*Agricultural and Resource Economics Review* (2024), 1–19
doi:10.1017/age.2024.5

RESEARCH ARTICLE

# The effectiveness of a green default nudge in achieving resource conservation

Jimena González-Ramírez

O'Malley School of Business, Manhattan College, Riverdale, NY, USA
Email: jimena.gonzalez@manhattan.edu

(Received 29 June 2023; revised 9 January 2024; accepted 16 March 2024)

**Abstract**

Green nudges are used to promote conservation and pro-environmental behavior. This study examines the lasting effectiveness of a green default nudge in paper conservation, where price incentives are absent. At a private college in New York City, the default print setting was changed from single-sided to double-sided in Spring 2019, accompanied by a salient pop-up window that asked students to print double-sided. Analyzing student-level data over four semesters (Spring 2018 and Fall 2018 as control, Spring 2019 and Fall 2019 as treatment), this research contributes to the literature as it studies the effect of the nudge in the absence of pecuniary incentives. The findings support the hypothesis that this green default nudge was effective in promoting paper conservation and increasing resource efficiency. Results show that double-sided printing increased while single-sided printing decreased, leading to an overall reduction in paper usage. Employing a panel regression model with student fixed effects, this study finds that the nudge had a statistically significant effect in reducing the sheets per page ratio, and it improved the efficient use of paper by 19 percent. This inexpensive behavioral intervention proves successful in promoting environmental behavior and reducing paper consumption, which reduces greenhouse gas emissions.

**Keywords:** conservation; default nudges; green nudges; nudges; printing

**JEL Codes:** Q00; Q50; Q59; D9

## Introduction

Resource conservation and the reduction in greenhouse gas emissions require multiple efforts at different levels. For example, a decrease in paper from printing is a relatively easy way to achieve conservation, as this activity is universal, frequent, and resource intensive (Egebark and Ekström 2016). Producing a ton of virgin paper uses 3,688 pounds of wood and 240,000 gallons of water and requires the treatment and disposal of 84, 36, and 176 pounds of air pollutants, water pollutants, and solid waste, respectively (Madison College Libraries 2021). In the U.S., yearly office paper used is sufficient to build a 10-foot wall two and a half times the distance between New York to Los Angeles (Madison College Libraries 2021). U.S. office

workers use around five million metric tons of paper yearly, which can be translated to about 20 million metric tons of wood (Egebark and Ekström 2016). Reducing this consumption by five percent protects about half million trees and avoids annual greenhouse gas emissions equivalent to that of about 140,000 cars (Egebark and Ekström 2016).

One way to decrease paper consumption is to promote double-sided printing through either pecuniary mechanisms (e.g. a discount for double-sided printing) or behavioral economics strategies (e.g. nudges). In this paper, I concentrate on college students' printing behavior. At some universities, students are charged per page or face a lower price if they print double-sided. Alternatively, the default print setting can be switched to duplex to nudge individuals through the powers of suggestion and inertia. This green default nudge is especially useful in contexts where people are not directly charged as they print, which resembles printing environments at offices. In this paper, I study the effectiveness of a green default nudge at a university where students are given a generous printing endowment and do not face pecuniary incentives as they print. At this university, the default setting switched to duplex at the beginning of 2019. Moreover, the nudge was salient through a pop-up window that asks students to print double-sided and that includes environmental information. Using student-level data during four semesters, two before the change and two after the default nudge was introduced, I assess the lasting effect of this default nudge on four outcomes: number of simplex pages, number of duplex pages, total sheets, and the sheets per page ratio, which measures conservation and the efficient use of paper. A panel regression model with student fixed effects shows that simplex pages decreased by 47 percent, duplex pages increased by 63 percent, and total sheets decreased by 14 percent. Lastly, conservation and resource efficiency, measured by the sheets per page ratio, was improved by 19 percent with the nudge.

This research contributes to the literature by studying the effect of a default nudge by using individual printing data during a two-year period. Specifically, since this study includes individual printing data for two semesters after the nudge was introduced, this study shows evidence that this default nudge continued working within a year of its introduction. Secondly, this research studies the persistent effect of a default nudge in the absence of pecuniary incentives. As there is no payment as printing takes place, behavioral strategies become an alternative to promote conservation. This research concludes by doing back-of-the-envelope calculations of environmental measures before and after the nudge within the subset of the matched students observed across the four semesters. Such calculations show that this nudge achieved pollution abatement by reducing energy and paper usage. As a result, the nudge achieved conservation by reducing carbon emissions.

## Literature review

Within environmental economics policies, behavioral strategies emerge as a way to complement or substitute command-and-control and market-based policies. They are particularly useful when market-based policies are challenging to pass or establish (Allcott and Mullainathan 2010; Carlsson and Johansson-Stenman 2012; Egebark and Ekström 2016; Sunstein and Reisch 2014). Nudges are specially effective when decision makers rely on quick judgment or automatic reasoning (Thaler 2015; Thaler and Sunstein 2008). As defined by Thaler and Sustein (2008), a nudge is "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives." Nudges vary in purpose and design, including the usage of peer comparisons and default modifications. For this study, I concentrate on a default nudge since behavioral change may be observed when defaults are purposely chosen due to the powers of suggestion, inertia, and loss aversion

(Sunstein and Reisch 2014). For example, increase in retirement savings and organ donations were observed with automatic enrollment (Johnson and Goldstein 2003; Madrian and Shea 2001).

By applying this behavioral economics strategy to environmental problems, green default nudges promote pro-environmental behavior and conservation by carefully setting the default (Schubert 2017). The effect of green default nudges is mostly independent of environmental attitudes (Vetter and Kutzner 2016). Green defaults have increased enrollment in energy conservation and green energy programs (Broman Toft et al. 2014; Pichert and Katsikopoulos 2008; Sunstein and Reisch 2014, 2016). Furthermore, green defaults have increased the choice of more energy efficient light bulbs (Dinner et al. 2011) and Smart Grid technologies (Ölander and Thøgersen 2014).

In contrast to these successful green nudges, researchers also document green nudges that do not increase conservation. A green default was irrelevant to increase carbon offset donations at a conference in environmental and resource economics (Löfgren et al. 2012). Concerns about perverse reactions and unintended consequences of green defaults exist, as consumers may react against the default by increasing consumption or choosing fewer green alternatives. Khazzoom (1980) documented a decrease in demand for appliances as mandated energy efficiency standards increase. When a recycling option was introduced, Catlin and Wang (2013) observed an increase in paper consumption. These mixed results motivate more research to understand the effectiveness of behavioral interventions and green default nudges. The purpose of this research is to examine the results of a salient green default nudge introduced at a private college, where students are not charged as they print. As they do not face pecuniary incentives, non-price behavioral interventions are the only alternative to increase resource conservation. At other universities, students are charged per printed page and some face a discounted price for double-sided printing pages.

Within the green nudge literature, there is a is a single peer-reviewed article[1] on printing behavior, which is most influential for this work. Egebark and Ekström (2016) studied the use of the default setting in reducing paper usage at a university in Sweden. Within a 15-week period, the default setting was randomly switched from simplex to duplex printing between the fifth and tenth week. Their study included data from 25 printers that introduced the nudge in a different week. They tested whether people's tendency to stick to the pre-set alternative save resources by analyzing printing data during at least 5 and at most 10 weeks after the nudge was introduced. Using daily printer-level data at a Swedish university, the default intervention was successful and clearly improved resource efficiency. This green default nudge increased duplex printing and decreased the number of sheets used per day by 15 percent on average (Egebark and Ekström 2016).

This study builds upon Egebark and Ekström's (2016), but differs in the design, unit of analysis, and time span. While they randomly introduced the treatment to each printer between week 5 and 10, I assess the effectiveness of a salient green default nudge using a natural experiment at a private college in New York City. Prior to 2019, the default print setting was simplex (single-sided). At the beginning of 2019, the default print setting switched to duplex. Using student-level data across four semesters (Spring 2018, Fall 2018, Spring 2019, and Fall 2019), I answer three research questions: (1) Is this salient green

[1]Within Sunstein and Reisch (2014), they reference a green nudge at Rutgers university. There, the double-sided printing default decreased paper consumption by more than 55 million sheets (equivalent of 4,650 trees) during the first four years of the default nudge. The above information was obtained from the Print Management Services at Rutgers University (2012). However, the latter is derived from tallies of total sheets before and after the default was changed, not controlling for other factors that may affect printing that are explored in this article.

default nudge effective in promoting pro-environmental behavior in the absence of pecuniary incentives? (2) Does this salient green default effectiveness work after a year of its introduction? and (3) How much conservation is achieved by this green default nudge?

Different than Egebark and Ekström's (2016) who employed printer-level data from 25 printers in 18 departments during 15 weeks (one semester), I use student-level data across two control and two treatment semesters, observing individual behavior more directly during two years. Instead of studying printers as the unit of analysis, I study decision makers. I focus on students as my population of interest because they do not face a direct financial incentive in conserving paper or using paper efficiently. At the college, students get a generous endowment of printing pages per semester. Furthermore, by concentrating on students as my unit of observation, I follow and compare the behavior of the same students across two years: two initial semesters with simplex default followed by two treatment semesters with duplex default. In contrast with Egebark and Ekström's (2016), who used daily printer data during 15 weeks and aggregated decision makers print choices per printer per day, I concentrate on semester data, as assignments and exams happen at different points during and across semesters. Aggregating printing data per semester allows me to remove effects that may arise from within semester variations.

Moreover, my strategy allows me to examine whether the nudge effect continues after a year of its introduction. Within the behavioral economics literature, efforts have been made to understand why some treatments have only a short-term effect (Frey and Rogers 2014). After decision makers are nudged for a period of time, the information may become less relevant and be seen more as background noise (Sunstein 2017). Even if default nudges are more likely to have a persistent effect, some may still suffer as the information is muted or inertia is overcome (Sunstein 2017). Thus, it is important to understand the continued effect of any nudge or behavioral intervention. In short, this research contributes to the literature on green default nudges for paper conservation by studying individual printing decisions, aggregated per semester, during two years. Using a panel regression model with individual effects, I examine the effect of the nudge and whether the nudge continues to work within the first year of implementation, addressing a common concern about the lasting effects of this change.

## Materials and methods

This section includes the background on printing options at the college as well as the description of the natural experiment and the data. It concludes with the methods used to answer the research questions.

### *Background*

Every semester, students are given an endowment of 1,000 pages for printing. If they go over that limit, students have the opportunity to complete a form requesting more pages, which is typically approved.[2] As students print, they do not incur an outlay of money because they do not pay for paper or printed pages. At the college, printing costs are part of semester fees. Thus, students do not face pecuniary incentives to decrease paper consumption. This unique characteristic of the population allows me to test the ability of a default nudge to increase resource conservation in the absence of pecuniary incentives. At the time of the study, students primarily print from computer stations located at the library

[2]At least 50 students printed more than 1000 pages each of the four semesters in the dataset.

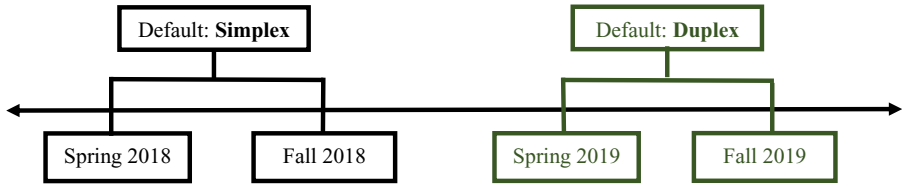


**Figure 1.** Timeline of natural experiment.

and at computer labs throughout campus buildings.[3] From these computers, students are free to modify print settings.

### *Default green nudge*

Prior to Spring 2019, the default setting was simplex when printing. At the end of Fall 2018, the Political Science department hosted an event where students, faculty, staff, and administrators discussed ways to improve sustainability on campus. I had the opportunity to share the power of default nudges and suggested switching the default setting to double-sided. After the meeting, the President of the college asked the Information Technology department to switch the default settings from simplex to duplex. At the beginning of Spring 2019, all the computer labs and printing stations on campus started including a salient green default nudge. The timeline of this natural experiment is summarized in Fig. 1.

Starting in Spring 2019 and continuing in Fall 2019, when students print, a pop-up window asks them to use double-sided printing and includes environmental information, as illustrated in Fig. 2.

This window includes information on the grams of $CO_2$ equivalent the printing job produces if simplex is chosen for the number of pages printed. The information in Fig. 2 is for a 2-page printing job. Moreover, it converts the grams of $CO_2$ into equivalent time of leaving a 60 W bulb.[4] For example, for a two-page print job, the message states: *"Did you know that this job will produce 25 grams of $CO_2$ equi.? This is equivalent to leaving a 60W bulb on for **1.6 hours!** You could halve this impact by printing double-sided."* This message is followed by a green tree figure.[5] Lastly, students are asked: *"Would you like to **convert this job to duplex?**"* At the bottom of the window, students encounter an action drop-down menu with a default stating: *Convert to Double-Sided* as depicted in Panel (a). Double-sided printing is not binding since students may click the drop-down menu and choose: *"I understand, but this job is important"* to print single-sided as depicted in Panel (b).

By having to choose a different option from the drop-down menu to print single-sided, this pop-up window illustrates a duplex default nudge. Moreover, the switch to simplex does not require much effort or time since students simply click on the drop-down menu

[3]Since March 2018, students also have the option to print from their personal laptops using a browser application called Web Print, which restricts printing to PDF and picture files and does not allow students to modify print settings. The data shows that this option is not very popular, encompassing less than 4 percent of total printed pages in Spring 2019. Moreover, since students are not allowed to change print settings, data from this printing option is not included in the analysis as my objective is to measure the effectiveness of a default nudge, which requires the ability to modify print settings.

[4]Light bulbs vary in terms of watts.

[5]The pop-up window and its information come from PaperCut, a print management software: papercut.com (PaperCut Software Pty Ltd, 2022).

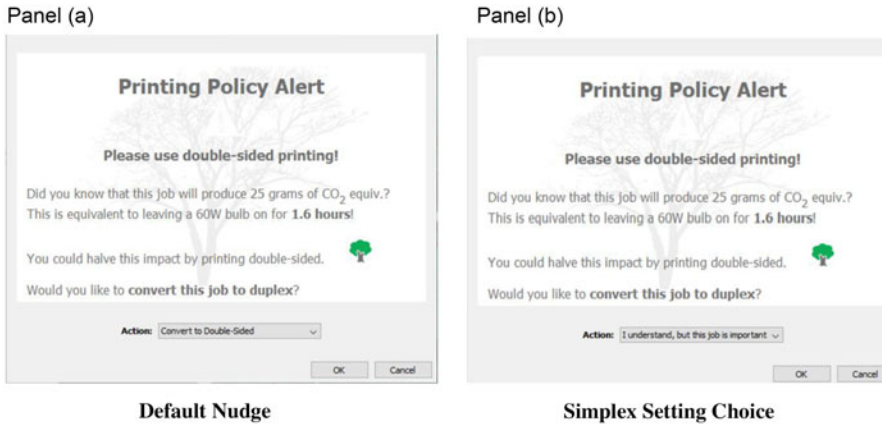


**Figure 2.** Default nudge for 2-page print job.

and select the option depicted in Panel (b). Consequently, the cost of switching is minimal, discarding the switching cost as a driver of behavior. This default nudge is salient as this pop-up window is displayed every time a student prints and the information varies with the number of pages printed. Even though it is possible that students pay attention to the environmental information when they first encounter the pop-up window, they likely pay less to no attention to it as they continue printing. Moreover, it is reasonable to assume that students stop paying attention to the message as they print more files during the Spring semester and following Fall semester. These assumptions are confirmed with a survey given to students that is described in the results section. Thus, the most important component of this change is the default option, which is to print duplex. Furthermore, this default nudge appeals to a semi-automatic decision mode, in which choices are made fast and effort is decreased by employing heuristics and mental shortcuts (Kahneman 2011).

## *Printing data analysis*

The primary data for this research comes from the Information Technology Services and includes student-level printing information for two years.

### *Printing data*

Given this natural experiment, I assess the effectiveness of this salient green default nudge and estimate the size of its effect using anonymized student-level printing data across four semesters: Spring 2018, Fall 2018, Spring 2019, and Fall 2019. The data includes the following variables: an anonymized user ID as well as the number of simplex pages and number of duplex pages printed, and the printer location. The location allows me to compute a proxy for the type of courses the student was taking. At the college, engineering, computer science, mathematics, and science lab courses are taught in the lower part of the campus. The data allows me to compute the share of pages printed in the lower campus relative to total pages. I assume that students who print at the buildings in the lower campus are taking primarily STEM courses. I confirmed this assumption through informal conversations with students and through a survey that will be discussed later in the paper.

The user ID can be used to match students across semesters. Simplex and duplex printed pages allow me to observe changes in printing behavior across semesters and to quantity the effect of this nudge in Spring 2019 and Fall 2019 relative to previous two control semesters. I include both Spring and Fall semesters prior and after the change as there may be differences across Fall and Spring semesters in terms of types of courses offered. For example, one semester may have more writing or reading intensive courses that require more printing. At the college, some courses are offered every Fall or Spring semester, which may explain printing variations across semesters. Moreover, students may behave differently across semesters due to experience or proximity to graduation. Before matching and merging the data across semesters, I excluded any observation with a single-page print job, as the student does not face any print choice in those cases.

### Methods

When studying printing behavior, there are two straightforward variables of interest: number of simplex pages and number of duplex pages printed. From these two variables, I computed the number of sheets used by adding simplex pages and half of duplex pages, as each sheet encompasses two duplex pages. Following Egebark and Ekström (2016), I also examined the sheets per page ratio as a measure of conservation and efficient use of paper:

$$sp = \frac{sheets}{pages} = \frac{simplex + \frac{duplex}{2}}{simplex + duplex} \tag{1}$$

Notice that $sp = 1$ if all the pages were printed single-sided, showing the least conservation behavior. Conversely, $sp = 0.5$ if all the pages were printed double-sided, showing the most environmental conservation.

To assess the success of this green nudge in changing printing behavior, I employ a number of comparisons across semesters. In this study, the treatment is observed during Spring 2019 and Fall 2019. Both Spring 2018 and Fall 2018 serve as control semesters. I start with aggregate summaries and visual inspections including bar charts and box plots across semesters. Then, I employ Welch two sample $t$-tests comparing averages across semesters for the sheets per page ratio. The null hypothesis is that the averages across comparison groups are equal to each other. The alternative hypothesis is that the averages differ.

Since the introduction of the default nudge occurred for the entire campus, the nudge cannot be studied as an experiment with random assignment as it was done by Egebark and Ekström (2016). However, this is advantageous as students cannot switch printing location to get around the nudge. Student-level information across four semesters (2 control and 2 treatment semesters) coupled with panel data regression techniques can be used to examine the research questions. Specifically, I estimate the following entity fixed effects panel regression model:

$$y_{it} = \beta_1 T_{it} + \beta_2 X_{it} + \sum_{j=1}^{n} \gamma_j Dj_i + u_{it} \tag{2}$$

where $i = 1, \ldots, n$, capturing every student in the data set across the four semesters. Moreover, $t = 1, 2, 3, 4$ representing Spring 2018, Fall 2018, Spring 2019, and Fall 2019, respectively. The model includes individual specific intercepts, $D1, D2, \ldots, Dn$, capturing time-invariant heterogeneity across students. Furthermore, $T_{it} = 1$ if default setting is duplex and $T_{it} = 0$ if print default is simplex. Lastly, $X_{it}$ is the share of pages printed in the lower campus relative to total pages, which serves as a proxy for the type of courses taken during that semester. I use survey results to validate this assumption. I study

four outcome variables ($y_{it}$): sheets per page ratio ($sp_{it}$), total sheets ($s_{it}$), simplex pages ($simplex_{it}$), and duplex pages ($duplex_{it}$). The main goal of the model is to estimate the treatment effect: $\widehat{\beta}_1$ for each outcome variable.

## Survey data analysis

Since the printing data is anonymized, it does not offer identifiable information on students. Thus, its analysis relies on student fixed effects and the share of pages printed on the lower campus to control for unobservables. To complement that analysis, survey data is employed to validate assumptions and understand students' preferences and attitudes towards printing. In essence, the printing data offers information on actual, revealed, behavior, and the survey data elicits stated preferences.

### Survey distribution

The survey was designed to complement the printing data analysis and to validate assumptions. The population for the survey was all 3006 undergraduate students in Spring 2022. The survey was distributed through Qualtrics and included a personalized email invitation and four personalized email reminders. Students had to be at least 18 years old and were offered the opportunity to enter a raffle to win one out of five $25-Amazon gift cards. This same incentive has been used with the same population (Annabi et al. 2018; Cheng and Gonzalez-Ramirez 2020). The survey includes questions about printing behaviors and preferences. The response rate for the survey is around 27.5 percent, with 827 students completing the survey.

# Results

This section is organized as follows. First, aggregate summaries from the printing data are presented followed by the results from the regression analysis. Then, survey results are shown to validate key assumptions and understand stated print behavior and preferences among students. Lastly, an environmental impact section is offered to describe the implications of the results.

## Aggregate printing data results

I start the analysis by comparing aggregate measures across semesters as depicted in Table 1.

Table 1 illustrates the contrast between control and treatment semesters. Comparing Spring semesters, 262,000 fewer simplex pages (55 percent) were printed in 2019 relative to 2018. Analogously, 328,000 fewer simplex pages (60 percent) were in Fall 2019 relative to Fall 2018. Focusing on duplex pages, I highlight the substantial increase in Spring 2019 and Fall 2019 relative to both control semesters despite having fewer students relative to the respective semester in 2018. Duplex pages increased by 185,000 (44 percent) in Spring 2019 relative to Spring 2018 and by 140,000 (30 percent) in Fall 2019 compared to Fall 2018. In terms of paper usage, Spring 2019 and Fall 2019 exhibited a decrease in sheets by about 25 and 33 percent relative to Spring 2018 and Fall 2018, respectively. Narrowing the comparisons to the sheets per page ratio, the average and median decreased in the treatment semesters getting closer to 0.5, which is the ratio that exhibits the most conservation behavior. For both control semesters, the average and median sheets per page

**Table 1.** Aggregate results across semesters

| | Control default: Simplex | | Treated default: Duplex | |
|---|---|---|---|---|
| Measure | Spring 2018 | Fall 2018 | Spring 2019 | Fall 2019 |
| Simplex Pages | 478,000 | 546,000 | 216,000 | 218,000 |
| Duplex Pages | 417,000 | 468,000 | 602,000 | 608,000 |
| Total Pages | 895,000 | 1,014,000 | 818,000 | 826,000 |
| Total Sheets | 686,500 | 780,000 | 517,000 | 522,000 |
| Average Sheets per Page Ratio | 0.8422 | 0.8520 | 0.6970 | 0.6807 |
| Median Sheets per Page Ratio | 0.8974 | 0.9266 | 0.6515 | 0.6307 |
| Number of Students | 3,697 | 3,884 | 3,616 | 3,821 |

ratio was closer to 1, indicating that students were closer to the least conservation behavior in those semesters.

These aggregate comparisons offer a first look at the changes across semesters suggesting a positive effect of the nudge that was still visible two semesters after the change was implemented. However, Table 1 shows that the number of students varied per semester, with more students during both Fall semesters relative to Spring semesters. These differences across semesters reinforced the importance of including Spring 2018 and Fall 2019 in the analysis. Moreover, to have a clean assessment of the nudge's success, a subset of students observed across the four semesters is required.

### *Subset of matched students across semesters*

Even though I observe evidence that supports the effectiveness of the nudge through aggregate summaries, the differences between treatment and control semesters may be attributed to enrollment discrepancies across semesters. To remove this source of variation, I continue the analysis with the subset of students that is observed across the four semesters. Within this subset, I cannot match seniors who graduated in Spring 2018 or Spring 2019 nor first-year students who started in Fall 2018 or Fall 2019. Moreover, I cannot match any students who transferred in or out of the university in any of the semesters. The subset of matched students is reduced to 1,512 individuals. From this point onwards, I study the research questions on this subset of the data providing a cleaner analysis.

Table 2 shows differences across semesters with the subset of matched students.

As with Table 1, we see the same patterns. The default nudge reduced single-sided printing, increased double-sided printing, decreased total sheets, and made the average of sheets per page ratio closer to 0.5 supporting the success of this behavioral intervention. Given the differences across the academic semesters and schedules, I compared Spring 2018 (control) relative to Spring 2019 (treated) and Fall 2018 (control) relative to Fall 2019 (treated). With the default nudge in 2019, there was 45 (Spring) and 50 (Fall) percent reduction in simplex pages relative to their analogous semesters in 2018. Duplex pages went up by 78 (Spring) and 48 (Fall) percent relative to 2018. Paper usage (total sheets) decreased by 8 (Spring) and 20 (Fall) percent. Figure 3 shows the difference in total simplex and duplex pages across semesters.

**Table 2.** Aggregate results across semesters with subset of matched students

| | Control | | Treated | |
|---|---|---|---|---|
| Measure | Spring 2018 | Fall 2018 | Spring 2019 | Fall 2019 |
| Total Simplex Pages | 201,000 | 253,000 | 111,000 | 127,000 |
| Total Duplex Pages | 172,000 | 225,000 | 306,000 | 333,000 |
| Total Pages | 373,000 | 478,000 | 417,000 | 460,000 |
| Total Sheets | 287,000 | 365,500 | 264,000 | 293,500 |
| Average Sheets per Page Ratio | 0.843 | 0.835 | 0.687 | 0.682 |
| Median Sheets per Page Ratio | 0.894 | 0.877 | 0.642 | 0.635 |
| Number of Students | 1512 | 1512 | 1512 | 1512 |

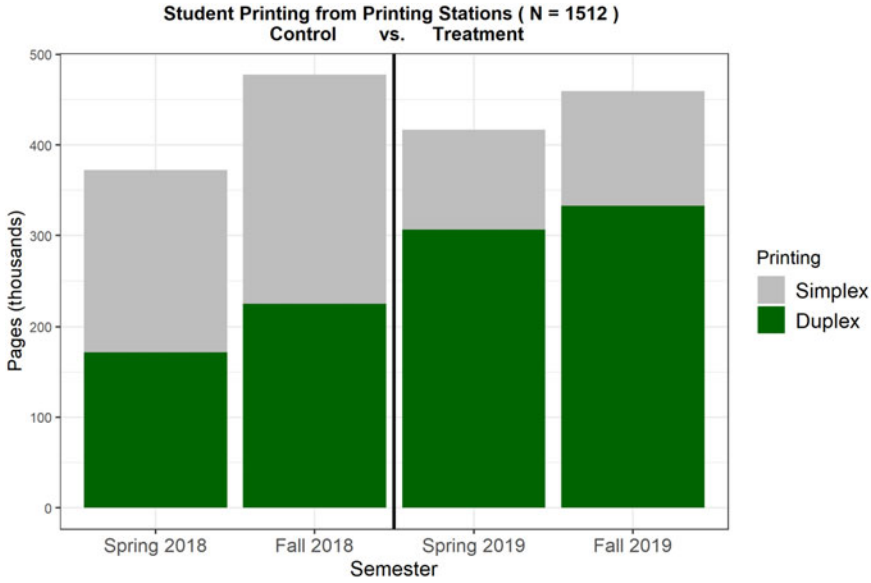


**Figure 3.** Simplex and duplex pages across semesters.

As with Table 2, a clear increase in duplex pages was observed across semesters depicted by the green bars. The increase continued in Fall 2019, showing the sustained effect of the default nudge in promoting duplex printing. For simplex pages, an initial increase was seen from Spring 2018 to Fall 2018, followed by a sharp decline in Spring 2019, as shown by the gray bars. In 2019, the difference between simplex printing was less noticeable. Moreover, the bars show that there was more printing during Fall relative to Spring semesters, reinforcing the importance of considering both semesters before and after the behavioral intervention.

To test differences across treatment and control semesters, I employed Welch Two Sample *t*-tests focusing on the sheets per page ratio for the following control versus treatment groups: (a) Fall 2018 versus Spring 2019, (b) Spring 2018 versus Spring 2019, (c) Fall 2018 versus Fall 2019, and (d) 2018 versus 2019. In the four *t*-tests, I rejected the

null hypothesis of equal means across semesters with $p$-values below 0.01. Thus, these differences in means between control and treatment were statistically significant at the 99 percent confidence level. I also used a $t$-test to compare both control semesters (i.e. Spring 2018 versus Fall 2018) and both treated semesters (i.e. Spring 2019 versus Fall 2019) and failed to reject the null in both tests. Thus, there were no statistically significant differences within control and within treated semesters. Figure 4 illustrates box plots for the sheets per page ratio for each semester.

The sheets per page ratio is the most important measure of conservation and resource efficiency, as it takes into account the quantity of paper used relative to printed pages. Figure 4 shows strong evidence supporting the effectiveness of this green default nudge and its lasting effect. Prior to the green nudge, both Spring 2018 and Fall 2018 box plots looked similar and closer to 1 (least conservation). After the nudge was introduced, both box plots shifted down and got closer to 0.5 (most conservation). Moreover, these results showed that the effectiveness of this nudge did not change after the initial introduction and was visible in Fall 2019, a year after the change.

### Panel regression results

To estimate the four models described in Equation (2), I employed the *plm* R package, which uses an entity-demeaned Ordinary Least Squares (OLS) algorithm in its estimation (Croissant et al. 2020; Hanck et al. 2019).[6]

Table 3 shows the estimation results for four outcome variables: simplex pages, duplex pages, total sheets, and sheet per page ratio.

The four models confirm the hypotheses that the default nudge decreased single-sided printing, increased double-sided printing, dropped paper usage, and reduced the sheets per page ratio. Model (I) demonstrates that the green nudge decreased single-sided printing by about 71 pages per student on average. Dividing the estimated coefficient by the average from the control semesters, I find sizable percentage changes due to the default nudge. Specifically, on average, simplex pages were reduced by 47 percent relative to control semesters. Model (II) shows that the nudge increased duplex pages per student by about 83 pages on average, meaning that duplex pages increased 63 percent, on average. Model (III) demonstrates that about 30 pages were saved with this green nudge on average per student, achieving conservation. This estimated coefficient translates to an average reduction of 14 percent per student relative to control semesters. This result is in line with the one observed by Egebark and Ekstrom (2016), who found a 15 percent cut in paper use at their university. One of the limitations of the data is the lack of information on course hours and on changes in major, minor, or commuter vs. resident status that may affect the quantity of pages printed. While I used a proxy for the share of STEM courses, this proxy does not account for other changes a student may experience across semesters that affect printing.

While switching majors, taking more courses, or becoming a commuter may affect the quantity of pages printed, these changes should not affect the sheets per page ratio, as it considers both paper usage and printing behavior and measures conservation efficiency. For example, a student who always prints double-sided may continue that same practice even if he or she prints fewer pages during one semester. Model (IV) illustrates that the sheet per page ratio decreased by 0.16 on average relative to the control semesters. This is a sizable impact given that the ratio ranges between 0.5 and 1. Moreover, since the average sheets per page ratio was 0.84 in Spring and Fall 2018, this drop shows a strong conservation effect, decreasing the

[6]For robustness, models were estimated with the *fixest* R package (Berge et al. 2023), yielding identical results.

https://doi.org/10.1017/age.2024.5 Published online by Cambridge University Press



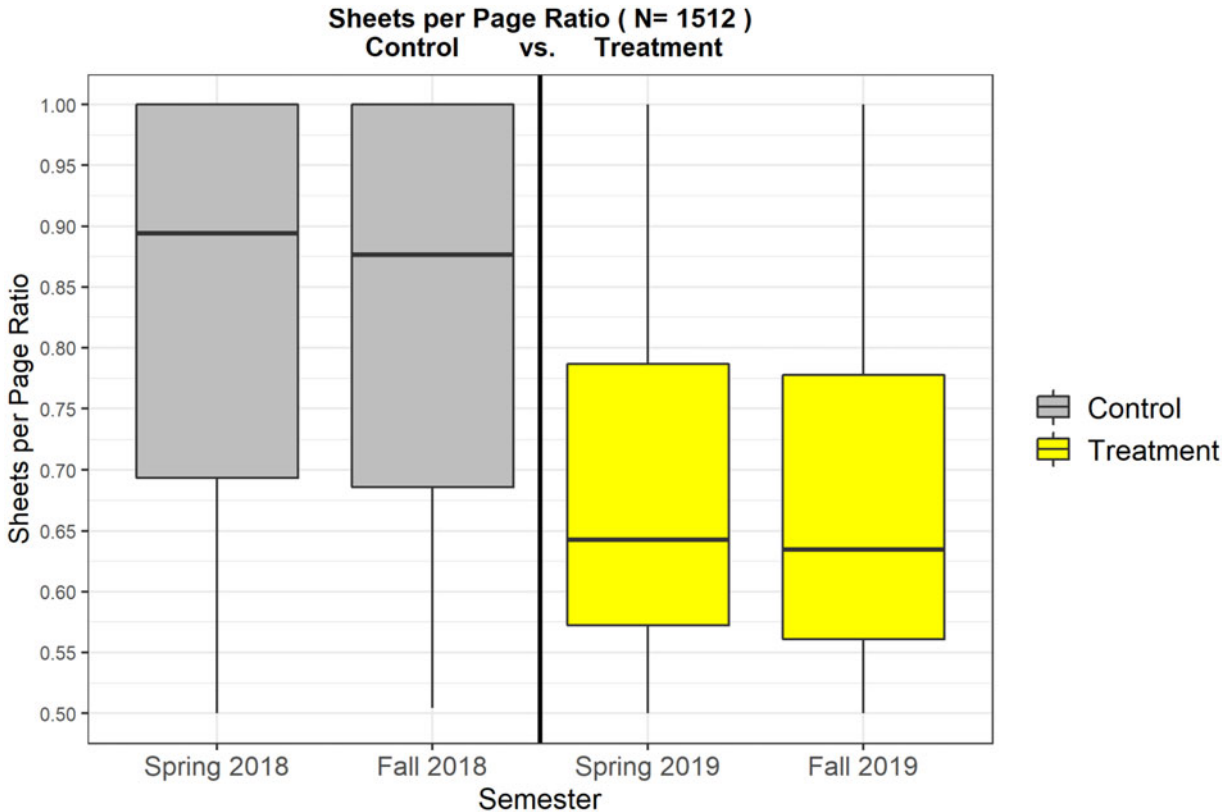


**Figure 4.** Box plots of sheets per page ratios across semesters for matched subset.

**Table 3.** Fixed effects panel regression results

| | (I) | (II) | (III) | (IV) |
|---|---|---|---|---|
| | Simplex pages | Duplex pages | Total sheets | Sheets per page ratio |
| | Estimate | Estimate | Estimate | Estimate |
| Treatment | −71.06*** | 82.55*** | −29.78*** | −0.16*** |
| | (3.2006) | (6.2945) | (4.1205) | (0.0028) |
| Student FE | Y | Y | Y | Y |
| Control[1] | Y | Y | Y | Y |
| Within R^2 | 0.078 | 0.029 | 0.011 | 0.335 |
| Adjusted R^2 | 0.661 | 0.739 | 0.847 | 0.458 |
| F-Statistic | 133.65*** | 47.69*** | 36.84*** | 832.45*** |
| Students | 1512 | 1512 | 1512 | 1521 |
| Semesters | 4 | 4 | 4 | 4 |
| N | 6048 | 6048 | 6048 | 6048 |
| Mean from Control Semesters | 150 | 131 | 215 | 0.84 |
| Change | ↓ 47% | ↑ 63% | ↓ 14% | ↓ 19% |

*Note:* *** $p < 0.001$. Robust standard errors are in parentheses.
[1]Control is the share of pages printed in the lower campus (proxy for share of STEM courses taken that semester).

ratio by 19 percent. Different that totals studied in Models (I), (II), and (III), model (IV) considers the efficient usage of paper by considering simplex, duplex, and total sheets. As a result, model (IV) offers the most important estimation of the effectiveness of this nudge. These regression results allow me to examine and quantify the statistically significant effect of this default nudge. They show that students switched from simplex to duplex printing, saving paper usage and improving the conservation of paper at the college. This analysis shows paper conservation continued within a year of the introduction of the default nudge. Thus, the effect was still observable within a year of the behavioral intervention.

## Survey results

The regressions in Table 3 include the share of pages printed in the lower campus relative to total pages that serves as a proxy of STEM courses taken during the semester. To verify this assumption, the survey asked students about where they print during a typical semester. The survey presented a map and students were asked to allocate a percentage to each location. Survey results show that liberal arts, business, and education students primarily print at the library (upper campus). The average percentage of printing at the library was above 90 percent for these groups. Engineering and science students print at the library but less frequently: 58 and 72 percent, respectively. In contrast to other students, engineering and science students allocated a much higher percentage to printing on the lower campus. On average, they reported at least 20 percent of printing jobs done at the lower campus. Thus, the share of pages printed in the lower campus is a reasonable proxy for STEM courses taken on campus.

**Table 4.** Environmental information from pop-up window

| Question | Count (%) |
|---|---|
| Answers | **N = 827** |
| ***When you first encountered the pop-up message, what did you do?*** | |
| I carefully read the environmental information presented in the pop-up window | 201 (26%) |
| I skimmed through the environmental information presented in the pop-up window | 434 (57%) |
| I skipped the environmental information | 126 (17%) |
| ***As time went on and you continued encountering the pop-up message, which statement best describes your behavior?*** | |
| I carefully read the environmental information presented in the pop-up window | 57 (7.5%) |
| I skimmed through the environmental information presented in the pop-up window | 250 (33%) |
| I skipped the environmental information | 453 (60%) |
| ***Does the environmental information displayed in the pop-up window vary by the number of pages?*** | |
| Yes | 154 (20%) |
| No | 152 (20%) |
| I don't know | 462 (60%) |

A second assumption behind this research is that students likely do not pay as much attention to the environmental information presented in the pop-up window (Fig. 1), particularly as time goes on. If they did, it would not be clear whether the changes in print behavior are attributed to the green default nudge or to the environmental information presented or to a combination of both. Thus, this assumption is key to understanding the power of this green default nudge. To verify this assumption, three questions were asked in the survey. Table 4 summarizes the responses.

When asked what students did when they first encountered the pop-up window, 26 percent stated they carefully read the environmental information, 57 percent said they skimmed through it, and 17 percent skipped it. As time went on, students paid less attention to the pop-up window. Notably, 60 percent said they skipped it, and 33 percent skimmed it. Thus, a small percentage claimed to pay careful attention to the environmental information as time went on, offering evidence in favor of the assumption. The first two questions asked stated behavior. Some students may have wanted to signal that they care about the environment by stating that they paid more attention to the information. If that is the case, these answers are biased towards more attention to the information. Since the answers reveal a decrease in attention to the information as time goes on despite the potential bias, this further supports the assumption behind the research. The third question captures whether students paid attention to the environmental information in a different way. Students who careful read the information, even if only at the beginning, should know that the environmental information presented in the pop-up window changed with the number of pages of the print job. In other words, as more pages are printed, the environmental savings of printing double-sided increase and students saw substantially different environmental metrics for 2-page and a 20-page job, for example.

**Table 5.** Change in print settings

| How often did you change the print setting from double-sided to single-sided through the action drop-down menu? | Fall 2021 | Spring 2021 |
|---|---|---|
| Never | 211 (30%) | 232 (34%) |
| Rarely | 160 (26%) | 148 (21%) |
| Sometimes | 144 (21%) | 138 (20%) |
| Often | 96 (14%) | 89 (13%) |
| Always | 83 (12%) | 84 (12%) |

When asked whether the environmental information varied with the number of pages, only 20 percent answered correctly. Notably, a student could have noticed the variation by attentively reading the information of a minimum of two print jobs with different page numbers, not having to do it every single time. Thus, having only 20 percent answering the question correctly reveals that students, generally, do not pay careful attention to the environmental information. From these answers, it is reasonable to assume that the results from the nudge come primarily from the default change and not the environmental information presented.

The survey also offers an opportunity to understand students' printing preferences and behaviors. The survey asked about the preferred default print setting on campus. The results show that 59 percent preferred double-sided, 24 percent single-sided, and 17 percent did not care. The survey also asked for the frequency in which students changed the print setting. Table 5 includes the distribution of answers for two semesters.

Table 5 offers more evidence of the effectiveness of the nudge, based on stated behavior by students. The answers across both semesters are generally similar. Between 30 and 34 percent never changed the print setting from double-sided to single-sided, offering evidence of the inertia of this default nudge. Between 21 and 26 percent rarely changed it, which also supports the effectiveness of the nudge (There are certain documents that need to be printed single-sided (e.g. specific forms)). Together, between 55 and 56 percent of the students kept the default setting most of the time. About 20 percent changed the setting sometimes. Lastly, around 13 percent often changed it, and 12 percent always changed it. Thus, the nudge did not work among those who stated often or always, which is a relatively small percentage.

Among the green nudge literature, there are concerns about rebound effects. To check whether students print more pages as they do not use as many sheets with the double-sided setting, the survey asked about how the pop-up window affected printing habits. 39 percent stated that they printed fewer pages, 57 percent stated that the pop-up window did not affect their printing habits, and only 3.3 percent stated that they printed more pages. In addition to the rebound effect, there may be concerns about printing multiple times due to the default setting (e.g. a student prefers to print single-sided and prints the job twice). When asked for the number of times they re-sent a print job because they wanted single-sided printing during a semester, 67 percent answered none. Around 30 percent of students stated that they re-printed between 1 and 10 times per semester. Together, these results suggest that this default green nudge does not have a rebound effect or other unintended consequences.

The survey results complement the print data analysis. Its results validate the assumptions behind the research and offer more evidence of the effectiveness of the nudge. Moreover, the survey expands the understanding of printing preferences and behaviors on campus. The analysis offers strong evidence in support of this default nudge.

### *Environmental impact*

Using back-of-the-envelope calculations, I estimate the financial and environmental impact of the default nudge, summarized in Table 6.

From the regression results in Table 3, the nudge achieved a 30-sheets reduction on average per student per semester. Using this information, I computed the sheets saved per semester after the nudged was introduced. For the lower bound, I made these calculations based on the subset of students across the four semesters (See Table 6 – Panel A). For the upper bound, I used the overall enrollment in both treatment semesters (See Table 6 – Panel B). A financial benefit of reducing paper usage is the cost savings from the reams that were saved. The cheapest ream of A4 paper on Amazon.com costs $8.20 (Amazon 2021). Using this information, I find that the nudge resulted in cost savings between about $1,500 and $3,700 after a year of its introduction.

For the environmental benefits, I followed the environmental statistics from the Standard Chartered report in 2010, which have been used in studies examining paper usage at offices or universities (Abdel Jawad et al. 2020; Shah et al. 2019; Standard Chartered Bank 2010). The report includes environmental measures for 1 ton of A4 paper (400 reams). Specifically, 400 reams of A4 paper is equivalent to 3.47 tons of wood, 24.29 trees, 38.7 million of btus energy, 5,868.8 lbs of CO2 equivalent emissions, 0.5 year emissions from a car (Standard Chartered Bank 2010).

Using these statistics, I computed the annual abatement achieved by the nudge by saving sheets. The default nudge saved between 1.6 and 3.9 tons of wood after its introduction. This is equivalent to saving between 11 and 27 trees. The nudge also resulted in energy savings between 8,800 and 21,600 million btus. Moreover, it achieved a reduction of CO2 equivalent emission tons between 700 and 2,500, which is equivalent to between 114 and 429 years of a typical car emissions.

Table 6 shows that while the financial savings are low relative to university budgets, this simple change had a substantial environmental impact, showing the power of nudges in changing behavior and promoting conservation. Effective default nudges such as this one have the potential to reduce greenhouse gas emissions that contribute to climate change.

## Discussion and conclusion

Behavioral economics strategies may be implemented to complement or substitute command-and-control or market-based policies. These interventions are desirable in the absence of financial incentives. Within behavioral strategies, nudges are inexpensive tools to change behavior in a predictable way without alternating the choice architecture. Within the intersection of both environmental and behavioral economics, green nudges are employed to promote conservation and pro-environmental behavior. In this paper, I studied the effectiveness of a salient green default nudge in conserving paper in the absence of pecuniary incentives. At a private college in New York City, the default print setting switched from simplex to duplex in Spring 2019. The nudge included a pop-up window that asked students to print double-sided and that included environmental information. Using student-level data, I observed printing behavior for the same students across four semesters: Spring 2018 (control), Fall 2018 (control), Spring 2019 (treatment), and Fall 2019 (treatment). The data from this natural experiment supports the hypothesis that this green default nudge is effective in changing behavior and increasing conservation. Specifically, this nudge reduced single-sided printing while increasing double-sided printing. Moreover, this nudge reduced paper usage and increased resource efficiency. The effectiveness of the nudge is observed within a year of the change, showing the continued

https://doi.org/10.1017/age.2024.5 Published online by Cambridge University Press

**Table 6.** Financial and environmental benefits of the green default nudge

| | | | | | Abatement/Environmental benefit | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Panel A – Subset of matched students | Students | Sheets saved | Reams saved | Cost savings | Wood (tons) | Trees Saved | Energy (million btus) | CO2 equiv. emissions (tons) | Emissions from a car (years) |
| Treated semester | 1512 | 45360 | 91 | $744 | 0.79 | 5.5 | 4389 | 333 | 57 |
| Total (Annual) | | 90720 | 182 | $1488 | 1.58 | 11 | 8778 | 666 | 114 |
| Panel B – Overall Population | Students | Sheets Saved | Reams Saved | Cost Savings | Wood (tons) | Trees Saved | Energy (million btus) | CO2 equiv. emissions (tons) | Emissions from a car (years) |
| Spring 2019 | 3616 | 108480 | 217 | $1779 | 1.88 | 13.2 | 10495 | 841 | 143 |
| Fall 2019 | 3821 | 114630 | 229 | $1880 | 1.99 | 13.9 | 11090 | 1682 | 286 |
| Total (Annual) | | 223110 | 446 | $3659 | 3.87 | 27.1 | 21585 | 2523 | 429 |

*Notes:* Sheets saved = 30 sheets * students; 1 ream = 500 sheets.

effect of this default nudge. This inexpensive behavioral intervention proves successful in promoting environmental behavior and reducing paper consumption, which reduces greenhouse gas emissions. Given that this study was completed at a small university, it is worth considering the potential sizeable environmental benefits at larger universities with more students (there are universities with more than 10 times the enrollment of this study's college). A similar story can be told of large offices where workers do not pay as they print. By changing the default to double-sided, these institutions and organizations can contribute to paper conservation and sustainability efforts in a cheap and straightforward way. In sum, this study encourages institutions and organizations to adopt this green default nudge to help address climate change and pollution in contexts where pecuniary incentives are not available.

**Data availability statement.** The printing data was obtained from the Information Technology Office at Manhattan College and cannot be shared. The survey data was collected through Qualtrics and cannot be shared due to IRB.

**Acknowledgments.** I acknowledge the help from the Information Technology Services in providing anonymized print data. A special thanks to Rich Musal, Alberto DeAngelis, Susanne Leavy, and Gregory Quaglieni. Moreover, I would like to thank Pamela Chasek for hosting the space to discuss campus sustainability and to Heyi Cheng, Sierra Arral, Veronica Cheng, and Saran Camara for their student sustainability perspectives. I am also grateful for the insightful comments from conference and seminar presentations at the AERE sessions at the EEA and MEA, BEEMA, CREAA, NAREA, SEA, Lafayette College, University of Rhode Island, and the University of Delaware. I am also grateful for feedback from Billur Aksoy, Tanu Jhunjhunwala, Priyanka Chakraborty, Sara Solnik, Sarah Jacobson, Jeffrey Cross, Tracy Boyer, and Diane Dupont. Lastly, I thank Anna Klis and the two anonymous referees for their useful feedback.

**Funding statement.** This research was benefited by the Gabriel Hauge Fellowship and the support of the O'Malley School of Business Dean's Office at Manhattan College.

**Competing interests.** There are no competing interests.

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**Cite this article:** González-Ramírez, J. 2024. "The effectiveness of a green default nudge in achieving resource conservation." *Agricultural and Resource Economics Review*. https://doi.org/10.1017/age.2024.5