoretical framework and empirical investigation of the individual level food waste problem in a cafeteria (dining hall) setting. Whitehair et al. (2013) show that displaying of food waste awareness messages in dining halls could raise students' awareness concerning food waste. They determine such intervention led to approximately a 15% reduction in food waste and improvement in the sustainability of foodservice facilities. Similarly, Follows and Jobber (2000) show that individuals with environmentally responsible behavior base their consumption decisions on such behavior. Qi and Roe (2017) suggest informing individuals about food waste externalities in landfills decreases the propensity to create food waste. In contrast, Just and Wansink (2010) find trayless university dining halls led to a reduction in intake of fruits and vegetables without reducing food waste. Similarly, reducing plate size and introducing social cues in hotel buffets reduced food waste (Kallbekken & Sælen, 2013; Wansink & Van Ittersum, 2013). We extend this literature by studying the effect of a fixed financial incentive on student level plate waste in an all-you-can eat university dining hall.

Furthermore, our study contributes to the economic incentive literature addressing direct fixed financial incentives to induce behavioral change. Previous studies have employed fixed financial incentives (Acland & Levy, 2015; Charness & Gneezy, 2009; Royer et al., 2015; Volpp et al., 2008) to motivate healthy behavior, including increased physical exercise and decreased smoking. The food waste literature in economics indicates when consumers are faced with high transaction costs for matching food consumption with purchases; they will tend to absorb the cost of some food waste as a premium for food safety and convenience (De Gorter, 2014). This results in some positive levels of food waste. Katare et al. (2017) theoretically investigate this positive level by deriving social optimal food waste taxes and subsidies for reducing food waste. Their results indicate the optimal level of these mechanisms depends on how responsive individuals are to reducing food waste given the mechanisms. However, empirical estimates on this responsiveness are unknown. There are limited if any efforts on quantifying the impact of financial incentives on food waste behavior. Policymakers are unable to make informed decisions without knowledge of this responsiveness. An analysis linking consumer food waste behavior to incentive mechanisms will provide necessary information for understanding tradeoffs leading to sound policies for efficient food waste reduction. We contribute to the economics of monetary incentives by studying the effect of a financial incentive on individual food waste.

In summary, this study offers three unique contributions. First, to the best of our knowledge, this is the first study to investigate the effect of a fixed financial (Take/Eat) incentive on individual food waste behavior. Second, we study the consumption behavior in a natural environment, a university dining hall, as compared to previous studies analyzing this behavior in a controlled environment (Qi & Roe 2017). Third, our intervention targets college students who are receptive to nudges or incentives (Deliens et al., 2014) and may be forming lifelong habits. Specifically, our efforts extend the literature by testing if a university dining hall is a possible point of intervention for reduction in food waste.

CHAPTER 2. THEORETICAL MODEL

As a foundation for framing the empirical intervention analysis, we theoretically solve the student's utility maximization problem for taking and wasting food on a plate. The theory is unique to an all-you-can-eat dining hall under the influence of a Take/Eat incentive. Following the recent development of food waste economic theory by Katare et al. (2017), the focus is on a static individual decision problem, which embodies the characteristics of Take/Eat decisions.

Consider a student's dining hall consumption of food, *C*, is net of food taken, *F*, subtracting any plate waste, *W*, $C = F - W$. For a given level of food, assume a student will attempt to minimize his/her level of waste. This waste minimum is represented as *W(F),* so a student then derives utility, *u,* from food consumption, *C,* by:

$$u = u[F - W(F)] \tag{2.1}$$

where F represents "take all you want" and $-W(F)$ is "but eat all you take." This assumes some possible prosocial or individual behavior, which results in leaving food (waste) being a bad commodity, $\frac{\partial u}{\partial W} < 0$. In contrast, food, *F*, is desirable, $\frac{\partial u}{\partial F} > 0$. Maximizing (2.1) with respect to food taken, *F*, yields $\frac{du}{dF} = \frac{\partial u}{\partial C}\left(\frac{\partial C}{\partial F} + \frac{\partial C}{\partial W}\frac{dW}{dF}\right) = 0$.

A student will maximize utility where the marginal benefits of food consumption, $\frac{\partial u}{\partial C}\frac{\partial C}{\partial F}$, is equal to the marginal costs, $-\frac{\partial u}{\partial C}\frac{\partial C}{\partial W}\frac{dW}{dF}$. The additional pleasure of eating is equal to the additional disutility of not eating and wasting food.

To modify this behavior, a policy intervention is required. One such intervention considered is a Take/Eat incentive, *s*. Let the incentive, *s*, be a lump-sum payment if a student eats all he/she takes (clean plate), otherwise he/she receives no payment. The level of plate waste is now dependent on the amount of food taken along with a Take/Eat incentive. This assumes the Take/Eat incentive not only directly influences the waste level, but also indirectly effects waste by motivating the student to reduce the amount of food taken, so *W[F(s), s]*. The individual's preferences are then modified as

$u = u\{F(s) - W[F(s), s], s\}$, where utility is also influenced directly by the level of the Take/Eat incentive *s*. A student will make the determination of leaving a clean plate and receiving a Take/Eat incentive if the associated satisfaction is greater than leaving plate waste with no incentive payment. Specifically, the utility maximizing problem is $max(u\{F(s) - W[F(s), s], s\}, u\{F - W(F)\})$.

The threshold or switching trigger is then:

$$u\{F(s) - W[F(s), s], s\} = u\{F - W(F)\} . \tag{2.2}$$

For a given incentive, if the number of students cleaning their plates is very responsive to the incentive, *s*, then the incentive may be effective in reducing food waste.

The determinants of this response for a given Take/Eat incentive, *s*, may be investigated by totally differentiating (2.2) with respect to the Take/Eat incentive, *s*. Simplifying yields:

$$\frac{\partial u}{\partial C}\left[\left(\frac{\partial W}{\partial F} - 1\right)\frac{dF}{ds} + \frac{\partial W}{\partial s}\right] = \frac{\partial u}{\partial s} \tag{2.3}$$

where $\left(\frac{\partial W}{\partial F} - 1\right) \leq 1$, assuming $\frac{\partial W}{\partial F} \leq 1$, which indicates a given amount of food, *F*, cannot generate waste above *F*.

The left-hand side of (2.3) is the marginal sacrifice, MC, in consumption from a change in the Take/Eat incentive. The term, $-\frac{\partial u}{\partial C}\frac{dF}{ds} > 0$, is the direct sacrifice in consumption from food. This sacrifice is mitigated by the indirect impact of food on waste from the incentive, $\frac{\partial W}{\partial F}\frac{dF}{ds} < 0$, plus the direct influence of waste from a change in *s*, $\frac{\partial W}{\partial s} < 0$. The right-hand side is the direct marginal benefit (MB), $\frac{\partial u}{\partial s}$, from a change in *s*. Students with MB greater than MC will leave a clean plate for the given Take/Eat incentive, *s*. At the threshold, the marginal student's MB will just equal his/her MC. The consumer surplus for this marginal student is zero and positive for students with MB > MC. In contrast, for some students MC will exceed benefits, so they may leave plate waste.

Converting to elasticities:

$$\frac{W}{s}\frac{\partial u}{\partial C}[(\epsilon_{WF}-1)\epsilon_{Fs}+\epsilon_{Ws}]=\frac{\partial u}{\partial s} \quad (2.4)$$

where $\epsilon_{WF} > 0$ denotes the responsiveness of plate waste to food taken and $\epsilon_{Fs} < 0$ and $\epsilon_{Ws} < 0$ represent the responsiveness of food taken and plate waste to the Take/Eat incentive, respectively. Equation (2.4) results in the following proposition.

Proposition 1: Marginal rate of substitution, consumption, *C*, for Take/Eat incentive, *s*, is proportional to the elasticities of food taken and plate waste with respect to the incentive:

$$MRS \propto -\epsilon_{Fs}+\epsilon_{WF}\epsilon_{Fs}+\epsilon_{Ws} \quad (2.5)$$

Proof: Dividing (2.4) by $\frac{\partial u}{\partial C}$ and noting $MRS=\frac{\frac{\partial u}{\partial s}}{\frac{\partial u}{\partial C}}$ yields the proposition.

For $MRS > 0$, $\epsilon_{Fs} < \frac{\epsilon_{Ws}}{1-\epsilon_{WF}}$. An increase in the Take/Eat incentive will yield a decline in food taken *F*, leading to a decline in consumption, *C*. The incentive is then a substitute for consumption. Food taken decreases more than the decline in plate waste, so with *C* = *F* – *W*, consumption decreases. In contrast, if ϵ_{Fs} and ϵ_{WF} are relatively inelastic compared to ϵ_{Ws}, then it is possible $MRS < 0$. This implies an increase in the Take/Eat incentive, *s*, will increase consumption by food taken not declining as much as the decline in plate waste. This tradeoff among the Take/Eat incentive, food taken, plate waste, and resulting consumption depends on their relative responsiveness. If a student is willing to sacrifice a large reduction in the incentive for a small increase in consumption, then the incentive will have relatively limited impact on food taken and a relatively larger impact on plate waste. This possible result directly supports Take/Eat. An incentive would then discourage plate waste (eat all you take) with limited impact on food taken (take all you want). Again, it is the relative elasticities, which determine the effect of a given Take/Eat incentive.

The trigger (2.2) will vary by students, so a given Take/Eat incentive, *s*, may result in some individuals with a clean plate, $u(s) \geq u$, and others without, $u(s) < u$. In terms of the testable hypothesis, a Take/Eat incentive will encourage students in cleaning their plates if students' $MRS < 0$. Food taken is not relatively responsive to the incentive and plate waste is responsive to food taken. They will then not tradeoff consumption for the Take/Eat incentive. As a test of this hypothesis, a field intervention experiment is conducted by considering a given Take/Eat incentive.

CHAPTER 3. MATERIALS AND METHODS

3.1 Experimental design

In the spring 2017 semester, the experiment was conducted at a fixed price all-you-can-eat student dining hall at a large Midwest public university. A week prior to the experiment, students frequenting the dining hall were recruited. To avoid any self-selection bias, food waste was not mentioned while recruiting the students. Students signed a consent form and completed a survey containing their demographic information and email address. Students were requested to have lunch in the dining hall at least three times per week.[1] The experiment spanned a two-week period with the first week for baseline data and the second for intervention data collection. On the first day, students received instructions about the sitting arrangements and non-sharing of food. Students ate meals alone (not in a group), which prevented food sharing. The experiment was conducted at a dining hall that has no-takeout policy.

We collected photographs of students' plates at the beginning (pre) and end (post) of their lunch. This allowed us to record food consumption and waste data without interfering with students' lunch. The digital photography method is an established, reliable, and accurate tool for data collection, which is extensively employed for collecting and analyzing plate waste and consumption information (Hanks et al., 2014; Taylor et al., 2014; Williamson et al., 2003). All students had a pre-paid meal card allowing them unlimited access to all food items (take all you want). This design provides zero marginal monetary cost in having a dining hall lunch and participating in the study for the students. All students were compensated with a $10 Amazon gift card for study participation.

Our sample consists of 90 volunteer students, with 39 randomly assigned to the treatment and 51 to the control group. For minimizing the interaction between the control and treatment groups, throughout the experiment, groups were assigned separate sections in the dining hall. Table 1 reports the descriptive statistics of students' baseline

[1] During the experiment, 75% of the students had lunch at the dining hall at least three times a week.

characteristics for both groups. As indicated in the table, the sample is well balanced between treatment and control groups with no statistical difference in the pre-treatment baseline characteristics.

Table 1. Descriptive Statistics of Students' Demographic Variables

Variable Name	Treatment Group	Control Group
Age (years)	20.358	19.568
	(3.452)	(1.431)
Female	0.435	0.490
	(0.502)	(0.504)
Local Student	0.769	0.803
	(0.426)	(0.400)
Foreign Student	0.230	0.196
	(0.426)	(0.400)
Race = Other	0.282	0.215
	(0.455)	(0.415)
Race = White	0.384	0.490
	(0.492)	(0.504)
Race = Asian	0.333	0.294
	(0.477)	(0.460)
Freshman	0.435	0.490
	(0.502)	(0.504)
Urban	0.487	0.411
	(0.506)	(0.497)
Rural	0.512	0.588
	(0.506)	(0.497)
Number of Students	39	51

Standard deviations are in parentheses.

We also conduct a balance test by estimating the pre-treatment characteristics on a constant and a treatment group dummy (Glewwe et al., 2009). As expected from random sampling, results in table 2 indicate no significant difference between student's baseline characteristics in the treatment and control groups.

Table 2. Difference between the Base Characteristics of Students in the Treatment and Control Group (N = 90)

Variable Name	Difference between Treatment and Control Group[a]
Age (years)	0.790
	(0.587)
Female	−0.054
	(0.107)
Local Student	−0.034
	(0.088)
Foreign Student	0.034
	(0.088)
Race = Other	0.066
	(0.093)
Race = White	−0.105
	(0.105)
Race = Asian	0.039
	(0.099)
Rural	−0.075
	(0.106)
Urban	0.075
	(0.106)
Clean Plate	0.121
	(0.080)
Food Taken (lb)	−0.056
	(0.060)

Standard errors in parentheses are corrected for heteroscedasticity and clustered at individual level. * p < 0:10, ** p < 0:05, *** p < 0:01.

3.2 Clean plate financial incentive

The treatment group was offered a fixed financial incentive during the second week of the experiment. They were offered $2 per day for cleaning their lunch plate of edible food. This represents a 15% discount on their fixed priced lunch. The treatment was based on the economic incentive supporting the Take/Eat incentive. Students are provided a financial reward for eating all the food on their plates, thus encouraging taking only the amount of food they can consume, Take/Eat. Maximum payout for the treatment group was $10.

At the beginning of the experiment's second week (intervention week), students in the treatment group were sent emails providing information on the intervention – the financial incentive for cleaning their plates. No other emails were sent during the week. A reminder email about the continuation of the experiment and data collection through the second week was sent to the control group. This email was similar to the one sent at the beginning of the first week.

Within a week of study completion, compensation in the form of Amazon gift cards was emailed to all students. For each day, a treatment group student presented a clean plate, he/she was provided additional compensation of $2. All the gift cards were redeemed within 48 hours, indicating students in the treatment group read our email, and were aware of the incentive.

3.3 Data collection and extraction

Pre- and post-lunch photos were collected daily, for the entire two weeks of the experiment. Each student received a card with group assignment and unique ID. At the end of each day, the photos were tagged with group assignment and ID. This tagging convention facilitated data extraction with pre-lunch preceding the corresponding post-lunch photos.

Three experienced and trained data assessors were employed for data extraction and estimation. This was accomplished in three phases: estimating percentage of food waste by food item, determining food item weights, and estimating portion size. In the first phase, data assessors estimated the percentage of food wasted by employing pre- and post-lunch photos using a 10% estimation scale (e.g. 0, 0.1, 0.2, 0.3 … 1). For a certain food item to be deemed wasted, at least 0.1 of the item had to be left on the plate, otherwise it was considered zero food waste. After estimations for each food item, the average percent wasted by student was calculated for each food item. In the second phase, weights of one serving for each food item were obtained from the dining hall services. We validated these weights by physically weighing each food item per serving size.

The third phase estimated portion size for each food item wasted by comparing pre-lunch photos using the 10% estimation scale. Food items served individually such as cheeseburgers, hotdogs, and cookies, were counted as one serving (one portion size). To aid assessment of food items not countable, such as curry, salad, and stir-fry, a photo standard representing one serving for each of them was employed. Photo standards were determined from the existing photo files, in cooperation with a trained dietitian at the university dining hall services. Portion size for these food items were estimated employing the 10% estimation scale. If the portion in the picture was greater than the standard serving size, the estimation would be greater than one, and vice versa. Finally, the amount wasted of each food item was calculated by multiplying together percent of food item wasted, weight of one serving, and portion size. The outcome variable is then total food wasted, calculated by adding all food items wasted by a student per day. The amount of food taken was calculated following the same procedure, excluding the percentage of food item wasted from the calculations. The outcome variable *Clean Plate* was generated looking at the post-lunch photos. The variable was coded 1 if a student left zero plate waste, and 0 otherwise. Table 3 lists the descriptive statistics for outcome variables.

Table 3. Descriptive Statistics for Outcome Variables

Variable Name	Week 1		Week 2	
	Control Group	Treatment Group	Control Group	Treatment Group
Average Number of *Clean Plates*	0.456 (0.499)	0.577 (0.496)	0.472 (0.500)	0.858 (0.350)
Average Total *Food Taken* (lb)	1.052 (0.407)	0.995 (0.382)	1.053 (0.461)	1.036 (0.449)
Observations	160	116	161	134

Standard deviations are in parentheses.

3.4 Empirical framework

We begin by comparing the average treatment effect with the linear probability model

$$(Clean\ Plate)_{i,t} = \beta_0 + \beta_1 Treatment_{i,t} + \beta_2 Post_{it} + \beta_3 \left(Treatment_{i,t} * Post_{it}\right) + \boldsymbol{\beta_4 Z_i} + \boldsymbol{\beta_5 Day_t} + u_i \tag{3.1}$$

where $(Clean\ Plate)_{i,t}$ is a dummy variable equal to 1 if student i has cleaned his/her plate on day *t* and 0 otherwise. $Treatment_{i,t}$ is a dummy variable with 1 indicating exposure to the treatment and 0 otherwise, $Post_{it}$ is a dummy variable indicating the treatment week and 0 otherwise, and vector $\boldsymbol{Z_i}$ represents a vector of demographic control variables such as age, gender, race, if international, if freshman, and if the student is from a rural/urban area. $\boldsymbol{Day_t}$ is the day fixed effect to control for the common shocks that all the students faced on a given day (e.g. a bad tasting food item). Standard errors are corrected for heteroscedasticity and are clustered at individual level.

As noted, the treatment group received an email containing the nudge on the weekend before the intervention week (week two). We did not send any follow-up or reminder emails during the weekdays. Hence, to explore possible heterogeneity in the response to the financial incentive through the intervention week, we interact $Treatment_{i,t}$, and exposure, $Post_{it}$. This interaction captures the effect of being in the treatment group relative to being in the control group on a given day. This specification is represented in equation 3.2 and contains the demographic and day fixed effect as described for equation A. $\boldsymbol{Post\_Day_{i,d}}$ represents a set of dummies for the treatment days during the intervention week, where d = 6, …, 10.

$$(Clean\ Plate)_{i,t} = \beta_0 + \beta_1 Treatment_{i,t} + \beta_2 \left(Treatment_{i,t} * \boldsymbol{Post\_Day_{i,t}}\right) + \\ + \boldsymbol{\beta_3 Z_i} + \boldsymbol{\beta_4 Day_t} + u_i \qquad (3.2)$$

The outcome variable total *Food Taken* is also estimated using equations 3.1 and 3.2 as described above.

CHAPTER 4. RESULTS

Figure 1 plots the average number of clean plates by day comparing the treatment and control groups. The financial incentive had a persistent effect on the average number of clean plates through the intervention period. Appendix figure A.1 plots the distribution of clean plates over the experiment period for both the treatment and control groups.

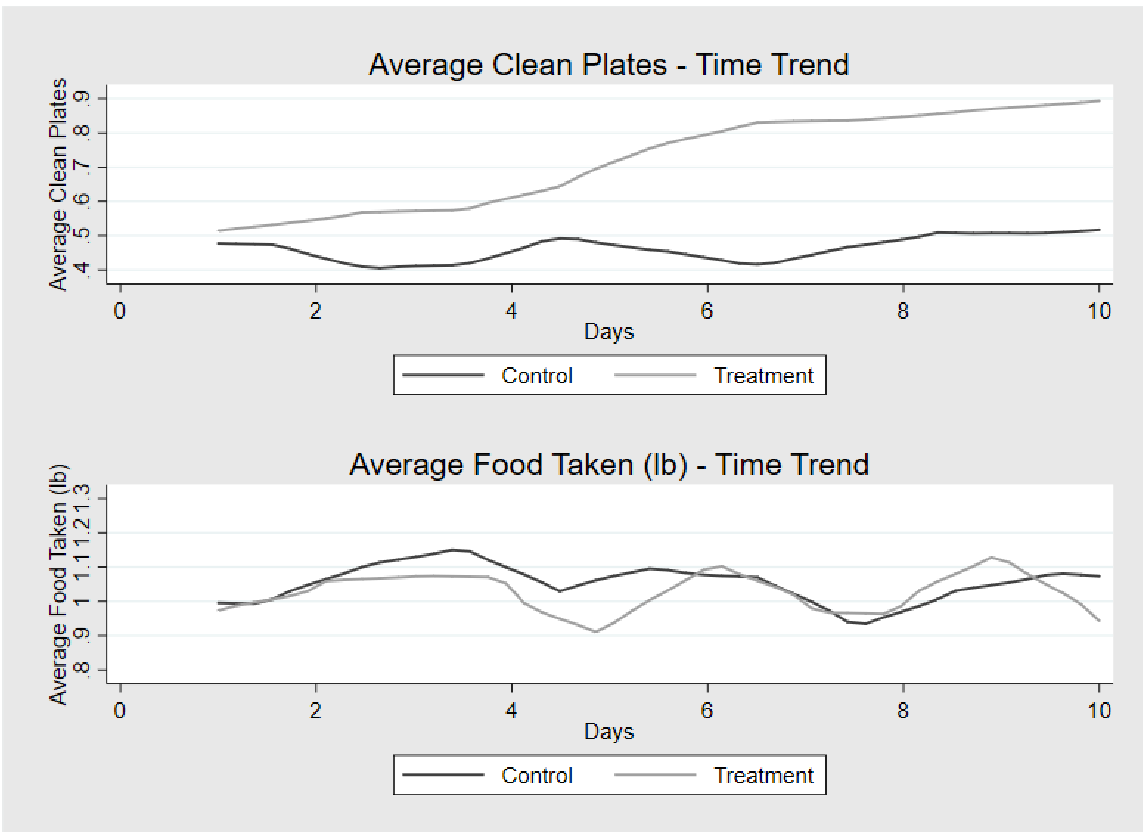

Figure 1. Average Clean Plates and Average Food Taken (lb) for Treatment and Control Group

Table 4 presents regression results for the financial incentive treatment using equation 3.1, where the outcome is an indicator variable for a clean plate by each student (Column 1). The second outcome is the total amount of food taken by students for each day (Column 2).

Table 4. Impact of Financial Incentive on Probability of Clean Plates and Food Taken

Variable Name	Clean Plate = 1	Food Taken (lb)
Treatment	0.112	−0.068
	(0.081)	(0.060)
Post	0.107	−0.010
	(0.085)	(0.060)
Treatment*Post	0.265***	0.027
	(0.083)	(0.063)
Age (years)	0.005	0.021**
	(0.010)	(0.010)
Female	−0.075	−0.106*
	(0.068)	(0.060)
Local Student	Base	Base
Foreign Student	−0.055	0.012
	(0.111)	(0.099)
Race = Other	Base	Base
Race = White	−0.020	−0.016
	(0.078)	(0.082)
Race = Asian	−0.050	−0.062
	(0.088)	(0.091)
Freshman	−0.050	−0.010
	(0.068)	(0.068)
Rural	Base	Base
Urban	−0.038	0.008
	(0.073)	(0.058)
Constant	0.417**	0.659***
	(0.195)	(0.228)
Observations	571	571

Standard errors in parentheses are corrected for heteroscedasticity and clustered at individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. We control for individual demographic variables, and day fixed effects.

Results indicate students in the treatment group respond to the financial incentive and modify their consumption behavior. For the treatment group, the probability of cleaning their plates during the intervention was roughly 0.26 per day higher than for the control group from a base of 0.41 per day. Specifically, the probability of the treatment group cleaning their plate was 63% higher than the control group.

Table 5 presents the results for equation 3.2, which captures the heterogeneity in the financial nudge through the intervention week. Results indicate students' responsiveness to the treatment was constant throughout the treatment week. The probability of cleaning the plate each day of the intervention week was not statistically different from each other ($p > 0.1$), implying the financial incentive effect was consistent through time. Note, the students were emailed only once before the intervention week and no reminder emails were sent. These results are encouraging as they show even in the absences of repeated reminders; our treatment was salient and effective.

Table 5. Impact of Financial Incentive on Probability of Clean Plates and Food Taken for each Treatment Day

Variable Name	Clean Plate = 1	Food Taken (lb)
Treatment	0.112	−0.068
	(0.082)	(0.060)
Treatment*Day6	0.318***	−0.051
	(0.117)	(0.118)
Treatment*Day7	0.270**	0.115
	(0.123)	(0.108)
Treatment*Day8	0.221*	0.068
	(0.123)	(0.098)
Treatment*Day9	0.250*	0.113
	(0.135)	(0.115)
Treatment*Day10	0.257**	−0.117
	(0.110)	(0.100)

Continued

Table 5. continued

Variable Name	Clean Plate = 1	Food Taken (lb)
Age (years)	0.005	0.021**
	(0.010)	(0.010)
Female	−0.075	−0.107*
	(0.068)	(0.060)
Local Student	Base	Base
Foreign Student	−0.055	0.011
	(0.111)	(0.099)
Race = Other	Base	Base
Race = White	−0.019	−0.016
	(0.078)	(0.082)
Race = Asian	−0.050	−0.063
	(0.088)	(0.092)
Freshman	−0.052	−0.011
	(0.068)	(0.068)
Rural	Base	Base
Urban	−0.038	0.009
	(0.073)	(0.058)
Constant	0.421**	0.656***
	(0.198)	(0.228)
Observations	571	571

Standard errors in parentheses are corrected for heteroscedasticity and clustered at individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. We control for individual demographic variables, and day fixed effects.

After showing the participants' response to the financial incentive, we now focus on the mechanism for this behavioral change. We employ the total food taken, *F*, by the participants during the entire lunch period as the outcome variable. Results for the estimation of equations 3.1 and 3.2 for food taken as the outcome variable are reported in column 2 of tables 4 and 5 respectively. The Take/Eat incentive had no effect on the amount of food taken, *F*, by the students.

To understand further the underlying mechanisms, we estimated equations 3.1 and 3.2 with plate waste per student per day as an outcome. Results in appendix table 6 (column 1) indicate the treatment group had significantly less plate waste than the control group during the intervention week. However, the average treatment effect is relatively small in magnitude 0.037 lb (17 grams). Results from appendix table 7 (column 1) indicate this effect is driven by the change in consumption on the last day of the intervention (day 10). The coefficient for day 10 associated with the amount of food waste is 0.085 lb (38 grams). This implies the treatment group wasted 38 grams less food per student as compared to control group, with a base of 0.109 lb (49 grams). Specifically, the treatment group wasted 77% less food than the control group on day 10.

As an all-you-can-eat buffet during lunch, students could return to the buffet line as many times as they desired. To understand if the students made multiple trips to adjust the quantity of food in order to avoid waste, we estimated the main specifications with the number of trips made by each student as the dependent variable. Results from appendix table 7 (column 2) indicate the treatment group made 0.1 more trips on average than the control group during the intervention week. Although the magnitude is relatively small, the results indicate the financial incentive motivated the treatment group to calculate the amount of food they should take and then consume.

The overall results indicate the Take/Eat incentive has a relatively strong effect on students cleaning their plate with no effect on food taken. Given the incentive, the increased probability of students cleaning their plate indicates the incentive is influencing food waste. The associated no response of food taken, *F*, and a resulting increase in consumption, *C*, indicates a negative *MRS.* The actual consumption of food increases with a relatively larger decline in plate waste. There appears to be no tradeoff between consumption, *C*, and the Take/Eat incentive, *s*. In terms of the hypothesis, students will likely not tradeoff consumption for the Take/Eat incentive. Specifically, the Take/Eat incentive has limited impact on “take all you want” with a relatively large impact on “but eat all you take.”

CHAPTER 5. DISCUSSION AND CONCLUSION

We employ a financial incentive intervention, in the form of a Take/Eat incentive, to encourage students to reduce plate waste at a fixed price all-you-can-eat university dining hall. The incentive reduced the cost of students' fixed cost for a meal by 15% in exchange for eating all the food on their plates. Recent literature has found mixed results in dining hall interventions on the reduction of individual food waste. Our results indicate a financial incentive can have a positive and significant effect on reducing students' plate waste. The change in behavior is without any reduction in food taken; thus, leading to an increase in consumption. This suggests intervening at dining halls, buffets, and cafeterias is effective in food waste reduction where such venues are possible points of intervention. Our results of 85% of the participants cleaning their plates during the intervention week are also consistent with previous studies. Just and Wansink (2011) estimated 63% to 81% pizza buffet diners and Qi and Roe (2017) estimated 68% of the subjects in their study left zero plate waste (clean plate). For a payout of $2 a meal, the incentive was able to increase the probability of a clean plate by 22% per day. Our results are also consistent over the period of intervention and we do not see a decline in the effect, which is common in financial incentive interventions (Royer et al., 2015).

The Take/Eat incentive investigation further compliments efforts addressing policies to motivate healthy behavior (Pope & Harvey-Berino, 2013; Royer et al., 2015; Volpp et al., 2008) and environmentally sustainable behavior (Alcott, 2011; Ayres et al., 2013). These results are important to policymakers and stakeholders (universities and other institutions providing meals through all-you-can-eat dining), as they demonstrate the effectiveness of a well-established policy in behavior modification toward waste reduction. This encompasses conducting the experiment in real-time during dining hours at a well-functioning dining hall. The students had no constraints on the amount or type of food they could order, eat, or waste. Results are consistent over time, without any repeated reminders.

The main question is whether a financial incentive is an appropriate tool for motivating individual food waste reduction. Financial incentive as a policy tool is successful in motivating positive behavior such as increase in physical exercise (Royer et al., 2015), smoking cessation (Volpp et al., 2009), and weight loss (Volpp et al., 2008). Given the treatment group students did not change the amount of food taken on their plate, they wasted less food after the intervention as compared to the control group. An unintended consequence of the Take/Eat incentive might have led students to consume relatively more food, thus encouraging unwanted eating habits. In terms of second-best Pareto-efficient policies for internalizing the negative externalities of food waste and poor diets, policies encouraging cleaning plates with healthy foods may be warranted. Policies such as using nutrition labeling (Driskell et al., 2008) and benefit based messages indicating healthy food choices (Peterson et al., 2010) can be used in tandem with a Take/Eat incentive to overcome challenges of motivating students to develop healthy eating habits (Just & Price 2013). The Take/Eat incentive is then an incentive to eat healthy and in this sense, can be considered as a reverse soda tax. Future research is required to understand the impact of Take/Eat incentives on health outcomes and food choices.

One drawback of our study is the small sample size. Although only 90 students participated, repeated measurements were collected from the same student. This led to a larger set of observations, which contributed to our significant results. An offshoot of this effort is conducting a cost benefit analysis measuring the effect of an incentive on operational costs, which would aid in providing an optimal solution for policy design and implementation. Further research is required to estimate the cost of policy implementation as well as the effect on other externalities, such as effects on student health and nutrition outcomes. Peer effects might also play a part in this behavior modification. Research indicates peer effects can influence individual food consumption behavior (Fortin & Yazbeck, 2015). Additional research is required to understand the effect of interventions and peer effects on food waste and food consumption behaviors.

Our intervention was conducted in real-time during lunch dining hours at a functioning all-you-can-eat university dining hall. Students arrived at their usual lunch hour, paid for their meal, chose the food of their liking, and were free to help themselves as many times as desired. Considering these aspects of our study, the results can be translated to other food service settings with fixed entry pricing and zero marginal food cost. Buffet style restaurants, cafeterias and dining halls are an important part of the food service industry (Gunders, 2012), especially in work places, universities, and school settings. However, these results might not hold true in a full-service pay-per-item restaurant setting, as there is cost associated with the amount of food ordered. Hence, further research is required to understand consumption behavior in these cases.

Our results provide a foundation for policymakers implementing and evaluating policies to reduce food waste. Specifically, the failure to consider the relative responses of food taken, plate waste, and consumption from a waste reduction policy can lead to ineffective policies and programs. Results illustrate the importance of developing an underlying theory and, based on this theory, empirically measuring the magnitude of policy responsiveness. Failure to follow such a development can lead to erroneous policies.

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APPENDIX

Appendix Table 1. Impact of Financial Incentive on Plate Waste and Number of Trips

Variable Name	Food Waste (lb)	Number of Trips
Treatment	−0.053**	0.003
	(0.021)	(0.064)
Post	0.042	−0.033
	(0.028)	(0.079)
Treatment*Post	−0.037*	0.106*
	(0.020)	(0.062)
Age (years)	0.000	−0.005
	(0.003)	(0.009)
Female	−0.002	−0.020
	(0.018)	(0.071)
Local Student	Base	Base
Foreign Student	0.013	−0.044
	(0.028)	(0.108)
Race = Other	Base	Base
Race = White	−0.045	0.018
	(0.040)	(0.082)
Race = Asian	−0.051	0.001
	(0.034)	(0.088)
Freshman	0.007	0.037
	(0.026)	(0.055)

Continued

Appendix Table 1. continued

Variable Name	Food Waste (lb)	Number of Trips
Rural	Base	Base
Urban	0.014	0.100
	(0.026)	(0.079)
Constant	0.110*	1.252***
	(0.062)	(0.207)
Observations	571	571

Standard errors in parentheses are corrected for heteroscedasticity and clustered at individual level. * p < 0:10, ** p < 0:05, *** p < 0:01. We control for individual demographic variables, and day fixed effects.

Appendix Table 2. Impact of Financial Incentive on Plate Waste for each Treatment Day

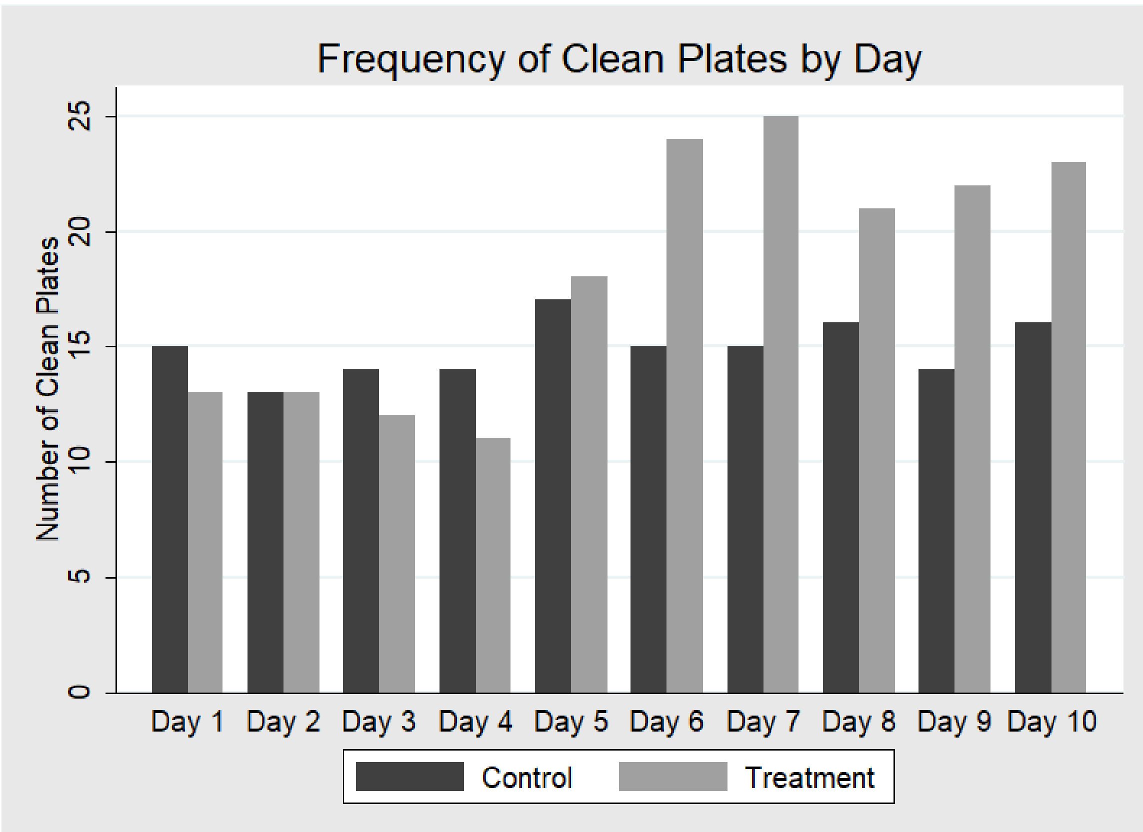
Variable Name	Food Waste (lb)	Number of Trips
Treatment	−0.053**	0.003
	(0.021)	(0.065)
Treatment*Day6	−0.053	0.042
	(0.034)	(0.109)
Treatment*Day7	0.002	0.107
	(0.028)	(0.090)
Treatment*Day8	−0.018	0.153
	(0.030)	(0.134)
Treatment*Day9	−0.036	0.168
	(0.035)	(0.133)
Treatment*Day10	−0.085**	0.070
	(0.040)	(0.112)
Age (years)	−0.000	−0.005
	(0.003)	(0.009)
Female	−0.002	−0.021
	(0.018)	(0.071)
Local Student	Base	Base
Foreign Student	0.013	−0.045
	(0.028)	(0.109)
Race = Other	Base	Base
Race = White	−0.045	0.017
	(0.040)	(0.082)
Race = Asian	−0.052	0.005
	(0.034)	(0.088)
Freshman	0.007	0.038
	(0.026)	(0.055)

Continued

Appendix Table 2. continued

Variable Name	Food Waste (lb)	Number of Trips
Rural	Base	Base
Urban	0.014	0.100
	(0.026)	(0.079)
Constant	0.109*	1.247***
	(0.061)	(0.209)
Observations	571	571

Standard errors in parentheses are corrected for heteroscedasticity and clustered at individual level. * p < 0:10, ** p < 0:05, *** p < 0:01. We control for individual demographic variables, and day fixed effects.



Appendix Figure 1. Number of Clean Plates for Control and Treatment Group