Nudging as an Environmental Policy Instrument

Fredrik Carlsson[*], Christina Gravert[ξ], Olof Johansson-Stenman[ζ], and Verena Kurz[§]

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Abstract

We discuss the use of green nudges – nudges intended to reduce negative externalities – as an environmental policy instrument. We propose a new classification of nudges, pure and moral nudges, based on the mechanism through which they affect individual decision-making. A review of empirical studies reveals that green nudges can have a sizeable impact on behavior and the environment but that the effects are highly context-dependent. In the policy discussion, drawing on both the empirical overview and basic welfare-economic models, we present considerations that need to be made by policymakers when choosing between implementing a green nudge and conventional policy instruments.

[*] University of Gothenburg, Department of Economics, Box 640, 405 30 Gothenburg, Sweden; Telephone: + 46 31 7864174; e-mail: fredrik.carlsson@economics.gu.se.
[ξ] University of Copenhagen, Department of Economics, Øster Farimagsgade 5, 1353 Copenhagen, Denmark; email: cag@econ.ku.dk
[ζ] University of Gothenburg, Department of Economics, Box 640, 405 30 Gothenburg, Sweden; e-mail: olof.johansson@economics.gu.se.
[§] University of Gothenburg, Department of Economics, Box 640, 405 30 Gothenburg, Sweden; e-mail: verena.kurz@web.de.

Introduction

Behavioral interventions, most prominently in the form of nudges, are rapidly entering the public policy toolkit. A *nudge* is generally interpreted as a change in 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 (Thaler and Sunstein, 2009). The role of nudges has typically been to counteract poor choices made by individuals, in areas such as personal savings and health. While such decisions can create negative externalities, such as rising health care costs, the focus has been on improving the individual's own welfare. If it is well designed, a nudge "[…] creates large benefits for those who make errors, while imposing little or no harm on those who are fully rational" (Camerer et al., 2003). Thus, such nudges constitute a behavioral solution to a behavioral problem.

The concept of nudging has also found its way into environmental policy. Nudges are then utilized to influence people's behavior in order to reduce negative externalities. Nudging, in this context, is a behavioral solution to a conventional economic problem. To distinguish between a nudge that improves the welfare of the individual herself and a nudge that reduces a negative environmental externality, we will call the latter a *green nudge*. A green nudge is a change in any aspect of the choice architecture that is intended to alter people's behavior in a predictable way and result in a *reduction of a negative external effect* without forbidding any options or significantly changing the economic incentives.

In this paper, we propose a new, simple classification of nudges, give a systematic review of empirical field studies testing green nudges, and based on these findings discuss the role of green nudges as an environmental policy instrument. In particular, we discuss when green nudges can and should be used as substitutes and complements to standard policy instruments such as a Pigovian tax.

A Simple Classification of Interventions and Their Motivations

Inspired by the classification of policy instruments by Loewenstein and Chater (2017), we classify public policy interventions by type and rationale; see Figure 1. Cell A includes conventional polices used to reduce externalities, including command-and-control measures, Pigovian taxes, tradeable permits, and information disclosure. Cell B includes conventional policy instruments that have been adjusted to account for behavioral biases, such as a tax that takes limited price attention into account (Farhi and Gabaix, 2019). This category also includes conventional interventions that have a behavioral rationale due to internalities, where people fail to fully take the future (or other) consequences for themselves into account (Madrian, 2014). Cell D reflects behavioral interventions that counteract internalities caused by bounded rationality, i.e. decisions made with cognitive or self-control limitations compared to the standard economic model. We call these nudges "self-focused" nudges to highlight the focus on the individual's own utility. In this paper, we focus on Cell C, green nudges. The rationale for such an intervention is conventional, while the type of intervention is behavioral. A green nudge does not aim to correct a mistake in decision-making but instead uses people's biases and moral utility to nudge them away from creating negative externalities.

	Type of Intervention	
Rationale for Intervention	Conventional	Behavioral
Conventional Economic (externalities, public goods, common-pool resources, asymmetric information)	A. Externality-correcting taxes, tradeable permits, command and control, information	C. Green nudge: pure and moral
Behavioral Economic (internalities, bounded rationality)	B. Internality-correcting taxes, regulation, information	D. Self-focused nudge: pure and moral

Figure 1. Overview of interventions

Hence, the distinction between self-focused nudges and green nudges is not based on the type of nudge, but rather on the *rationale for nudging*, where self-focused nudges focus on reducing internalities, and green nudges focus on reducing externalities with behavioral tools. This also means that green nudges are not motivated by paternalism, implying that we can partly sidestep the sometimes-heated discussions on libertarian paternalism (e.g. Sugden 2018; Sunstein and Thaler, 2003). One may still have ethical objections regarding the government's exploitations of people's bounded rationality, regardless of the overall objective.

Extending our framework, we further classify the mechanism through which the nudges – both self-focused and green ones – affect the individual decision-making into two categories: *pure* and *moral* nudges. As we will argue below, this classification is important for welfare evaluations.

Pure Nudges

A self-focused pure nudge aims to correct for cognitive limitations, inattention, or self-control problems. It steers choices by affecting decision utility without directly affecting experienced utility (the hedonic experience from the outcome). A pure nudge makes it easier to "do the right thing," meaning, in a broad sense, acting in the individual's long-run interest. A pure self-focused nudge could be putting healthy foods at the top of a menu to make them more salient or to enroll employees in an employer-matched savings plan by default.

A pure green nudge works in the same way as a pure self-focused one, but the motivation for the nudge does not require that the individuals are making poor choices for themselves due to bounded rationality. For example, an individual could make a perfectly rational choice concerning her welfare by not electing a green electricity tariff. Yet, for a pure green nudge to work as intended, individuals must have cognitive, attention, or self-control limitations. For

example, bounded rationality could lead an individual defaulted into a green tariff to stick with the new socially desirable default. Thus, rather than correcting for a cognitive or self-control limitations, a pure green nudge makes use of such limitations to encourage socially desirable behavior that may or may not be in the individual's best self-interest. Pure nudges that make it easier to do the right thing, such as a smaller plate size at a buffet to reduce food waste, generally have less potential to wear off, as they are not consciously noticed by the decision-maker.

Moreover, for both self-focused and green pure nudges, it is sometimes impossible *not* to nudge; this is the case whenever there is a given choice environment such as a default or a menu. Menus first present either the healthy or the unhealthy options, the green or the grey tariff, and the decision-makers will be influenced either way.

Moral Nudges

A *moral nudge* draws on people's social preferences, their desire for status, to follow norms, or to have a positive self-image. The nudge rewards "doing the right thing" by providing the individual with moral utility or disutility. As opposed to pure nudges, moral nudges thus work directly through effects on experienced utility. While they can be self-focused such as encouraging exercise (Butera et al., 2019) or increasing savings (Beshears et al., 2015), they are often employed to encourage pro-social or green behavior such as tax compliance (Hallsworth et al., 2017), charitable giving (Shang and Croson, 2009) and energy consumption (Allcott, 2011). Comparing the decision-maker with their neighbor in terms of electricity consumption or highlighting the status that comes with driving an environmentally friendly car are examples of creation of moral (dis-)utility to increase socially desirable behavior. Whether the induced experienced utility is positive or negative depends on the reference point. As opposed to pure nudges, moral nudges are never an inevitable part of the choice environment.

Green Nudges – A Review of Empirical Field Studies

In this section, we review field studies of green nudges and discuss their empirical support and why they could affect behavior, focusing on adequately powered experiments that measure behavioral outcomes. Table 1 presents published studies of green nudges that we review based on the type of nudge and environmental problem, while we also refer to several still unpublished studies in the text. Behavior change induced by both pure and moral green nudges can be used on the intensive as well as the extensive margin. Using a default green energy tariff is a pure nudge on the extensive margin, while decreasing the plate size at a breakfast buffet to avoid food waste is a pure nudge on the intensive margin. Using social comparisons to encourage people to reuse their towels by placing them on the rack is a moral nudge on the extensive margin, while the classic home energy reports encourage energy reduction on the intensive margin.

Table 1. Green nudge field studies published in peer-reviewed international journals

Study	Description	Target good	Effect size	Statistically sign. effect?
Pure Nudge – Defaults				
Arana, Leon	Opt-in vs. opt-out	Carbon offsetting of air travel	+27%	Yes
Brown et al.	Default	Default temperature on the thermostat	-1,8%	Yes
Ebeling, Lotz	Opt-in vs. with opt-out	Green energy contract	+860%	Yes
Egbark, Ekström	Default	Paper use	-14%	Yes
Löfgren et al.	Opt in/opt out/active choice	Carbon offsetting of air travel	-16% (opt in) -7.7% (opt out)	No
Toft et al.	Opt-in vs. opt-out	Purchase of steering unit with heat pump	-10% (opt-in) -23% (opt-out)	Yes
Pure Nudge - Simplification of information and salience				
Gravert, Kurz	Order on menu	Meat consumption	-55%	Yes
Kurz	Order on menu and presentation	Vegetarian food	+45%	Yes
Tiefenbeck et al.	Feedback in a salient way	Electricity consumption	-22%	Yes
Pure Nudge - Changes in the physical environment				
Kallbekken, Saelen	Change plate size	Food waste	-21%	Yes
Pure/ Moral Nudge – Reminders				
Gillbert, Zivin	Reminder	Electricity consumption	-0.89%	Yes
Wallander et al.	Reminder	Sign-up conservation program	+2.9%	Yes
Moral Nudge - Social comparison				
Allcott	Comparison	Electricity consumption	-2.72%	Yes
Asensio, Delmas	Comparison + framing	Electricity consumption	+3.8% (private framing) -8.2% (social framing)	Mixed
Ayres et al.	Comparison	Electricity consumption	-2%	Yes
Bernedo et al.	Comparison, long run	Water use	-0.89%	No
Brent et al.	Comparison	Water use	-1% – -5%	Mixed
Costa, Kahn	Comparison	Electricity consumption	-2.1%	Yes
Delmas, Lessem	Comparison; private and public	Electricity consumption	-5.6% (private) -19.2% (public)	Yes
Ferraro. Price	Comparison; strong and weak	Water use	-2.8% (weak) -4.6% (strong)	Yes
Ferraro et al.	Comparison, long run	Water use	-0.16% (weak) –0.96% (strong)	Yes if strong
Holladay et. al.	Comparison	Purchase of efficient durables	0%	No
Jaime, Carlsson	Comparison	Water use	-5.4%	Yes
Mizobuchi, Takeuchi	Comparison; financial reward	Electricity consumption	-6.8%	Yes
Richter et al.	Comparison; varying reference group	Share of sustainability-labeled seafood	+6% – +21% (small) +8% – +18% (large)	Mixed
Sparkman, Walton	Dynamic and static norms	Meatless lunch	+42% (dynamic) +36% (static)	Mixed
Sudarshan	Comparison	Electricity consumption	-5.6%	Yes

Pellerano et al.	Comparison, financial reward	Electricity consumption	-0.6% – -1.1%	Yes if no reward
Schultz et al.	Social comparison	Electricity consumption	+ 8% (descriptive, short run) -5.7% (injunctive, long run) +2.3% (descriptive, long run) -8.3% (injunctive, long run)	Mixed
Moral Nudge - Normative appeal and peer pressure				
Ito et al.	Normative appeal	Electricity consumption	-0.03% (short run) +0.01% (long run)	Only short run
Goldstein et al.	Normative appeal	Towel reuse rate	+26%	Yes
Kallbekken, Saelen	Normative appeal	Food waste	-28%	Yes
Egbark, Ekström	Normative appeal	Paper use	-2.6%	No
Schultz et al.	Plea	Recycled waste	0%	No
Yoeli et al.	Observability	Sign-up energy conservation program	80% – 200%	Yes
Moral Nudge - Commitment and goal setting				
Baca-Motes et al.	Commitment	Using towel additional days	+3.5% (general), +28% (specific)	Mixed
Bryce et al.	Commitment	Number of weeks household recycled waste	+13%	Yes
Harding, Hsiaw	Goal	Electricity consumption	-0.04%	Yes
Jaeger, Schultz	Commitment + social norms	Water use	-3.5% (social norm, short run) -5.6% (warning, short run) -8% (social norm, long run) -3% (warning, long run)	Mixed
Loock et al.	Goal	Electricity consumption	-2.3%	Yes
Terrier, Marfaing	Commitment + appeal	Towels replaced in hotel room	-19.5% (commitment) -20.5% (commitment + appeal)	Yes

Pure Green Nudges

We classify defaults, simplification of information and salience, and changes to the physical environment as pure nudges. We also include reminders here, even though they can be seen as a hybrid between pure and moral nudges.

Defaults

The *default effect* refers to the tendency of people to stick with an alternative already chosen by someone else, even when the cost of making an active choice is very small (Johnson and Goldstein, 2003). The most well-known example of a prosocial default nudge is that the fraction of people who are willing to donate their organs is substantially higher in countries where people are organ donors by default (Johnson and Goldstein, 2003). Sunstein and Reisch (2013) identify three principal factors why defaults can influence behavior. First, people may interpret the default as a suggestion from someone – an expert or a policymaker – who has additional information justifying the recommended option. Thus, setting a default can lower the decision costs for some individuals. Second, people may put off deciding altogether, and then providing a default choice may result in them moving from no decision at all to the pre-set decision. Finally, loss aversion or status quo bias can contribute to a default effect, as many individuals will evaluate available options in comparison with the default

A few studies look at default effects and environmentally friendly behavior. Egebark and Ekström (2016) found a default effect on computer printing behavior: by changing the default printer setting from simplex to duplex, the consumption of printer paper dropped by around 15 percent, and there were no indications that the effect was any smaller 28 weeks after the change. Pichert and Katsikopoulos (2008) illustrate with two examples that many German electricity consumers stick with an environmentally friendly default option. Ebeling and Lotz (2015) compared customer choice of green energy between an opt-in and an opt-out case. In the opt-

in group, 0.6 percent purchased a green contract, while in the opt-out group, the figure was 5.6 percent. In Brown et al. (2013), the default temperature on thermostats was changed from the standard 20 °C to a lower default. While a 1-degree decrease resulted in a lower average temperature initially, the effect disappeared and went in the opposite direction after a few weeks. What this suggests is that a default can have the most impact if it is close enough to people's actual preferences, so present-bias or inattention will deter them from switching back (Löfgren and Nordblom, 2019). Individuals with strong preferences for another option than the default will be more likely to override it (Johnson and Goldstein, 2003). However, there is little empirical evidence supporting this claim, partly because underlying attitudes and preferences are hard to measure. Vetter and Kutzner (2016) did not find any interaction effect between environmental attitudes and a green default in a survey-based online experiment. Löfgren et al. (2012) conducted a field experiment with experienced users in the domain of carbon offsetting and found no difference in the choice to offset emissions from flying between a default to compensate, a default not to compensate, and an active choice setting. They concluded that experience attenuates default effects.

Simplification of Information and Salience

If decision-makers are inattentive to some factors of a decision problem, they will come to a different solution than predicted by conventional economic theory. Chetty, Friedman, and Kroft (2009) found that shoppers pay only limited attention to a sales tax compared to the price before tax. Similarly, Allcott (2011), Allcott and Taubinsky (2015), and Allcott and Knittel (2019) found that consumers pay little attention to fuel and electricity costs compared with the sales prices they face when buying cars or lightbulbs. This does not have to be irrational in a broader sense; it would be a rational strategy to limit costs of information acquisition and decision to

cope with the multitude of decisions individuals have to make in everyday life (Caplin and Dean, 2015).

The design of different types of consumer product labels is a primary example of information provision and simplification of information. In Kallbekken, Saelen, and Hermansen (2013), electrical retail stores provided information on lifetime energy costs of appliances through a label and training of staff. A strong initial effect was found for only one type of appliance. Other studies have also found mixed results. Stadelmann and Schubert (2018) found effects of both providing a label per se and of a visually augmented label containing monetary and lifetime-oriented information on the energy efficiency of dryers and vacuum cleaners sold. Allcott and Knittel (2019) found no effect of providing individually tailored information about lifetime fuels cost on the average fuel economy of vehicles purchased. Allcott and Sweeny (2017) found no effect of information provision on the demand for energy-efficient durable goods. However, the primary purpose of a label is to provide better information to improve choices, which is not a nudge per se. A label could still reduce problems of inattention, but it is difficult to know how large this effect is. For that reason we do not report the effects of these studies in Table 1.

The order in which information is presented can affect the salience of the information. In Kurz (2018), the salience of a vegetarian option was increased by changing the menu order and placing the dish at a place visible to customers. This increased the share of vegetarian dishes sold by six percentage points. In Gravert and Kurz (2019), an even larger effect was found by rearranging a menu in favor of a vegetarian option. Placing the vegetarian dish at the top of the menu reduced the share of meat dishes ordered from 46 percent to around 21 percent. In a study by Tiefenbeck et al. (2016), real-time feedback on energy use was given in the form of an animation of a polar bear standing on melting ice. The visual feedback reduced the average shower time by 22 percent. Yet, they find no lasting effects of feedback on shower time once the visual feedback device is turned off.

Changes in the Physical Environment

The physical environment itself may be important if people have limited attention or if the environment provides barriers to preferable behavior. The physical environment can also give clues on appropriate conduct.

Kallbekken and Saelen (2013) evaluated a green nudge provided through the physical environment, to reduce food waste in buffet restaurants. In one treatment, the nudge consisted of providing plates that were almost 50 percent smaller than the standard ones. The effect on food waste was substantial, with a reduction of around 20 percent.

Designs of the physical environment are often used for waste and recycling: designs of waste bins and footsteps to the waste bin are some examples of nudges. There are, however, few academic and adequately statistically powered evaluations of such nudges.

Reminders

Reminders fall somewhere between pure and moral nudges. A reminder increases attention to a decision and reduces forgetfulness. However, reminders can also impose moral costs if they draw attention to a decision that the decision-maker would rather avoid (Damgaard and Gravert, 2018).

Wallander, Ferraro, and Higgins (2017) investigated the effect of reminders on participation in voluntary land conservations programs and found that a reminder sent out to participants with expiring contracts increased participation rates. There was no additional effect of letters providing peer comparisons and social norms messaging. Gilbert and Zivin (2014) investigated the effect of receiving the electricity bill, which is a type of reminder, on hourly electricity consumption. They found a 0.6–1 percent reduction in electricity consumption following receipt of the bill, but the effect varied considerably across households and seasons.

Gosnell, Metcalfe and List (2019) sent reminders with personalized targets to airline pilots to encourage them to fly more fuel efficiently. In the subsequent eight months, the airline saved around 6.8 million kilograms of fuel, mostly due to a Hawthorne effect of the monitoring. However, the individual target treatments added another 1–10 percent in fuel savings.

Moral Green Nudges

First, we discuss moral green nudges related to inter-personal motivations and social comparisons with peers. Then we present moral green nudges related to pleas, commitment, and goal setting that make use of individuals' intra-personal motivation to act consistently over time.

Social Comparisons and Social Preferences

One important driver of human behavior is the desire for prestige, success relative to others, and esteem. There is extensive empirical evidence that people care about their status and relative consumption (Frank, 1985; Johansson-Stenman, Carlsson, and Daruvala, 2002). Sexton and Sexton (2014) use the term "conspicuous conservation" to describe consumption that signals pro-environmental action and generates green status, and which are hence not only motivated by pure or impure altruism (Andreoni, 1990; Kotchen and Moore, 2008).

In several studies, social information – information about other people's behavior – has been provided to influence people's decisions based on the idea that individuals tend to conform to the behavior of others. Cialdini (2003) suggests that the extent to which social information affects behavior depends not only on the actual information regarding what others do (i.e., descriptive messages) but also on whether it conveys approval of certain behavior (i.e., injunctive messages). Norms can be particularly powerful in unfamiliar situations where decision-makers might look for cues on how to behave.

A series of field experiments on water and energy conservation suggests that the provision of both descriptive and injunctive messages can affect individuals' behavior by reducing water and electricity use (e.g., Allcott, 2011; Ferraro, Miranda, and Price, 2011; Ferraro and Price, 2013; Costa and Kahn, 2013; Ayres, Raseman, and Shih, 2013; Bernedo, Ferraro, and Price, 2014; Allcott and Rogers, 2014; Brent et al., 2015; Jaime and Carlsson, 2018). A statistically significant effect on behavior is often found, although the size of the effect varies considerably. For example, Allcott (2011) found a 2 percent reduction in electricity use, and Ferraro and Price (2013) found a 3–5 percent decrease in water use.

There are also interesting studies on how social information is communicated. Delmas and Lessem (2014) studied the effects of private information on the household and public information to all neighbors on electricity use. They found that only a combination of private and public information reduced energy use (by 20 percent). Sparkman and Walton (2017) investigated the role of dynamic norms, information on how other people's behavior changes and found stronger effects of dynamic than static norms.

There is still limited evidence on the long-term effects of green moral nudges. Brandon et al. (2017) showed that 35-55% of the treatment effect of home energy reports lives on, even when the treated individuals move out of the house. Intuitively, a nudge to buy an energy-efficient water heater will continue to affect energy consumption also for the next residents. On the intensive margin, individuals will need to be "re-nudged" through, for example, reminders. Moral nudges such as social comparisons, reminders or feedback bear the risk of wearing off once an individual is exposed to them repeatedly. Allcott and Kessler (2019) found that social norm comparisons have long term effects on behavior and that households can be re-nudged.

A related challenge is whether the behavior in question is "nudgeable." To classify as a nudge, including a moral nudge, the intervention should not significantly change the incentives of the decision-maker. Thus, if the difference in utility between two options, or the costs of a

behavioral change, is too high, a nudge cannot change behavior. For example, Holladay et al. (2019) found that providing social comparisons increases free initial audits for home installations of energy-efficient products, but there was no effect on actual purchases. Hahn et al. (2016) found that providing social comparisons affect water consumption but not on switching to less water-intensive landscaping arrangements. Similarly, Andor et al. (2017) found in a large study that the effects on behavior of norm messages are almost non-existent in Germany, where the authors note that there is simply less room for a reduction if the initial energy use level is already low, such that additional energy consumption reduction would be very costly. This is in line with Ferraro and Price (2013), who found that treatment effects of social comparisons for high-consumption households are almost double compared to low-consumption households.

Moral Pleas

Some types of nudges are linked to social preferences but do not directly involve social comparisons (e.g., Schultz, 1999; Goldstein, Cialdini, and Griskevicius, 2008). Ito, Ida, and Tanaka (2018) used moral suasion to reduce energy use during peak hours by providing the following message to some households: "Substantial energy conservation will be required for the society during critical peak-demand hours in summer and winter." This was compared with a control group and a group that received economic incentives to reduce energy use. Electricity use was reduced by around eight percentage points in the moral suasion group and by around 15 percent by the households that received economic incentives. However, the effect of moral suasion diminished quickly when repeated, while the effect of the economic incentives did not. In Egebark and Ekström (2016), a moral message was provided to reduce the use of printer paper, but no effects were found.

Commitment and Goal Setting

Nudges based on commitment and goal setting relate primarily to problems with self-control. Identity can be a driver of behavior if an action is important for one's "sense of self" (Akerlof and Kranton, 2000; Benabou and Tirole, 2006), where people gain utility by behaving in line with what they perceive as consistent with their self-image, whereas the opposite would result in cognitive dissonance (Festinger, 1957). People who define themselves as "green" or socially responsible are then likely to strive for consistency by avoiding environmentally unfriendly behavior.

Harding and Hsiaw (2014) investigated how voluntary goal-setting concerning electricity savings affected electricity use. Those who set a realistic goal saved more than those who set a very low or very high goal. Loock, Staake, and Thiesse (2013) found that both individual and default goals lead to significant energy savings, but default goals that deviate too much from self-set goals could be detrimental for energy savings. Kormos, Gifford, and Brown (2015) combined goal-setting with descriptive social norms to influence private vehicle use. Goal-setting alone had a small effect on private vehicle use, but the effect became considerably larger when combined with information on what others had done.

Offering voluntary ways to commit constitutes a stricter nudge than just setting goals. In Giné, Karlan and Zinman (2010), smokers received a savings account offer. If they opted in to the program, they had to deposit money into the account. After six months, they got their money back if they passed a urine test; otherwise, the money was given to charity. Eleven percent of the smokers accepted the offer. The rate of cessation was around 3–6 percentage points higher for those enrolled in the program than for a control group. In Baca-Motes et al. (2013), hotel guests were given the opportunity to commit to acting more sustainably and received a pin enabling them to signal commitment. Treated guests were more likely to reuse their towels than those who were not asked to commit. The effect of the commitment was stronger if they

received a pin, and it was stronger if the commitment was more specific (reuse towels) than general (act in an environmentally friendly way).

General lessons

The review points to three general lessons: First, the observed effects vary to a large extent between studies. This could be due to context, ineffective nudges or no room for behavior change. Second, nudges that work on the extensive margin, such as defaults for green energy tariffs, tend to have larger and more permanent effects than those targeted at the intensive margin, such as social norms for electricity consumption. Third, little has been done on the effects in the long-run. The evidence we have suggests that effects decrease over time unless they result from structural changes such as more efficient technologies or a different energy tariff.

Green Nudges versus Conventional Policy Instruments

The design of conventional instruments such as taxes and standards when consumers are bounded rational have to some extent been discussed in the literature (Tsvetanov and Segerson, 2013; Allcott, Mullainathan, and Taubinsky, 2014; Heutel, 2015; Farhi and Gabaix, 2019). However, as far as we know, there is little work on optimal nudges as an environmental policy instrument.

Few comparisons of the effectiveness of green nudges with that of conventional policy instruments have been made. Benartzi et al. (2017) compared a social norm message (Allcott, 2011) with discounts of the electricity bill in Ito (2015) and found that for the nudge 27.3 kWh was saved per dollar spent on the intervention, while for the discount the figure was only 3.41 kWh. Whittington and Nauges (2018) found that the net-benefits for society tends to be higher

for a price instrument than for a social-information nudge, but that price increases also imply that households would bear most of the costs.

Many of the reviewed empirical cases of green nudges have been implemented by firms, organizations, utilities, and only sometimes by a regulator. These studies are nevertheless important since a regulator can influence non-governmental agents to implement green nudges. For example, a policy-maker can require that a vegetarian option should be put on the top of menus, to make peer consumption comparisons mandatory, or mandate a green option as a default. In any case, decisions will have to be made by on the intensity of the nudge, the extent of the nudge, and the particular behavior the nudge should target.

Below we outline some fundamental reasoning about when it may be socially optimal to use a nudge and when it is better to rely solely on conventional policy instruments. We discuss which criteria should guide how the nudge should be implemented. We largely base our discussion on the models in Carlsson and Johansson-Stenman (2019) and Farhi and Gabaxi (2019). We start by analyzing the scope for nudging in a simplified case of identical individuals and then explore additional mechanisms with heterogeneous individuals.

Optimal nudging in the case of identical individuals

To begin with, consider a simple textbook model with identical individuals and two goods, one clean and one dirty, where the dirty generates a negative environmental externality. The objective of the government is to maximize the sum of utilities, which is equivalent to obtaining a Pareto-efficient allocation since individuals are identical.

Following Farhi and Gabaix (2019), a pure nudge is assumed to affect choices by influencing decision utility, but not experienced utility. In this case, as long as there are no administrative costs or limitations regarding the implementation of a tax, it would never improve welfare to

complement the tax with pure green nudge (Carlsson and Johansson-Stenman, 2019). Thus, an optimal allocation is obtained by solely using a Pigovian tax.

A moral nudge, on the other hand, could affect individual's own moral self-image, which is a part of experienced utility (Allcott and Kessler, 2019; Carlsson and Johansson-Stenman, 2019). This moral self-image decreases in consumption of the dirty good. The direct hedonic effect of strengthening the norm through the moral nudge is positive if it reinforces the self-image as a good and responsible person, whereas it is negative if it makes people feel guiltier. Allcott and Kessler (2019) denote moral nudges with positive utility effects *moral subsidies*, and Carlsson and Johansson-Stenman (2019) call such nudges *encouraging nudges*; moral nudges with negative utility effects are correspondingly denoted *moral taxes* and *discouraging nudges*. The welfare effects of introducing moral green nudges on top of Pigovian taxes are similar to introducing pure green nudges, with the difference being the direct hedonic effects of the nudge itself. This implies that it may be optimal to introduce encouraging (but not discouraging) moral green nudges to complement an optimal Pigovian tax. The welfare effect motivating the nudges would e.g. be a feeling of pride of not consuming very much of the dirty good.

While there are methods to estimate the effects of an intervention to reduce externalities and calculate administrative costs, methods to estimate direct effect on moral utility are still in their infancy. Allcott and Kessler (2019) measured the willingness to pay to opt-out of social comparisons for energy consumption, Damgaard and Gravert (2018) identified the annoyance costs from receiving reminders from unsubscriptions from the mailing list and Butera et al. (2019) showed the deadweight loss of a social recognition program by measuring the willingness to pay to opt-out. While in all three studies the targeted behavior change is positive and significant on average, the moral nudges also impose disutility on decision-makers.

Naturally, when the existing tax is too low, or non-existent, a nudge could play a bigger role. If there were no administrative costs related to the intensity of the nudge, an optimal pure green nudge would be used to complement the tax so that the combination of mimics the choices that would result from an optimal Pigovian tax. Let us illustrate with a numerical example. Suppose that without any regulation, the prices of both goods are 10 USD and that the dirty good generates constant marginal damage of 3 USD per unit consumed. A first-best Pigovian tax is 3 USD per unit consumed. An optimal nudge, in the absence of a tax, should then affect decision utility to an extent such that the consumption pattern would be the same as with a 3 USD tax. The level of the nudge depends on how effective the nudge is in affecting the decision utility, i.e. the *nudgeability* of decision-makers (Gabaix and Farhi, 2019). The larger the nudgeability, the lower the amount of the nudge needed. If, on the other hand, there were a cost related to the intensity of the nudge, the optimal nudge would reflect a tradeoff between getting the incentives right and the cost of the nudge.

It is easy to generalize this case to a situation with misperceptions or internalities, in addition to the externality. Suppose that people, for whatever reason, misperceive the initial price of the dirty good (one interpretation might be that people misperceive associated subsequent energy costs). In our example, suppose that people perceive the price of the dirty good to be 8 USD instead of 10 USD. The optimal tax is 5 USD, i.e. the sum of the external cost and the misperception. Note that despite a misperception a pure green nudge would still not be welfare improving with an optimal tax in place.

However, if there are limitations on possible tax levels, the appropriate use of pure nudges corresponds to the case without initial biases: the nudge should be set so that the combinations of the nudge and the tax mimics the outcome of an optimal tax. There is then more room for moral nudges as well, including discouraging moral nudges. With a discouraging moral nudge, there is a trade-off between the reduction of the negative external effect vs. the direct negative

effect on moral utility and the marginal cost of providing the nudge. With an encouraging nudge, there is a trade-off between the reduction of the negative external effect and the direct positive effect on utility vs. the marginal cost of providing the nudge.

While we have solely discussed the choice whether to implement a nudge together with a pre-existing tax, the same kind of reasoning carries over to the case with a pre-existing tradeable permit system.

Optimal nudging with heterogeneous individuals

With heterogeneous individuals, there are a number of reasons why it may be optimal to use a nudge. An important source of heterogeneity comes from different behavioral responses to nudges, which can be used to motivate nudges when environmental taxes can target neither externalities nor internalities perfectly. We will also briefly discuss distributional and political economy issues.

Imperfect Externality Targeting

Suppose that some individuals generate much larger externalities than others when consuming the same goods, but that the tax can only be differentiated at the goods level. Such imperfect externality targeting of a tax is very common. Consider gasoline taxation, which can obviously not induce a first-best allocation since many of the externalities depend on where, when, and how a car is used. The optimal level of a second-best gasoline tax then becomes a weighted average of the marginal damage caused by car transport, where the weights are given by the derivative of the gasoline demand for the dirty good with respect to the tax (cf. Diamond 1973; Knittel and Sandler 2018). The gasoline tax will be too high for those causing low externalities, and too low for those causing high externalities. If it is possible to implement a traffic-reducing nudge that largely affects those who cause large externalities then it may be optimal to

complement an optimal gasoline tax with a nudge. Focusing the nudge to urban areas will reduce traffic where the externalities are large, without affecting traffic in the countryside where the gasoline tax is too low.

An extreme case of imperfect externality targeting is when a tax does not target the end-users. For example, airline pilots often do not have a direct incentive to avoid carbon taxes, and hotel guests have no direct incentive to reduce food waste.

Imperfect Internality Targeting

Consider instead a situation with heterogeneity in the misperception of the price of the dirty good. Suppose, for example, that some people underestimate future electricity costs when buying a new refrigerator, while others do not. This is an internality, where people are not making a choice that would be in their best interest. An optimal second-best tax on the refrigerator will depend on the externality (which is presumably small, given that the electricity price internalizes the electricity externalities) plus the weighted average of the misperception of the future cost, where the weights are given by the derivative of the demand for the refrigerator with respect to the tax. The second-best optimal tax will then be too high for those without cost misperceptions and too low for those with high-cost misperceptions. Then there is a potential for a costly nudge on top of an optimally chosen tax, provided that those with a cost misperception would be affected more by the nudge than those without cost misperceptions. Formally, this holds when the covariance between the cost misperception and the nudgeability is positive (Carlsson and Johansson-Stenman, 2019). A straightforward purpose of such a nudge would be to induce people to reflect more on future costs, but it is also possible to more directly target the nudge towards certain age or socio-economic groups where the cost misperceptions are large.

Distributional and Political-Economy Issues

Both taxes and nudges have distributional effects, and the government typically has some equity concerns as a part of its objective function. The direct monetary effects are, in general, much larger for taxes than for nudges. Would a nudge to reduce consumption of the dirty good be more attractive if a tax disproportionally affects poor people? Not necessarily. There are a number of theoretical results that present conditions for separating efficiency and equity concerns, and hence when it is optimal to delegate distributional issues to an optimal non-linear income tax and focus solely on efficiency when it comes to public goods and externalities; see e.g. Boadway and Keen (1993) and Pirttillä and Tuomala (1997). While these results do not imply that it is always optimal to delegate equity concerns to an income tax – see, e.g. Johansson-Stenman (2005) – the overall welfare effects due to distributional measures in the environmental area tends to be smaller when considering the fact that there are other policy instruments that can deal with equity issues. However, even when equity-efficiency separation is possible, there may exist political-economy reasons related to distributional and/or perceived fairness argument that sometimes make it impossible, or at least very difficult, to internalize externalities by taxes; the difficulties in raising fuel taxes in many countries is a prime example, implying a potential for nudges as well as other policy instruments.

Crowding Out and In

Much empirical evidence suggests that individuals have other motives beyond narrow self-interest, and it has been argued that economic policy instruments may crowd-out intrinsic motivations to behave environmentally friendly. However, as argued by Carlsson and Johansson-Stenman (2012), there are, in fact, arguments why economic policy instruments could either crowd in or crowd out other motivations. When there is a risk that conventional policy instruments would crowd out intrinsic motivations for acting pro-socially, and the

expected crowding-out effect of a nudge is expected to be smaller, there could be a role for nudging, e.g. such that induce moral subsidies.

There is little empirical evidence of spillover effects and crowding out by nudges in the field. Chetty et al. (2014) compare the effects of a subsidy and a default enrollment in a pension plan and find that the latter is more effective for a majority of inattentive savers, while the subsidy crowds out savings for the minority of savers who are attentive to it. Jaime and Carlsson (2018) find substantial spillover effects between households targeted by a social information campaign on water savings and untargeted households in the same city.

Practical considerations for implementing green nudges

When it comes to the practical implementation of nudges as policy instruments, the following aspects must be considered.

Implementation costs and standards

An important factor to consider is the cost of implementing a nudge. Some nudges only require minimal changes in the choice architecture or changes in communication, such as default nudges. Many other nudges require non-negligible fixed costs and/or variables costs. While one might conjecture that nudges are cheap, they often are not (Allcott and Kessler, 2019). Sending norm messages, or reminders, and giving feedback and measuring goals, etc. could result in large implementation costs. The extent of these costs depends on the type of nudge and whether it involves smaller adjustments of current systems (e.g., adding a small message to electricity bills) or more fundamental changes (estimating and then designing information about relative electricity consumption). If we compare the costs of a nudge to changing the level of an existing environmental tax, the administrative costs are, in most cases, larger for a nudge. Yet, if there is no existing tax or if it is difficult to implement a new tax, then a tax will also involve non-

negligible costs, and these costs may sometimes be higher than the corresponding administrative costs for nudging. Depending on the costs of the nudge it might be optimal not to nudge, even in the case where optimal taxation is not feasible

There are also potential differences between nudges and taxes in terms of enforcement costs. While one might initially think that the enforcement costs associated with nudges should be smaller than for other instruments, this is not at all clear. The implementation cost would be small if they would be implemented voluntarily by private firms. If the government would need to ensure that private firms are implementing certain nudges, there is no reason to believe that the enforcement costs would be low. For conventional environmental regulations, it is clear who decides on the design and extent of the regulation. Green nudges could either be mandated or implemented by the government. In both cases, though, the government needs to suggest which nudges to use and allow. In the UK, the Behavioral Insights Team is responsible for this as part of the government. Similar units have been created in the U.S. and Australia, and other countries, the World Bank and the OECD are following suit.

Scalability, external validity, and site selection bias

One advantage of most nudges is that they can be evaluated a pilot study before being rolled out to the entire population. For example, the Danish fat tax was abolished after 15 months due to avoidance behavior and the fact that no visible effects on saturated fat consumption were detected. Here a pilot study could have saved a lot of money and time (Bødker et al., 2016). However, in the case of taxes, the behavioral response mechanism is clear. Increased prices are supposed to reduce consumption. For nudges, there could be dozens of heuristics, biases, and behavioral motivations at play that could be addressed with several types of nudges.

For both conventional policy instruments and nudges, scalability, external validity, and site selection are important considerations when applying research finding to large-scale policies.

Allcott (2015) showed the problem of site selection bias for social comparison field experiments and shows how treatment effects vary over 111 studies. To conduct a field experiment, researchers need a highly motivated partner, and these partners are not random. Further, both researchers and policymakers might want to give a program "the best chance to succeed" and might intentionally choose target populations that have the chance to change behavior significantly. Effect sizes are influenced, for example, by baseline behavior, motivation to change, implementation skills of the field partner, and possibly general equilibrium effects. If the first studies are run in "problem areas," then later effects might be much smaller than the initial trials. If instead early studies are run by partners who already have many other interventions in place, such as programs encouraging biking vs. car use for commuters, then larger effects could be generated with partners that have no other policies.

Al-Ubaydi et al. (2017) extend this discussion by also highlighting the problem of publication bias; studies with significant results are more likely to be published than insignificant ones. The reported effect sizes in our overview should thus not be taken at face value, but only as an indication for a potential treatment effect. Context-dependent evaluations and pilot studies should be conducted.

Conclusions

Green nudges are a new addition to the policy maker's toolkit. Rather than correcting an internality, green nudges make use of behavioral tools to correct for externalities. We propose a simple framework to distinguish self-focused and green nudges. Further, we classify nudges into pure and moral nudges. A classification that we argue is relevant for welfare calculations. The rationale for using green nudges to correct for externalities makes comparison with conventional policy instruments such as Pigovian taxes relevant. We discuss under which circumstances nudges might be superior to Pigovian taxes and in particular when nudges are

likely to be good complements to environmental taxes. First, even with optimal Pigovian taxes, encouraging moral nudges can increase utility. Second, if taxes are not set optimally, then nudges can be efficiency-improving. Finally, when taxes do not perfectly target the externality-generating agents, even if they are optimal on average, nudges can help improve overall targeting.

Based on a thorough literature review of green nudge studies, we highlight challenges with implementing nudges and estimating welfare effects. The arguments in this paper are intended to provide a basis for policymakers to determine which aspects need to be considered when deciding whether a green nudge is a suitable policy instrument.

More research is needed, and new insights can affect some of the conclusions we have drawn. We know little about the relative effectiveness of nudges compared to, for example, taxes and their long-run effects.

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References

Akerlof, G., Kranton, R. 2000. Economics and identity. *The Quarterly Journal of Economics*. 115:715–753.

Allcott, H. 2011. Social norms and energy conservation. *Journal of Public Economics*. 95:1082-1095.

Allcott, H. 2013. Consumers' perceptions and misperceptions of energy Costs. *American Economic Review*. 101:98–104.

Allcott, H. 2015. Site selection bias in program evaluation. *Quarterly Journal of Economics*. 1117–1165.

Allcott, H., Kessler, J. 2019. The welfare effects of nudges: A case study of energy use social comparisons. *American Economic Journal: Applied Economics.* 11:236-276.

Allcott, H. Knittel, C. 2019. Are Consumers Poorly Informed about Fuel Economy? Evidence from Two Experiments. *American Economic Journal: Economic Policy*. 11:1-37.

Allcott, H., Mullainathan, S., Taubinsky, D. 2014. Energy policy with externalities and internalities. *Journal of Public Economics*. 112:72-88.

Allcott, H., Rogers, T. 2014. The short-run and long-run effects of behavioral interventions: Experimental evidence from energy conservation. *American Economic Review*. 104:3003-37.

Allcott, H., Sweeny, R. 2017. The role of sales agents in information disclosure: Evidence from a field experiment. *Management Science* 63:21-39.

Allcott, H., Taubinsky, D. 2015. Evaluating Behaviorally Motivated Policy: Experimental Evidence from the Lightbulb Market. *American Economic Review*. 105:2501–2538.

Al-Ubaydli O., List, J., LoRe, D., Suskind, D. 2017. Scaling for Economists: Lessons from the Medical Literature. *Journal of Economic Perspectives*, 31:125-144.

Andor, M., Gerster, A., Peters, J., Schmidt, C. 2017. Social norms and energy conservation beyond the US, Ruhr Economics Paper 714.

Andreoni, J. 1990. Impure altruism and donations to public goods: A theory of warm-glow giving. *Economic Journal*. 100:464–477.

Araña, J., León, C. 2013. Can defaults save the climate? Evidence from a field experiment on carbon offsetting programs. *Environmental and Resource Economics*. 54:613-626.

Asensio, O., Delmas, M. 2015. Nonprice incentives and energy conservation. *Proceedings of the National Academy of Sciences*. 112:E510-E515.

Ayres, I., Raseman, S., Shih, A. 2013. Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage. *The Journal of Law Economics and Organization.* 29:992-1022.

Baca-Motes, K., Brown, A., Gneezy, A., Keenan, E., Nelson, L. 2012. Commitment and behavior change: Evidence from the field. *Journal of Consumer Research*. 39:1070-1084.

Benabou, R., Tirole, J. 2006. Incentives and prosocial behaviour. *American Economic Review* 96:1652-78

Benartzi, S. et al. 2017 Should governments invest more in nudging? *Psychological Science* 28:1041-1055.

Bernedo, M., Ferraro, P., Price. M. 2014. The persistent impacts of norm-based messaging and their implications for water conservation. *Journal of Consumer Policy.* 37:437-452.

Beshears, J., Choi, J., Laibson, D. Madrian, B. Milkman, K. 2015. The effect of providing peer information on retirement savings decisions. *Journal of Finance*. 70:1161–1201.

Boadway, R., Keen, M. 1993. Public goods, self-selection and optimal income taxation. *International Economic Review*, 463-478.

Brandon, A., Ferraro, P.J., List, J.A., Metcalfe, R.D., Price, M.K. Rundhammer, F. 2017. Do the effects of social nudges persist? Theory and evidence from 38 natural field experiments (No. w23277). *National Bureau of Economic Research.*

Brent, D., Cook, J., Olsen, S. 2015. Social comparisons, household water use, and participation in utility conservation programs: Evidence from three randomized trials. *Journal of the Association of Environmental and Resource Economists*. *2*:597-627.

Brown, Z., Johnstone, N., Hascic, I., Vong, L., Barascu, F. 2013. Testing the effect of defaults on the thermostat settings of OECD employees. *Energy Economics* 39:128-134.

Bryce, W., Day, R., Olney, T. 1997. Commitment approach to motivating community recycling: New Zealand curbside trial. *Journal of Consumer Affairs*. 31:27-52.

Butera, L., Metcalfe, R., Morrison, W., Taubinsky, D. 2019. The Deadweight Loss of Social Recognition (No. w25637). National Bureau of Economic Research.

Bødker, M., Pisinger, C., Toft, U., Jørgensen, T. 2015. The rise and fall of the world's first fat tax. *Health Policy*. 119:737-742.

Caplin, A. and Dean, M., 2015. Revealed Preference, Rational Inattention, and Costly Information Acquisition. *American Economic Review,* 105:2183–2203.

Carlsson F., Johansson-Stenman, O. 2012. Behavioral economics and environmental policy. *Annual Review of Resource Economics*. 4:75-99.

Carlsson, F., Johansson-Stenman, O. 2019. Optimal prosocial nudging. Paper presented at the World Congress of Environmental and Resource Economists, Gothenburg.

Camerer, C., Issacharoff, S., Loewenstein, G., O'Donoghue, T., Rabin, M. 2003. Regulation for Conservatives: Behavioral Economics and the Case for Asymmetric Paternalism. *University of Pennsylvania Law Review* 151:1211-1254.

Chetty, R., Looney, A., Kroft, K. 2009. Salience and Taxation: Theory and Evidence. *American Economic Review*. 99:1145–77.

Chetty, R., Friedman, J., Leth-Petersen, S., Nielsen, T., Olsen, T. 2014. Active vs. passive decisions and crowd-out in retirement savings accounts: Evidence from Denmark. *The Quarterly Journal of Economics*, 129:1141-1219.

Cialdini. R. 2003. Crafting normative messages to protect the environment. *Current Directions in Psychological Science.* 12:105-109.

Costa, M., Kahn, M. 2013. Energy conservation "nudges" and environmentalist ideology: Evidence from a randomized residential electricity field experiment. *Journal of the European Economic Association*. 11:680-702.

Damgaard, M., Gravert, C. 2018. The hidden costs of nudging: Experimental evidence from reminders in fundraising. *Journal of Public Economics*. 157:15-26.

Delmas, M., Lessem, N. 2014. Saving power to conserve your reputation? The effectiveness of private versus public information. *Journal of Environmental Economics and Management*. 67:353-370.

Diamond, P. A. 1973. Consumption Externalities and Imperfect Corrective Pricing. *Bell Journal of Economics and Management Science* 4: 526–38.

Ebeling, F., Lotz, S. 2015. Domestic uptake of green energy promoted by opt-out tariffs. *Nature Climate Change*. 5:868-871.

Egebark, J., Ekström, M. 2016. Can indifference make the world greener? *Journal of Environmental Economics and Management*. 76:1-13.

Farhi, E., Gabaix, X. 2019. Optimal taxation with behavioral agents, *American Economic Review*, forthcoming.

Ferraro, P., Miranda, J., Price, M. 2011. The persistence of treatment effects with norm-based policy instruments: Evidence from a randomized environmental policy experiment. *American Economic Review*. 101:318-322.

Ferraro, P., Price, M. 2013. Using non-pecuniary strategies to influence behavior: Evidence from a large-scale field experiment. *The Review of Economics and Statistics.* 95:64-73.
Festinger, L., 1957. *A theory of cognitive dissonance*. Stanford, Calif: Stanford U.P.
Frank, R. 1985. The demand for unobservable and other nonpositional goods. *American Economic Review.* 75:101-16.
Gillbert, B., Zivin, J. 2014. Dynamic salience with intermittent billing: Evidence from smart electricity meters. *Journal of Economic Behavior and Organization*. 107:176-190.
Giné, X., Karlan, D., Zinman, J. 2010. Put your money where your butt is: a commitment contract for smoking cessation. *American Economic Journal: Applied Economics*, 2:213-35.
Goldstein, N., Cialdini, R., Griskevicius, V. 2008. A room with a viewpoint: Using social norms to motivate environmental conservation in hotels. *Journal of Consumer Research*. 35:472-482.
Gosnell, G., Metcalfe, R., List, J. 2019. The impact of management practices on employee productivity: A field experiment with airline captains, Working Paper London School of Economics.
Gravert, C. Kurz, V. 2019. Nudging à la carte: a field experiment on climate-friendly food choice. *Behavioral Public Policy*. Forthcoming.
Hahn, R., Metcalfe, R. Novgorodsky, D. Price, M. 2016. "he Behavioralist as Policy Designer: The Need to Test Multiple Treatments to Meet Multiple Targets. NBER Working Paper #22886.
Hallsworth, M., List, J., Metcalfe, R., Vlaev, I. 2017. The behavioralist as tax collector: Using natural field experiments to enhance tax compliance. *Journal of Public Economics*. 148:14-31.
Harding, M., Hsiaw, A. 2014. Goal setting and energy conservation. *Journal of Economic Behavior and Organization*. 107:209-227.
Heutel, G. 2015. Optimal policy instruments for externality-producing durable goods under present bias. *Journal of Environmental Economics and Management*. 72:54-70.
Holladay, S., LaRiviere, Novgorodsky, D., Price, M. 2019. Prices versus Nudges: What Matters for Search Versus Purchase of Energy Investments? *Journal of Public Economics*, 172:151-173.
Ito, K. 2015. Asymmetric incentives in subsidies: Evidence from a large-scale electricity rebate program. *American Economic Journal: Economic Policy*. 7:209–237.
Ito, K., Ida, T., Tanaka, M. 2018. Moral Suasion and Economic Incentives: Field Experimental Evidence from Energy Demand. *American Economic Journal: Economic Policy*. 10:240-67.
Jaeger, C., Schultz, P. 2017. Coupling social norms and commitments: testing the underdetected nature of social influence. *Journal of Environmental Psychology*. 51:199-208.
Jaime, M., Carlsson, F. 2018. Direct and spillover effects of a social information campaign on residential water savings. *Journal of Environmental Economics and Management*. 92:222-243.
Johansson-Stenman, O. 2005. Distributional weights in cost-benefit analysis—should we forget about them? *Land Economics*, 81:337-352.
Johansson-Stenman O., Carlsson F., Daruvala D. 2002. Measuring future grandparents' preferences for equality and relative standing. *Economic Journal.* 112:362-383
Johnson, E. Goldstein, D. 2003. Do Defaults Save Lives? *Science*, 302:1338–1339.
Kalbekken and Saelen, H. 2011. 'Nudging' hotel guests to reduce food waste as a win–win environmental measure, *Economics Letters* 199:325-327

Kallbekken, S., Sælen, H., Hermansen, E. 2013. Bridging the energy efficiency gap: A field experiment on lifetime energy costs and household appliances. *Journal of Consumer Policy*, 36:1-16.
Kormos, C., R. Gifford, Brown, E. 2015. The influence of descriptive social norm information on sustainable transportation behavior: A field experiment. *Environment and Behavior*. 47:479-501.
Knittel, C. R., Sandler, R. 2018. The Welfare Impact of Second-Best Uniform-Pigouvian Taxation: Evidence from Transportation. *American Economic Journal: Economic Policy*, 10: 211-42.
Kotchen, M. Moore, M. 2008. Conservation: From voluntary restraint to a voluntary price premium. *Environmental and Resource Economics*. 40:195-215.
Kurz, V. 2018. Nudging to reduce meat consumption: Immediate and persistent effects of an intervention at a university restaurant. *Journal of Environmental Economics and Management*. 90:317-341.
Loock, C. M., Staake, T., Thiesse, F. 2013. Motivating Energy-Efficient Behavior with Green IS: An Investigation of Goal Setting and the Role of Defaults. *Mis Quarterly*. 37.
Lowenstein, G. Chater, N. 2017. Putting nudges in perspective. *Behavioral Public Policy*. 1:26-53.
Löfgren, Å., Martinsson, P., Hennlock, M., Sterner, T., 2012. Are experienced people affected by a pre-set default option—Results from a field experiment. *Journal of Environmental Economics and Management*. 63:66–72.
Löfgren, Å, Nordblom, K., 2019. A theoretical framework explaining the mechanisms of nudging, Working paper No. 754, Department of Economics, University of Gothenburg.
Madrian, B., 2014. Applying Insights from Behavioral Economics to Policy Design. *Annual Review of Economics*, 6:663–688.
Mizobuchi, K., Takeuchi, K. 2013. The influences of financial and non-financial factors on energy-saving behaviour: A field experiment in Japan. *Energy Policy*. 63:775-787.
Pellerano, J. A., Price, M., Puller, S. L., Sánchez, G. E. 2017. Do extrinsic incentives undermine social norms? Evidence from a field experiment in energy conservation. *Environmental and resource Economics*. 67:413-428.
Pichert, D., Katsikopoulos, K. 2008. Green defaults: Information presentation and pro-environmental behavior. *Journal of Environmental Psychology*. 28:63-73.
Pirttilä, J., Tuomala, M. 1997. Income Tax, Commodity Tax and Environmental Policy, *International Tax and Public Finance*. 4: 379-393.
Richter, I., Thøgersen, J., Klöckner, C. 2018. A social norms intervention going wrong: Boomerang effects from descriptive norms information. *Sustainability*. 10:2848.
Sexton, S.E. and Sexton, A.L., 2014. Conspicuous conservation: The Prius halo and willingness to pay for environmental bona fides. *Journal of Environmental Economics and Management*, 67:303–317.
Schultz, P. 1999. Changing behavior with normative feedback interventions: A field experiment on curbside recycling. *Basic and Applied Social Psychology*. 21:25-36.
Schultz, P., Nolan, J., Cialdini, R., Goldstein, N., Griskevicius, V. 2007. The constructive, destructive, and reconstructive power of social norms. *Psychological Science*. 18:429-434.
Shang, J., Croson, R. 2009. A field experiment in charitable contribution: The impact of social information on the voluntary provision of public goods. *The Economic Journal*. 119:1422-1439.
Sparkman, G., Walton, G. 2017. Dynamic norms promote sustainable behavior, even if it is counternormative. *Psychological Science*. 28:1663-1674.

Stadelmann, M., Schubert, R., 2018. How Do Different Designs of Energy Labels Influence Purchases of Household Appliances? A Field Study in Switzerland. *Ecological Economics.* 144:112-123.

Sudarshan, A. 2017. Nudges in the marketplace: The response of household electricity consumption to information and monetary incentives. *Journal of Economic Behavior and Organization*. 134:320-335.

Sunstein, C., Reisch, L. 2013. Automatically Green: Behavioral Economics and Environmental Protection. *Harvard Environmental Law Review*. 38:127.

Sunstein, C., Thaler, R. 2003. Libertarian paternalism is not an oxymoron. *The University of Chicago Law Review*, 1159-12

Sugden, R. 2018. *The Community of Advantage: A Behavioural Economist's Defence of the Market*. Oxford: Oxford University Press.

Thaler, R., Sunstein, C. 2009. *Nudge: Improving Decisions about Health, Wealth, and Happiness*. New York: Penguin Books.

Terrier, L., Marfaing, B. 2015. Using social norms and commitment to promote pro-environmental behavior among hotel guests. *Journal of Environmental Psychology*. 44:10-15.

Tiefenbeck, V., Goette, L., Degen, K., Tasic, V., Fleisch, E., Lalive, R., Staake, T. 2016. Overcoming salience bias: how real-time feedback fosters resource conservation. *Management Science*. 64:1458-1476.

Toft, M. B., Schuitema, G., Thøgersen, J. 2014. The importance of framing for consumer acceptance of the Smart Grid: A comparative study of Denmark, Norway and Switzerland. *Energy Research & Social Science*. 3:113-123.

Tsvetanov, T., Segerson, C. 2013. Re-evaluating the role of energy efficiency standards: A behavioral economics approach. *Journal of Environmental Economics and Management.* 66:347-363.

Vetter, M., Kutzner, F., 2016. Nudge me if you can - how defaults and attitude strength interact to change behavior. *Comprehensive Results in Social Psychology*. 1:1–27.

Wallander, S., Ferraro, P., Higgins, N. 2017. Adressing participant inattention in federal programs: A field experiment with the conservation reserve program, American Journal of Agricultural Economics 99:914-931.

Whittington, D., Nauges, C. 2018 Social norms information treatments in the municipal water supply sector: Some new insights on benefits and costs, Working Paper.

Yoeli, E., Hoffman, M., Rand, D., Nowak, M. 2013. Powering up with indirect reciprocity in a large-scale field experiment. *Proceedings of the National Academy of Sciences*. 110:10424-10429.