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# Additionality Violations in Payment for Ecosystem Service Programs: Experimental Evidence

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**Abstract**: Payment for ecosystem service (PES) programs incentivize farmers to implement agricultural best management practices (BMPs) with the goal of reducing nutrient and sediment runoff and improving water quality. These programs are widespread at both the federal and state level. Because some farmers adopt BMPs even in the absence of PES programs, it is natural to question the extent to which BMPs adopted by program participants are additional to the counterfactual scenario of no program. I test the assumption of perfect program additionality for a variety of subsidy programs in an experimental setting using a variant of the common public good game. I find that a large proportion of enrollments are not additional, as much as 100% for some subsidy programs. Further, I identify two sources through which additionality is violated: the pay-for-nothing (P4N) effect, in which the subsidy pays for a practice that would be done without incentives, and behavioral substitution, in which the subsidy generates substitution from an unincentivized BMP to the incentivized one, and quantify each effect for a series of subsidy regimes. I find that subsidies for "good" BMPs are largely ineffective, especially when a "great" BMP option is also available.

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Engaging in pro-social behavior provides its own reward. However, in many instances this reward is not sufficient to generate the level of pro-social behavior desired by policymakers, economists, and other stakeholders. In the parlance of economics, pro-social behaviors (e.g. giving blood, land conservation, volunteerism, adopting agricultural best management practices (BMPs), donating to charities or public goods, etc.), generate positive externalities. While intrinsic and social rewards increase pro-social behavior, these behaviors will be under-provided as long as the relevant positive externalities are greater than their associated rewards.

Basic economic theory dictates that additional monetary incentives will encourage more of the incentivized behavior. The apparent policy recommendation would thus be to subsidize pro-social behavior. While this truism (more incentives lead to more of a behavior) holds in domains where the predominant reward for action is already monetary, it is often violated when dealing with pro-social behaviors (Benabou and Tirole 2005; Gneezy *et al.* 2011). If pro-social behaviors are largely intrinsically motivated and the introduction or increase of monetary rewards decreases intrinsic motivation, monetary incentives may fail to increase or even decrease pro-social behavior. This phenomenon has been given many labels and studied by both social psychologists and economists. It has been called motivation crowding-out (Frey and Jegen 2000), the hidden cost of reward (Lepper and Greene 1987), overjustification (Lepper, Greene and Nisbett 1973), and the corruption effect (Deci 1975).

While the theoretical and empirical framework herein can be applied to many diverse pro-social behaviors, this paper focuses on the adoption of agricultural best management practices (BMPs) that increase the delivery of ecosystem services. The adoption of BMPs can improve ecosystem functioning through multiple channels, from reducing nutrient runoff into the watershed to encouraging bacterial biodiversity in the soil to reducing greenhouse gas emissions.

Even in instances where subsidies lead to a net increase pro-social behavior, crowding-out and other inefficiencies may exist. In the context of agricultural payment for ecosystem service (PES) programs, environmental scientists and environmental economists discuss this phenomenon using the concept of "additionality." If a program achieves perfect additionality, all payments generate new positive changes. For instance, the USDA's Conservation Reserve Program (CRP) and Environmental Quality Incentives Program EQIP) achieve perfect additionality if none of the practices they finance would have occurred in the absence of the programs. Claassen et al. (2013) examine several PES programs and find that 13-46% of payments were non-additional, meaning they purchased practices that would have occurred without monetary compensation. In this context, violation of the additionality assumption implies crowding out of the pro-social behavior.

This effect, referred hereafter as the "Pay-for-Nothing" (P4N) effect, is one channel through which additionality may be violated, but it is not the only one. Indeed, Pay-for-Nothing behavior is largely distinct from the crowding out observed in much of the social psychology literature. In a series of studies, Alpizar *et al.* (2013a and 2013b) use lab and field experiments to examine what they call "behavioral leakage" that occurs from targeted PES programs. They find that increased adoption in the targeted group is accompanied by decreased adoption in the excluded group. This type of behavioral leakage, behavioral crowding-out (BCO), leads to a violation of additionality even in the absence of a P4N effect because the net impact on ecosystem services is less than what would be predicted if the only impact of the program was to increase BMP adoption among those offered the subsidy.

In addition, there is another form of behavioral leakage best described as behavioral substitution (BS). In a world where many BMPs may be adopted, incentivizing the adoption of one BMP may reduce the adoption of another BMP. For example, a farmer with a comprehensive nutrient management plan may increase nutrient use or switch from conservation tillage to conventional tillage after being incentivized to implement a separate BMP, like installing a field-edge filter strip. Like BCO, BS leads to violations of perfect additionality even in the absence of the P4N effect.

This research presents the first attempt to empirically separate and estimate the magnitude of the P4N effect and both behavioral leakage effects, and in doing so identify the degree to which perfect additionality is violated under a variety of subsidy regimes. The context examined is of voluntary enrollment into a subsidy program for BMPs which mirrors currently utilized agricultural PES programs like CRP and EQIP, but the findings reflect a phenomenon that is likely present for all manner of policies using financial incentives to encourage pro-social behaviors. The data, collected using economics lab experiments, demonstrate that all three effects likely contribute to additionality violations. The relative magnitude of these effects varies based on the specifics of the subsidy policy. Additionally, different policies lead to large differences in net benefits per capita and the degree to which assuming perfect additionality overstate the true benefits of the subsidy. In particular, low subsidies of practices that deliver only modest benefits are the most problematic policies. These policies can deliver zero or even negative benefits relative to a counterfactual without any subsidy program.

## Data

The data were collected using lab experiments of undergraduates at East Carolina University. In each session, 25 subjects play a “public bad” game. Subjects are split into groups of five, with group membership being anonymous and group composition changing in each round of the game. Each round involves subjects choosing from a list of three “technology” options. Each technology offers a “yield” value, which represents the private benefits of the technology, and a “runoff” value, which captures the group costs of the technology. The technologies are given generic names (Technology 1, 2 and 3) in the experiment but for exposition purposes will be referred to as Traditional, BMP1, and BMP2, respectively. The Traditional (BMP2) technology has the highest (lowest) value for both yield and runoff. In each period, the subjects receive profit equal to their yield minus the sum of all runoff values for members of the group. Profit is denominated in tokens that are exchanged for dollars at the end of the experiment. Screenshots of the experiment are provided in Figure 1.

A total of 225 subjects were recruited over nine sessions. In six of the sessions, each technology was mutually exclusive, meaning subjects could only choose on option. In the remaining three sessions, this restriction was relaxed and subjects could choose Traditional, BMP1, BMP2 or both BMPs. In all sessions, the option that minimized runoff (BMP2 for the mutually exclusive sample, both BMPs for the other sample) was the “socially optimal” choice by virtue of maximizing total group tokens, while the Traditional technology is the dominant strategy for each subject but also generates the fewest group tokens. Each session consisted of a practice round, used to familiarize subjects with the experiment and omitted from the analysis, and 21 incentivized rounds. In all sessions, the first incentivized round was a “baseline” treatment, meaning there was no subsidy policy in place. The final 20 rounds were broken into five-round treatment blocks. Treatment order was varied by session to control for order and learning effects. The full experimental design is outlined in Table 1.

In addition to the baseline treatment, four subsidy regimes were used. They form a 2x2 matrix of subsidy size (full or half subsidy) and subsidy target (BMP1 or BMP2). Full subsidies increase the subjects' profit when they choose the target BMP so that the subsidized BMP weakly dominates the Traditional option.[1] The structure of half subsidies is equivalent to that of full subsidies but subsidy payments are diminished by half. The size of the full subsidy is 10 tokens for BMP1 and 20 tokens for BMP2. Conditions were varied by session to allow for each subsidy regime to be presented in three different contexts. In addition to the mutually exclusive technology context, there were two mutually inclusive technology contexts, full enrollment and stochastic enrollment. Under full enrollment, subjects are informed that there are enough funds available to enroll all interested parties in the subsidy program. Under stochastic enrollment, subjects are informed "The government has limited funds available, so it may not be able to enroll all interested parties." Subjects who elect to enroll in the subsidy program are randomly assigned to either they success group (who are then asked whether they wish to adopt the subsidized BMP or both BMPs) or the fail group (who are told they were not able to receive the subsidy and were given the full set of technologies to choose from). All mutually exclusive sessions were full enrollment.

Each subject received a \$10 show-up fee and additional incentives based on one round of the experiment. These variable incentive payments ranged from \$3.50 to \$26. The average payment (show-up fee plus additional incentives) made to subjects was \$24.27.

## Model

Agents in the model choose among three technology options. Each technology $t$ chosen by agent $i$ generates yield $Y_{it}$, where $t \in \{\text{TRAD}; \text{BMP1}; \text{BMP2}\}$. Agents exist in groups of $N$

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[1] When choosing between the Traditional technology and a BMP with the full subsidy, personal profit is equal and group profit is greater under the BMP. This is referred to as weakly dominant because subjects will be indifferent between the two options if they have no other-regarding preferences and will prefer the subsidized BMP option if they have positive other-regarding preferences.

individuals, and each technology generates a cost, $N^*X_{it}$, which is equally distributed among members of the group. As such, this cost can be separated into private cost ($X_{it}$) and external cost ($[N-1]^*X_{it}$). Individual profit ($w_{it}$) and group profit ($W$) when agent $i$ chooses technology $t$ are given by the following equations:

$$w_{it} = Y_{it} - \sum_{k=1}^{N} X_{kt}, \tag{1}$$

$$W = \sum_{k=1}^{N} w_{kt} = \sum_{k=1}^{N} Y_{kt} - N^*\sum_{k=1}^{N} X_{kt}. \tag{2}$$

In the experiment, yield and costs are specified such that BMP technologies decrease individual profit and increase group welfare according to the following relationships:

$$Y_{iTRAD} > Y_{iBMP1} > Y_{iBMP2} \tag{3a}$$

$$X_{iTRAD} > X_{iBMP1} > X_{iBMP2} \tag{3b}$$

$$N^*(X_{iTRAD} - X_{iBMP1}) > Y_{iTRAD} - Y_{iBMP1} > X_{iTRAD} - X_{iBMP1} \tag{3c}$$

$$N^*(X_{iBMP1} - X_{iBMP2}) > Y_{iBMP1} - Y_{iBMP2} > X_{iBMP1} - X_{iBMP2} \tag{3d}$$

Agent $i$'s utility is defined as a weighted combination of individual and group profit:

$$U_i\ (X_{it}, Y_{it}; \boldsymbol{X}_{-i}, \boldsymbol{Y}_{-i}) = \alpha_i w_{it} + (1 - \alpha_i)W, \tag{4}$$

where $\boldsymbol{X}_{-i}$ and $\boldsymbol{Y}_{-i}$ are vectors of yield and cost values selected by all agents in the group besides agent $i$ and $\alpha_i \in (0,1)$ reflects agent $i$'s utility weight placed on personal profit relative to other-regarding preferences.

Next, consider a policy maker with the objective of maximizing group profit. The marginal social benefit of an agent switching from the Traditional technology to technology $t$ is given by

$$MB_t = N^*(X_{TRAD} - X_t) - (Y_{TRAD} - Y_t). \tag{5}$$

Given the relationships outlined in equations (3a-d), it is possible to offer a subsidy of either BMP option that a) increases group profit even after netting out the cost of subsidy payments and

b) equalizes individual profit gained from the subsidized BMP and Traditional technologies. The subsidy necessary to equalize individual profit for a switch from the TRAD to technology t is equal to $Y_{iTRAD} - Y_{it} - (X_{iTRAD} - X_{it})$, which from equation (3c) must be less than the increase in group profit from such a switch, given by $N^*(X_{iTRAD} - X_{it})$.

*Program Effects with and without Perfect Additionality*

I now define several concepts that are useful for evaluating the efficiency of a subsidy program and compare how various subsidy programs perform under different assumptions regarding program additionality.

> *Perfect Program Additionality*: All individuals who enroll in the subsidy program would otherwise choose the Traditional technology.

Under the assumption of perfect program additionality, the per-capita benefits from a subsidy of technology *t* are given by $EN_t * MB_t$, where $EN_t$ is the proportion of agents who enroll in the subsidy program. The cost of the program is given by $EN_t * SUB_t$, where $SUB_t$ is the size of the subsidy. Lastly, I define two measures of program effectiveness, the benefit/cost ratio (*B/C*) and net benefits per capita (*NB/Cap*):

$$B/C = \frac{MB_t}{SUB_t}, \tag{6}$$

$$NB/Cap = EN_t * [MB_t - SUB_t]. \tag{7}$$

Relaxing the assumption of perfect program additionality allows for both the Pay-for-Nothing and behavioral substitution effects. Determining the per capita benefits from a subsidy without assuming perfect additionality requires four additional pieces of information: the proportion of agents who choose BMP1 and BMP2 when the subsidy of technology $t$ is in place ($BMP1_t$ and $BMP2_t$, respectively) and the proportion of agents who choose BMP1 and BMP2 in a baseline counterfactual scenario without the subsidy program ($BMP1_{BASE}$ and $BMP2_{BASE}$, respectively). Following the With-Without principle of program evaluation, the per-capita benefits from a subsidy of technology $t$ are given by

$$MB_{BMP1}*[BMP1_t - BMP1_{BASE}] + MB_{BMP2}*[BMP2_t - BMP2_{BASE}], \tag{8}$$

where $MB_{BMP1}$ and $MB_{BMP2}$ are the marginal social benefits of choosing BMP1 and BMP2, respectively, as specified in equation (5). From this, it follows that the benefit/cost ratio ($B/C$) and net benefits per capita ($NB/Cap$) of the subsidy program are

$$B/C = \frac{MB_{BMP1}*[BMP1_t - BMP1_{BASE}] + MB_{BMP2}*[BMP2_t - BMP2_{BASE}]}{EN_t*SUB_t} \tag{9}$$

$$\begin{aligned} NB/Cap = {} & MB_{BMP1}*[BMP1_t - BMP1_{BASE}] + \\ & MB_{BMP2}*[BMP2_t - BMP2_{BASE}] - EN_t*SUB_t \end{aligned} \tag{10}$$

Using the above definitions of per-capita program benefits with and without PA, it is possible to decompose the benefits under PA into the true effect, the P4N effect, and the BS effect. A general form of this decomposition is given by:

$$EN_{BMP1}*MB_{BMP1} + EN_{BMP2}*MB_{BMP2} = \tag{11a}$$
$$MB_{BMP1}*[BMP1_t - BMP1_{BASE}] + MB_{BMP2}*[BMP2_t - BMP2_{BASE}] + \tag{11b}$$
$$MB_{BMP1}*[EN_{BMP1} - (BMP1_t - BMP1_{BASE})] + \tag{11c}$$
$$MB_{BMP2}*[EN_{BMP2} - (BMP2_t - BMP2_{BASE})] \tag{11d}$$

Here, expression (11a) is the program benefits with PA and (11b) is the true effect. If BMP1 is the recipient of the subsidy (i.e., $EN_{BMP2} = 0$), then expression (11c) captures the Pay-for-

Nothing effect and expression (11d) captures the behavioral substitution effect. If BMP2 is the recipient of the subsidy (i.e., $EN_{BMP1} = 0$), then expression (11c) captures the behavioral substitution effect and expression (11d) captures the Pay-for-Nothing effect.

Figure 2 illustrates how program benefits are defined for a subsidy of BMP1. The top panel shows benefits assuming PA. No Pay-for-Nothing or behavioral substitution effects are presented as these would be violations of program additionality. In the figure, the area A + B represents benefits attributed to the subsidy program. In the bottom panel, which allows for violations of PA, the area B + C – D is attributed to the subsidy program. This area represents the net change in BMP adoption for both the subsidized and unsubsidized BMPs multiplied by their respective marginal benefits. Further, the areas corresponding to the Pay-for-Nothing and behavioral substitution effects are A – C and D, respectively. The behavioral substitution effect represents the change in adoption of the unsubsidized BMP multiplied by the marginal benefit of said BMP. The Pay-for-Nothing effect is defined as the subsidized benefits that would occur even in the absence of the subsidy program and can be found by taking the total benefits from enrollees (A + B) and subtracting the true BMP1 benefits from the program (B + C), leaving the misattributed benefits (A – C).

### *Hypotheses*

In all sessions, the marginal impact of switching technologies on personal and group profit (measured in tokens) was held constant. Specifically, A switch from TRAD to BMP1 (BMP2) resulted in a 10 (20) token decrease in runoff and a 20 (40) token decrease in yield. Table 2 outlines the marginal effects (PA and true) of enrollment in a subsidy program under a series of counterfactuals. Additionally, the table identifies the size of the residual PA benefits

(benefits incorrectly attributed to the subsidy program under the PA assumption) and specifies when the residual is designated as Pay-for-Nothing and behavioral substitution effects.

Using this framework, several predictions can be made about the relationships between PA benefits, true program effects, and the pay-for-nothing and behavioral substitution effects.

> *Hypothesis 1*: Behavioral substitution effects will be more pronounced for BMP1 subsidies than for BMP2 subsidies. Conversely, Pay-for-Nothing effects will be more pronounced for BMP2 subsidies than for BMP1 subsidies.

Both subsidies will likely generate behavioral substitution, which occurs when enrollees switch from the unsubsidized BMP to the subsidized BMP. However, Table YY demonstrates that the gap between perceived program benefits under PA and true benefits is larger under a BMP1 subsidy than under a BMP2 subsidy. Likewise, both subsidy programs will likely generate residual PA benefits due to the Pay-for-Nothing effect, but conditional on the Pay-for-Nothing effect explaining an enrollment, the residual PA benefits under a BMP2 subsidy are larger than those under a BMP1 subsidy. These results are by no means mathematical certainties; if, for instance, nobody adopts BMP2 in the baseline condition, there will be no behavioral substitution effect for BMP1 subsidies. What is certain is each individual who engages in behavioral substitution under the BMP1 subsidy generates twice as many misattributed benefits as an individual who engages in Pay-for-Nothing behavior under the same subsidy. As a result, behavioral substitution will be responsible for the majority of misattributed benefits unless the number of individuals engaging in Pay-for-Nothing behavior is at least double the number of behavioral substitution individuals. The converse is true for BMP2 subsidies; unless at least twice as many individuals engage in behavioral substitution compared with Pay-for-Nothing behavior, the majority of misattributed benefits will be due to Pay-for-Nothing.

> *Hypothesis 2*: Behavioral Substitution effects will be more pronounced when technology options are mutually exclusive.

When BMP options are mutually inclusive, choosing both BMPs allows subjects to collect the subsidy selecting the subsidized BMP while still avoiding any behavioral substitution effects. This strategy is not available when BMPs are mutually exclusive; choosing the incentivized BMP must generate a behavioral substitution effect if the subject chose the unsubsidized BMP in the counterfactual condition.

## Results

### *Descriptive Statistics*

All four subsidy programs predictably spur program enrollment. Enrollment is significantly higher with full subsidies than with half subsidies,[2] and there is some evidence that subjects respond more to subsidies of BMP2 than BMP1, with a greater proportion enrolling when the program is a half subsidy of BMP2 compared with a half-subsidy of BMP1.[3] However, there is no significant difference in enrollment rates between the two full subsidy programs.[4] Unsurprisingly, subjects' tendency to choose the traditional technology is greatest in the baseline no-subsidy condition and lowest during the full subsidy of BMP2 condition.

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[2] p values are $< 0.005$ when comparing half- and full- subsidy enrollment rates for both BMP1 and BMP2.

[3] p value $< 0.005$.

[4] p value $= 0.424$.

In order for the assumption of perfect additionality to be valid, all enrollees must either a) switch from the traditional technology to the subsidized technology or b) switch from the unsubsidized technology to both technologies.[5] Table 3 shows this is violated in all programs, with the gap between the proportion enrolled and the proportion making the technology change dictated under PA ranging from 35 to 42 percentage points ( for the half subsidy of BMP2 and the full subsidy of BMP1, respectively).

Table 4 evaluates the per-capita benefits of each subsidy program with and without the PA assumption. Strikingly, almost all perceived benefits of BMP1 subsidies are illusory. Using the entire sample (mutually exclusive and inclusive samples), true benefits make up only 1.3% of the benefits assigned using the PA assumption for the full subsidy, while the half subsidy actually generates negative benefits. This occurs because the proportion of subjects switching from BMP2 to BMP1 for the subsidy (a net negative impact) is greater than the proportion of subjects switching from TRAD to BMP1. While subsidies for BMP2 tend to perform better than subsidies for BMP1, the true benefits of BMP2 subsidies are consistently only 30-50% of the benefits under PA.

Table 4 also allocates the residual PA benefits (benefits incorrectly attributed to the subsidy program under the PA assumption) to the pay-for-nothing and behavioral substitution effects. Several trends emerge from the data. First, across programs, more residual PA benefits are attributed to the pay-for-nothing effect than to behavioral substitution. This gap between P4N and behavioral substitution is more pronounced when BMP2 is subsidized, which supports Hypothesis 1. Using the full sample, behavioral substitution accounts for 20-22% of residual PA benefits under BMP2 subsidies, which is substantially lower than the 34-44% of PA benefits attributable to behavioral substitution under BMP1 subsidies.

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[5] This second option is only possible in the mutually inclusive sample.

I find strong support for Hypothesis 2 in the context of BMP2 subsidies, but not for BMP1 subsidies. The behavioral substitution effect declines from 26-29% of residual PA benefits in the mutually exclusive scenarios to 0-6% in the mutually inclusive scenarios. There is no similar clear trend with BMP1 subsidies; indeed, for the half subsidy, the relative impact of the BS effect is greater in the mutually inclusive sample than in the mutually exclusive sample. With the full subsidy, the mutually inclusive sample has a lower BS effect, but the change is modest (39% in the inclusive sample vs. 44% in the exclusive sample).

### *Regression Analysis*

Subjects face a discrete choice when choosing technologies. In the mutually exclusive sample, this choice is among three options (TRAD, BMP1 and BMP2), with a fourth option of both BMPs available in the mutually inclusive sample. Tables 5 and 6 present marginal effect estimates from multinomial logit models of technology choice for the mutually exclusive and inclusive samples, respectively. In the mutually exclusive sample, I find full subsidies lead to a statistically significant 9% decrease in the probability of choosing the traditional technology, regardless of which BMP is being subsidized. Similarly, both half subsidies decrease the probability of choosing the traditional technology by 3%, but this impact is not statistically significant for either BMP. As one would anticipate, BMP1 subsidies increase the probability of choosing BMP1 and decrease the probability of choosing BMP2. The converse is true with BMP2 subsidies, which increase the probability of choosing BMP2 at the expense of choosing BMP1.

I find similar trends in the mutually inclusive data, with a few caveats. Subsidies for each BMP boost the probability of choosing the subsidized BMP and decrease the probability of choosing the unsubsidized BMP, although for some subsidies this effect is not statistically significant. In general, BMP subsidies also reduce the probability of choosing the traditional technology. Both of these effects are more pronounced for full subsidies than for half subsidies. The mutually inclusive data takes two distinct forms, complete and stochastic enrollment. The signs of each marginal effect are generally consistent between the two samples and magnitudes are largely similar. While the model presented in Table 6 pools the stochastic and complete enrollment observation, I additionally use bootstrapping with 10,000 replications to test for differences in marginal effects between complete and stochastic enrollment groups and find only two significant effects. First, the full subsidy of BMP1 has a much smaller effect on choosing the Traditional technology in the stochastic enrollment sample (p value = 0.028). Second, the half subsidy of BMP2 has a smaller effect on choosing BMP2 in the stochastic sample[6] (p value < 0.005).

While a discrete choice analysis of technology adoption is useful, an additional test of this type of subsidy policy should focus on the net impact of the policy on pro-social behavior (in this context, reducing runoff) and the net benefits of the policy (weighing the pro-social benefits against the costs of policy implementation). To this end, Table 7 presents OLS models with total group runoff[7] and group surplus (group profit minus subsidies paid to members of the group) as dependent variables. Each model is run on the mutually exclusive and mutually inclusive

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[6] It is possible that these effects may be partially or completely due to order effects. In the case of the full subsidy for BMP1, there was one 5-period treatment for each complete and stochastic enrollment to date. In the stochastic enrollment, this treatment came in the final rounds of the session. In the complete enrollment, the treatment occurred immediately following the baseline and so may have an outsize effect due to it being the first subsidy subjects were introduced to.

[7] In this context a group is defined as the set of five subjects whose runoff values impact each other's profit in a given period.

samples separately because yield and runoff values are slightly different[8] in the two samples. Turning first to group runoff, subsidies for BMP2 consistently reduce runoff for both samples and both types of enrollment (complete vs. stochastic). The story is more complicated with BMP1 subsidies. There are no significant impacts for the mutually exclusive group. With full enrollment in the mutually inclusive group, the effect is positive but not statistically significant for the half subsidy and negative for the full subsidy. When enrollment is stochastic, however, both subsidies lead to significant increases in group runoff.

Analyzing group surplus, I find the impact of BMP2 subsidies is once again consistently positive and statistically significant, with both subsidies increasing group surplus by 45-80 tokens across samples. Subsidies for BMP1 reduce group surplus in the stochastic enrollment sample and have not significant effect in the other samples.

## Conclusion

Using a controlled and incentivized economics experiment, I find evidence of substantial pro-social behavior in the absence of subsidies, as well as strong evidence that subsidies fail to achieve perfect program additionality. I examine a mutually exclusive sample where subjects cannot choose both BMP and a mutually inclusive sample where they can and find similar results in both conditions.

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[8] In both samples, movement from TRAD to BMP1 and from BMP1 to BMP2 reduces yield by 20 tokens and runoff by 10 tokens. In the mutually exclusive sample, the yield and runoff values for TRAD are 150 and 20, while in the mutually inclusive sample they are 200 and 30.

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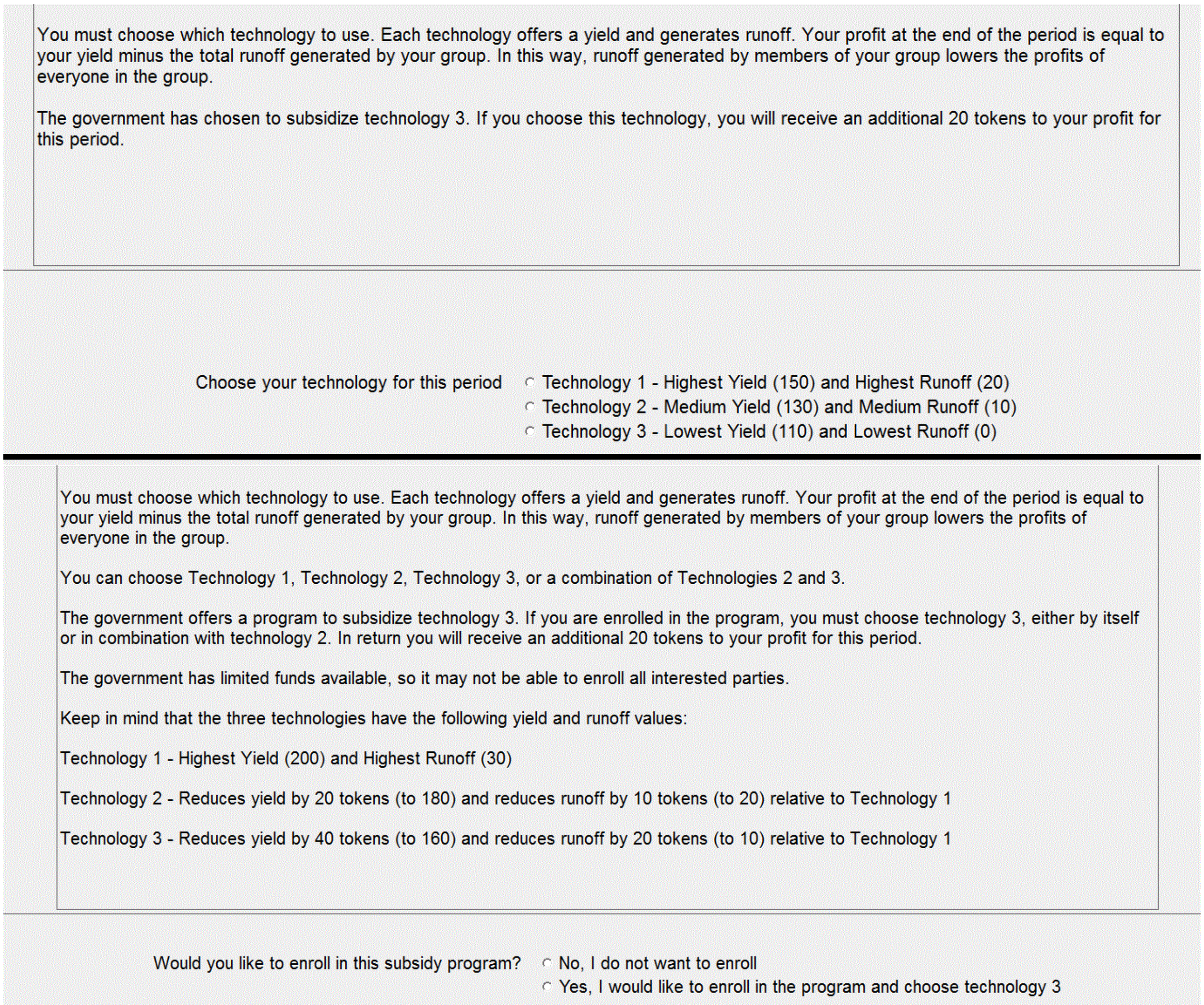

You must choose which technology to use. Each technology offers a yield and generates runoff. Your profit at the end of the period is equal to your yield minus the total runoff generated by your group. In this way, runoff generated by members of your group lowers the profits of everyone in the group.

The government has chosen to subsidize technology 3. If you choose this technology, you will receive an additional 20 tokens to your profit for this period.

Choose your technology for this period
○ Technology 1 - Highest Yield (150) and Highest Runoff (20)
○ Technology 2 - Medium Yield (130) and Medium Runoff (10)
○ Technology 3 - Lowest Yield (110) and Lowest Runoff (0)

You must choose which technology to use. Each technology offers a yield and generates runoff. Your profit at the end of the period is equal to your yield minus the total runoff generated by your group. In this way, runoff generated by members of your group lowers the profits of everyone in the group.

You can choose Technology 1, Technology 2, Technology 3, or a combination of Technologies 2 and 3.

The government offers a program to subsidize technology 3. If you are enrolled in the program, you must choose technology 3, either by itself or in combination with technology 2. In return you will receive an additional 20 tokens to your profit for this period.

The government has limited funds available, so it may not be able to enroll all interested parties.

Keep in mind that the three technologies have the following yield and runoff values:

Technology 1 - Highest Yield (200) and Highest Runoff (30)

Technology 2 - Reduces yield by 20 tokens (to 180) and reduces runoff by 10 tokens (to 20) relative to Technology 1

Technology 3 - Reduces yield by 40 tokens (to 160) and reduces runoff by 20 tokens (to 10) relative to Technology 1

Would you like to enroll in this subsidy program?
○ No, I do not want to enroll
○ Yes, I would like to enroll in the program and choose technology 3

Figure 1: Experiment Screenshots. The top panel displays a screenshot from the mutually exclusive sessions. The bottom panel displays a screenshot from the mutually inclusive sessions.

Table 1: Experimental Design

| Session | | Practice Round | Round 1 | Rounds 2 to 6 | Rounds 7 to 11 | Rounds 12 to 16 | Rounds 17 to 21 |
|---|---|---|---|---|---|---|---|
| 1 | Mutually Exclusive | Baseline | Baseline | Half Subsidy BMP1 | Half Subsidy BMP2 | Baseline | Full Subsidy BMP1 |
| 2 | Mutually Exclusive | Baseline | Baseline | Full Subsidy BMP2 | Half Subsidy BMP1 | Full Subsidy BMP1 | Baseline |
| 3 | Mutually Exclusive | Baseline | Baseline | Full Subsidy BMP1 | Baseline | Full Subsidy BMP2 | Half Subsidy BMP2 |
| 4 | Mutually Exclusive | Baseline | Baseline | Half Subsidy BMP2 | Full Subsidy BMP2 | Half Subsidy BMP1 | Baseline |
| 5 | Mutually Exclusive | Baseline | Baseline | Baseline | Full Subsidy BMP1 | Full Subsidy BMP2 | Half Subsidy BMP1 |
| 6 | Mutually Exclusive | Baseline | Baseline | Half Subsidy BMP1 | Full Subsidy BMP1 | Half Subsidy BMP2 | Full Subsidy BMP2 |
| 7 | Mutually Inclusive | Baseline | Baseline | Full Subsidy BMP1 | Baseline | Full Subsidy BMP2 Stochastic | Half Subsidy BMP2 |
| 8 | Mutually Inclusive | Baseline | Baseline | Half Subsidy BMP1 Stochastic | Full Subsidy BMP2 | Baseline | Full Subsidy BMP1 Stochastic |
| 9 | Mutually Inclusive | Baseline | Baseline | Baseline | Half Subsidy BMP2 Stochastic | Half Subsidy BMP1 | Full Subsidy BMP2 Stochastic |

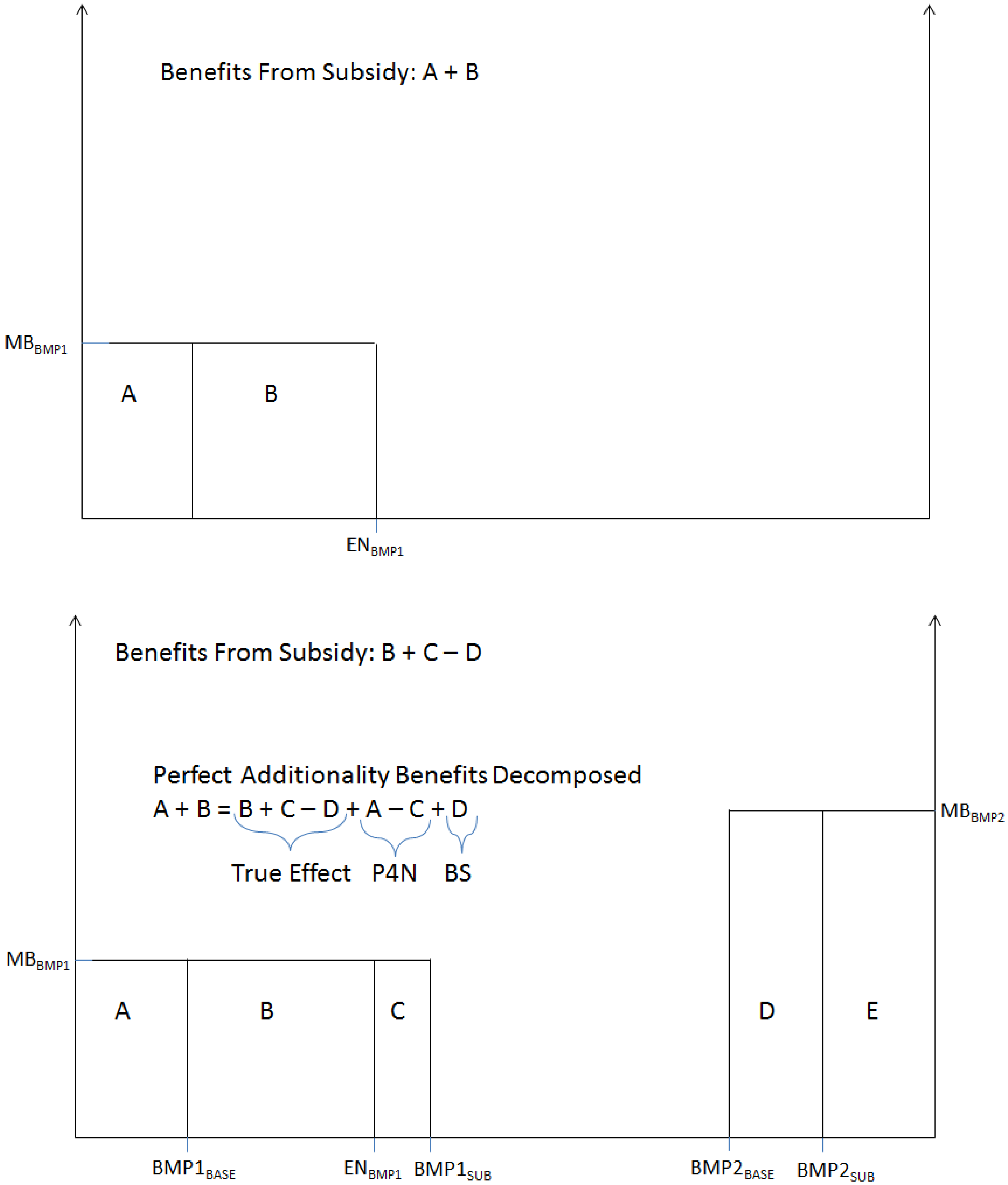

Figure 2: Graphical representation of benefits from a subsidy of BMP1. MB$_{BMP1}$ and MB$_{BMP2}$ are the marginal social benefit from an additional agent choosing BMP1 and BMP2, respectively. EN$_{BMP1}$ is the proportion of agents who enroll in the subsidy program for BMP1.

$BMP1(2)_{BASE(SUB)}$, are the proportion of agents who select BMP1 (BMP2) in the baseline scenario of no subsidy (when BMP1 is subsidized). The top panel shows the benefits under the perfect additionality assumption, while the bottom panel shows i) the benefits when this assumption is relaxed and ii) decomposes the effect of the program under perfect additionality into the true effect, the pay-for-nothing effect, and the behavioral substitution effect.

Table 2:

| Counterfactual Tech Choice | Subsidized Tech | PA Effect | True Effect | Pay-for-Nothing | Behavioral Substitution |
|---|---|---|---|---|---|
| TRAD | BMP1 | 30 | 30 | 0 | 0 |
| | BMP2 | 60 | 60 | 0 | 0 |
| BMP1 | BMP1 | 30 | 0 | 30 | 0 |
| | BMP2 | 60 | 30 | 0 | 30 |
| BMP2 | BMP1 | 30 | -30 | 0 | 60 |
| | BMP2 | 60 | 0 | 60 | 0 |

Table 3: Descriptive Evidence of Additionality Violations

| | **No Subsidy** | **Half Subsidy BMP1** | **Full Subsidy BMP1** | **Half Subsidy BMP2** | **Full Subsidy BMP2** |
|---|---|---|---|---|---|
| **Proportion Choosing TRAD** | 0.433469 | 0.408 | 0.296 | 0.342667 | 0.26 |
| **Proportion Choosing Both BMPs** | 0.071837 | 0.041143 | 0.062857 | 0.082667 | 0.078 |
| **Proportion Changed by Subsidy** | | -0.00522 | 0.12849 | 0.101633 | 0.179633 |
| **Proportion Subsidized** | | 0.379429 | 0.555429 | 0.450667 | 0.563 |
| **Proportion Subsidized – Proportion Changed** | | 0.384653 | 0.426939 | 0.349034 | 0.383367 |

Notes: Proportion Changed by Subsidy equal ($TRAD_{NoSubsidy}$ – $TRAD_{Subsidy}$) – ($BOTHBMPS_{NoSubsidy}$ – $BOTHBMPS_{Subsidy}$)

Table 4: Program Analysis

| **Program** | **Breakdown of Perfect Additionality Benefits** | **Percentage of PA Benefits** | | | | |
|---|---|---|---|---|---|---|
| | | Entire Sample | Mutually Exclusive | Mutually Inclusive | Mutually Inclusive, Not Stochastic | Mutually Inclusive, Stochastic |
| **Half Subsidy BMP1** | PA Benefits/Capita | 11.38 | 12.432 | 8.76 | 11.04 | 6.48 |
| | True Effect | 0% (negative) | 1.5% | 0% (negative) | 0% (negative) | 0% (negative) |
| | Pay-for-Nothing | 65.2% | 78.4% | 45.5% | 48.8% | 43.2% |
| | Behavioral Sub. | 34.8% | 21.6% | 54.5% | 51.2% | 56.8% |
| **Full Subsidy BMP1** | PA Benefits/Capita | 16.66 | 17.952 | 13.44 | 19.92 | 6.96 |
| | True Effect | 1.3% | 4.5% | 10.6% | 66.8% | 0% |
| | Pay-for-Nothing | 55.8% | 56.0% | 61.1% | 100% | 34.6% |
| | Behavioral Sub. | 44.2% | 44.0% | 38.9% | 0% (negative) | 65.4% |
| **Half Subsidy BMP2** | PA Benefits/Capita | 27.04 | 29.88 | 21.36 | 29.28 | 13.44 |
| | True Effect | 35.4% | 33.7% | 44.3% | 56.9% | 16.9% |
| | Pay-for-Nothing | 80.0% | 73.9% | 100% | 97.9% | 100% |
| | Behavioral Sub. | 20.0% | 26.1% | 0% (negative) | 2.1% | 0% (negative) |
| **Full Subsidy BMP2** | PA Benefits/Capita | 33.78 | 37.82 | 27.04 | 39.36 | 20.88 |
| | True Effect | 44.2% | 45.3% | 40.6% | 35.0% | 45.9% |
| | Pay-for-Nothing | 78.1% | 70.8% | 93.9% | 80.2% | 100% |
| | Behavioral Sub. | 21.9% | 29.2% | 6.1% | 19.8% | 0% (negative) |

Notes: Benefits per capita are measured in experimental tokens. Percentages in the “True Effect” rows represent the percentage of PA benefits per capita that are rightly attributed to the subsidy program. Percentages in the “Pay-for-Nothing” and “Behavioral Sub.” rows describe the proportion of the misattributed per-capita benefits that are attributed to each phenomenon.

Table 5: Multinomial Logit, Mutually Exclusive Data

| | | **Traditional** | **BMP1** | **BMP2** |
|---|---|---|---|---|
| Full Enrollment<br>Mutually Exclusive | Half Sub BMP1 | -0.034<br>(0.192) | 0.087***<br>(< 0.005) | -0.053**<br>(0.020) |
| | Full Sub BMP1 | -0.093***<br>(< 0.005) | 0.230***<br>(< 0.005) | -0.137***<br>(< 0.005) |
| | Half Sub BMP2 | -0.031<br>(0.291) | -0.180***<br>(< 0.005) | 0.210***<br>(< 0.005) |
| | Full Sub BMP2 | -0.094***<br>(0.009) | -0.196***<br>(< 0.005) | 0.290***<br>(< 0.005) |
| | Female | -0.079***<br>(0.024) | 0.079***<br>(< 0.005) | -0.000<br>(0.995) |
| | Session Effects? | Yes | Yes | Yes |
| | Observations<br>(Subjects) | 3,150<br>(150) | 3,150<br>(150) | 3,150<br>(150) |
| | | | | |

Notes: *, **, and *** denote significance at the 90, 95, and 99% confidence level, respectively. The top row indicates the dependent variable in each model. Marginal effects are reported for all models.

Table 6: Multinomial Logit, Mutually Inclusive Data

| | | **Traditional** | **BMP1** | **BMP2** | **Both BMPs** |
|---|---|---|---|---|---|
| Full Enrollment<br>Mutually Inclusive | Half Sub BMP1 | -0.0463<br>(0.290) | 0.1552***<br>(< 0.005) | -0.0856<br>(0.178) | -0.0232<br>(0.667) |
| | Full Sub BMP1 | -0.1860***<br>(< 0.005) | 0.1959***<br>(< 0.005) | -0.1070*<br>(0.053) | 0.0970**<br>(0.018) |
| | Half Sub BMP2 | -0.0942<br>(0.117) | -0.0981*<br>(0.061) | 0.1661***<br>(< 0.005) | 0.0261<br>(0.519) |
| | Full Sub BMP2 | -0.1675**<br>(0.014) | -0.1383<br>(0.122) | 0.2206***<br>(< 0.005) | 0.0851<br>(0.191) |
| Stochastic Enrollment<br>Mutually Inclusive | Half Sub BMP1 | 0.0678<br>(0.209) | 0.0826*<br>(0.070) | -0.1662***<br>(0.005) | 0.0158<br>(0.744) |
| | Full Sub BMP1 | 0.0136<br>(0.762) | 0.1628***<br>(< 0.005) | -0.1641***<br>(0.007) | -0.0123<br>(0.836) |
| | Half Sub BMP2 | -0.0023<br>(0.966) | -0.0224<br>(0.684) | -0.0112<br>(0.752) | 0.0359<br>(0.450) |
| | Full Sub BMP2 | -0.0899**<br>(0.011) | -0.0076<br>(0.824) | 0.0941***<br>(< 0.005) | 0.0034<br>(0.923) |
| | Female | -0.1933***<br>(< 0.005) | 0.1269***<br>(< 0.005) | 0.0242<br>(0.390) | 0.0422<br>(0.270) |
| | Session Effects? | Yes | Yes | Yes | Yes |
| | Observations (Subjects) | 1,575<br>(75) | 1,575<br>(75) | 1,575<br>(75) | 1,575<br>(75) |

Notes: *, **, and *** denote significance at the 90, 95, and 99% confidence level, respectively. The top row indicates the dependent variable in each model. Marginal effects are reported for all models.

Table 7: OLS Models

| | | **Total Group Runoff (OLS)** | **Total Group Runoff (OLS)** | **Group Net Benefits (OLS)** | **Group Net Benefits (OLS)** |
|---|---|---|---|---|---|
| Full Enrollment<br>Mutually Exclusive | Half Sub BMP1 | 0.2926<br>(0.738) | | -0.8778<br>(0.738) | |
| | Full Sub BMP1 | -1.4794<br>(0.101) | | 4.4382<br>(0.101) | |
| | Half Sub BMP2 | -16.3077***<br>(< 0.005) | | 48.9231***<br>(< 0.005) | |
| | Full Sub BMP2 | -26.7394***<br>(< 0.005) | | 80.2182***<br>(< 0.005) | |
| Full Enrollment<br>Mutually Inclusive | Half Sub BMP1 | | 3.6485<br>(0.113) | | 2.0816<br>(0.403) |
| | Full Sub BMP1 | | -11.9152***<br>(< 0.005) | | 3.8653<br>(0.230) |
| | Half Sub BMP2 | | -17.5152***<br>(< 0.005) | | 45.4906***<br>(< 0.005) |
| | Full Sub BMP2 | | -32.5144***<br>(< 0.005) | | 82.6095***<br>(< 0.005) |
| Stochastic Enrollment<br>Mutually Inclusive | Half Sub BMP1 | | 10.2856***<br>(< 0.005) | | -29.1753***<br>(< 0.005) |
| | Full Sub BMP1 | | 7.8856***<br>(< 0.005) | | -15.1753***<br>(< 0.005) |
| | Half Sub BMP2 | | -3.1515<br>(0.382) | | 60.5387***<br>(< 0.005) |
| | Full Sub BMP2 | | -10.5333***<br>(< 0.005) | | 65.5592***<br>(< 0.005) |
| | Total Women | -0.6942**<br>(0.043) | -3.8064***<br>(< 0.005) | 0.4161<br>(0.671) | 4.8983***<br>(< 0.005) |
| | Session Effects? | Yes | Yes | Yes | Yes |
| | Observations (Subjects) | 3,150<br>(150) | 1,575<br>(75) | 3,150<br>(150) | 1,575<br>(75) |

Notes: *, **, and *** denote significance at the 90, 95, and 99% confidence level, respectively. The top row indicates the dependent variable in each model. The variable "Total Women" captures the number of women in a given observation's group.