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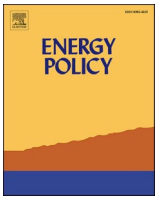

Perceptions of accountability and trust in the regulatory governance of wood burning stove sustainability: Survey evidence from the post-Brexit UK

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1. Introduction

Residential stove burning using treated or untreated wood, or manufactured woody 'pellets' (a form of biomass), has grown in popularity globally as an environmentally sustainable alternative to residential coal or gas heating. The exponential growth of the global production of wood pellets illustrates the reach of this industry. Between 2004 and 2015 the global production of wood pellets surged from 1.7 million tonnes to 13 million tonnes, 60% of which is used in the residential home market (IEA Bioenergy, 2019). In 2013, the European Environment Agency estimated that between 1990 and 2011, the use of biomass for home heating grew by 56% among European Union member states (EEA, 2013, p.90). This growth has been driven by the global demand for sustainable energy sources, and biomass has been promoted by some governments since the mid-2000s to this end, for example with tax incentives and public information campaigns (Badouard et al., 2021).

However, domestic wood burning can have dangerous effects on human health. Wood burning in homes is one of the key causes of a particularly potent air pollutant in advanced capitalist economies - fine particulate matter ($PM_{2.5}$) - which can have severe effects on both indoor and outdoor air quality (EEA, 2016, pp.22-26). In 2014, domestic heating, encompassing mainly wood burning, contributed 56% of particulate matter pollution in Europe, making it the single largest source (EEA, 2016, p.23). The effects of $PM_{2.5}$ are potentially severe, directly causing noncommunicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer (World Health Organization, 2021). Over 3.8 million deaths worldwide are directly attributable to household air pollution caused by burning wood and similar solid fuels (World Health Organization, 2021).

Given the potential for chronic health effects, and consequent impacts on long term negative health outcomes and resultant burden on health systems, wood burning stoves have become a significant policy problem. Very few countries have legal controls of any kind on indoor air quality, and even fewer specifically focused on any form of household fuel combustion. A United Nations Environmental Programme (UNEP) report surveying air quality standards in UN countries found that 88% had no legal indoor air quality legal standards (UNEP, 2021, p.56). The lack of such standards may be due to complexities in enforcement, particularly for households with old stoves already installed, and the benefits of encouraging transitions to sustainable energy sources, of which biomass is one of the easiest to implement. Regulating how individuals behave in heating their residential home is a potentially highly contentious political issue, given that regulations need to closely affect consumer purchasing decisions and behaviours in using wood burning stoves that are usually considered private matters beyond legitimate state control. Moreover, wood burning stoves are cheaper compared to gas or coal heating systems (Nunes et al., 2016), and so may be an attractive heating source during times of economic hardship. Studies in Greece show the Global Financial Crisis contributed to increased use of biomass as a residential fuel (Paraskevopoulou et al., 2015; Saffari et al., 2013). At the same time, wood burning stoves are purchased by middle and high income households for their aesthetic and cultural value, and environmental friendliness (Nyrud et al., 2008; Jalas and Rinkinen, 2016). They are also marketed by producers as increasing a property's market value and desirability (Petersen, 2008). Policy makers therefore confront a series of intersecting economic, social and political interests that make wood burning stoves profitable for producers and socially and economically desirable for consumers. Compliance with regulations restricting wood burner purchase and use is challenging to ensure.

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These problems of regulatory compliance are far from exclusive to wood burning stoves. Policy makers dealing with issues of environmental sustainability often encounter problems with ensuring compliance, because sustainability as an overarching policy goal requires the fundamental reordering of the norms, practices, and behaviour of a multitude of diverse actors in advanced capitalist economies, including consumer behaviours in open market contexts (Bailey, 2020; Eckersley, 2021). While consumer behaviour can be shaped by formal state regulations banning particular actions, the conditions of state restructuring in advanced capitalist economies, including shifts in the global economy that foster complex private and public networks and supply chains, makes the assertion of regulatory authority a problem for open empirical research (Black, 2017). How do policy makers ensure regulations will be effective through compliance by consumers and producers?

In this context, it is vital to understand how *consumers* - who are crucial targets for wood burning stove regulations in particular, and sustainability policies more generally - *view the legitimacy of key regulatory actors in regulatory governance regimes promoting sustainability*. We define legitimacy following existing research on regulatory governance (see Black, 2002, 2008; Bernstein and Cashore, 2007) as a combination of perceptions held by consumers that they ought to adopt sustainable behaviours because they view relevant regulators as 1) accountable and 2) trustworthy (for a theoretical discussion of legitimacy see Schmidt, 2013). We contend that where consumers view regulatory authorities as more legitimate, that will shape their compliance with the recommendations of those regulators. We hence follow existing theory that suggests effective 'polycentric' regulatory governance regimes ought to be designed in a way that compels action from actors in those regimes that consumers view as more trustworthy and accountable (that is, legitimate). Our overarching research question is therefore:

> "Which regulatory actors do consumers view as trustworthy and accountable in polycentric regulatory governance regimes for sustainability?"

We use wood burning stoves as a case study through which to answer this broader question. We analyse new empirical evidence from a survey we conducted of UK homeowners (N = 108), including homeowners who own a wood burning stove (n = 50) and those who do not currently own a wood burning stove (n = 58). The UK is an exemplary case study in which wood burning stoves are a major cause of outdoor and indoor pollution, and in which an emerging regulatory governance regime includes multiple state and non-state actors. Shifts in the UK regulatory regime for environmental sustainability, with the recent creation of an Office for Environmental Protection (OEP) in the wake of the UK's exit from the European Union (Brexit), make this case study particularly timely because it provides an empirical context of regulatory uncertainty, that allows us to pose survey questions about the potential trustworthiness and accountability of actors within the design of an emerging regulatory regime. Recent UK legislation bans the use of particular types of wet wood for household burning, implemented from May 2021 (*Air Quality (Domestic Solid Fuels Standards) (England) Regulations 2020*). However, the implementation of this regulation has thus far been through an industry-led scheme highlighting fuels that are 'ready to burn', which third sector organisations have criticised for being ineffective (Mums for Lungs, 2021). Responsibility for air quality regulation in general is diffused between local governments, the UK Environment Agency, Public Health England (recently re-established as the UK Health Security Authority) and private sector actors, including the Heating Equipment Testing and Approvals Scheme (HETAS). Our evidence hence provides an empirical contribution to understanding how emergent sustainability regulatory governance regimes can be designed based on the views of consumers of accountability and trustworthiness, as well as providing evidence for policy makers on how to design regulatory governance regimes that compel action from actors that consumers view as accountable and trustworthy. From the viewpoint of practitioners, this research also has obvious benefits for the shaping of actual regulatory rules and practices.

The article proceeds as follows. First we outline the context of 'polycentric' regulatory governance and the way in which regulatory authority is an open empirical question, rather than a fact of legal imposition. Second, we develop a conceptual framework for understanding how the prospective reputation of regulatory authorities can be built, through perceived accountability and trust. Third, we outline the empirical context, operationalisation of concepts, and methodological approach. Fourth, we detail and analyse findings from our survey of UK homeowners. Fifth, we conclude by summarising the key contributions, and emphasise limitations of the study and directions for further research.

2. Securing authority in a world of 'polycentric' regulatory governance

This article conceptualises the process through which wood burning stoves may be effectively governed using the concept of 'polycentric' regulatory governance (Black, 2002). Regulatory governance is a general concept or approach used in political science to understand the evolution of legal regulation within late capitalist economies since a programme of mass deregulation was instituted by right wing governments in the 1980s (Levi-Faur and Jordana, 2005). It emerged because researchers showed that, despite attempts by those governments to 'free the market' through privatisation, the number of laws regulating privatized industries (or rather, attempts at regulating them) paradoxically *increased* in the 1990s (Moran, 2002). As market innovations created complex negative impacts, including environmental pollution, attempts at 're-regulating' industries producing those externalities have proliferated from multiple directions, including from public, private and third sector actors. Such complex regulatory governance 'regimes' have been termed 'polycentric' (Black, 2017). Polycentric regulatory governance combines traditional 'hard' legal instruments, including compulsory fines and prosecution, with 'soft laws' and non-legal instruments. These include, for example, standards setting, kite-marking, and certification schemes, that are implemented by state and non-state actors (Bernstein and Cashore, 2007; Scott, 2000).

The complexity of polycentric regulatory governance has raised a number of questions about how regulators can effectively exert authority through 'soft' or 'hard' legal instruments. On the one hand, 'hard' legal instruments have struggled to keep pace to control globalised economic activity, while 'soft' instruments raise critical questions about their effectiveness in shaping market behaviour. Julia Black's (2008) important work on regulatory legitimacy suggested that authority is not easily won in a globalised world. She defines regulation as '*sustained and focused attempts to change the behaviour of others in order to address a collective problem or attain an identified end or ends, usually through a combination of rules or norms and some means for their implementation and enforcement, which can be legal or non-legal*' (Black, 2008, p.139, italics added). Black's work directed researchers of regulation to assess not only the content of legal and non-legal rules, but *how regulated consumers and other key actors view and respond to those rules.* Black argued for a *decentred* approach, which 'rejects a linear conception of regulation, in which regulatees are assumed to comply with regulatory requirements, and instead *problematizes the response of different actors to attempts by others to regulate them, emphasizing their operational autonomy*' (Black, 2008, p.139, italics added).

Black's work proved influential for directing the research agenda to the study of how individual state and non-state agencies communicate with diverse stakeholders to shape their support for new regulatory rules (Bernstein and Cashore, 2007; Wood, 2015). More recently, scholars have moved towards understanding the implementation of regulatory rules and norms, through the study of individual and organisational attitudes and behaviour (van der Heijden, 2019). The influential work of the Behavioural Insights Team (John, 2018) has been adopted by researchers seeking to understand how diverse regulatory tools can be

used to influence individual and organisational behaviour (Alemanno, 2012; Amir and Lobel, 2012). This article takes a similar approach to understanding the authority of regulatory regimes among a particular target population – users and potential users of wood burning stoves in the UK.

3. Building authority in polycentric regulatory governance regimes: the importance of perceived accountability and trust

Regulatory authority has been shown to rely substantively on the *reputation* of regulators for their technical and scientific expertise, moral efficacy and legal competence (Carpenter, 2010). Evidence shows that stakeholders are able to distinguish different dimensions of a regulator's reputation (Overman et al., 2020), and that reputational considerations can be linked to the likelihood of private actors' compliance with rules and norms promoted by regulators (Carpenter, 2010; Busuioc and Rimkutė, 2020). Studies have shown that the reputation of nongovernmental voluntary programmes improves the compliance of facilities with governmental standards (Potoski and Prakash, 2005). Private firms introduce internal environmental governance reforms to protect the firm from reputational harm (rather than proactively improve environmental performance) (Rodrigue et al., 2013), and compliance with health and safety protocols in the shipping industry has been shown to depend upon the potential of non-compliance to inflict reputational damage to managers and the workforce of particular ships (Sampson et al., 2014).

Through what mechanisms does compliance through reputation work? Existing research shows regulatory regimes that involve *voluntary compliance* (i.e. compliance with rules designed by a public body of some sort that *is not legally enforced or enforceable in practice*), effectively share 'reputational risk' between the regulators and the target populations they want to regulate by communicating with them (May 2005). The target populations then (ideally) behave in a way that is influenced by norms associated with their own *reputation*, as a function of the overall regulatory regime. This relationship has been shown in the case of the regulation of lobbying in the European Union, where lobbyists that are encouraged (rather than mandated) to sign up to a 'transparency register', are more likely to do so in order to protect their reputation (Năstase and Muurmans, 2020). Reputational risk is *constructed* through the consideration of *normative* and *instrumental* concerns. Normative concerns are 'based on judgments regarding the "wisdom" of the regulation (i.e. people comply because they believe a genuine problem exists and authorities propose the right kind of intervention toward it)' (Năstase and Muurmans, 2020, p.240). Instrumental concerns, in contrast, are based on material gain or loss. Năstase and Muurmans (2020, p.241) explain: 'In the absence of legal sanctions, alternative incentives can be used to alter the targets' cost–benefit analyses and make it profitable for them to comply'. Such incentives include tax exemptions, subsidies, and other tools aimed at making compliance profitable. Reputational concerns are a 'hybrid' of normative and instrumental concerns. They are based on the threat of social shame that individuals would experience if they failed to comply, either because their peers would view their non-compliance as wrong, or because they would expect to lose out materially for their indiscretion.

Reputation theory is useful for assessing how a regulatory regime may frame normative and instrumental concerns in a way that encourages individuals to voluntarily comply with certain behaviours that governments seek to regulate (for example, buying and using their wood burning stove). In polycentric governance regimes, however, this is a more complex task than simply measuring the reputation of an existing regulator. Where regulation is not linked to a single legal authority, reputation gets messy. Regulatory actors struggle over similar bureaucratic turf (Busuioc, 2016). This in turn can lead to problems with coordinating the implementation of regulations, particularly in emergent regulatory regimes where institutional responsibilities are unclear. Under these circumstances, the design of regulatory regimes, and in particular which actors are given regulatory power - or compelled to implement regulatory requirements - is a crucial decision. Polycentric regulatory regimes can be shaped by governments who assign regulatory responsibilities to non-state actors, as a result of the structuring (or 'meta-governing') effects that formal legislative changes have (Sørensen and Torfing, 2017).

We develop the reputational approach by framing normative and instrumental concerns as *prospective* concerns about a variety of governing actors and institutions in the polycentric regulatory regime. In doing so, we translate these two concerns into the substantive concepts of *accountability* and *trust*. First, we use *accountability* as an analytical concept to specify the normative concerns of target populations when considering their voluntary compliance. Accountability, at base, is 'a principle for organizing relations between rulers and ruled, and making public officials accountable is a democratic achievement' (Olsen, 2015, p.425). Where individuals believe it is *right* that a particular actor ought to be *responsible* for a function or rule, this constitutes a *demand* that doing so is likely to be a better way of *improving and ensuring democratic accountability* (Olsen, 2017). Overman and Schillemans' (2022) recent work on 'felt accountability' links beliefs in actors' accountability, to voluntary behaviour. They show that the extent to which actors within governance networks 'feel' that a lead government department is accountable has important implications for their desire to work with that department. Such feelings depend upon perceptions that the lead departments have 1) the capacity to process complex evidence to hold others to account, and 2) the tendency to be transparent in making all relevant documentation and evidence available.

Second, we also use *trust* as an analytical concept to specify 'instrumental concerns'. Trust is, at base, about the *expectations* individuals hold about others' behaviour (Hardin, 1993). More precisely, it is about the expectation that others' behaviour *is more or less likely to harm the interests of the individual* (Six, 2013). In environments where individuals have high levels of trust in each other, they behave more collaboratively, and are more likely to share resources and knowledge. Research shows that high levels of trust correlate with voluntary compliance, for example in the case of public adherence to COVID-19 guidelines including mask wearing and social distancing (Weinberg, 2022). Conceptual frameworks about trust are manifold, and some include concepts that measure anticipated behaviour based on normative agreement. However, these normative concerns are typically secondary - while the decision to trust is a normative one, considerations of trustworthiness are 'unmoralized' (Hardin, 1996). Instead, trust functions as a *calculation* of how a person expects an individual or institution to behave in the future, and specifically whether their behaviour will harm the person's *interests*, typically conceived in material terms (Six, 2013). Therefore, trust can be conceptualised as a *judgement of trustworthiness*, with trustworthiness associated with attitudes such as 'loyalty, commitment [and] confidence' (Jennings et al., 2021, p.1177).

In sum, assessing *perceptions of who should be accountable for regulating a policy problem*, and *judgements of the trustworthiness of different authorities*, can allow us to assess the likelihood that empowering actors within polycentric regulatory governance regimes will enable them to build authority and effect changes in consumers' voluntary compliance. Our exploratory research project on the perceptions of wood burning stove users and non-users sought to do precisely this.

4. Research design

We take wood burning stove regulation in the UK as a relevant context for designing our research, because wood burning stoves cause a significant policy problem, and an emerging 'polycentric' regulatory regime exists, in the wake of the UK's exit from the European Union. Data from the Department for Environment, Food and Rural Affairs (DEFRA, 2020) shows 7.5% of UK households use wood fuel in their homes, and recent studies suggest that figure may be a significant under-estimate given the informal economies around wood gathering and use of old wood burning stoves. Recent estimates suggest 'around

10% of households, or 2.5m, use a stove or open fire, even though 96% of them have an alternative source of heat' (ENDS Report, 2021).

As of July 2022, the structure of the existing regulatory regime includes regulations focused on three 'objects' of the wood burning stove market, including: the physical design of stoves; quality of wood used for burning, and burning activities of consumers. We set out the distribution of institutional responsibilities below, and then the contents of regulatory arrangements. Crucially, responsibility for wood burning stove regulation in the UK is in flux. The UK's exit from the European Union's legal jurisdiction in January 2020 created space for regulatory reform of this system. The high prevalence of wood burning stove users and context of institutional change thus makes the UK a good empirical site for our research.

4.1. The empirical context

First, regarding the physical design of stoves, legislation has been transferred onto UK Statute from the European Union 2009 Ecodesign Directive (Directive 2009/125/EC and Regulation (EU) 2017/1369). As of July 2022, the Office for Product Safety and Standards (OPSS) is the primary regulatory surveillance authority in the UK for Ecodesign, and can act to prosecute businesses. OPSS is a regulatory agency formally accountable to the Department for Environment, Food and Rural Affairs (DEFRA). Since 2009, local authorities can become 'Primary Authorities' in partnership with businesses producing relevant energy products. This means that they collaborate with local businesses to meet regulatory requirements for the businesses' products. For example, firms producing wood burning stoves may partner with local authorities to solicit advice on how to ensure their products meet regulatory standards. The OPSS advertises 'Primary Authority' as a way of increasing efficiency in implementing environmental health regulations for a range of energy products.

Second, regarding the quality of wood used for burning, regulations are primarily implemented through the industry representative organisation HETAS (Heating Equipment Testing and Approvals Scheme). HETAS produces evidence to influence national standards for appliances and fuels, maintains a database of which fuels and appliances meet industry standards, registers appliance engineers and chimney sweeps, approves training centres for industry professionals and 'engages' with central government (HETAS, 2022). HETAS' 'Ready to Burn' certification scheme acts in practice as the way in which Ecodesign regulations are implemented within the UK wood burning stove industry. The organisation's 'Impartiality Committee' assesses companies' compliance with product certification standards, with a self-declared 'commitment to operate openly, objectively and impartially', with objectivity defined in terms of a lack of conflicts of interest among Impartiality Committee members (HETAS, 2023). Local authorities have responsibility for checking the visibility of 'Ready to Burn' logos, and have powers to check storage practices and sales records.

Third, there are also regulations aimed at controlling consumer burning practices and purchasing behaviours. In terms of use of stoves, the *Clean Air Act 1993* introduced Smoke Control Areas, which prohibit chimney smoke from unauthorised appliances or fuels. DEFRA has overall responsibility for implementing the 1993 *Act,* while enforcement of Smoke Control Areas regulations are the responsibility of local government authorities. which hold information about Smoke Control Areas and have power to issue fines for non-compliance. DEFRA's website on Smoke Control Areas is maintained by HETAS. In terms of shaping consumer purchasing practices, DEFRA communicates public information about best practices for wood burning.

Regarding the contents of existing regulations, the EU Directive introduced mandatory requirements for producers of energy-using products to reduce negative environmental impacts of their products throughout their lifecycle. One key aim of the regulation was *'significant reduction of $PM_{2.5}$ emissions from solid fuel local space heaters and boilers compared to baseline projections'*. This regulation was implemented via a mandatory labelling regime, whereby stoves producing fewer $PM_{2.5}$ emissions were given a higher rating, as a way of influencing consumer purchasing behaviour. As a result of the translation of EU legislation into UK statute, from January 2022 only stoves that meet Ecodesign regulatory requirements can be sold on the market, regardless of where they are used.

This industry-led labelling approach is replicated in regulations controlling the quality of wood used for burning. DEFRA's *Air Quality (Domestic Solid Fuels Standards) (England) Regulations 2020* entered into force in May 2021, banning wet wood and other similar sources that emit higher levels of $PM_{2.5}$. The way these have been implemented in practice is through HETAS' 'ready to burn' labelling scheme, which requires wood producers to label wood that is not explicitly banned by the 2020 *Regulations* as 'approved' for burning by consumers.

In terms of regulations to shape consumer behaviour, in Smoke Control Areas there are legal limits on how much smoke can be emitted from household chimneys, and households can only burn authorised 'smokeless' fuels, including anthracite, gas and low volatile steam coal, unless using appliances that are exempt. Households can be fined up to £300 if a local council decides the house is emitting too much smoke. They can also fine households up to £1000 for burning unauthorised fuels without an exempt appliance. Aside from fines, local authorities, DEFRA and health authorities, including the UK Health Security Agency (previously Public Health England) communicate information about the risks of wood burning stoves to the public via mainstream and social media outlets, and HETAS provides leaflets for consumers about health risks (Air Quality News, 2019).

Combining private and public sector actors, and multiple levels of governance at multiple stages of product development, purchasing and consumer use, the UK may hence be regarded as exhibiting a polycentric regulatory governance regime for wood burning stoves. However, the emergence of this regime has been ineffective in reducing fine particulate pollution from wood burning stoves. UK-wide $PM_{2.5}$ emissions from domestic heating doubled between 2003 and 2019 (from 20,000–41,000 tonnes), making it the single most prevalent major source of $PM_{2.5}$ (DEFRA, 2020: https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-particulate-matter-pm10-and-pm25). Between 2018 and 2019 alone there was a 1% increase in this emission source.

Why has this polycentric regulatory regime not been successful? Limitations can be identified in relation to all three objects of regulation identified above. The latest Ecodesign standards do not limit $PM_{2.5}$ emissions from stoves strictly enough to meet international standards. Indoor air pollution from the latest Ecodesign labels ('Nordic Swan') has been shown to be no different in terms of their emissions than current regulatory requirements allow in Germany, a country that was recently fined for exceeding EU air pollution limits (Client Earth, 2020; Reuters, 2021). Campaigners have argued for far more stringent Ecolabel designs, and a wider public health campaign to raise consumer awareness (Guardian, 2021). The 'read to burn' labelling regime has also attracted criticism for effectiveness, because it does not place requirements on producers to store wood in a way that prevents it becoming wet at the point of purchase (British Lung Foundation, 2018). In terms of regulation of consumer behaviour, there is evidence of weak regulatory enforcement. Campaigners have exposed that local councils only issued 19 fines between 2015 and 21, despite over 18,000 complaints of illegal burning practices in Smoke Control Areas (Guardian, 2021). The *Environment Act 2021* did make several changes to the 1993 *Act*, for example providing more resources to improve local capacity to synthesise data on smoke levels. However, it did not change fundamental aspects of the limitations of the regulatory regime, pushing regulation in the direction of monitoring smoke quality rather than focusing on the design and use of stoves (Heydon, 2023, p.14). Research has also shown that UK consumers receive inadequate messaging about wood burner related health risks to enable informed decision making about how often to use their wood burner (Chakraborty et al., 2020).

As a field for empirical study of legitimacy, the UK is interesting because there is both an urgent need for strengthening regulatory requirements, but also evidence of regulatory malfunction and a case for clarifying regulatory responsibilities. Assessing consumer views regarding the trustworthiness and perceived accountability of key actors within the regime will allow us to specify how and where regulatory relationships may be further shaped by public policy change, in a way that is likely to garner support from wood burner users and non-users.

4.2. Operationalisation of concepts

Because our study is forward-looking, in terms of seeking to develop recommendations for policy reforms to regulatory requirements that may garner *political legitimacy*, we seek to operationalise our concepts in a way that measures public opinion, but points to concrete recommendations for the design of regulations. Studying public opinions about the future in complex policy areas is notoriously tricky, suffused with speculation and low levels of information, and often leading to unreliable data. Moreover, asking questions about complex polycentric regimes can be problematic, given low general public knowledge of the details of regulatory laws and organisations, and fuzzy understanding of the nuanced reputations of existing institutions (Overman et al., 2020). To avoid these reliability problems, we sought to access *normative preferences* and *expectations of key actors - in other words, respondents' convictions*. Questions about normative preferences and expectations do not ask respondents to speculate directly about institutional designs they likely know little about, but rather seek to indirectly access their *convictions about the policy field*, which respondents are more likely to have stable opinions on. Moreover, understanding convictions is useful for the purposes of this study, because it connects more closely with the requirements of legitimacy – that an institutional arrangement be perceived, and is more likely to be accepted, as *rightful* (Reus-Smit, 2007). We integrated two specific questions to assess convictions, linked back to our conceptual framework, including normative preferences (perceived accountability) and expectations of reliability (trustworthiness).

First, we operationalised perceived accountability using the question: *"Who do you think should be responsible for minimising the impact of wood-burners on indoor and outdoor air pollution?"* This question taps into normative conceptions of accountability – namely, perceptions of who ought to be 'held to account', or be legally or politically *responsive* in relation to the problem of air pollution from wood burners. Asking the question in this way enables us to tap into *ideal normative conceptions* of the regulatory regime. It will allow us to deduce what balance of responsibility would be viewed as normatively fair or just by wood burning and non-wood burning members of the public.

Second, we operationalised trustworthiness by asking: *"How much confidence do you have in the following sources to give credible information about the impact of wood-burners on health?"* This question taps into a key aspect of trust, related to expectations about how *reliable* different actors are, specifically the extent to which information received from those actors would be considered *trustworthy* in the sense of being deemed *credible*. Existing studies do identify different dimensions of trustworthiness, but tend to privilege credibility as a measure of trust because it relates more closely to reasoned calculations about future behaviour, a core dimension of the concept. Finally, we operationalised the prospective reputation of the actor by asking whose advice the respondent would be most likely to follow out of each of the actors indicated in the previous. Respondents could select up to three actors.

4.3. Method and data

UK residents who owned their own home were recruited for an online survey exploring attitudes, beliefs, knowledge and behaviours relating to domestic wood burning stoves. Data was collected in March 2021, during which time the UK population were subject to a stay-at-home order due to the COVID-19 pandemic. The use of an online survey was therefore considered the most appropriate methodological approach. The survey was administered via Qualtrics, an online survey platform.

In this paper, we report data from only those survey questions relevant to perceived accountability and trustworthiness, as detailed below - all other data is beyond the scope of the current paper.

Perceived accountability: Respondents were asked to indicate *"Who do you think should be responsible for minimising the impact of wood-burners on indoor and outdoor air pollution?"*, by selecting as many options as applicable from the following list: People who use wood-burners, the general public, national government, local government/councils, manufacturers/suppliers of wood-burners, fuel suppliers, other. The 'other' option was accompanied by an open-text field for further description.

Trustworthiness: Respondents were asked to rate *"How much confidence do you have in the following sources to give credible information about the impact of wood-burners on health?"*, using a 7-point scale (1 = no confidence at all; 7 = a lot of confidence): Family/friends, other people who use wood-burners, internet, appliance retailer/installer, fuel supplier, chimney sweep, local council, media (radio, TV news, newspapers), Heating Equipment Testing and Approvals Scheme (HETAS), World Health Organisation, UK Stoves, Public Health England, Department for Environment, Food and Rural Affairs (DEFRA), UK Environment Agency, British Medical Association, your GP, scientific researchers, other.

Respondents were then asked to select up to 3 sources from the above list whose advice they would be most likely to follow.

Participant sample and recruitment**:** UK homeowners were recruited via Prolific (www.prolific.co), an online participant recruitment platform that maintains a database of UK and US-based participants interested in completing paid research.

80 UK homeowners were initially recruited to complete the survey via a study advertisement placed on Prolific. This was expected to oversample homeowners who do not own a wood-burning stove. An additional 200 homeowners were recruited to complete a short survey that screened for wood burning stove ownership. Homeowners who reported owning a wood burning stove were then invited to complete the full survey. Participants were paid £3.75 for completion of the full survey and £0.63 for the screening survey. Sample size was determined by the funding available for participant remuneration.

1 respondent did not complete the questions relevant to the current report, leaving a sample of 108 participants (30 male, 78 female). 89.81% of participants identified as White, 4.63% as of mixed/multiple ethnic groups, 4.63% as Asian/Asian British, and 0.92% as Black/Black British. The mean age was 44.61 years (SD = 12.96; range = 20–75 years). 46.30% (n = 50) of respondents reported currently owning a wood burner and 53.70% (n = 58) reported not owning a wood-burner. Full demographic information is detailed in Table 1 (see Appendix).

5. Results

5.1. Perceived accountability

The percentage of wood-burner owners and non-owners attributing responsibility for minimising the impact of wood-burners on indoor and outdoor air pollution, to each type of actor, was calculated and is reported in Table 2 (see Appendix). As shown in Table 2, both wood-burner owners and non-owners thought that people who use wood burners, and manufacturers/suppliers of wood-burners should be most responsible for minimising their impact, with less weight of responsibility placed on national and local government and fuel suppliers, and the least weight placed on the general public.

5.2. Trustworthiness

To examine potential differences in trustworthiness as a function of

actor type and wood burning stove ownership, ratings of confidence in different sources to give credible information about the impact of wood burning stoves on health were subject to a 2 (Wood burner ownership: Owners vs. non-owners) x (Actor type: Full list in Table 2) ANOVA with repeated measures on the last factor. Mauchly's Test of Sphericity indicated that assumptions of sphericity were not met, χ^2 135) = 669.16, p < .001, so statistics are reported with a Greenhouse-Giesser correction where relevant.

This analysis revealed a significant difference in respondents' rated confidence as a function of the actor type, F (6.63, 702.47) = 25.92, p < .001. As shown in Table 3, the actors generating most confidence (i.e. those scoring >5 on the 7 point scale) were the British Medical Association, scientific researchers, the UK Environment Agency, the World Health Organisation, Public Health England (now the UK Health Security Agency) and the Heating Equipment Testing and Approvals Scheme (HETAS). The actors generating least confidence (below the mid-point of the scale) were the media, family/friends and other people who use wood-burners.

There was no main effect of wood-burner ownership on respondents' rated confidence in actors, F (1, 106) = 0.03, p = .874, and no interaction between actor type and wood-burner ownership, F (6.63, 702.47) = 1.36, p = .221. Accordingly, there was no evidence that wood burning stove owners and non-owners differed in their perceived trustworthiness of actors (see Table 3, Appendix).

5.3. Reputation

To examine the likelihood of complying with advice or regulation concerning wood burners (prospective reputation), respondents were asked to indicate up to 3 actors from the above list whose advice they would be most likely to follow. The percentage of wood-burner owners and non-owners selecting each type of actor was calculated and is reported in Table 4 (see Appendix).

As shown in Table 4, when collapsing over wood-burner ownership, participants indicated that they were most likely to follow the advice of Public Health England, scientific researchers and/or the UK Environment Agency, closely followed by the British Medical Association, the Internet, the World Health Organisation, and other people who use wood-burners. However, there were also some distinct differences in likelihood of following advice as a function of wood-burner ownership. In particular, wood-burner owners tended to indicate that they would be most likely to follow the advice of actors with formal expertise in health or the environment (top 3 actors were Public Health England, UK Environment Agency, Scientific Researchers), while respondents who do not own a wood-burner were more likely to also indicate that they would follow the advice of actors with lived experience or amorphous sources of information (top 3 actors were the Internet, other people who use wood-burners, Public Health England).

5.4. Analysis of results

Respondents indicated that owners of wood burners should be responsible for minimising the impact of wood burning stoves on air quality. The highest percentage of respondents indicated this conviction. A majority of respondents (74.31%) also indicated that they think the manufacturers of wood burners should be responsible, compared to only 47.71% who thought that the suppliers of fuel should be responsible. Moreover, appliance retailers and installers were viewed as being more authoritative sources for advice to follow, compared to fuel suppliers, who come bottom of the trusted actors.

These results need to be interpreted carefully and should be done so in relation to the current distribution of responsibility within the regulatory governance regime. In this respect, respondents hold normative convictions where responsibility should lie among industry actors, which contrast with shifts in the regulatory reforms set out in this article. First, the apparent preference that manufacturers of wood burners ought to be responsible goes against recent regulatory change, which has placed more of the burden on fuel suppliers than on the manufacturers of wood burners, via the 'Ready to Burn' legislation.

When comparing normative convictions about responsibility with convictions about trustworthiness, and authority, we see that although respondents think that wood burner owners should be responsible for minimising their impact on air quality, they nevertheless would not have confidence that owners would give credible information about the health impacts of stoves. We can interpret this as suggesting respondents are conflicted in how they think regulatory functions might be effectively compelled. They think owners ought to take more personal responsibility, but that owners are less likely to be trustworthy in how they behave in relation to this area. This could be interpreted to indicate a preference for stronger rules that make owners take responsibility, that compel action more directly, rather than a relaxation of rules to leave owners to take action at their own discretion.

How and where might rules be strengthened? As outlined above, there are already a range of actors who are involved in this polycentric regime, with more or less power. The current regime closely ties industry representative actors, most prominently HETAS, with local government and regulatory monitors sponsored by DEFRA. In our survey, respondents indicated trust in Public Health England, the UK's public health agency, which has recently been replaced by a Health Security Agency. Moreover, they indicated relative trust in scientific researchers, the UK Environment Agency, and the British Medical Association as outlets for information and authoritative sources for compelling their own actions. These sources indicate a heightened trust in independent public agencies, and the medical health profession. Such trust may be shaped to some extent by the ongoing COVID-19 pandemic, which has seen trust in health expertise, and scientific expertise more generally, increase (Devine et al., 2021). Nevertheless, it does indicate that respondents tended to value information provided by sources that are both public, and professionally competent in the area of health.

This latter point is especially interesting because of the relative lack of regulatory oversight of air quality in the field of health. Wood burning stove regulation is overseen by DEFRA, working through the OPSS, in relationship with HETAS and local government authorities. In our survey, local government performs relatively poorly as an authoritative source of information, and as a likely source to compel consumer action. Health regulators are relatively absent from the regulatory arena.

6. Conclusion and policy implications

This study aimed to assess how a polycentric regulatory governance regime ought to be designed, on the basis that regulatory power is dispersed and in flux, and on the basis that trustworthiness and perceived accountability are important for ensuring the prospective reputation of lead regulators, and therefore the overall authority and legitimacy of the regulatory governance regime. Based on analysis of UK survey data covering 108 UK-based homeowners, this article suggests that regulatory authority could be strengthened in three areas. First, respondents agreed for the need to strengthen regulatory pressures on consumers to comply - as demonstrated by the data suggesting that wood burner users should have responsibility in this area, but this group are considered less trustworthy sources of information or advice to follow about wood burner use. Second, authorities in the health and environmental fields are both considered trustworthy authorities, and respondents agreed that suppliers should also hold responsibility for compliance. We may hence suggest that future regulatory approaches ought to link up authorities across these areas in regulating suppliers and consumers, rather than centring regulatory responsibility around just one actor. Third, existing regulatory responsibilities focused on the local level seem inadequate. Local government finished low down consumers' lists in terms of perceived accountability, trustworthiness and authority. The results suggest policy change would be more effectively directed towards expert delegated agencies at the national level,

including the Environment Agency and Public Health England (now the UK Health Security Authority). This approach would introduce a stronger form of central 'steering', or what governance researchers call 'meta-governance' (Bailey and Wood, 2017; Daugbjerg and Fawcett, 2017). Meta-governance does not involve direct government intervention, but instead requires central public authorities to coordinate resources and offer strategic leadership in a way that enhances the capacity of local authorities to address complex problems more effectively.

Two limitations are worth noting about our data. First, because we were surveying homeowners and wanted half of our sample to include those who had wood burners in their household, we sought to sample a small, non-representative part of the overall UK population. This population is *hard to survey* by conventional survey standards (Tourangeau et al., 2014)- recent reports indicate that only 7.5% of the UK population report burning wood indoors (DEFRA, 2020). The use of Prolific was a cost-effective solution, allowing us to screen for and reach a small sample of wood-burner owners in a short amount of time, with limited financial resources. While recruitment of a larger sample (e.g., via market research companies) would improve statistical generalisability, this was not financially viable. Future research may seek to replicate the patterns from the current research with a larger sample. Second, as the data reported here was part of a larger survey on attitudes, beliefs, knowledge and behaviours relating to domestic wood -burning stoves, we did not ask more detailed questions about regulatory roles and mechanisms, nor about trustworthiness and accountability for specific regulations (e.g. concerning stove design or smoke control areas). While the use of interview rather than survey methods would also have allowed us to delve further into the complexities of trustworthiness and perceived accountability, the research was conducted during the COVID-19 pandemic, during a period of 'lockdown' when UK residents were asked to stay at home. As such, interviews were not considered feasible. Similarly, our data does not cover producers of wood burning stoves and wood for burning, so we cannot claim that our results will be able to change patterns of behaviour in the industry. Our choice of participant sample rests on the theoretical argument that respondents' convictions about trustworthiness and perceived accountability of different actors, and the link to their reputation as sources of advice regarding wood burning practices, will point to which actors are more likely to be effective in implementing regulatory functions. Mapping the convictions of UK homeowners is therefore important, not least because of the way in which consumer demand shapes market supply practices. Further research might test how wood burner owners and non-owners respond to specific regulatory proposals from the actors covered in this study.

CRediT authorship contribution statement

Matthew Wood: Funding acquisition, Conceptualization, Methodology, Project administration, Writing – original draft. **Chantelle Wood:** Methodology, Validation, Investigation, Writing – review & editing, Project administration, Data curation. **Peter Styring:** Conceptualization, Supervision. **Christopher R. Jones:** Writing – review & editing, Methodology. **Jeffery K. Smith:** Conceptualization. **Marianne Day:** Methodology, Validation, Data curation. **Rohit Chakraborty:** Conceptualization. **Gloria Mensah:** Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Rohit Chakraborty reports a relationship with AirRated that includes: employment.

Data availability

Data will be made available on request.

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Appendix. Tables

Table 1
Demographic characteristics of the participant sample. Percentages expressed as percentage of ownership type (wood-burner owners vs. non-owners).

	Wood-burner owners (n = 50)	Non-owners (n = 58)
Age	$M = 46.22 (SD = 11.70)$	$M = 43.22$ ($SD = 13.91$)
Gender	70.00% female; 30.00% male	74.14% female; 25.86% male
Ethnicity	94.00% White; 2.00% mixed/multiple ethnic groups; 4.00% Asian/Asian British; 0% Black/Black British.	86.21% White; 6.90% mixed/multiple ethnic groups; 5.17% Asian/Asian British; 1.72% Black/Black British.
Children in the home	44.00% have children; 56.00% have no children	55.17% have children; 44.83% have no children
Someone in the home with a respiratory condition	72.00% have no one with respiratory conditions; 28.00% have someone with respiratory conditions	74.14% have no one with respiratory conditions; 25.86% have someone with respiratory conditions
Home in a rural, urban or suburban area	32.00% suburban; 14.00% urban; 54.00% rural	58.62% suburban; 25.86% urban; 15.52% rural
Home in a smoke control area	24.00% not sure; 24.00% do not know what a smoke control area is; 28.00% do not live in a smoke control area; 24.00% live in a smoke control area.	37.93% not sure; 34.48% do not know what a smoke control area is; 15.52% do not live in a smoke control area; 12.07% live in a smoke control area.

Table 2
Percentage of wood-burner owners and non-owners indicating responsibility of different actors for minimising the impact of wood-burners on indoor and outdoor air pollution

	Percentage of wood-burner owners (n = 50)	Percentage of non-owners (n = 58)	Percentage of total participant sample (collapsed over ownership) (N = 108)
People who use wood-burners	78.00%	77.59%	77.78%

(*continued on next page*)

Table 2 (*continued*)

	Percentage of wood-burner owners (n = 50)	Percentage of non-owners (n = 58)	Percentage of total participant sample (collapsed over ownership) (N = 108)
Manufacturers/suppliers of wood-burners	70.00%	79.31%	75.00%
National Government	56.00%	53.45%	54.63%
Local Government/Councils	46.00%	56.90%	51.85%
Fuel suppliers	46.00%	50.00%	48.15%
The general public	22.00%	22.41%	22.22%
Other	2.00%	1.72%	1.85%

Table 3
Means and standard deviations of wood-burner owners' and non-owners' confidence in different sources to give credible information about the impact of wood-burners on health

Actor type	Wood-burner owners (n = 50) *M* (*SD*)	Non-owners (n = 58) *M* (*SD*)	All participants (collapsed over ownership) (N = 108) *M* (*SD*)
British Medical Association	5.38 (1.29)	5.52 (1.27)	5.45 (1.28)
Scientific researchers	5.48 (1.23)	5.41 (1.43)	5.44 (1.33)
UK Environment Agency	5.12 (1.22)	5.29 (1.26)	5.21 (1.24)
World Health Organisation	5.08 (1.40)	5.31 (1.49)	5.20 (1.44)
Public Health England	5.02 (1.41)	5.34 (1.33)	5.19 (1.37)
Heating Equipment Testing and Approvals Scheme (HETAS)	5.02 (1.27)	5.03 (1.28)	5.02 (1.27)
Department for Environment, Food and Rural Affairs (DEFRA)	4.82 (1.32)	5.03 (1.41)	4.94 (1.37)
Internet	4.42 (1.29)	4.95 (1.11)	4.70 (1.22)
Appliance retailer/installer	4.70 (1.53)	4.57 (1.50)	4.63 (1.51)
Your GP	4.80 (1.52)	4.48 (1.69)	4.63 (1.61)
Chimney Sweep	4.46 (1.43)	4.34 (1.47)	4.40 (1.45)
UK Stoves	4.36 (1.35)	4.03 (1.27)	4.19 (1.31)
Local Council	4.40 (1.34)	4.29 (1.51)	4.34 (1.43)
Fuel Supplier	4.10 (1.55)	3.91 (1.42)	4.00 (1.48)
Other people who use wood-burners	3.86 (1.31)	4.10 (1.56)	3.99 (1.45)
Family/Friends	3.96 (1.37)	3.50 (1.57)	3.71 (1.49)
Media (Radio, TV news, newspapers)	3.52 (1.43)	3.78 (1.43)	3.66 (1.43)

Table 4
Percentage of wood-burner owners and non-owners including each actor in the top 3 actors whose advice they would be most likely to follow

Actor type	Percentage of wood-burner owners (n = 50)	Percentage of non-owners (n = 58)	Percentage of total participant sample (collapsed over ownership) (N = 108)
British Medical Association	30.00%	17.24%	23.15%
Scientific researchers	32.00%	27.59%	29.63%
UK Environment Agency	32.00%	18.96%	25.00%
World Health Organisation	16.00%	25.86%	21.30%
Public Health England	38.00%	27.59%	32.41%
Heating Equipment Testing and Approvals Scheme (HETAS)	20.00%	12.07%	15.74%
Department for Environment, Food and Rural Affairs (DEFRA)	14.00%	15.52%	14.81%
Internet	6.00%	37.93%	23.15%
Appliance retailer/installer	14.00%	17.24%	15.74%
Your GP	16.00%	6.90%	11.11%
Chimney Sweep	16.00%	8.62%	12.04%
UK Stoves	6.00%	5.17%	5.55%
Local Council	6.00%	5.17%	5.55%
Fuel Supplier	4.00%	5.17%	4.63%
Other people who use wood-burners	8.00%	31.03%	20.37%
Family/Friends	14.00%	22.41%	18.52%
Media (Radio, TV news, newspapers)	0.00%	0.00%	0.00%
Other	2.00%	1.72%	1.85%

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