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Abstract

A rebound effect occurs when an energy efficiency improvement results in less energy savings than expected. Usually, this phenomenon is attributed to a price effect, as improvements in the energy efficiency of a technology reduce its cost of use, thereby encouraging increased usage. Recent studies taking into account environmental preferences suggest that the rebound effect is not only due to a price effect. A behavioral phenomenon, called moral licensing effect, may also lead users of a more efficient technology (often less damaging for the environment) to feel less guilt to use it more, and thus to increase the rebound effect. We conducted a survey involving 1,510 French households to explore the moral licensing effect in the context of heating behavior. First, we show that most people declare they would increase their heating consumption if it had a lesser environmental impact. Second, we show that wood heating is perceived as a heating fuel with less environmental impact than oil, gas and electricity. Based on these results we conclude that policies promoting wood heating as a more environmentally-friendly energy source may indeed induce a moral licensing effect, leading people to increase their heating use and potentially counteracting expected environmental benefits of wood heating.

Keywords: Rebound effect, Moral licensing effect, Heating fuel, Wood heating, Survey study

1. Introduction

In France, the residential sector is a significant contributor to greenhouse gas emissions, accounting for 16% of the total emissions and 30% of total energy con-

sumption, making it the second-largest consumer sector after transportation (SDES, 2023). Within the residential sector, heating represents approximately 66% of energy consumption and 81% of CO_2 emissions (SDES, 2022). To meet its climate change targets, the French government has identified the heating sector as a crucial area for intervention. To decarbonize this sector and encourage the adoption of more efficient and environmentally-friendly heating systems, various support measures, such as government subsidies, grants, and tax breaks, have been implemented.

Wood heating (more specifically wood pellet heating) has benefited from these governmental policies, as it constitutes a sustainable and economically viable alternative to conventional fossil fuel-based heating systems. Utilizing wood as a renewable energy source offers numerous environmental benefits, including a significant reduction in greenhouse gas emissions and a lower carbon footprint[1] (Gielen et Bos, 2000; Suter *et al.*, 2017). Additionally, wood heating can contribute to energy security by decreasing dependence on imported fuels and stimulating local economies through the use of locally sourced biomass (Wolf *et al.*, 2016). Despite its negative impact on air quality and the subsequent effects on human health (Naeher *et al.*, 2007), wood pellet heating generates less air pollution compared to other wood burning appliances (Sun *et al.*, 2017; Mawusi *et al.*, 2023). Overall, wood heating avoids CO_2 emissions, reduces heating costs, and increases consumer comfort (Thomson et Liddell, 2015). In light of these advantages, people switching to wood heating may decide to use their heating system more intensively. This phenomenon is called the rebound effect[2].

The rebound effect has become a well-known undesirable effect of energy-efficiency

[1]Unlike fossil fuels, wood is a carbon-neutral resource, as the carbon dioxide released during combustion is offset by the carbon dioxide absorbed by trees during their growth.

[2]The microeconomic definition of the rebound effect distinguishes between the direct and the indirect rebound effects. The direct rebound effect occurs when energy efficiency improvements lead to increased use of the same service, such as using a more efficient heater more frequently. The indirect rebound effect happens when savings from efficiency are spent on other energy-consuming goods and services. In this article, we focus exclusively on the direct rebound effect. When we mention the rebound effect, we are specifically referring to this direct rebound effect.

policies. A multitude of studies have demonstrated that the implementation of more efficient heating systems frequently results in lower-than-anticipated energy savings, primarily due to increased usage by individuals (Haas *et al.*, 1998; Haas et Biermayr, 2000; Hens *et al.*, 2010; Madlener et Hauertmann, 2011; Galvin, 2015). By estimating the price elasticity of the demand for heating services, these studies assess the magnitude of the rebound effect resulting from a price change in heating fuel. They find a 10% to 30% rebound effect, meaning that between 10% and 30% of the expected energy savings are not achieved due to changes in people's heating behavior. In addition to this economic compensatory behavior due to price effects, people who believe that the environmental impact of their heating has been reduced may feel free to increase their heating use. This phenomenon, called moral licensing, has recently been considered as another potential source of the rebound effect (Dütschke *et al.*, 2018; Sorrell *et al.*, 2020; Mathex, 2023).

Moral licensing refers to a psychological phenomenon in which individuals allow themselves to engage in undesirable behavior after performing a good deed (Monin et Miller, 2001; Merritt *et al.*, 2010). In other terms, adopting more energy-efficient and environmentally-friendly technologies may allow individuals to feel less guilty about using them more frequently and/or intensively (Sorrell *et al.*, 2020; Reimers *et al.*, 2021). To the best of our knowledge, no study has provided empirical evidence of moral licensing following the use of a more efficient and environmentally-friendly heating technology[3]. The closest studies are Jacobsen *et al.* (2012) and Schleich *et al.* (2022), which show that subscribing to a green electricity tariff can lead to an increase in electricity consumption, possibly due to moral licensing.

Several studies show that the environmental impact of a heating system can significantly influence consumers' choice when selecting a new heating system (Ma-

[3]One potential explanation for this could be that it is difficult to identify a single factor that drives behavioral change. When an individual increases their use of a more efficient technology, it is difficult to determine whether this change in behavior is due to a price effect or a moral licensing effect, for example.

hapatra et Gustavsson, 2008; Michelsen et Madlener, 2012; Decker et Menrad, 2015). In addition to influencing the initial decision, we hypothesize that the perceived environmental impact of the heating system may also influence its subsequent use, leading to the risk of an additional rebound effect (i.e., a moral licensing effect). In this paper, we attempt to evaluate the possible occurrence of this phenomenon when consumers switch to wood heating, as we anticipate that people perceive wood heating as having a lower environmental impact than other heating systems. To this end, we first investigate the issue of moral licensing in the context of heating and then explore people's perceptions of the environmental impact of different heating fuels.

In the following section, we detail the survey conducted on 1,510 respondents who use wood, oil, gas, or electricity as heating fuel to investigate our research question. These heating fuels represent 95% of those used in France (SDES, 2023). Our findings, presented in Section 3, aim to provide a deeper understanding of the moral licensing effect in the context of residential heating and show that wood heating is overwhelmingly perceived as a heating fuel with less environmental impact than oil, gas, and electricity. In the final section, we offer insights into how a moral licensing effect may contribute to an additional rebound effect when a switch to wood heating is made. This knowledge is crucial for allowing policymakers to design more effective energy policies that account for behavioral responses and ultimately enhance the environmental benefits of promoting wood heating systems.

2. Methodology

2.1. Survey design and key variables

To determine the main drivers of a moral licensing effect on heating behaviors, we conduct a survey based on self-reported data. The survey is divided into three parts. The first part collects information on participants' housing characteristics. The second part contains questions about the participants' behaviors and

perceptions related to heating. The last part is dedicated to the socio-demographic characteristics of the participants. The questionnaire can be found in Appendix C.

In the following subsections we detail key variables of our analysis: the proxy to capture the moral licensing effect, household perceptions of the environmental impact of heating fuels, satisfaction and guilt related to respondents' current heating system, and their environmental attitudes.

2.1.1. Proxy for the moral licensing effect

To assess the extent to which an individual is subject to moral licensing in the context of heating, we ask: '*Do you think that if you were to use a more environmentally friendly heating mode or system, you would increase your heating use?*' (see Q30 on Appendix C). Respondents answer on a 7-point Likert-type response scale, ranging from '*1 - No, definitely not*' to '*7 - Yes, absolutely*'. The question was designed to be as neutral as possible, ensuring that it did not convey any judgment or suggest any expected behavior. We speak about 'increased heating use' rather than specifying a particular behavior, such as raising the heating temperature, for example, because various behavioral adjustments (e.g., airing more frequently, turning the heating on earlier, or delaying switching it off) may result in rebound effects within the heating domain (Galassi et Madlener, 2017; Hediger *et al.*, 2018). It is worth noting that the 7-point Likert scale answers need to be interpreted as the likelihood of respondents increasing their heating use, and not as a potential measure of the intensity of any such increase. Thus, we exclude any moral licensing by respondents only if they select '*1 - No, not at all*' .

Additionally, to capture the classic price effect responsible for the rebound effect respondents were asked: '*Do you think that if the price of your heating fuel decreased, you would increase your heating use?*' (see Q24). The aim is to confirm the price effect, already widely studied in the literature (see for example Haas et Biermayr (2000)), as a contributing factor to the rebound effect and to compare it with the moral licensing effect.

2.1.2. Environmental perceptions of heating fuels

Perceptions, regardless of their accuracy, seem to be important in predicting consumer behaviors (Lichtenstein *et al.*, 1993). In the context of heating, Decker et Menrad (2015) show, for example, that consumers' perceptions of the quality of different heating fuels (gas, oil, electricity, and wood pellets) influences their choice of a specific heating system. In the moral licensing literature, perceived morality of (past) behavior is seen as a key condition for inducing this effect[4]. Therefore, we explore how individuals perceive the environmental impact of different heating fuels (wood, oil, gas, and electricity). Respondents were asked to rate the environmental impact of each heating fuel on a 7-point Likert scale, ranging from '*1 - Not harmful at all*' to '*7 - Very harmful*' (Q25). To limit potential order effect, the heating fuels are presented to the participants in random order. We choose to ask about environmental damage in a general sense, rather than refer to specific emissions such as greenhouse gases or fine particles, in order to capture participants' overall environmental perception of the different heating fuels.

2.1.3. Temperature satisfaction

In order to find out whether people are satisfied concerning their heating, we created a dummy variable based on the difference between their (self-declared) home's usual heating temperature (Q15) and their desired or ideal heating temperature (Q17). The desired heating temperature corresponds to the temperature a person would prefer if they were not subject to any constraints (price, environment, difficulty of adjustment) when setting their heating. The dummy variable *Temperature satisfaction* takes the value 1 if an individual declares that they are not constrained in adjusting their heating or if they report that their current and desired heating temperatures are the same. The dummy variable takes the value 0 if the usual heating temperature is different from the desired heating temperature.

[4]According to Monin et Miller (2001), in order to be compensated, past behavior must be judged as morally good by the individual who performs it, as well as by society.

2.1.4. Heating guilt

In moral licensing studies, the guilt reduction mechanism is employed to elucidate this phenomenon: a prior virtuous act diminishes people's guilt when engaging in subsequent undesirable behaviors (Khan et Dhar, 2006; Truelove *et al.*, 2014). Therefore, respondents were asked on a 7-point Likert scale ranging from '*1 - No, not at all*' and '*7 - Yes, absolutely*': '*Do you feel guilty about the environmental impact of your heating*' (see Q29).

2.1.5. Environmental attitudes

We use the Environmental Attitudes Inventory (EAI) to capture the importance people give to the environment (Milfont et Duckitt, 2010). More precisely, we use the French version of the EAI scale validated by Moussaoui *et al.* (2016). This version uses a 12-item Likert scale, with scores ranging from 1 to 7 for each item (Q37). The average of these scores reflects the environmental attitudes and values of individuals. The higher the score, the more highly the individual values the environment.

2.2. Data collection and sample description

The survey[5] was conducted online between April and May 2022. Respondents were recruited by a private company (*Foule Factory*) in France. We did not target any specific population. The survey is presented to the respondents with the neutral title of *Panel* to avoid a potential self-selection bias. Respondents are informed that the survey lasts on average 7 minutes to complete and that they will receive €1 for their participation.

We collected 1,510 complete responses from residents of metropolitan France, whose main heating appliance uses wood, gas, oil, or electricity as a heating fuel. The socio-demographic characteristics of our sample and its representativeness of the French population are described in Table A.4 in Appendix A. In compari-

[5]Using LimeSurvey software.

son to the overall French population, our sample exhibits a higher proportion of women and a slightly younger age distribution. A large majority of people (70%) report feeling financially tight or very tight, which can be explained by the fact that our participants are online panelists (Chandler *et al.*, 2019). The statistics of the variables related to the participants' housing and heating characteristics are presented in Table A.5 in Appendix A. In terms of heating fuels, our sample is well representative of the French population.

Table 1 shows the statistics of our key variables used in the results section. To examine potential interactions between heating guilt and the variable EAI, we create dummy variables. The dummy variable *High heating guilt* takes the value 1 if individuals report a level of guilt equal or higher than the median (4 in our sample) and 0 if they report a level of guilt lower than the median. In the same way, we use the median score (4.91) to define the dummy variable *High EAI*, which refers to respondents with the highest EAI score.

Table 1: Statistics of key variables

Statistics	Mean	Std. dev.	Min.	Median	Max.
Proxy of moral licensing	3.33	1.89	1	3	7
Proxy of price effect	2.93	1.85	1	3	7
Environmental perceptions:					
Wood	3.91	1.69	1	4	7
Oil	5.75	1.48	1	6	7
Gas	5.08	1.44	1	5	7
Electricity	4.30	1.61	1	4	7
Temperature satisfaction	0.41	0.49	0	-	1
Heating guilt	3.49	1.68	1	4	7
High heating guilt	0.52	0.50	0	-	1
EAI	4.90	0.73	2.33	4.92	7
High EAI	0.47	0.50	0	-	1

3. Results

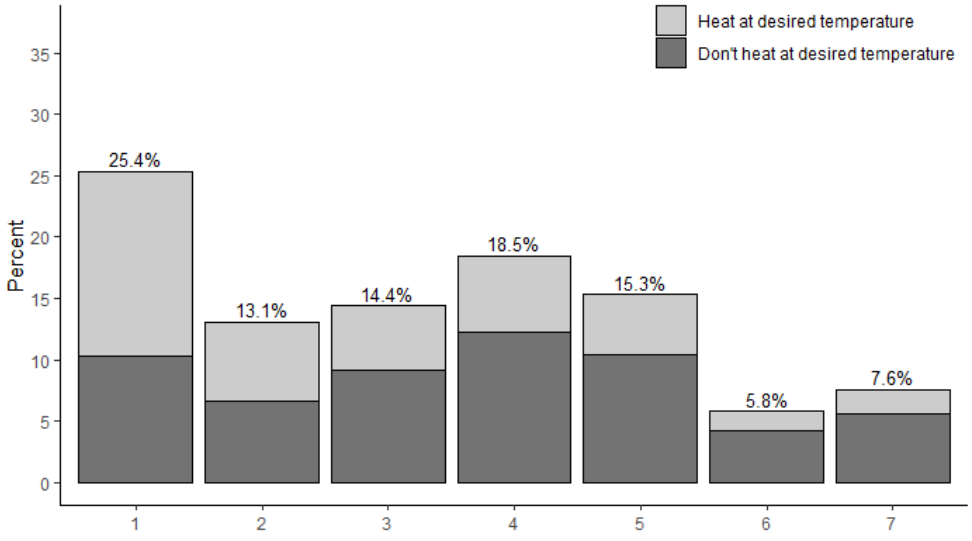
The empirical analysis is conducted in two parts. First we examine the issue of the moral licensing effect related to heating choices. Second, we investigate perceptions of the environmental impacts of the different heating fuels. Based on these empirical results, we then explore the likelihood of the switch to wood heater being susceptible to inducing the moral licensing effect.

3.1. Moral licensing effect in the context of heating

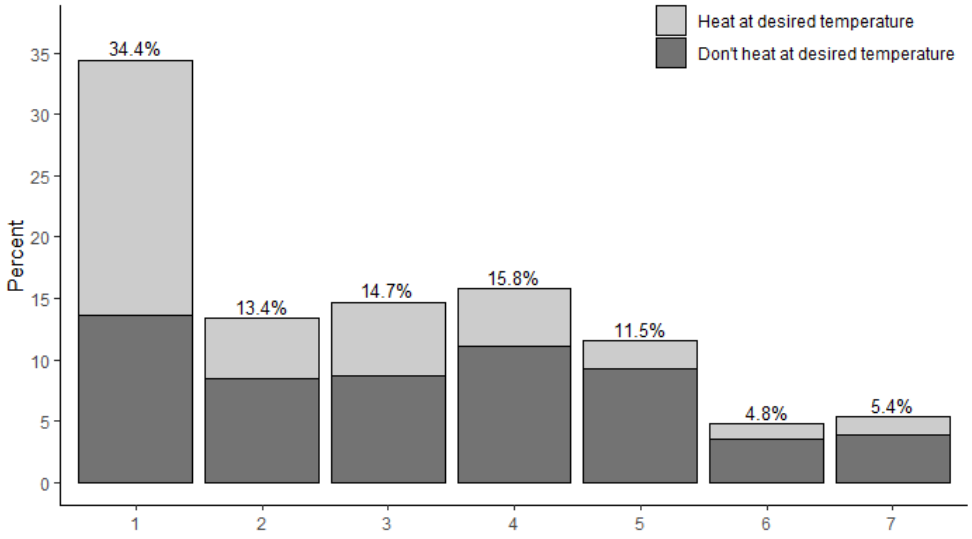
In Figure 1 we represent the likelihood of respondents increasing their heating use if it becomes more environmentally friendly (1a), which is our proxy for moral licensing. It is interesting to compare these responses to the more classic cause of the rebound effect due to a price effect. In the lower part of Figure 1, we represent the likelihood of respondents increasing their heating use if the heating becomes less expensive (1b). In both histograms, for each possible answer we differentiate between those who heat their housing to the desired temperature and those who do not.

We can see that about 25% (respectively 34%) of the participants in our study reported not increasing their heating use if it became more environmentally friendly (respectively, less expensive). Moreover, the average likelihood of increasing heating use is significantly higher (Mann Whitney U test, $p < 0.001$) in the case of a moral licensing effect, i.e., a lower environmental impact of a heating technology ($M = 3.33$, $SD = 1.89$) than a price effect, i.e., lower heating costs ($M = 2.93$, $SD = 1.85$). This result is surprising given that the price effect is generally presented in the literature as the main source of the rebound effect. An explanation might be that the survey relies on self-reported behaviors rather than observed ones. Indeed, a participant's acknowledgment that they would increase their heating use due to a reduction in environmental damage could be seen as virtuous and thus easy to disclose, while admitting that they regulate their heating use for economic reasons could cause discomfort or embarrassment and potentially inhibit honest disclosure.

Figure 1: Likelihood of increasing heating use (from '*1 - No, not at all*' to '*7 - Yes, completely*')



(a) if heating becomes less polluting (moral licensing effect)



(b) if heating becomes less expensive (price effect)

Figure 1 also highlights a negative correlation between increasing one's heating use and heating to one's desired temperature (*Temperature satisfaction*). In other words, the likelihood of increasing heating use is higher for respondents who don't heat their home to the desired temperature.

More precisely to the moral licensing effect, which is the core of our analysis,

we observe that 75% of participants say they would be more (29% select 5, 6 or 7) or less (46% select 2, 3 or 4) likely to increase their heating use if their heating mode were more environmentally friendly. This result underlines the fact that the environmental impact of heating is an important factor for individuals and influences their heating behavior.

To identify the variables that explain the moral licensing effect related to heating, Table 2 presents the results of different ordered logistic regressions using the proxy of the moral licensing effect as the dependent variable (see Table B.6 in the Appendix for details of full regressions). The first model includes only the key variables that moderate the effect of moral licensing, i.e., *Temperature satisfaction*, *Heating guilt*, and *Environmental attitudes*. In the second model, we introduce an interaction variable between heating guilt and environmental attitudes. Finally, the last three models include the heating and dwelling characteristics presented in Table A.5 and the socio-demographic characteristics presented in Table A.4, respectively.

Table 2: Ordered logistic regression on the likelihood of a moral licensing effect

VARIABLES	(1)	(2)	(3)	(4)	(5)
Temperature satisfaction	-0.7977***	-0.7956***	-0.7528***	-0.7790***	-0.7442***
	(0.0951)	(0.0951)	(0.0971)	(0.0956)	(0.0976)
High heating guilt	1.0714***	1.2410***	1.2032***	1.2258***	1.2012***
	(0.0960)	(0.1280)	(0.1296)	(0.1293)	(0.1308)
High EAI	-0.2131***	-0.0100	-0.0492	0.0027	-0.0287
	(0.0925)	(0.1368)	(0.1389)	(0.1385)	(0.1410)
High heating guilt × High EAI	-	-0.3728**	-0.3105*	-0.3771**	-0.3233*
	-	(0.1854)	(0.1875)	(0.1861)	(0.1882)
Heating and housing characteristics	No	No	Yes	No	Yes
Socio-demographic characteristics	No	No	No	Yes	Yes
Observations	1,510	1,510	1,486	1,510	1,486
Log likelihood	-2689.208	-2687.186	-2629.961	-2680.482	-2625.917

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Models (3) and (5) have 24 fewer observations due to the lack of response for the *Heating time* variable.

One factor contributing to the occurrence of the moral licensing effect on heating behavior is that people do not already heat their homes to their desired temperature. This finding aligns with the hierarchical choice theory (Drakopoulos, 1994), which posits that at the point of satiation (in this context, the ideal comfort temperature), the marginal utility is zero. Individuals who have reached this point are less likely to increase their heating temperature, even if heating becomes less damaging for the environment. Hediger *et al.* (2018) similarly rely on this theory to explain why a third of their sample does not exhibit a rebound effect following a decrease in heating prices. Therefore, individuals who heat their homes at the desired temperature will be less susceptible to the rebound effect when switching to a more efficient heating system, regardless of whether the rebound effect is driven by a price effect or a moral licensing effect. Nevertheless, as heating temperature is not the only parameter to measuring heating use, the rebound effect can involve other behavioral adjustments in the heating domain (e.g., extending heating time or paying less attention to heating) but also in other domains[6] (e.g., increasing electricity consumption).

Another significant driver for the occurrence of the moral licensing effect concerns guilt feelings related to the environmental impact of the heating technology used. Consistent with the moral licensing literature, our results show that the more guilty people feel about the environmental impact of their heating, the more likely they are to increase their heating consumption when their heating becomes more environmentally friendly. A parallel can be drawn between the rebound effect caused by a price change and that caused by a moral licensing effect. In the former, the higher the price elasticity of an individual's demand, the more likely they will increase their heating use when the price of heating decreases (Sorrell et Dimitropoulos, 2008). The feeling of guilt linked to the environmental impact of

[6] As the price effect can lead to a direct or indirect rebound effect, the moral licensing effect can also occur in either the same or a different domain. For example, in a field experiment Tiefenbeck *et al.* (2013) show that providing households with information about their water use reduced water consumption but increased electricity consumption.

heating seems to operate according to the same mechanism: the more guilty an individual feels, the higher their 'guilt elasticity of demand', the more likely they are to increase their heating use when the environmental damage decreases.

Table 2 also highlights that the importance the individual attaches to the environment (materialized by the variable *High EAI*) moderates the moral licensing effect. However, this moderation occurs indirectly, through the impact of guilt associated with the environmental impact of heating, since we find a significant interaction effect between environmental attitudes and heating guilt. The interaction effect is negative, which means that the impact of heating guilt on the probability of a moral licensing effect is lower for individuals who report stronger environmental attitudes than for those who report weaker environmental attitudes. The extant literature reveals an ambivalent relationship between the moral licensing effect and environmental preferences. Some studies show a stronger moral licensing effect in individuals who report that they value the environment less (Meijers *et al.*, 2015; Garvey et Bolton, 2017), while others find a higher moral licensing effect in individuals who indicate they highly value the environment (Truelove *et al.*, 2014; Dorner, 2019). Our results bring us closer to the findings of Garvey et Bolton (2017) and Meijers *et al.* (2015), who find a negative correlation between the moral licensing effect and individuals' environmental attitudes.

3.2. Perception of the environmental impact of heating fuels

The perception of the environmental impact of heating fuels is a key determinant of the moral licensing effect on heating behaviors. We therefore examine how wood heating is perceived compared to other heating fuels. Respondents indicated on a 7-point Likert scale the perceived environmental damage of their heating fuel, as well as that of all other types of heating fuel.

Figure 2 shows these average perceptions (and associated standard errors) of the environmental damage caused by the four heating fuels. We distinguish the perceived environmental damage reported by respondents who actually use that

heating fuel from the perceived environmental damage of heating fuels not used by the respondents. For example, the average perception of the environmental damage caused by wood fuel among wood fuel users is 3.31, but it rises to 3.99 among respondents who use electricity, gas, or oil. Interestingly, the tendency to underestimate the environmental impact of one's own heating fuel type is also observed among users of other fuels. Indeed, for each heating fuel, users of that fuel (represented by the darkest bars) perceive it as less harmful to the environment than do users of other heating fuels (represented by the lightest bars). Except for electric heating, differences are statically significant between users and non-users (Mann-Whitney U tests, wood fuel $p<0.001$, electricity $p=0.2351$, gas $p<0.001$, fuel oil $p<0.001$). This result could be due to a potential optimism bias (Sharot *et al.*, 2007), whereby people tend to think that their heating causes less damage to the environment than it actually does. Specifically on wood heating, Hine *et al.* (2007) have already shown that wood-heater users have more positive affective associations with wood heating and perceive fewer health risks from wood smoke relative to non-users. Similarly, Decker et Menrad (2015) find that wood fuel users assessed their fuel as being much better than oil, gas, or electric fuel.

Figure 2: Perception of the environmental damage caused by different heating fuels

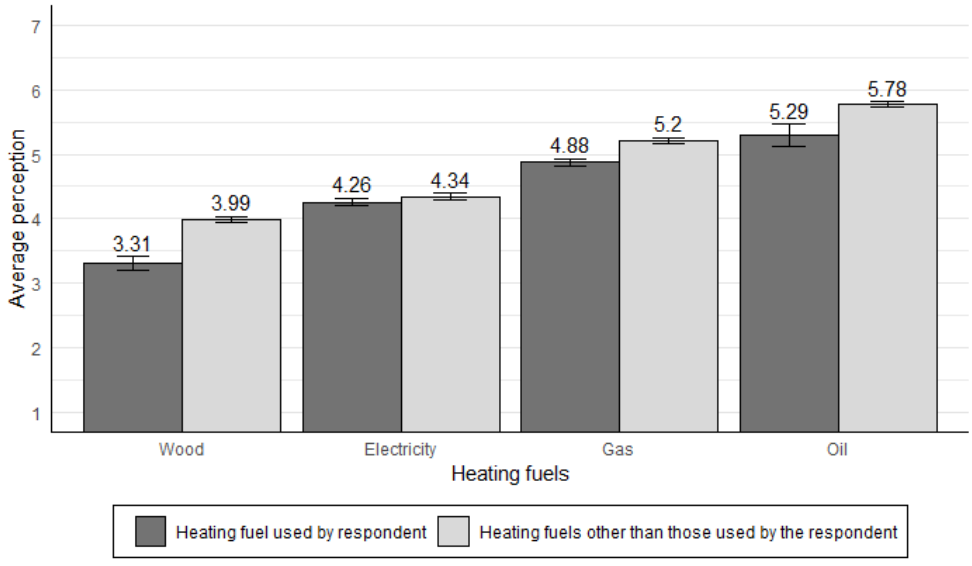


Figure 2 also shows a consistent ranking 'wood, electricity, gas, oil' both for respondents who use the specific fuel and those who don't. It is difficult to determine the accuracy of this ranking, as it depends on a number of factors, such as the types of environmental damage considered (e.g., greenhouse gases, air pollutants, particulate matter, etc.), the heating technology considered, and even the energy mix of the country considered (particularly for electric heating). In a recent study, Mahmoud *et al.* (2021) review the environmental impacts[7] of most heating systems and rank them (from the least to the most damaging) as follows: electricity, gas, oil, and wood. Wood heating is also poorly ranked due to its high pollutant emissions (PM, CO, NO_x and SO_2), notably caused by the older fuel wood heating systems. By comparison, the latest wood-burning technologies, such as pellet stoves, have a much lower environmental impact (Wolf *et al.*, 2016; Sun *et al.*, 2017). Participants in our survey rank wood heating as the heating fuel with the lowest environmental impact. This suggests that people seem to attach more importance to the positive effects of wood fuel on the global environment (reduced climate effects) than to the negative effects on the local environment (increased particle emissions) and confirms the findings of Nyrud *et al.* (2008), who demonstrate similar results in a study of 800 Norwegian households.

We next test whether the perception of the environmental impact of wood fuel differs from that of other heating fuels. As shown in Table 3, we observe that wood heating is perceived as less harmful to the environment than any other heating fuel, both by wood users and users of other types of heating fuel. All differences are statistically significant at the 1% level.

[7]They consider the following pollutant emissions: CO, CO_2, NO_x, SO_2, PMs, N_2O, CH_4, volatile organic compounds, polycyclic aromatic hydrocarbons, and aldehydes.

Table 3: Comparisons of environmental perceptions of heating fuels with a Mann-Whitney U test

Comparisons	Average differences in perceived environmental damage	
	if heating fuel is used by respondent	if heating fuel is not used by respondent
Wood vs. electricity	-0.945***	-0.350***
Wood vs. gas	-1.564***	-1.211***
Wood vs. oil	-1.980***	-1.785***

Notes: Continuity correction is applied. Significant levels *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

3.3. Does wood heating lead to moral licensing?

Based on our findings, presented above, we can indeed expect individuals who switch to wood heating to increase their heating usage, i.e., to engage in moral licensing. First we showed that most people state they would increase their heating usage if their heating mode were less damaging to the environment. Second, among the main heating fuels, wood is perceived as the least damaging. Thus, switching to wood heating may lead individuals to feel less guilty about increasing their usage, either because they consider they have contributed positively by investing in a less environmentally-damaging heating technology or because they perceive wood heating as having a lower environmental impact. In other words, the probability that a moral licensing effect could increase a potential rebound effect should not be overlooked. The likelihood of a moral licensing effect is expected to be strengthened by two factors. The first is related to the observation that gas, oil, and electricity users report weaker environmental attitudes. As shown in Table 2, the influence of guilt on increasing heating usage is more pronounced on individuals with weaker environmental attitudes. The second factor concerns the observed optimism bias.

We can assume that if an individual replaces their heater with a more efficient one, they are likely to overestimate the environmental benefits of this replacement, which should further reduce their feelings of culpability about increasing its use, thus increasing the risk of a moral licensing effect.

4. Discussion and conclusion

This paper examines the question of the moral licensing effect as a potential source of the rebound effect. Based on a survey of residential heating users in France, the objective is to determine whether there is a risk of an additional rebound effect due to a moral licensing effect when a consumer switches to wood heating.

Our findings suggest that switching to wood heating may indeed induce a moral licensing effect, leading people to increase their heating use and potentially counteracting the environmental benefits of this more eco-friendly heating option. This finding is based on two key insights. Firstly, people's heating behavior is affected by the perceived environmental impact of their heating system. In line with the moral licensing effect, a majority of people say they would increase their heating use if it were less harmful to the environment. The risk of a moral licensing effect increases when people do not already heat to their desired temperature and when they feel guilt about their current heating system. Secondly, wood is perceived as the heating fuel with the lowest environmental impact, both by its users and by those who use oil, gas, and electric fuels.

For policymakers, our findings have important implications. Primarily, when designing energy policies, failure to account for the moral licensing effect may lead policymakers to underestimate the magnitude of the rebound effect, resulting in overestimating the expected policy benefits and potentially leading to sub-optimal decisions. In the literature, the rebound effect related to heating is estimated at between 10% and 30% (Sorrell *et al.*, 2009; Madlener et Hauertmann, 2011). These figures are generally based on estimates of the elasticity of service demand with respect to energy prices, and thus refer only to the economic dimension of the

rebound effect. In addition, due to a lack of data, the rebound effect is not estimated specifically for wood heating. As a result, it is difficult to get a precise idea of the effectiveness of policies that promote wood heating. A second implication of our results concerns the effectiveness of communications policies designed to encourage individuals to invest in wood heating. In general, these campaigns emphasize the environmental benefits of this type of heating. Nevertheless, such emphasis may increase the likelihood of a moral licensing effect by making people feel less guilty about increasing their heating consumption. Furthermore, it is possible that this adverse effect may affect both new and long-term users of wood fuel systems. The effectiveness of policies that promote wood heating depends on the accuracy of estimates of the rebound effect, which in turn depends on the ability to determine whether, and to what extent, a moral licensing effect may occur.

A limitation of our work is linked to the use of self-reported data, which may introduce biases that could compromise the external validity of our results. However, it is worth mentioning that the moral licensing effect is a psychological phenomenon influenced by individual factors that are difficult to quantify objectively. These factors include feelings of guilt regarding perceptions of the environmental impact associated with the use of various heating fuels.

In conclusion, while wood heating presents a promising avenue for reducing greenhouse gas emissions, attention must be paid to the behavioral responses it may elicit. In particular, policymakers and researchers should be aware of the moral licensing effect, which could lead to an additional rebound effect and limit the environmental benefits of wood heating. Future research is needed to further explore the moral licensing effect, seeking to provide empirical evidence of it, quantify its impact on behaviors, and identify solutions to mitigate it.

Appendix A. Summary statistics

Statistics on the French population are based on INSEE data[8] and statistics on the distribution of heating fuels are based on SDES data[9].

Table A.4: Socio-demographic characteristics of our sample

Statistic	Number of respondents	Percentage	Percentage of French population
Gender			
Female	853	56.5%	51.6%
Male	657	43.5%	48.4%
Age			
From 18 - 24 years	185	12.3%	10.5%
From 25 - 34 years	448	29.7%	14.5%
From 35 - 49 years	566	37.5%	23.6%
From 50 - 64 years	261	17.3%	24.5%
Over 64 years	50	3.3 %	26.9%
Highest level of education			
No diploma	28	1.9%	16.3%
Junior high school certificate	111	7.4%	
High school diploma	506	33.5%	22.4%
Bachelor's degree	487	32.1%	18.8%
Master's degree	302	20.0%	42.4%
Beyond a master's degree	79	5.2%	
Perceived financial situation			
Very tight	300	19.9%	-
Tight	738	48.9%	-
Secure	441	29.2%	-
Very secure	31	2.1%	-
Total	1510	100%	-

[8]Source: https://www.insee.fr/fr/statistiques

[9]Source: https://www.statistiques.developpement-durable.gouv.fr/consommation-denergie-par-usage-du-residentiel

Table A.5: Housing and heating characteristics of our sample

(a)

Statistic	Number of respondents	Percentage	Percentage of French population
Housing			
Apartment	711	47.1%	33.6%
House	799	52.9%	65.8%
Type of municipality			
Rural	563	37.3%	32.8%
Peri-urban or urban	947	62.7%	67.2%
Heating fuels			
Wood	183	12.1%	10.5%
Oil	79	5.2%	9.0%
Gas	585	38.7%	37.5%
Electricity	663	43.9%	37.5%
Thermostat			
No thermostat	607	40.2%	-
Thermostat	903	59.8%	-
Collective heating system			
Individual heating	1188	78.7	-
Collective heating	322	21.3	-
Collective heating bill			
Individual bill	1346	89.1	-
Collective bill	164	10.9	-
Total	1510	100%	-

(b)

Variable	Mean	Std. dev	Min.	Median	Max.
Heating temperature (°C)	18.75	3.61	0	19	30
Heating time (day)	160.28	41.74	31	165	287
Household composition (people)	2.72	1.36	1	2	9

Appendix B. Supplementary results

Table B.6: Ordered logistic regression on the likelihood of a moral licensing effect (full version)

VARIABLES	(1)	(2)	(3)	(4)	(5)
Temperature satisfaction	-0.7977***	-0.7956***	-0.7528***	-0.7790***	-0.7442***
	(0.0951)	(0.0951)	(0.0971)	(0.0956)	(0.0976)
High heating guilt	1.0714***	1.2410***	1.2032***	1.2258***	1.2012***
	(0.0960)	(0.1280)	(0.1296)	(0.1293)	(0.1308)
High EAI	-0.2131***	-0.0100	-0.0492	0.0027	-0.0287
	(0.0925)	(0.1368)	(0.1389)	(0.1385)	(0.1410)
High heating guilt × High EAI		-0.3728**	-0.3105*	-0.3771**	-0.3233*
		(0.1854)	(0.1875)	(0.1861)	(0.1882)
Apartment			0.4218***		0.3838***
			(0.1219)		(0.1232)
Urban			-0.1445		-0.1144
			(0.1066)		(0.1095)
Household composition			0.0718*		0.0713*
			(0.0375)		(0.0378)
Thermostat			-0.0817		-0.0670
			(0.1002)		(0.1004)
Collective heating			-0.4957***		-0.5054***
			(0.1697)		(0.1696)
Collective bill			0.2433		0.2478
			(0.2022)		(0.2023)
Heating temperature			-0.0420***		-0.0400**
			(0.0156)		(0.0157)
Heating time			0.0002		0.0007
			(0.0012)		(0.0012)
Female				-0.1026	-0.1057
				(0.0943)	(0.0964)
Age				-0.0754	-0.0553
				(0.0462)	(0.0485)
Education				-0.0069	-0.0008
				(0.0452)	(0.0464)
Finance				-0.1961***	-0.1603**
				(0.0670)	(0.0683)
Observations	1,510	1,510	1,486	1,510	1,486
Log likelihood	-2689.208	-2687.186	-2629.961	-2680.482	-2625.917

Notes: Models (3) and (5) have 24 fewer observations due to the removal of outliers for the *heating time* variable. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix C. Survey

The following questions were originally written in French.

Table C.7: Questions related to housing characteristics

Question	**Answer Options**
1. In which department do you live?	List of French departments
2. What type of dwelling do you live in?	House/Apartment/Other
3. What type of municipality do you live in?	Rural municipality/Suburban municipality/ Urban municipality
4. How many people are in your household?	Numeric answer

Table C.8: Questions related to heating characteristics

Question	**Answer Options**
5. Is your household equipped with a collective or individual heating system?	Collective/Individual
6. Are your heating costs individually metered?	Yes/No
7. Do you control the heating temperature in your household yourself?	Yes/No
8. What is your primary heating system?	Wood heating/Electric heating/Fuel oil heating/Gas heating/Other
9. Do you also use wood heating to supplement your primary heating system?	Yes/No
10. In winter, how often do you use this supplementary heating?	Often/Occasionally/Rarely
11. What device do you use for heating?	Wood boiler/Closed fireplace/Open fireplace/Wood cooking stove/Wood stove/Pellet stove
12. Do you have access to free fuels (self-supply) for this heating device?	Never/Sometimes/Often/Always
13. Do you think your home is well insulated?	"1. No, not at all" - "7. Yes, absolutely"
14. Do you use a thermostat to adjust the temperature of your home?	Yes/No
15. When at home during the day, at what approximate temperature do you heat your home in winter?	Numeric answer (0 - 30)
16. Is the choice of this temperature constrained by any of these factors?	No constraints/I heat my home to the desired temperature/Desire to reduce the heating bill/Desire to reduce the environmental impact of heating/Difficulty in adjusting the heating/Other
17. Without these constraint(s), at what temperature would you heat your accommodation?	Numeric answer (0 - 30)
18. On average, what date do you turn on your heating?	Date (month, day)
19. On average, on what date do you turn off your heating?	Date (month, day)
20. Do you ever use your wood heating for a reason other than heating (for pleasure or comfort, for example)?	"1. No, never" - "7. Yes, always"
21. In your opinion, how does the temperature of your heating compare to that of similar households to yours?	"1. Much lower" - "7. Much higher"

Table C.9: Questions related to the economic dimension of heating

Question	**Answer Options**
22. Do you adjust the temperature of your heating to save money?	"1. No, never" - "7. Yes, always"
23. How much does your heating budget impact the total budget of your household?	"1. Not at all" - "7. Very strongly"
24. Do you think that if the price of your heating fuel decreased, you would increase your heating use?	"1. No, definitely not" - "7. Yes, absolutely"

Table C.10: Questions related to the environmental aspects of heating

Question	**Answer Options**
25. How do you perceive the environmental impact of these different heating systems:	
Wood heating	"1. Not harmful at all" - "7. Very harmful"
Electric heating	"1. Not harmful at all" - "7. Very harmful"
Fuel oil heating	"1. Not harmful at all" - "7. Very harmful"
Gas heating	"1. Not harmful at all" - "7. Very harmful"
26. Specifically for wood heating, please indicate what you think the impact is in terms of greenhouse gas emissions for each of these devices:	
Closed fireplace	"1. Not harmful at all" - "7. Very harmful"
Open fireplace	"1. Not harmful at all" - "7. Very harmful"
Log-burning stove or boiler	"1. Not harmful at all" - "7. Very harmful"
Pellet stove or boiler	"1. Not harmful at all" - "7. Very harmful"
27. For these different wood heating devices, please indicate what you think the impact is on air quality:	
Closed fireplace	"1. Not harmful at all" - "7. Very harmful"
Open fireplace	"1. Not harmful at all" - "7. Very harmful"
Log-burning stove or boiler	"1. Not harmful at all" - "7. Very harmful"
Pellet stove or boiler	"1. Not harmful at all" - "7. Very harmful"
28. In your opinion, how do other individuals generally perceive the environmental impact of wood heating?	"1. Not at all harmful" - "7. Completely harmful"
29. Do you feel guilty about the environmental impact of your heating?	"1. No, not at all" - "7. Yes, absolutely"
30. Do you think that if you were to use a more environmentally friendly heating mode or system, you would increase your heating use?	"1. No, definitely not" - "7. Yes, absolutely"

Table C.11: Questions related to the socio-demographic characteristics

Question	**Answer Options**
31. Do you think your recent heating practices have been influenced by the current situation between Ukraine and Russia?	Yes/No
32. What is the main reason for this change?	Rising energy prices/Guilt over consuming energy imported from Russia/Other
33. What is your gender?	Female/Male
34. In which age group do you place yourself?	18-24/25-34/35-49/50-64/+65
35. What is your highest level of education?	No diploma/Junior high school diploma/High school diploma/Bachelor's degree/Master's degree/Study beyond a master's degree
36. How do you perceive your current financial situation?	Very tight/Tight/Secure/Very secure

Table C.12: Environmental Attitude Inventory (EAI) survey

Question	**Answer Options**
37. To finish, please indicate if you agree with the following statements:	
I think spending time in nature is boring.	"1. Totally disagree" - "7. Totally agree"
I am opposed to governments controlling and regulating the way raw materials are used in order to try and make them last longer.	"1. Totally disagree" - "7. Totally agree"
I would like to join and actively participate in an environmentalist group.	"1. Totally disagree" - "7. Totally agree"
We need to keep rivers and lakes clean in order to protect the environment, and NOT as places for people to enjoy water sports.	"1. Totally disagree" - "7. Totally agree"
Modern science will not be able to solve our environmental problems.	"1. Totally disagree" - "7. Totally agree"
Humans are severely abusing the environment.	"1. Totally disagree" - "7. Totally agree"
I'd much prefer a garden that is well groomed and ordered to a wild and natural one.	"1. Totally disagree" - "7. Totally agree"
I am not the kind of person who makes efforts to conserve natural resources.	"1. Totally disagree" - "7. Totally agree"
Human beings were created or evolved to dominate the rest of nature.	"1. Totally disagree" - "7. Totally agree"
Protecting the environment is more important than protecting peoples' jobs.	"1. Totally disagree" - "7. Totally agree"
It makes me sad to see forests cleared for agriculture.	"1. Totally disagree" - "7. Totally agree"
A married couple should have as many children as they wish, as long as they can adequately provide for them.	"1. Totally disagree" - "7. Totally agree"

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