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Comparing Alternative Economic Mechanisms To Increase Fruit and Vegetable Purchases

Mark Prell and David Smallwood

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Abstract

Participants in USDA's Supplemental Nutrition Assistance Program (SNAP) typically consume less than the amounts of fruits and vegetables (FVs) recommended by the Dietary Guidelines for Americans. The study considers three economic mechanisms to incentivize purchases of FVs: a bonus for FV spending; a rebate for FV spending; and a Cash Value Voucher (CVV) redeemable for FVs up to a fixed dollar amount. This USDA Economic Research Service (ERS) report uses neoclassical economics to provide a unifying conceptual framework for explaining the effects of these mechanisms, using simplified abstract models. In principle, all three mechanisms can increase FV purchases for the average SNAP consumer. Distributional effects matter in addition to average effects; SNAP consumers who purchase no FVs (in a typical month) can be a sizable subgroup that is important for analysis. For that subgroup, implementing a CVV tends to increase purchases by more than other mechanisms. If the nonpurchasing subgroup is a large proportion of SNAP households, a CVV also tends to be the mechanism that increases average FV purchases the most. If the subgroup is relatively small, a rebate or bonus may promote average FV purchases the most.

Keywords: Supplemental Nutrition Assistance Program, SNAP, SNAP-based incentive programs, Healthy Incentives Pilot, HIP, Special Supplemental Nutrition Program for Women, Infants, and Children, WIC, cash value voucher, CVV, nutrition, fruits and vegetables

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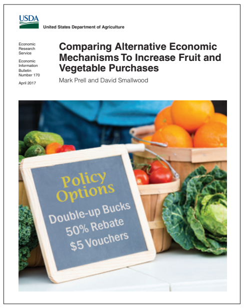

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Comparing Alternative Economic Mechanisms To Increase Fruit and Vegetable Purchases

Mark Prell and David Smallwood

What Is the Issue?

Participants in USDA's Supplemental Nutrition Assistance Program (SNAP) typically consume less than the amount of fruits and vegetables (FVs) recommended by the *Dietary Guidelines for Americans*. To incentivize purchases of FVs by SNAP participants, an additional program benefit could be added to regular SNAP benefits in different forms, each based on an economic mechanism. In this report, the authors develop models of SNAP consumers' expected purchase decisions for three different forms of the benefit (or economic mechanisms):

- A *bonus* for fruit and vegetable spending
- A *rebate* for fruit and vegetable spending
- A *Cash Value Voucher* (CVV) that SNAP consumers redeem (at no charge to the participant) for fruits and vegetables at food retailers, up to a given dollar limit.

The three models chosen for development were based on economic mechanisms used in past U.S. Department of Agriculture (USDA) pilots or programs.

Three fundamental issues are also examined in this report. First, do each of the three mechanisms have the desired effect on behavior, increasing FV purchases at least on average? The second issue is distributional, focusing on an important component of the SNAP population: Which of the mechanisms might increase FV purchases the most among the subgroup of SNAP consumers who, in a typical month, were purchasing no FVs? And third, which economic mechanism might increase FV purchases the most for the average SNAP household, and how might that depend on whether the subgroup who purchases no FVs is a relatively small or large share of all SNAP households?

Recently, in SNAP's Healthy Incentive Pilot, participants in a treatment group of randomly selected SNAP households were eligible to receive a rebate of an additional $0.30 worth of SNAP benefits for every dollar spent on Targeted Fruits and Vegetables at participating retailers. Adults in these SNAP households had greater fruit and vegetable consumption, on average, compared to a control group that was not eligible for rebates. However, while the treatment group's *average* response involved earning a rebate and increasing consumption, in a typical month about one-third of the treatment households did not earn any rebate. They are the participants arguably most in need of additional FVs and may be viewed as a high-priority subgroup within the overall SNAP population.

What Did the Study Find?

The economic models suggest that not all SNAP consumers increase FV purchases using each form of benefit, but at least some do. Therefore, each form will have the desired effect on average behavior, increasing purchases of FVs for SNAP consumers on average.

In the *bonus* and *rebate* models, a SNAP consumer who receives either a bonus or a rebate for purchasing FVs receives a decrease in the effective price of FVs. Because the bonus or rebate is earned only by purchasing FVs, the incentive to purchase additional FVs can be strong. Some of the SNAP consumers who had purchased no FVs may be induced to start purchasing them, especially if the bonus or rebate is large.

In the *Cash Value Voucher* (CVV) model, a SNAP consumer receives FVs at no charge, up to the CVV's stated dollar limit. If the dollar-limit worth of FVs was being purchased previously using cash or regular SNAP benefits, it may be that now the CVV is simply substituted for other ways to purchase some FVs, resulting in only a small net increase in FV purchases. In contrast, a SNAP consumer who had previously purchased no FVs may now have a strong incentive—the FVs are *free* (up to the dollar limit)—to acquire as many FVs as the CVV provides.

In summary, the models suggest that each mechanism will increase FV purchases differently across subgroups of SNAP consumers:

- Among consumers who were already purchasing the CVV's dollar-limit's worth of FVs, a bonus or rebate tends to increase FV purchases by more than a CVV.
- In contrast, for those who were purchasing no FVs, a CVV tends to increase FV purchases by more than a rebate or bonus.
- As the proportion of SNAP consumers who purchase no FVs increases, the ability of the CVV to increase average FV purchases tends to strengthen, while the ability of a rebate or bonus to increase average FV purchases tends to diminish.

How Was the Study Conducted?

Researchers from USDA's Economic Research Service (ERS) used neoclassical economics to develop models of consumers' purchase decisions based on alternative economic mechanisms. They reviewed recent studies in the economics and nutrition literature on interventions in SNAP and other USDA food assistance programs. Strategies to promote FV purchases based on nutrition education were outside the scope of the study, but could be used to supplement any of the mechanisms considered.

Comparing Alternative Economic Mechanisms To Increase Fruit and Vegetable Purchases

Introduction

A critical issue in promoting good nutrition and health is how to increase purchases and consumption of fruits and vegetables (FVs)—especially for people with the lowest intakes. We use economic modeling to examine three alternative mechanisms that can potentially incentivize FV purchases among households participating in the Supplemental Nutrition Assistance Program (SNAP). While purchases of FVs by a household are not equivalent to consumption (intake) at the individual level, we assume that a mechanism that increases FV purchases at the household level results in improved FV intakes for at least some members.

Many studies point to substantial underconsumption of FVs relative to recommendations for usual intakes in the Dietary Guidelines for Americans (DGA). For example, using 2007-2010 data from the National Health and Nutrition Examination Survey (NHANES), the National Cancer Institute (NCI) of the U.S. Department of Health and Human Services (HHS) estimated that about three-quarters (75.5 percent) of the U.S. population did not meet recommendations for fruits, and more than four-fifths (87.3 percent) did not meet recommendations for vegetables (Castenson et al., 2015).

Like Americans in general, participants in SNAP are found to have average intakes of FVs that are below recommendations. Using NHANES data for 2001-08 and 1-day dietary recall data for SNAP participants and the Healthy Eating Index (HEI) of USDA's Center for Nutrition Policy and Promotion, Gregory et al. (2013) found that estimated HEI scores averaged about 34 percent (1.685/5.0) for fruit recommendations and about 54 percent (2.696/5.0) for vegetable recommendations. Gregory et al. also report frequencies of HEI scores for whole fruits, with the result that 59 percent of SNAP participants in the sample consumed no whole fruit (in the 1-day dietary recall data).

To incentivize purchases of FVs by SNAP participants, a nutrition intervention could provide an additional program benefit to augment regular SNAP benefits. For this report, the key issue is not the *size* of the additional benefit (although size is important) but whether the *form* of the benefit—in and of itself—affects the purchase of FVs by SNAP consumers.

We develop models of purchasing decisions by SNAP consumers for three different mechanisms (or "forms of the benefit"): a *bonus* for fruit and vegetable spending; a *rebate* for fruit and vegetable spending; and a *Cash Value Voucher* (CVV) that SNAP consumers redeem (at no charge) for fruits and vegetables at food retailers, up to the value of the voucher.[1] The mechanisms differ in terms of how the benefit is calculated and what the benefit can purchase and when (table 1).

Two of the three economic mechanisms have recently been used in SNAP. Many farmers markets that accept SNAP benefits use some version of the bonus model. A study of SNAP-Based Incentive Programs (SBIPs) found that "SBIPs vary in the matching funds they provide; for example, some programs provide a dollar-to-dollar match while others may provide a dollar for every $5 spent at the market on a given market day. Markets that offer a dollar-to-dollar match typically set a limit for such a match (i.e., the match is provided up to $10 or $20 per day)" (King et al., 2014, p. ix). Many such interventions are affiliated with the nonprofit organization Wholesome Wave, which in 2014 conducted its Double Value Coupon program (under various names) at more than 300 farm-to-retail venues in 24 States and the District of Columbia (Wholesome Wave, 2014).

The rebate model provided a basis for the Healthy Incentive Pilot (HIP) that SNAP conducted in western Massachusetts in 2011-12. HIP provided a treatment group of randomly assigned SNAP-participating households a 30-percent rebate to purchase a selected subgroup of FVs called Targeted Fruits and Vegetables (TFVs); a control group of SNAP households did not receive the rebate. To define HIP's set of TFVs that could be given a price incentive, HIP adopted the same set of fruits and vegetables that were then eligible for a WIC fruit and vegetable CVV—fresh, frozen, canned, and dried fruits and vegetables without added sugars, fats, oils, or salt (with some exceptions) (Bartlett et al., 2014, p. 11). About two-thirds (65.6 percent) of SNAP households in the treatment group received a rebate in an average month (during months of full operation of

Table 1
Features of three economic mechanisms

Mechanism (Form of the Benefit)	Calculation of Benefit	Benefit Can Purchase
(Farmers market) bonus	A farmers market provides α dollar's worth of additional benefits for each $1 of SNAP benefits that are committed to purchasing fruits and vegetables at farmers market.	Fruits and vegetables at farmers market even on the same shopping trip.
Rebate	A percentage β of expenditures on fruits and vegetables is reimbursed to the participant immediately after purchase.	Any SNAP-approved foods on the next shopping trip.
Cash Value Voucher (CVV)	Not applicable—each participant receives each month a CVV worth a fixed dollar value.	Fruits and vegetables acquired for free up to fixed dollar value.

SNAP = Supplemental Nutrition Assistance Program.
Source: USDA, Economic Research Service, authors' definitions.

[1]Other strategies that may promote purchase and consumption of fruits and vegetables can involve environmental factors that affect access to or availability of fruits and vegetables (for example, see Centers for Disease Control and Prevention, 2011); the use of nutrition education to change consumer preferences through information messaging, and perhaps exposure to nutritious foods; or principles of behavioral economics to nudge consumers to opt for more nutritious foods through changing choice architecture. These strategies are not examined in the report.

the pilot in March-October 2012) (Bartlett et al., 2014, p. 101). This result means that, in a given month, about one-third (34.4 percent) of the treatment households made no use at all of the opportunity to earn a rebate. One factor that could have affected this finding is that although many food retailers in the region participated in the pilot, not all of them did (Bartlett et al., 2014, p. 108). As a result, some TFV purchases may have been made at nonparticipating retailers without being recorded by the pilot. On the other hand, households in the treatment group had a reason to purchase TFVs at participating retailers, even shifting purchases from nonparticipating retailers, in order to earn the rebate. In the end, we use the estimate of one-third nonusers as indicative of the challenges of trying to incentivize FV purchases in the SNAP population.

The third mechanism, a cash value voucher (CVV) for free FVs up to a set limit, has been used recently in another USDA food assistance program, the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). In October 2009, following recommendations of an expert panel convened by the Institute of Medicine (IOM) of the National Academies of Sciences (Institute of Medicine, 2005), WIC introduced nationwide a CVV for women and children as part of revised WIC food packages.

As we consider a mechanism's theoretical effects on the average SNAP consumer and on different types of SNAP consumers, we have in mind an intervention—perhaps especially a short-term pilot or demonstration—that provides some type of program benefit to SNAP participants in addition to their regular SNAP benefits. Our analysis is not designed to consider a ground-up redesign of SNAP.

We draw on neoclassical economics to provide a unified conceptual framework that highlights key design issues of nutrition interventions based on economic mechanisms. Past and proposed interventions can differ in so many details that it can be daunting to consider how to make comparisons and draw conclusions. The contribution of the economics framework is that it identifies the central features of the mechanisms that affect consumers' purchasing decisions, permitting analysis to focus on those features and to abstract from myriad details. The report's simplified abstract models show that a mechanism's effect on FV purchases depends on how it changes the budget constraint of the SNAP consumer. The economics framework is unifying in the sense that it provides a common approach and a common set of economic principles to show that the different mechanisms have major commonalities as well as important differences.

Each of the three models affects the SNAP consumer's budget constraint by changing relative prices or purchasing power. The CVV model provides additional purchasing power to buy FVs. The bonus model, which can be found implemented at farmers markets, lowers the effective price (post-bonus price) of FVs available at the farmers market. The rebate model also lowers the effective price (post-rebate price) of FVs, although its operational details differ from the bonus model. An actual nutrition intervention can resemble one of the models more or less closely.

We consider three key issues of program design using the models as tools for analysis. One fundamental issue is whether a mechanism has the desired effect on average behavior. That is, can the mechanism be expected to increase FV purchases—not necessarily for all SNAP consumers, but at least on average?

A second issue is distributional. For our modeling purposes, we consider three different "types" of SNAP consumers, distinguished by how many FVs they purchase (in a typical month) before an intervention—no FVs at all, a small amount, or substantial amount. We use the three models to analyze which mechanism tends to increase FV purchases the most among these three types of SNAP consumers. A key message of the report is that focusing exclusively on the average effects of a mechanism can miss important distributional consequences.

Our motivation for giving this attention to distribution stems from two sources of evidence showing that many people, including SNAP participants, purchase few or even no FVs or TFVs. First, Guenther et al. (2014) show that the shortfalls of FV intake are large for most Americans.[2] Second, in a typical month during the HIP, the SNAP households that did not earn any rebate (because they purchased no TFVs in participating retailers) were about one-third of the SNAP households in the treatment group. These SNAP participants arguably need additional FVs the most. The fact that these SNAP participants were not rare cases that totaled just a small percentage of HIP's treatment households, but instead were a sizable subgroup—*one-third* of the treatment households—prompts the analysis of program design issues and their distributional effects. What feature of the rebate mechanism might explain the limited response of the SNAP participants who are arguably most in need of additional FVs? Might a different mechanism hold promise of encouraging them to purchase FVs?

The following sections consider each of the three models in turn and compare the results of each, presenting conclusions and recommendations for the research community based on the study findings.

[2]Guenther et al. (2014) used 2003-04 NHANES data to estimate distributions of Healthy Eating Index (HEI) scores for various components of the index. With component scores ranging from 0 (zero intake) to 5 (consuming the recommended amount or more), the estimated HEI scores at the 25th percentile were 1.2, 0.9, 2.3, and 0.4 for total fruit, whole fruit, total vegetables, and greens and beans, respectively. Thus, at the first quartile, intakes represent less than half (2.5/5.0) of the recommendations for all four components, with intakes for whole fruits and for greens and beans representing just one-fifth (0.9/5.0) or one-tenth (0.4/5.0) of recommendations.

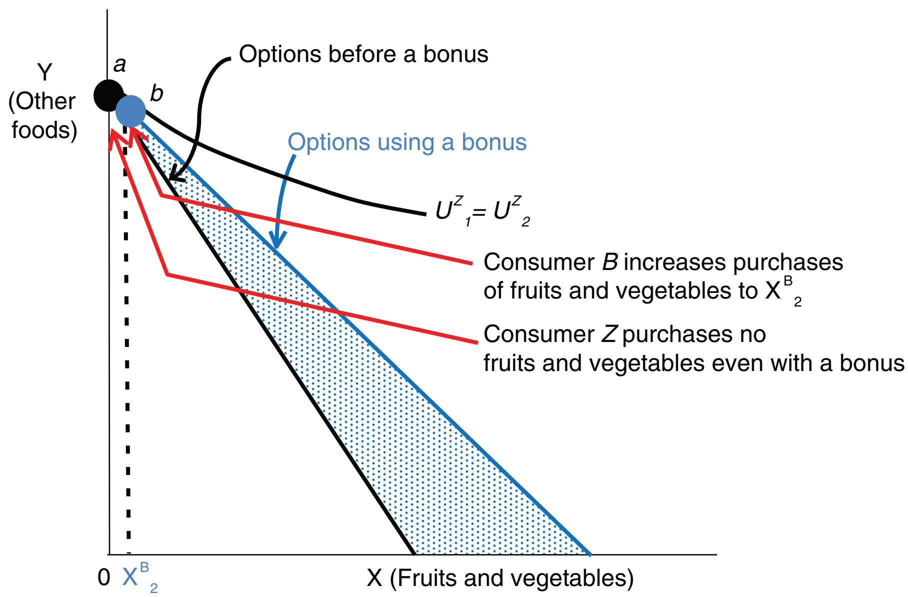
The Bonus Model

In the *bonus model*, a SNAP consumer obtains a bonus or match when using SNAP benefits (not cash) to purchase FVs. At an entrance booth of the farmers market, the SNAP consumer asks the attendant to swipe from the SNAP EBT card an expenditure of E dollars (up to some limit, e.g., $20). The attendant gives the consumer E worth of tokens plus bonus tokens valued at αE, where α is the *bonus rate*. In practice, the most common bonus is a dollar-for-dollar match (or "double bucks"). Programs that offer a bonus for purchasing FVs using SNAP benefits are designed to change consumption by changing relative prices (Finkelstein, 2004).

Figure 1 shows two budget constraints faced by consumers Z (for *Zero*) and B (for *Borderline*), before and after introduction of the bonus; the figure will also prove useful for the rebate model. Here X represents the quantity (measured in cup equivalents) of FVs purchased at the farmers market.[3] The regular farmers market price for X is p_X. Other foods are modeled as a composite good, represented by Y, with a retail price of p_Y.[4] A consumer's *food opportunity set* has combinations of X and Y that can be bought with a given food budget and given p_X and p_Y; the consumer's food budget equals the dollar value of the monthly allotment of SNAP benefits plus the amount of the household's own cash income devoted to food. To focus on the role of diverse preferences, we suppose that consumers Z and B have the same food budgets. The white triangle is the food opportunity set before the intervention. Reflecting weak preferences for X, consumer Z is at the upper corner

Figure 1

A bonus (or rebate) for fruits and vegetables (FVs) can result in no response among some consumers who initially purchase zero FVs



Note: Consumer *Z* and consumer *B* initially purchase no fruits and vegetables in the absence of a bonus.
Once a bonus is available, consumer *B* increases purchases to a positive X^B_2, while consumer *Z* continues to purchase none.
Source: USDA, Economic Research Service.

[3]Cup equivalents are a unit of measure used by the Dietary Guidelines for Americans. We do not suppose that consumers' choices among different fruits and vegetables are based on cup equivalents alone.

[4]In the bonus model, other foods include fruits and vegetables available outside of the farmers market.

at point a, purchasing zero units of X and devoting all of the limited food budget to other foods. Consumer B is also initially at point a.[5]

A bonus decreases the effective price (or net price or post-bonus price) on FVs, rotating the budget constraint so that the food opportunity set now includes the blue area, which allows the consumer to purchase more X, more Y, or more of both; for simplicity, the graph does not show the limit on FV expenditures that earn a bonus. The decrease in the effective price induces consumer B to move from point a to point b, increasing purchases from the initial X^B_1 at zero to a positive X^B_2. However, even after a bonus is available, consumer Z continues to purchase zero FVs and to obtain the same level of utility as before ($U^Z_1 = U^Z_2$, as shown).

A bonus rate, α, refers to the dollar value of FVs that are received for every $1 of SNAP benefits spent at the market, which lowers the effective price (p_X^*) to $p_X^* = p_x/(1+\alpha)$. For example, a "double-bucks" program of a $1 match for each $1 of SNAP benefits represents a bonus rate of $\alpha = 1.0$, which makes the effective price $p_x/2$. The effective price discount (δ) is given by $\delta = \alpha/(1+\alpha)$, which equals 1/2 or a 50-percent discount when $\alpha = 1.0$ under a dollar-for-dollar match, as intuition suggests. A less intuitive example, which shows the usefulness of a formula, is New York City's Health Bucks program, where a SNAP participant receives a bonus of $2 for every $5 spent at a farmers market, resulting in a match rate of 40 percent (2/5) and an effective price discount of about 29 percent [0.4/(1 + 0.4) = 0.286]. Expenditure on X using the SNAP EBT card is equivalent to the SNAP monthly allotment A that is not spent on other foods: $E=A - p_Y Y$. Without a bonus, E can purchase E/p_X worth of X. A bonus supports an additional $\alpha E/p_X$ worth of X, or in total $X = (1+\alpha)E/p_X$. Rearranging that expression and substituting it into the budget constraint shows the model's budget constraint to be $A = [p_X/(1+\alpha)]X + p_Y Y$. We define the effective price of X to be the amount of A that is required—"used up"—by a one-unit increase in X, which is the coefficient of X.[6] The effective price discount δ is defined by $\delta = (p_X - p_X^*)/p_X$ or, equivalently, by $p_X^* = (1-\delta)p_X$, making $\delta = \alpha/(1+\alpha)$ in terms of the bonus rate.

There are qualifications to the mathematical results. That is, a bonus that results in an effective price discount of 50 percent may not be fully equivalent to a simple price discount of 50 percent. A SNAP consumer faces at least three differences between a farmers market that offers double bucks and a second farmers market that simply charges one-half the first market's regular price without offering a bonus. At the first market, which offers a bonus, there is a limit on the SNAP consumer's FV expenditures that can earn a bonus, the SNAP consumer bears a transactions cost in the form of extra trouble to swipe the SNAP EBT card and get the additional tokens, and bonus tokens may be obtainable only in fixed increments of, say, swiping expenditures measured in whole-dollar or $5 increments of SNAP benefits.[7] The second no-bonus market has no limit, no additional transactions cost, and no increment requirements. Other possible differences between an effective price discount and a simple price discount are discussed in the section that examines the second, or rebate, model.

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[5]We consider a month to be the timeframe for examining purchases in the models and their figures. Consumers Z and B, who purchase no fruits and vegetables in the figure, may in fact purchase an apple occasionally over a longer period of a year. Such purchasing behavior is so infrequent that purchases can be treated as zero in a typical month. The Health Incentives Pilot (HIP) found that the prevalence of zero purchases of Targeted Fruits and Vegetables during a month was about one-third of HIP households eligible for a rebate.

[6]Mathematically, the effective prices of X and Y—the amount of SNAP benefits used up by a one-unit increase in X or Y—are obtained from the model's budget constraint as $\partial A/\partial X$ and $\partial A/\partial Y$.

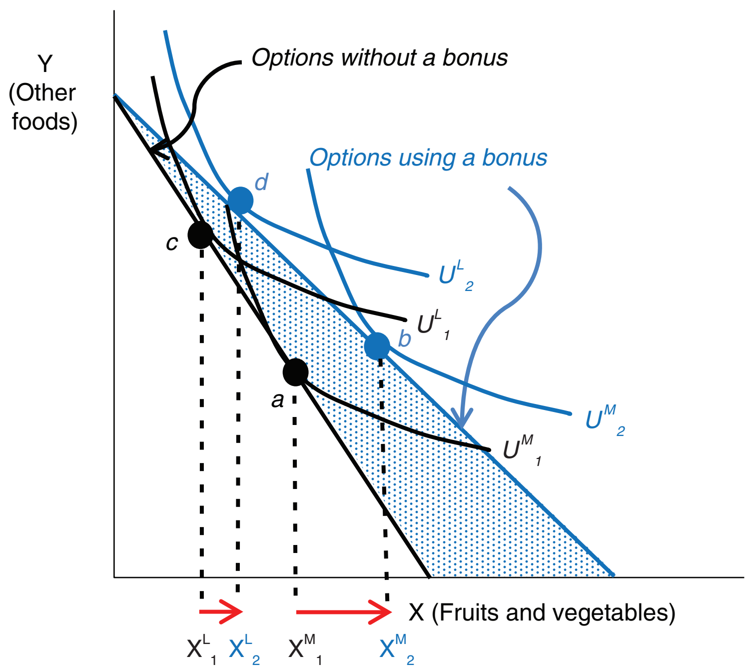
[7]For simplicity, the figure depicted a smooth budget constraint that ignored any increment requirement.

The concept of a reservation price explains the difference in behavior of consumers *Z* and *B*. The consumer's *reservation price* for FVs is a threshold price at which the consumer is on the borderline between making no purchase of *X* and purchasing a positive amount of *X*. If the (effective) price of *X* drops a bit below the threshold of a consumer's reservation price, the consumer makes a purchase. The initial price for FVs before the bonus exceeded the reservation prices for both consumers *Z* and *B*. Once the bonus is available, the effective price drops enough to be below the reservation price for consumer *B* but not enough to be below consumer *Z*'s reservation price.[8]

We next consider the behavior of two other consumers who initially purchase FVs even without a bonus (or rebate), as shown in black in figure 2. Consumers *M* (for *More*) and *L* (for *Less*) have different preferences and purchase different amounts of FVs even when facing an identical budget constraint (in black). Consumer *M* initially purchases X^M_1 at point *a*. When the bonus makes the blue-shaded triangle available, consumer *M* increases FVs to X^M_2 at point *b* and obtains more utility ($U^M_2 > U^M_1$). Consumer *L* initially purchases X^L_1 at point *c* and with the bonus moves to *d*, increasing FV purchases to X^L_2 (with $U^L_2 > U^L_1$).

Figure 2

A bonus (or rebate) for fruit and vegetables (FVs) increases consumption the most for the consumer who already purchases the most FVs



Note: Consumer *M* purchased more fruits and vegetables than consumer *L* before a bonus became available ($X^M_1 > X^L_1$). Consumer *M* responds to the bonus by more than consumer *L*, with the increase from X^M_1 to X^M_2 exceeding the increase from X^L_1 to X^L_2.
Source: USDA, Economic Research Service.

[8]The figure does not show reservation prices, but the model could be used to illustrate a reservation price for either consumer. As p_X is gradually lowered from its initial price, and the budget constraint becomes gradually flatter, the reservation price is that particular threshold p_X at which the consumer moves from zero *X* to purchasing one unit.

To assess the relative size of different consumers' responses to the bonus, we want to compare ΔX_i for *i* = *Zero*, *Borderline*, *Less* and *More*. First, $\Delta X_Z = 0$, which is therefore the smallest. Second, we argue that although ΔX_B is positive, it is likely to be small relative to ΔX_L and ΔX_M. Consumers *L* and *M*—both of whom initially purchase a positive X_i—have additional purchases spurred by the *full* amount of the effective price reduction. In contrast, consumer *B*'s purchases are induced to rise above zero only for that *part* of the price reduction that is below the reservation price.

Third, to make a comparison between ΔX_L and ΔX_M, the model needs additional structure. A consumer's *price elasticity of demand* is the percentage change in the consumer's quantity demanded, X_i, that results from a small change in price, holding constant other factors such as food expenditures.[9] The formula for the (effective) price elasticity can be written as:

$$(1)\quad \varepsilon_i = \frac{\%\Delta X_i}{\%\Delta p_X^*} = \frac{\left(\dfrac{\Delta X_i}{X_i}\right)}{\left(\dfrac{\Delta p_X^*}{p_X^*}\right)}.$$

In applied economics, a predominant model for product demand has a price elasticity that is constant across prices and across consumers. Because the constant-elasticity model of demand has proven to be a simple, yet powerful, specification in many settings, we use it here and draw on an earlier study for an estimate of the price elasticity for FVs among SNAP households.

Yen et al. (2003) estimated a set of price elasticities for SNAP households using data on household food use for 7 days from the National Food Stamp Program Survey (NFSPS) conducted in 1996. Yen et al. examined 13 food categories, including FVs, using three statistical methodologies. The estimated price elasticities for FVs were -0.71, -0.73, and -0.74 (with standard errors of 0.05, 0.04, and 0.05). A price elasticity of -0.73 implies that if the price of FVs decreases (increases) by 10 percent, then purchases will increase (decrease) by approximately 7.3 percent. As a subgroup of FVs, TFVs can be expected to have a price elasticity that is larger (in absolute value) than -0.73, but we retain the -0.73 estimate for illustration.

For specificity, we consider a bonus program offering double bucks and its effective price discount of 50 percent; using a different value would not affect the qualitative result. Rearranging (1), and treating ε_i as a constant -0.73 across prices and incomes (the constant-elasticity specification for product demand) and across SNAP consumers, the percentage increase in FVs is about 37 percent:

$$(2)\quad \left(\frac{\Delta X_i}{X_i}\right) = \varepsilon_i \left(\frac{\Delta p_X^*}{p_X^*}\right) = -0.73(-0.50) = 0.37.$$

Rearranging (2) gives the quantitative result:

$$(3)\quad \Delta X_i = (0.37)X_i.$$

[9]Strictly speaking, we are considering changes in the effective price p_X* due to a change in the bonus, rather than a change in the retail price p_X. A small change in (effective) price can be considered to be a change of 1 percent.

In equation (3), each consumer's increase in FV purchases (ΔX_i)is simply proportionate to that consumer's initial FV purchases (X_i)—a larger X_i results in a larger ΔX_i where ΔX_i is simply 37 percent of X_i. As a result, because $X_M > X_L$, consumer *M* is *more* responsive to the effective price discount than consumer *L* when response is measured in cup equivalents, that is, $\Delta X_M > \Delta X_L$ as shown in the figure.[10] At the same time, both consumers have the *same* response to the discount when response is measured in percentage terms (as in equation (2)) rather than in absolute terms (of cup equivalents, as in (3)). In fact, it is the equality in the *percentage increases*—both consumers increase purchases by 37 percent—that forces the (absolute) *increases* ΔX_i (in cup equivalents) to differ. When a baby elephant and a baby squirrel each gain 37 percent of weight, the baby elephant gains more weight measured absolutely in pounds.

Assembling results, we find that $\Delta X_Z < \Delta X_B < \Delta X_L < \Delta X_M$. Consumers *Z* and *B* respond by relatively little or not at all to the intervention (depending on their reservation prices). Consumer *M* purchased the most X_i before the bonus, and it turns out to be *M* who responds the most, exhibiting the largest ΔX_i (in cup equivalents).

[10]Even though the constant-elasticity specification is a predominant model for product demand in applied economics, it is not the only model. If instead the relatively rare linear model of demand is used with constant slopes (and consumer-specific intercepts), the prediction would be that consumers *L* and *M* increase their FV purchases by an equal absolute amount rather than an equal percentage amount. Even under linear demand, consumer *Z* increases FV purchases by none and consumer *B* by less than consumers *L* and *M*, leaving our comparisons for *Z* and *B* unchanged from the results for the constant-elasticity case.

The Rebate Model

In the *rebate model*, a SNAP consumer receives a price incentive in the form of an addition to the consumer's electronic SNAP benefits at checkout at a grocery store. The SNAP consumer receives some fraction, β, worth of additional SNAP benefits for every $1 of SNAP benefits used to purchase FVs, where $0 < \beta < 1$.[11] We use the term "rebate" to refer to these additional SNAP benefits even though a rebate is typically received in cash—here, the key feature of a rebate is that the benefit is received after the purchase. Once earned, the rebate can be used for any SNAP-allowed foods (not just FVs). We do not consider an upper limit on the amount of FVs that can earn a rebate, though this could easily be added to the model.

A rebate expands the food opportunity set because a given food budget is enabled to purchase more FVs, more of other foods, or more of both. A rebate, like a bonus, lowers the effective price of *X*. The diagrams in figures 1 and 2 for the bonus model also illustrate the rebate model. Other results from the bonus model also carry over to the rebate model (e.g., whether a consumer who purchases no FVs responds to the rebate depends on whether the effective price drops below the reservation price).

Although a rebate and a bonus each lowers the effective price, the two models have slightly different formulas for the effective price. In the rebate model, the budget constraint for spending a SNAP allocation *A* is given by $A = (1 - \beta)p_x X + p_Y Y$; the appendix shows the derivation of that result. The rebate rate β lowers the effective price to $p_X{}^* = (1 - \beta)p_x$, with an associated effective price discount of $\delta = \beta$. For example, a rebate of 30 cents for each dollar of SNAP benefits spent on *X* results in an effective price of $(1\text{-}0.30)p_x$ or $0.70p_x$.

There are qualifications to the mathematical results. That is, a rebate rate of 0.30 for each $1 spent on FVs may not be fully equivalent to a simple 30-percent price discount off the regular posted retail price. One difference involves the time at which the rebate and the discount can be used. A rebate is added at checkout after paying for the trip's purchases. To spend that rebate, the SNAP consumer must go through the checkout line a second time (which can be assumed to be on a return trip). In contrast, a simple price discount occurs the first time the consumer goes through checkout, with no waiting needed. Whether this difference creates any behavioral effects depends on the SNAP consumer. If the SNAP consumer would make the same number of trips to the store anyway, regardless of whether the consumer has a rebate or a price discount available, then the difference in timing has no effect on the consumer. However, for a SNAP consumer who would prefer to make one shopping trip for the month, it can make a difference whether a rebate or a simple price discount is available. On the other hand, a rebate may be simpler to manage for SNAP benefit delivery.

Klerman et al. (2014) discuss four additional reasons why in HIP the rebate (called a "price incentive" in HIP) might not have been fully equivalent to a simple price discount: there may be a difference in how SNAP households make purchasing decisions using SNAP benefits or cash; to earn a rebate, SNAP households had to purchase HIP's Targeted Fruits and Vegetables (TFVs) at retailers that were participating in the pilot; HIP participants may have had an imperfect understanding of the

[11]The Healthy Incentive Pilot (HIP) is an intervention that was based on a version of the rebate model. In HIP, the rebate could be earned for purchases of Targeted Fruits and Vegetables (TFVs), which did not include all fruits and vegetables (FVs). For the model, we abstract from the difference between TFVs and FVs and simply consider all FV purchases eligible for the rebate.

rebate program and how to earn a rebate; and HIP participants received HIP materials that explained the program and marketed TFVs, while a simple price discount does not carry implicit marketing.[12] Despite these differences, and abstracting from them, Klerman et al. (2014, p. 1,377) state, "Under HIP, the net price of incremental TFV purchases falls by 30 percent, which is the size of the HIP incentive." For our purposes, we too consider the rebate rate (of, say, 30 percent) to be the same as a discount in the effective (net) price.

At the baseline of the pilot, HIP used a modified version of the Eating at America's Table Study (EATS) Fruit and Vegetable Screener to ask sampled participants about their consumption over the prior month of nine common foods containing fruits and vegetables. From the screener's data, HIP calculated usual intakes and a binary measure of whether a participant consumed at least three servings per day of fruits and vegetables (before HIP). In considering possible responses from different subgroups of HIP participants, the HIP final report stated, "… larger impacts might be expected among those individuals who already eat and enjoy fruits and vegetables because they may be more responsive to opportunities to increase their intake" (Bartlett et al., 2014, p. 157). That statement is consistent with our outline above of how those consumers who have the largest initial X_i before an intervention can be expected to have the largest increase ΔX_i during the intervention (when receiving a bonus or rebate). Yet another possibility—one that we did not consider above—is that HIP changes the underlying preferences of consumers: "Alternatively, if HIP succeeds in shifting attitudes and preferences towards fruits and vegetables, larger impacts might be expected among those who started off with lower levels of intake or weaker preferences for fruits and vegetables, since those individuals have more room to improve" (Bartlett et al., 2014, p. 157).

Turning to empirical results, higher baseline fruit and vegetable intake (at least three servings per day) did have a positive effect on the impact of the HIP, but that effect was not statistically significant. It could be that the finding was statistically insignificant due to the roughness of the screener-based measure, which the HIP report deemed to be a "relatively noisy measure" of intake compared to a 24-hour dietary recall interview (Bartlett et al., 2014, p. 157). Despite that noisiness, though, HIP was found to have a larger impact on TFV intake among the subgroup of HIP participants with predicted TFV spending above the median at baseline, compared to the subgroup with below-median predicted TFV spending (Bartlett, 2014, p. 158). That finding is consistent with our expectation that those who already spent the most on TFVs respond most strongly to the rebate. Another finding from HIP was that the impact of HIP was increased by the HIP participants' positive attitudes about fruits and vegetables at baseline.

[12]These factors, or variations on them, may also make response to a farmers market bonus nonequivalent to a numerically equal discount in the regular price.

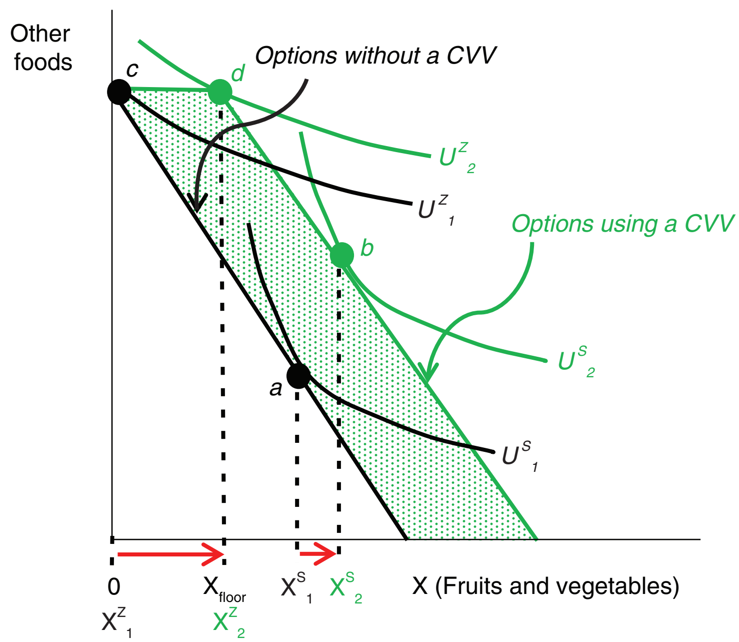
The Cash Value Voucher (CVV) Model

In the *Cash Value Voucher (CVV) model*, a SNAP consumer receives (at no cost to the participant) a CVV worth a stated dollar value of FVs.[13] The consumer can purchase more FVs than are covered by the CVV, but then the extra is paid for by cash or regular SNAP benefits.

The budget constraint before and after a CVV becomes available is shown in figure 3. In the absence of a CVV, when the food opportunity set is the white triangle, consumer *S* (for *Some*) purchases $X^S_1 > 0$ at point *a*, while consumer *Z* (for *Zero*) purchases no FVs at point *c*. The CVV provides a cash value of *V* dollars' worth of FVs. The number of cup equivalents of FVs that can be purchased using the CVV (X_{floor}) is $X_{floor} = V/p_X$. The CVV moves the food opportunity set's boundary horizontally to the right by the amount X_{floor} to include the green-shaded area.

Figure 3

A Cash Value Voucher (CVV) increases purchases of fruits and vegetables (FVs), and the response is largest among consumers who initially purchased no FVs



Note: Consumer *S* purchased a positive amount of fruits and vegetables, and consumer *Z* purchased none before the Cash Value Voucher (CVV) became available, that is, $X^S_1 > 0$ and $X^Z_1 = 0$. Consumer *Z* responds to the intervention by increasing purchases to X_{floor}—the full amount of *X* for which the CVV can be redeemed. Consumer *S* purchased X_{floor} worth of fruits and vegetables using the CVV, partially reducing purchases out of cash or SNAP benefits, resulting in a net increase in purchases from X^S_1 to X^S_2 that is only a fraction of X_{floor}.
Source: USDA, Economic Research Service.

[13]The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) introduced Cash Value Vouchers (CVVs) nationwide in October 2009. CVVs could be redeemed for WIC's Targeted Fruits and Vegetables (TFVs), a subset of fruits and vegetables (FVs). In the CVV model, we do not consider the difference between TFVs and FVs and treat all FVs to be eligible for the CVV.

Using the CVV, consumer *S* moves from point *a* to *b*, increasing purchases from X^S_1 to X^S_2 (and obtaining $U^S_2 > U^S_1$), under the assumption that both *X* and *Y* are normal goods.[14] The increase from X^S_1 to X^S_2 is not as large as X_{floor}, which requires explanation. A CVV cannot be used to purchase other foods directly. Therefore, consumer *S* used the full CVV to take ("accept") all the FVs obtainable for free. However, at the same time, consumer *S* partially reduced the amount of cash or regular SNAP benefits devoted to FVs, using the CVV to make up that difference. The net effect of the CVV on consumer *S* is to increase FV purchases, but by less than X_{floor}, and to increase purchases of other foods. Consumer *S* pays for the extra purchases of other foods using the cash or regular SNAP benefits that were "freed up" by using the CVV to purchase the FVs that were free. The assumption that FVs are a normal good means that at least some of the CVV value is used to add to the net purchase of FVs. That is, the consumer does not reduce cash-based purchases of FVs dollar-for-dollar when receiving the CVV and ends up with no net increase in FVs. The assumption that other foods are a normal good means the consumer does not use the CVV to purchase FVs alone.

For consumer *S*, who is obtaining more than X_{floor} at *b*, the relative price of FVs has not changed from what it was prior to the CVV (the segment of the budget constraint at *b* is parallel to the initial constraint). While the consumer would gladly accept an unlimited amount of FVs for free, once the consumer obtains X_{floor} for free using the CVV, the consumer must pay full price on the margin to obtain additional FVs. Consumer *S* is willing to do so, and ends up at *b*.

The net increase in FV purchases by consumer *S* is less than the increase by consumers *Z* and *B*. Unlike consumer *S*, consumers *Z* and *B* are unable to cut back on their non-CVV purchases of FVs to free-up cash or SNAP benefits to buy more other foods—consumers *Z* and *B* had bought zero FVs in the first place. Thus, unlike consumer *S*, their purchases of FVs increase by the full amount of the CVV. With the CVV, consumers *Z* and *B* still spend no cash or regular SNAP benefits on FVs, moving from point *c* to *d* and purchasing X_{floor} worth of FVs. Thus, each consumer purchases at least X_{floor}—hence the term "floor" for that quantity.

The CVV is a powerful policy instrument for prompting consumer *Z* to obtain every cup equivalent of FVs that can be purchased using the CVV. There is an intuitive explanation. Up to X_{floor}, the effective price to the consumer for each unit of *X* is literally zero—the consumer receives FVs for free. However, once consumer *Z* reaches *d*, the consumer must pay the full retail price p_X to obtain any additional units of *X*. Consumer *Z* increases FV purchases from zero to X_{floor}, but not beyond.

Some other consumers (not shown in the diagram) may initially purchase more than zero FVs but less than X_{floor}. One consumer who initially purchases close to zero FVs may partly resemble consumers *Z* and *B* by ending up at point *d*, but the resemblance is not complete because this consumer's net increase in FV purchases is a little less than X_{floor} (since the starting point was a little above zero). Another consumer who initially purchases close to X_{floor} may move to the downward-sloping segment of the budget constraint a little below point *d*.

We consider two reasons why, contrary to the model, a consumer might not spend all *V* dollars' worth of a CVV. First, neoclassical economics recognizes that a consumer may have a *satiation point*. Such a point occurs when a consumer obtains so many units of *X* that the consumer does not

[14]The term "normal goods" refers to how purchases of a good typically, or normally, increases when the budget constraint is relaxed by an increase in income while relative prices are unchanged.

want to consume any more (per month) even when *X* is available for free. The larger the amount of FVs that a CVV provides, the more likely some consumers reach satiation.[15] Second, it can be difficult in practice for a consumer to select a set of FVs that cost exactly the value of the CVV. If so, then a consumer who wants to spend no cash at all on FVs may leave some portion of the CVV unspent to ensure that the cost of the FVs does not exceed the value of the CVV.

For the CVV model, we find that $\Delta X_M < X_{floor}$ (when considering net purchases) and $\Delta X_Z = X_{floor}$ (apart from satiation and exact-spending issues). Thus, consumers who were purchasing no FVs respond more strongly to a CVV than do consumers who already purchased the CVV-worth of FVs. Some other consumer (not in the diagram) may initially purchase a few FVs, say X_{few}, and use the CVV to obtain free FVs and, like consumer *Z*, move to point *d*; the increase in purchases is (X_{floor} - X_{few}), which can be nearly as large as X_{floor}. Thus, when the form of the benefit is a CVV, the intervention's increase in *X* tends to be larger for the consumers who purchase no or few FVs than for other consumers.

[15]Alternatively, if food is shareable with friends or pets or has other uses, people may accept free food that they do not intend to eat themselves. People who place low personal value on cash value vouchers might also offer them for resale on a black market.

Comparisons of Economic Mechanisms

The analysis of the models shows that all three mechanisms have the desired effect of increasing average FV purchases. That is, they increase FV purchases at least for some SNAP consumers and, therefore, for the average SNAP consumer. The remainder of this section compares the mechanisms using a distributional perspective on FV purchases.

A rebate and a bonus differ largely because a bonus is received up front (before making FV purchases), while a rebate is received at checkout (once FV purchases have been paid for on that shopping trip), to be used at a later time. Each mechanism creates an incentive for FV purchases by lowering the effective price of FVs. For example, a rebate rate of 50 percent reduces the effective price of FVs by 50 percent—the same reduction that occurs with a double-bucks version of the bonus model. From here on, we focus on the rebate model, treating the bonus and rebate mechanisms as essentially equivalent for our purposes (apart from their different mathematical formulas based on the bonus rate α and the rebate rate β).

The rebate and the CVV mechanisms each have particular strengths and limitations. A strength of a rebate is that it operates by reducing the effective price of FVs. That reduction provides a strong incentive for purchasing FVs because SNAP consumers obtain the benefit only when they do so.

A limitation of a rebate is that SNAP consumers who respond the most are the ones who already purchase FVs. Consumers *M* and *L*, who initially purchase FVs, respond to the rebate more strongly than consumers *Z* and *B*. The latter pair of SNAP consumers initially purchase no FVs and have relatively limited responses, if any, to a rebate. Under a rebate, a SNAP consumer must still pay some amount of SNAP benefits to obtain any FVs, and the effective price may drop only a little below the reservation price (for consumer *B*) or still exceed the reservation price (for consumer *Z*). In addition, assuming that consumers will increase purchases proportionately (or even in rough proportion) to their initial purchase patterns, then consumer *M* responds more strongly than consumer *L*.

A strength of the CVV is that it lowers the effective price to zero for consumers who normally purchase no FVs. The CVV incentivizes them to increase FV purchases by the full amount of the CVV, and consumers who initially purchase a few FVs increase net purchases of FVs by nearly as much.

A limitation of the CVV becomes apparent for consumers like *S* who already purchase the amount of FVs that a CVV is worth. Given that FVs and other foods are normal goods, the consumer obtains free FVs using the CVV and uses some amount of freed-up cash or SNAP benefits to increase purchases of other foods as well. In the end, while the CVV is "fully spent" on FVs, the net purchases of FVs (after reducing cash spent on FVs) increase, but by just a fraction of what a CVV is worth.

The results discussed thus far, including the discussion of strengths and limitations of the mechanisms, were based on comparing different consumers in relation to each separate mechanism. We next compare results between a rebate and a CVV.

Which mechanism—rebate or CVV—can be expected to have a relatively large effect on FV purchases for a given consumer? The answer is, it depends. Intuition suggests that the effects on FV purchases of a CVV would be relatively large if, for instance, the CVV were worth an enormous $90 per month and the rebate were a paltry 1 percent. Intuition also suggests the ranking of the effects on FV purchases would be reversed if the CVV were worth only $1 per month and the rebate were 90 percent. Thus, when the amount of a rebate and a CVV are allowed to vary with no restrictions, results become ambiguous: either a CVV or a rebate can have a larger effect on FV purchases, depending on the size of the benefit.

For comparing the models, we achieve a more helpful analysis by imposing the condition that some factors are held constant in the comparison—in particular, the size of the benefit. We do so by supposing that an intervention has a fixed budget for providing additional benefits. That is, whether an additional benefit is provided in the form of a rebate or a CVV, the total cost to the Government is the same. In the conceptual comparison of the two mechanisms, the equal-cost condition provides the additional structure for isolating the effect of the *form* of the benefit, keeping it from being confounded with the effect of the *size* of the benefit. Neither a rebate nor a CVV is inherently a more costly mechanism than the other; the cost of a rebate mechanism increases as the rebate rate β increases, just as the cost of a CVV increases as the CVV value V increases. For simplicity, we assume that all of the program budget becomes allocated to additional benefits to participants, which sets aside the issue of whether administrative cost is the same under the different mechanisms.

Before considering numerous different SNAP consumers, we first examine a simple case in which the intervention serves just one consumer, using a small fixed-program-budget F. We focus on consumer S, who initially purchases more FVs than the CVV is worth. The key result is that consumer S increases FV purchases by *more* using a rebate than by using a CVV. Specifically, for consumer S, the effects on FV purchases are:

- *Large* using the rebate. The lower effective price from the rebate is a powerful incentive for consumer S to increase purchases of FVs by a relatively *large* amount; even though the consumer directs some of the savings afforded by the decrease in the effective price of FVs towards other goods, that effect is relatively small.

- *Small* using the CVV. When receiving a CVV (which must be fully spent on FVs), consumer S simultaneously reduces cash or SNAP benefits previously spent on FVs to increase spending on other foods by a relatively large amount, resulting in a relatively *small* net increase in FV purchases.

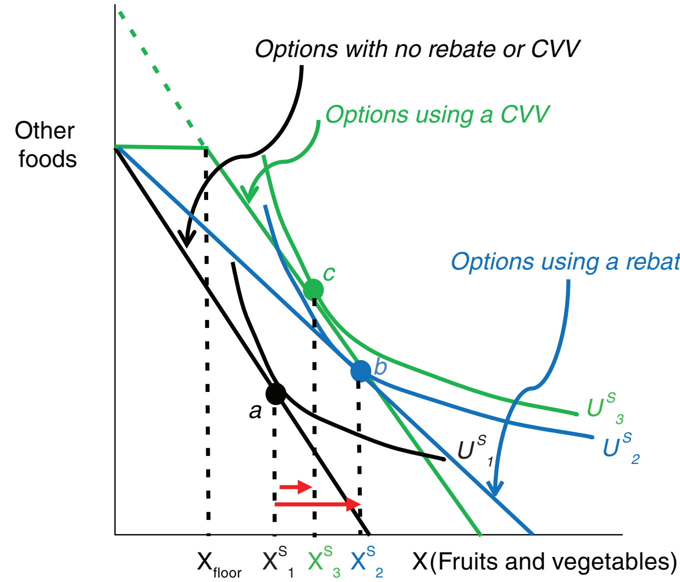
This result may at first be counterintuitive because the equal-cost condition, by which the *Government* spends the same under either mechanism, may suggest that the *consumer* spends the same under either mechanism. However, equal program costs do not imply equal program outcomes. After a demonstration of this result, we provide an explanation and interpretation in terms of the economic concepts of income and substitution effects.

To demonstrate the result, we suppose that initially, in the absence of a rebate or a CVV, the food options available for consumer S are bounded by the food budget constraint given by $B = p_X X + p_Y Y$ for food budget B, as shown in black in figure 4 in panel (a), which pertains to the scenario in which the intervention serves consumer S alone. The consumer initially chooses point a, purchasing X^S_I. Next, if the intervention were to use a very small rebate rate, the consumer would not purchase enough FVs for the rebate to exhaust the program budget F.

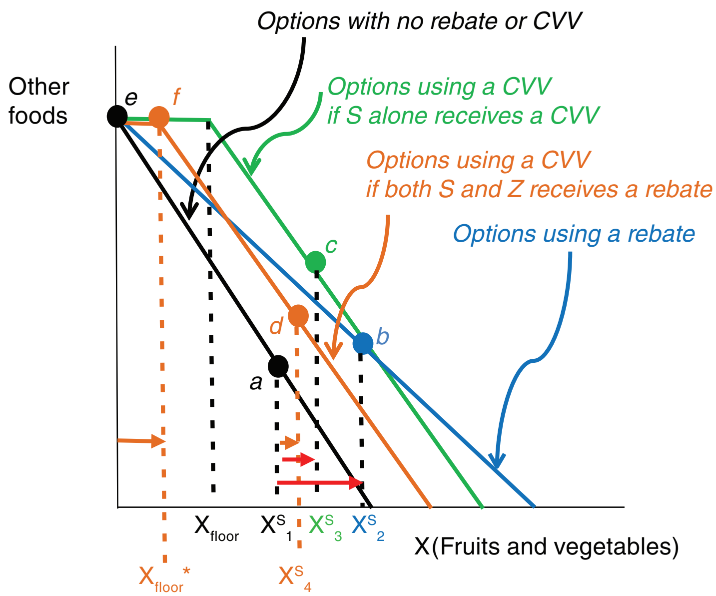
Figure 4

A rebate for consumer *S* can increase purchases of fruits and vegetables by more than a Cash Value Voucher (CVV) when each intervention has an equal program cost

(a) The intervention serves consumer *S* alone



(b) The intervention serves both consumers *S* and *Z*



Note for panel (a): Consumer *S* initially purchases X^S_1, a positive amount of fruits and vegetables (FVs) that exceeds X_{floor}—the full amount of *X* for which the Cash Value Voucher (CVV) can be redeemed. A rebate increases purchases by the relatively large amount from X^S_1 to X^S_2. A CVV with a value that equals the cost of the rebate to the program provides X_{floor}, after which the consumer pays full retail price for FVs. With a CVV instead of a rebate, consumer *S* purchases X^S_3. The increase from X^S_1 to X^S_3 is smaller than the increase from X^S_1 to X^S_2, showing that consumer *S* responds more strongly to a rebate than to a CVV when each intervention has the same cost to the program and consumer *S* is the only consumer.

Note for panel (b): When both consumer *S* and *Z* are present, a rebate has the same effects on consumer *S* as when consumer *S* is alone because consumer *Z* purchases no *X* under a rebate. The fixed program budget must be divided to provide two Cash Value Vouchers (CVVs), giving a value only half as large as when consumer *S* alone received a CVV. Using the CVV, consumer *Z* increases purchases from zero to X_{floor}*, exceeding the increase for consumer *S* from X^S_1 to X^S_4, which is a fraction of X_{floor}*. When both consumers are served by the intervention, at equal program cost, consumer *S* responds more strongly to a rebate than to a CVV: the rebate's increase from X^S_1 to X^S_2 exceeds the increase from X^S_1 to X^S_3 when consumer *S* alone received a CVV, which, in turn, exceeds the increase from X^S_1 to X^S_4 when CVVs are provided to two consumers.

Source: USDA, Economic Research Service.

So suppose the intervention sets β to be high enough, and the resulting *X* high enough, for the rebate to fully use the program budget, making

(4) $F = \beta(p_X X^S{}_2)$

where $X^S{}_2$ is the quantity of FVs purchased when the consumer receives a rebate. The rebate's blue budget constraint is less steep than the initial black budget constraint because the rebate lowers the effective price for FVs. The consumer's chosen point *b* provides the maximum possible utility under the rebate at $U^S{}_2$. As expected, $X^S{}_2 > X^S{}_1$ due to the lower effective price from the rebate.

Now suppose that, instead of a rebate, the same program budget *F* is provided to consumer *S* as a CVV with value $V = F$. The quantity of FVs provided by this CVV is $X_{floor} = V/p_X = F/p_X$. The available food options using a CVV are the trapezoid bordered by the horizontal and downward-sloping line segments in green. The downward-sloping green segment has the same retail prices as the initial black constraint, making them parallel.

The technical issue is to show that the CVV's green constraint and the rebate's blue constraint both pass through point *b*. The two constraints have different slopes at *b* because the prices that consumer *S* faces for purchasing FVs differ under two mechanisms—the CVV requires the full retail p_X to purchase FVs at *b* (or at any level exceeding X_{floor}), while the rebate requires a lower effective price $(1\text{-}\beta)p_X$. Two lines with different slopes intersect at a single point.

The equation for the rebate's constraint is $B = (1\text{-}\beta)p_X X + p_Y Y$. Because *b* was the consumer's chosen point on that constraint, evaluating that constraint's equation at $(X^S{}_2, Y^S{}_2)$ means that:

(5) $B = (1\text{-}\beta)p_X X^S{}_2 + p_Y Y^S{}_2$.

The equation for a second line that passes through *b*, but has a slope based on initial prices, is:

(6) $B + U = p_X X^S{}_2 + p_Y Y^S{}_2$

where the location of this line, as set by its intercept, is based on some unknown value *U*, to be determined. That value *U* must be added to *B* to shift the initial (black) constraint parallel outward so that the new (green) constraint passes through *b*. On the condition that both this new constraint and the rebate's blue constraint pass through *b*, then (5) can be subtracted from (6), which gives:

(7) $U = \beta p_X X^S{}_2$.

Using equations (7) and (4), the result follows that $U = F$ because they both equal $\beta(p_X X^S{}_2)$. This result means, first, that if consumer *S* faced initial prices and was given an amount of cash *F* (in addition to initial resources *B*), the constraint $B + F = p_X X + p_Y Y$ would pass through *b*. Second, the result also means that if consumer *S* faced initial prices and was given—instead of cash—a CVV valued at *F* (in addition to initial resources *B*), the CVV's constraint would also pass through *b*. The difference between receiving a CVV and receiving cash is that a CVV provides X_{floor} (equaling F/p_X), while a consumer who receives cash could purchase less *X* than X_{floor} in order to obtain additional *Y*. The figure reflects that difference: the CVV's green budget constraint has a horizontal line segment at the top of the trapezoid, while the dashed green line shows additional food options available from cash that are not available from the CVV. In the end, the constraint for consumer *S* passes through point *b* whether the consumer receives cash valued at *F* or a CVV valued at *F*.

We now reach our key result: that consumer *S* increases FV purchases more by using a rebate than by using a CVV. While the utility-maximizing choice under the rebate is at *b*, the utility-maximizing choice under the CVV is at point *c*, which lies to the left of *b*. Thus, $X^S{}_3$ under the CVV is strictly less than $X^S{}_2$ under the rebate. Both a CVV and rebate increase FV purchases compared to the initial scenario for consumer *S*. However, the rebate increases FV purchases from $X^S{}_1$ to $X^S{}_2$ (the long red arrow), which is more than the increase under the CVV from $X^S{}_1$ to $X^S{}_3$ (the short red arrow).

In terms of economic principles, the stronger response by consumer *S* to a rebate compared to a CVV can be interpreted using the concepts of a substitution effect and an income effect. While the CVV increases purchases of FVs through an income effect, a rebate increases purchases of FVs through both an income effect and a substitution effect. When added together, the rebate's income and substitution effects result in a larger increase in FV purchases than the CVV's income effect alone.[16]

We note that, in panel (a) of figure 4, the consumer's utility under the CVV, at $U^S{}_3$, exceeds the consumer's utility under the rebate, at $U^S{}_2$. That is, for a given cost to the Government program, a CVV enhances utility by more than a rebate. Because a CVV gives *more* utility than a rebate (under the *equal-cost* condition), a CVV that gives the *equal* utility as a rebate ($U^S{}_2$) must cost the program *less* than the rebate. An analogous result was demonstrated by Aaron and von Furstenberg (1971) for the case of housing; we have adapted the result to our case of promoting FV purchases. Economists often focus on outcomes involving utility, which relates to the economic concept of efficiency. However, our focus has been on which mechanism increases purchases of FVs the most (for a fixed budget) rather than on which one increases utility the most.[17]

We continue by next supposing that in addition to consumer *S* the intervention serves consumer *Z*. Initially, consumer *Z* purchases zero *X*, devoting all of the food budget to other foods at point *e* on the black budget constraint in the figure's panel (b), which pertains to the case in which the intervention serves both consumers *S* and *Z*; panel (b) replicates much of panel (a), but omits the consumer *S* indifference curves to simplify the illustration. Even when an intervention makes a rebate available, *Z* still purchases zero *X*; the effective price for *X*, which requires some out-of-pocket expenditures, remains above the reservation price for consumer *Z*. Under the rebate mechanism, the intervention's fixed budget *F* is used up entirely by consumer *S,* who chooses point *b* (as was the case above when consumer *Z* was not part of the analysis).

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[16]A price change can be decomposed into income and substitution effects using either the approach of Hicks (who held utility constant) or the approach of Slutsky (who held constant the bundle of goods that can be purchased before and after a price change). Strictly speaking, the figure depicts the Slutsky approach for a price increase from the rebate's effective price to the higher full retail price (rather than a price decrease), in which case the consumer moves from *b* to *a*, with the Slutsky substitution effect represented as the move from *b* to *c* and the Slutsky income effect represented as the move from *c* to *a*.

[17]In addition to Aaron and von Furstenberg (1971), a second basis for our comparison of the rebate and the Cash Value Voucher (CVV) for consumer *S* is a detailed analysis of taxation provided by Musgrave and Musgrave (1980). They compare an excise tax on good *X*, which increases the post-tax price of *X* to the consumer, and a general tax on both goods *X* and *Y*, which increases the prices of both goods but leaves relative prices unchanged; a general tax is akin to a decrease in income while holding prices constant. In order to isolate the effects of the *form* of the tax, as opposed to the *size* of the tax, Musgrave and Musgrave suppose that the Government raises the same given level of tax revenue from the consumer using either form of tax. Our analysis is symmetrical to the work in Musgrave and Musgrave because, first, a rebate acts like a negative excise tax and, second, for consumer *S* a CVV functions like an increase in income while holding prices constant. Musgrave and Musgrave conclude that, under the condition of equal tax revenues, the consumer purchases less of good *X* when facing the excise tax than when facing the general tax. Our symmetrical conclusion is that, under the condition of equal program cost, consumer *S* purchases more fruits and vegetables under a rebate than under a CVV.

A substantial change in the CVV's constraint occurs when a CVV is issued to both *S* and *Z* rather than to *S* alone. Now the fixed budget *F* must provide two CVVs instead of just one, making the CVV's value $V = F/2$ and cutting the amount of *X* provided by the CVV to X_{floor}* (in orange in panel (b))—exactly one-half of the X_{floor} (in black) when consumer *S* was the only participant. The CVV's budget constraint when both *S* and *Z* receive a CVV is shown in orange. When a CVV is available, consumer *Z* moves from *e* to point *f*, acquiring X_{floor}*.

To summarize, the key result for consumer *Z* is that the effects on FV purchases are

- *zero* using the rebate, because consumers still must pay something,
- *large* using the CVV, because it makes FVs free (up to a limit at X_{floor}*).

The sense in which the effects of a CVV are large on consumer Z is that the consumer's net purchases of X increase fully by the amount X_{floor}* provided by the CVV.

Several points are important for consumer *S* in the scenario with two consumers in the intervention. The first two results are familiar from results obtained above. First, consumer *S* increases net purchases (compared to the initial $X^S{}_1$) by some fraction of X_{floor}*, moving from $X^S{}_1$ at *a* to $X^S{}_4$ at point *d* (the short orange arrow). Second, a comparison of responses shows that consumer *S* increases *X* by less than consumer *Z,* for whom net purchases increase by the full amount X_{floor}* (the long orange arrow).

Third, when the intervention serves both consumers *S* and *Z*, the increase in *X* for consumer *S* from $X^S{}_1$ to $X^S{}_4$ (*a* to *d*) is smaller than the increase in *X* from $X^S{}_1$ to $X^S{}_3$ (*a* to *c*) when the intervention served consumer *S* alone. The increase $X^S{}_1$ to $X^S{}_4$ is smaller because now the CVV is worth only half as much when the fixed budget *F* must be split with consumer Z for two CVVs. If there were two *Z*-type consumers in ratio to the one *S*-type consumer, then the fixed budget *F* would have to provide three CVVs, each with a value equal to *F*/3.

Fourth, consumer *S* increases purchases of *X* by less under a CVV than under a rebate. This last result is, in some sense, the same result found above when *S* was the only consumer—but the result is even stronger when the intervention serves both consumers. When consumer *S* was the only consumer, the rebate resulted in an increase from $X^S{}_1$ to $X^S{}_2$ (*a* to *b*) and the CVV resulted in a (smaller) increase from $X^S{}_1$ to $X^S{}_3$ (*a* to *c*). Now, with both consumers present, the rebate still results in a move from *a* to *b* for consumer *S* (because consumer *Z* uses none of the rebate), but the CVV results in an increase only from $X^S{}_1$ to $X^S{}_4$ (*a* to *d*). Altogether, there are now two reasons why consumer *S* purchases less under a CVV than under a rebate:

(1) The income effect *a*-to-*c* (for a CVV worth F) is smaller than the combined income effect *a*-to-*c* and substitution effect *c*-to-*b* (under a rebate); and

(2) The income effect *a*-to-*d* for a CVV worth *F*/2 is even smaller than the income effect *a*-to-*c* for a CVV worth *F.*

Thus, when the intervention serves both types of consumers, a rebate increases FV purchases the most for consumer *S*, who already purchases the most; consumer *S*'s increase *a*-to-*b* exceeds consumer *Z*'s increase of zero. Under the equal-cost condition, a CVV increases FV purchases the most for consumer *Z,* who initially purchases no FVs; consumer *Z*'s increase from zero to X_{floor}* exceeds consumer *S*'s increase *a*-to-*d*—a fraction of X_{floor}*. These results for a comparison across mechanisms are in concordance with the results that would be expected from results in previous sections, but they rest on the condition that the rebate and the CVV each have the same program cost (in addition to other assumptions discussed earlier).

We now consider how the mechanism that can increase average FV purchases the most (under the equal-cost condition) depends in part on the mix of SNAP consumers, as measured by the proportion of all SNAP consumers who belong to the subgroup of *Z*-type consumers who purchase no FVs. We suppose there is a large population of *N* SNAP households, with a program budget *F* that is scaled up to some correspondingly large amount (versus the program budget available for just one or two consumers). The proportion of *Z*-type consumers varies across cases. The figure can be generalized. Panel (a), which was developed for the case of a single *S*-type consumer, is just as applicable when all *N* SNAP households are *S*-type consumers (i.e., when the proportion of *Z*-type consumers is zero). Panel (b) is applicable for a population of *N* SNAP households when *Z*-type consumers and *S*-type consumers are each 50 percent of the population. If the proportion of *Z*-type consumers is very small, a rebate may increase average FV purchases by more than a CVV because most consumers behave like consumer *S*. However, as the subgroup of *Z*-type consumers becomes a larger proportion of the SNAP population, the distributional advantage of a CVV becomes more important. If the proportion of the subgroup of *Z*-type consumers equals or exceeds some critical size, a CVV can increase FV purchases by more than a rebate.

Conclusions

A critical issue of nutrition and health is how best to incentivize SNAP participants to increase purchases of FVs. A simple premise of the report was that SNAP participants vary in the consumption of FVs.

A key message of the report is that focusing exclusively on average effects of a nutrition intervention can miss important distributional consequences. Who benefits from an intervention and by how much are important factors in assessing different economic mechanisms for promoting FVs. The form of the benefit can have effects on the distribution of consumers' FV purchases and, relatedly, the distribution of FV consumption and of health benefits.

We reviewed three economic mechanisms, or forms of the benefit, that SNAP could use for an intervention that provides an additional benefit, augmenting regular SNAP benefits. The models are useful because, based on neoclassical economics, they provide a unified conceptual framework for understanding how each form of the benefit affects the purchasing decisions of different types of SNAP consumers. Moreover, a model is useful at the design stage of an intervention to help select sample size and calibrate the size of the policy change.

A rebate and a bonus are similar because each lowers the effective price of FVs. Consumers who already purchase many FVs respond to the lower effective price by buying even more FVs. Consumers who initially purchase no FVs may respond by little, if any, to a rebate or bonus because they still have to pay something to use those mechanisms. In contrast, for the consumers who initially purchase no FVs, a CVV increases FV purchases substantially, by the full amount of the CVV (assuming these consumers consider FVs to be a normal good). While these consumers may be hesitant about purchasing FVs using a bonus or rebate, they respond strongly when a CVV makes FVs free of cost (up to some limit). Consumers who already purchase the CVV's worth of FVs also acquire all the free FVs they can obtain, but they simultaneously use the CVV to free up some of their cash or SNAP benefits to purchase other foods. In the end, their net FV purchases increase by less than the amount obtained with the CVV. To compare effects across mechanisms, we assumed that the funding for an intervention was provided entirely as benefits to participants, which set aside the issue of whether administrative costs are the same under the different mechanisms.

Among the SNAP households in HIP's treatment group that could obtain a rebate, about one-third earned no rebate (bought no qualifying FVs) in a typical month. A subgroup of that size points to a potential difference between the distributional effects of the rebate and CVV mechanisms.

A CVV holds promise for increasing nutrition and health among the SNAP population. First, as we have argued, a CVV is the mechanism that increases purchases the most among SNAP consumers who purchase no FVs. Second, people who consume no FVs are likely to benefit the most in health terms from additional consumption of FVs, due to diminishing returns.[18] Together, these two factors suggest that a CVV may increase nutrition and health among the SNAP population by more than a rebate, even if a rebate increases average consumption of FVs by more than a CVV.

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[18]Here, the term *diminishing returns* refers to how health improves as consumption of FVs increases, yet each additional increment of consumption results in health improvements that become smaller and smaller, perhaps even reaching a plateau.

We considered the effects of each of the mechanisms on purchases of FVs and, to a lesser extent, on consumption of FVs and the implied nutrition and health effects. If, instead, other outcomes were considered, then assessments of the mechanisms' strengths and limitations could differ from our conclusions. Two outcomes that are particularly important in many economic analyses are: (a) utility (or subjective well-being) from the perspective of a program participant, and (b) Pareto optimality—a condition under which the utility of one person cannot be increased without diminishing the utility of another person. Consideration of these outcomes can tilt an economist's recommendation away from CVVs and towards rebates or bonuses.[19] However, utility and Pareto optimality are not the only outcomes relevant for programmatic analyses. We chose to focus on nutrition-related outcomes such as FV purchases, FV consumption, and the associated health outcomes inasmuch as underconsumption of FVs among the SNAP population is the condition that motivated the report.

To evaluate and compare different mechanisms in actual practice for the same set of SNAP participants, a pilot could be developed that would compare them using a randomized control trial. Such an intervention would generate valuable empirical evidence on the different mechanisms, complementing this report's methodology of comparisons that used simplified economic models. We used economic models to show that, in principle, the form of a benefit is an important consideration in designing an intervention (though not to the exclusion of other factors, such as administrative complexity and public support).

Finally, a mechanism never operates in isolation. Its effects can depend on the characteristics of the target population and on the full array of policies experienced by that population. A pilot that compares two mechanisms for SNAP participants may obtain results that differ from a pilot comparing the same two mechanisms for another set of households (e.g., WIC participants or households with children who receive free or reduced-price school meals). We do not conclude that the form of the benefit is the only program-design feature that matters. We do conclude it can be one consideration, among many, when developing proposals or designing interventions to promote purchases and consumption of FVs among low-income Americans.

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[19]Relatedly, an economist who focuses on utility and Pareto optimality might recommend providing cash assistance. Conventionally, providing a pure cash benefit would increase utility of the consumer more than providing, say, a Cash Value Voucher of equal dollar value. However, our concern is how to design an intervention that increases FV purchases or nutrition and health the most—not necessarily one that most increases the utility of the consumer.

References

Aaron, Henry J., and George M. von Furstenberg. June 1971. "The Inefficiency of Transfers in Kind: The Case of Housing Assistance," *Economic Inquiry* 9(2):184-91. http://onlinelibrary.wiley.com/doi/10.1111/j.1465-7295.1971.tb01631.x/abstract

Bartlett, Susan, Jacob Klerman, Lauren Olsho, Christopher Logan, Michelle Blocklin, Marianne Beauregard, Ayesha Enver, Park Wilde, Cheryl Owens, and Margaret Melhem. September 2014. *Evaluation of the Healthy Incentives Pilot (HIP): Final Report*. Prepared by Abt Associates for the U.S. Dept. of Agriculture, Food and Nutrition Service. http://www.fns.usda.gov/sites/default/files/HIP-Final.pdf

Castenson, Dave, Kevin W. Dodd, Susan M. Krebs-Smith, Ruth Parsons, and Jill Reedy. 2015. *Usual Dietary Intakes: Food Intakes, U.S. Population, 2007-10*. Epidemiology Research Program Web site, National Cancer Institute. http://epi.grants.cancer.gov/diet/usualintakes/pop/2007-10/. Updated May 20, 2015.

Centers for Disease Control and Prevention. 2011. *Strategies to Prevent Obesity and Other Chronic Diseases: The CDC Guide to Strategies to Increase the Consumption of Fruits and Vegetables.* Atlanta: U.S. Department of Health and Human Services. https://www.cdc.gov/obesity/downloads/fandv_2011_web_tag508.pdf

Finkelstein, Eric, Simone French, Jayachandran N. Variyam, and Pamela S. Haines. 2004. "Pros and Cons of Proposed Interventions to Promote Healthy Eating," *American Journal of Preventive Medicine 27*(3S):163-71. http://www.sciencedirect.com/science/article/pii/S0749379704001722#

Gregory, Christian, Michelle Ver Ploeg, Margaret Andrews, and Alisha Coleman-Jensen. 2013. *Supplemental Nutrition Assistance Program (SNAP) Participation Leads to Modest Changes in Diet Quality,* ERR 147. U.S. Dept. of Agriculture, Economic Research Service. http://www.ers.usda.gov/publications/err-economic-research-report/err147.aspx

Institute of Medicine of the National Academies, Food and Nutrition Board, Committee to Review the WIC Food Packages. 2005. *WIC Food Packages: Time for a Change*. Washington, DC: National Academies Press. https://www.iom.edu/Reports/2005/WIC-Food-Packages-Time-for-a-Change.aspx

King, Melissa, Sujata Dixit-Joshi, Keith MacAllum, Michael Stiketee, and Stephen Leard. 2014. *Farmers Market Incentive Provider Study*. Prepared by Westat, Inc. for the U.S. Dept. of Agriculture, Food and Nutrition Service. http://www.fns.usda.gov/sites/default/files/FarmersMarketPriceIncentiveProvider.pdf

Klerman, Jacob A., Susan Bartlett, Parke Wilde, and Lauren Olsho. September 2014. "The Short-Run Impact of the Healthy Incentives Pilot Program on Fruit and Vegetable Intake," *American Journal of Agricultural Economics* 96(5):1372-82. http://ajae.oxfordjournals.org/content/96/5/1372.full.pdf+html

Musgrave, Richard A., and Peggy b. Musgrave. 1980. *Public Finance in Theory and Practice*, 3rd edition. New York: McGraw-Hill.

Wholesome Wave. 2014. *Wholesome Wave's Double Value CVV Program*. http://www.wholesomewave.

Yen, Stephen T., Biing-Hwan Lin, and David M. Smallwood. May 2003. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States," *American Journal of Agricultural Economics* 85(2): 458-78. http://www.jstor.org/stable/1245141

Appendix

The dynamics of the budget constraint in a rebate model

The heart of the rebate model involves the dynamics of purchasing fruits and vegetables and of earning rebates across multiple shopping trips within a month and, potentially, across months.

We suppose that at the start of an initial month, the SNAP consumer receives an allotment of SNAP benefits A that can be spent on fruits and vegetables (X) or on other foods (Y) or, in accordance with SNAP rules, carried over to be spent in future months; for simplicity, we ignore the use of cash.[20] Using SNAP benefits to purchase X on any one shopping trip earns a rebate, which is added to the consumer's SNAP benefits. Then on the next trip that rebate (or a portion of it) can be spent on X, earning additional rebate that, in turn, can be spent on a successive trip to earn a bit more rebate, etc.

To capture the essence of a dynamic budget constraint and to avoid considering an infinite number of shopping trips, we suppose that the consumer plans to spend A and its succession of rebates across some number of trips T, where T can be thought of as any number, large or small, as long as it is finite. On the last trip T, the last bit of the initial allotment A and all rebates received are fully spent. From that initial month's allotment, no X is purchased on trip T, or else there would be more rebate available for yet another trip, contradicting that T is the last trip. Whether the T shopping trips occur within 1 month or across months is up to the consumer.[21]

On the first shopping trip, the month's allotment A can be purchase X or Y or saved in part for the second trip:

$$(A1)\, A = p_X X_1 + p_Y Y_1 + S_1$$

where the subscript "1" refers to items purchased on the first shopping trip and some dollar amount S_1 of SNAP benefits is saved for the second trip. An entire set of dynamic equations is shown in (A2), beginning with the second trip in the top equation. As shown on the left-hand side of that top equation in (A2), the amount of SNAP benefits available for the second trip is S_1 (saved from the first trip) plus the amount received from the rebate, which for concreteness we suppose to equal 0.30 times the expenditures $p_X X_1$ made on the first trip; a rebate rate other than 0.30 would be easy to use instead. As shown on the right-hand side of the top equation, the SNAP benefits available for the second trip can be used to purchase X_2 or Y_2 or saved as S_2 for a following trip. The sequence of constraints for spending, saving, and earning rebates up to the last trip T is:

[20] If cash were included in the model, the resulting budget constraint would have two "kinked" segments with different slopes reflecting different prices. On one segment, when X is purchased with SNAP benefits and a rebate is earned, the effective price of X (derived below) is relatively low. On the second segment, once all SNAP benefits are fully devoted to X and cash is used to purchase additional X, the effective price of X becomes the retail price p_X.

[21] Before trip T, additional SNAP allotments may be received, but we trace the spending pattern only from the first month's allotment; the allotment from a month following the initial allotment can be used to purchase X on trip T.

$$
\begin{aligned}
(A2)\, S_1 + 0.30(p_X X_1) &= p_X X_2 + p_Y Y_2 + S_2 \\
S_2 + 0.30(p_X X_2) &= p_X X_3 + p_Y Y_3 + S_3 \\
&\vdots \\
S_{t-1} + 0.30(p_X X_{t-1}) &= p_X X_t + p_Y Y_t + S_t \\
&\vdots \\
S_{T-2} + 0.30(p_X X_{T-2}) &= p_X X_{T-1} + p_Y Y_{T-1} + S_{T-1} \\
S_{T-1} + 0.30(p_X X_{T-1}) &= p_Y Y_T
\end{aligned}
$$

Note that in the bottom equation for shopping trip *T*, all remainSing SNAP benefits are spent on *Y*—none is spent on *X* or saved because *T* is the last trip.

Equation (A1) and the set of equations in (A2) can be combined into a single overall budget constraint for all the shopping trips. The bottom equation in (A2) for trip *T* is substituted into its predecessor for trip *T-1* by re-expressing it in terms of S_{T-1} (subtracting $0.30(p_X X_{T-1})$ from each side) and then substituting in place of S_{T-1} in the next-higher equation for trip *T-1.* The process of recursive substitution can then be repeated using the equations for *T-1* and *T-2*, etc. The combined budget constraint is given by:

$$
\begin{aligned}
(A3)\, A &= (1-0.30)\, p_X X_1 + (1-0.30)\, p_X X_2 + \cdots + (1-0.30)\, p_X X_{T-1} \\
&\quad + p_Y Y_1 + p_X Y_2 + \cdots + p_Y Y_T \\
&= 0.70 p_X \left[X_1 + X_2 + \cdots + p_X X_{T-1}\right] + p_Y \left[Y_1 + Y_2 + \cdots + Y_T\right]
\end{aligned}
$$

The combined budget constraint in equation (A3) shows how expenditures on *X* and *Y* across all *T* trips must total up to *A*. Facing that constraint, the SNAP consumer chooses a time pattern of the most preferred quantities $\{X_t, Y_t\}$ t=1,2,…*T*. The combined budget constraint shows that a one-unit increase in Y_t always requires p_Y (whether *Y* is purchased on the first trip or any trip up to *T*). When *X* is purchased (on the first trip or any trip up to *T*-1), the effective price p_X* is (1-0.30) p_X or $0.70p_X$. This key result shows that, taking the rebate into account, a one-unit increase in purchasing good X_t uses up only $0.70p_X$ worth of SNAP benefits.

For succinctness, (A3) could be rewritten as:

$$(A4)\, A = 0.70 p_X X + p_Y Y$$

where, here, *X* and *Y* represent the sums of all the *X* and all the *Y* purchased on the separate trips.

More generally, the budget constraint becomes

$$(A5)\, A = (1-\beta)\, p_X X + p_Y Y.$$