Anticipating distributional impacts of peer-to-peer energy trading: Inference from a realist review of evidence on Airbnb

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Abstract

Peer-to-peer (P2P) energy trading – where energy prosumers transact directly between each other – could help enable transition to a low-carbon energy system. If it is to be supported in policy and regulation, it is important to anticipate the distributional impacts (or how it might impact segments of society differently). However, real-world evidence on P2P energy trading is currently extremely limited. To address this challenge in the short- to medium-term, this study aimed to explore what might be learned from the extensive body of research on a comparable offering in the accommodation sector: Airbnb. A realist review approach was employed to maximise transferability of findings, focused on what mechanisms are thought to lead to what distributional outcomes, in what contexts. On the basis of the review, the benefits of selling services in P2P energy trading schemes would be expected to accrue disproportionately to those living in areas with network management challenges, who are younger and more highly educated. The review also raised the prospect of discrimination on the basis of characteristics such as race and gender where there are high levels of individual choice over who to trade with. Recommendations include monitoring, incentivising diversity, anonymization, and limiting trading choices.

Keywords: Peer-to-peer energy trading, distributional impacts, realist review, Airbnb, sharing economy

1   Introduction

In a peer-to-peer (P2P) energy trading scheme, prosumers and consumers buy and sell electricity directly between each other rather than via a single supplier. The concept has been gaining prominence in recent years because it has a number of claimed advantages over the single supplier model. These include encouraging uptake of decentralised renewable generation (due to the potential to receive higher returns), supporting network management (such as by improving local supply/demand matching), and fostering wider social benefits (such as through offering preferential pricing or donation to certain groups) [1]. Its rise is also a reflection of similar trends towards decentralisation in other sectors of the economy such as accommodation (e.g. Airbnb) and mobility (e.g BlaBlaCar).

While P2P trading models may offer a range of advantages for energy systems and users, there are also likely to be risks. As with the introduction of any innovation, those who are slower to adopt or get access to it are at risk of exclusion from benefits. And those who do access it may experience new harms. In line with a responsible research and innovation approach [2], it is important to anticipate impacts (positive and negative) and inform future research, service design, and regulation in such a way as to foster more positive outcomes for society.

It is only in recent years that technology capable of tracking the high numbers of transactions required to enable P2P trading has become widely accessible. Such trading is also largely precluded (except in restricted forms) by energy market regulations around the world [3]. As such, research on its operation and impacts is limited either to simulations or to field small trials, often consisting of small number of residential and/or commercial participants. There is therefore little direct empirical evidence on what the impacts could be. However, P2P models operating in other sectors have a much longer track record of commercial operations and a concomitantly richer research base. The aim of this study was to explore whether this base of evidence might be a source of useful insight on the potential impacts of P2P trading in energy.

The study draws on a realist review approach, and uses research on the P2P accommodation platform Airbnb to inform an assessment of the potential distributional impacts of P2P energy trading. Realist review is an evidence review method focused on "complex social interventions, which provides an explanatory analysis of how and why they work (or don't work) in particular contexts or settings" [4]: iv. The approach taken particularly aims to exploit the power of realist review to transfer relevant findings from other research areas, as described in [5]:29: "Because it takes the underpinning *mechanism of action* rather than any particular topic area as a key unit of analysis, a much wider breadth of empirical studies may be deemed relevant and these will sometimes be drawn from different bodies of literature" (original emphasis). This review focused specifically on Airbnb for reasons set out in in section 2, but which include comparability of characteristics with P2P energy trading and the quantity of research evidence available.

Distributional impacts studies are concerned with the relative benefits or disadvantages due to interventions experienced by different population subgroups. Focusing the study in this area is justified on two main counts. First, as well as ensuring security of energy supply, ensuring fair access to energy systems (and the benefits they afford) for users is frequently an important goal in energy policy and regulation (e.g. see [6]). Understanding the ways in which access or benefits might be limited or maximised is therefore important to inform effective policy and regulation. Second, as well as having an intrinsic moral justification, ensuring the benefits of low-carbon transitions are distributed as broadly and fairly as possible as likely to be important in securing ongoing popular support [7].

The review question which this study set out to answer was: What differences are there in (a) participation (as host) in and (b) usage (as host or guest) of Airbnb between demographic groups, why are these differences thought to arise, and under what circumstances? A second (discussion) question was: Under what circumstances might these differences be expected to apply in the context of P2P energy trading, and why? The next section of this paper explains how Airbnb was selected as the focus of study, and details the review method. Section 3 sets out the review findings and considers the question of their applicability in the context of P2P energy trading. A final sub-section summarises the study conclusions and draws out recommendations for regulation and product/service design.

2   Materials and methods

2.1   Selection of the case of Airbnb

An original protocol for this review is available at [8]. While the broad structure outlined in the protocol has been retained, substantial changes to the focus have been made for reasons described here. As far as possible, the RAMESES guidelines for reporting of realist synthesis are followed [9].

Initial screening revealed that very few reports of empirical research dealing directly with P2P energy trading, with the vast majority focusing on P2P or sharing economy models in other sectors. However, it became clear that many of these latter reports would have limited relevance to the energy case – for example, research on damage rates in bicycle sharing schemes. To make the process of screening more efficient, existing commercial examples of P2P or sharing models were first screened to see if research focusing on them was likely to be relevant, and restricting inclusion on this basis.

To do this, it was necessary to be able to describe P2P energy trading in terms of a number of basic characteristics, which could then be compared with existing services in other sectors. A number of typologies have been constructed to help categorise and describe sharing economy business models (e.g. [10–15]). From these, the typology of Muñoz and Cohen [12] was selected as being the most appropriate due to the relevance of the main dimensions to P2P energy trading, the provision of a clear scoring system, and the rating it provides of many existing services against the typology. On the basis of qualitative research, [12] rated services against each of the seven dimensions (see Table 1) using a score from 0-100, where 100 indicates that that dimension is integral to the operation of that service, and 0 that it is irrelevant.

The first step in allowing comparison with these existing scores involved rating P2P energy trading on these same dimensions. This was a subjective process based on the author's judgement, which limits replicability of this exercise. However, wide score ranges were used to accommodate the range of possible P2P energy sharing models that could be used, and the scores are presented here along with their reasoning, for transparency (Table 1). For more details on the basis on which scores are assigned, see [12].

Table 1: Author-assigned scores based on generalised characteristics of P2P energy trading schemes against typology from [12], with short justification.

Dimension	Score	Reason
Platform for collaboration	80-100	A (digital) platform is expected to be integral to operation of most P2P energy trading schemes.
Under-utilised resources	0-80	Existing energy assets are not necessarily under-utilised (e.g. PV panels already export to grid), and may already be completely utilised.

Peer-to-peer interaction	20-80	Close personal interaction unlikely, but some level is likely (to differentiate from single-supplier offerings).
Collaborative governance	0-100	May be on a spectrum between fully collaborative or fully centralised.
Mission-driven	20-100	Existing P2P schemes largely draw on low-carbon generation, and this is likely to be part of their narrative.
Alternative funding	0-100	A wide possibility of funding options from conventional private investment to crowdfunding and other distributed options.
Leverage on technology	80-100	Digital technology likely to be integral part of most P2P energy trading schemes (e.g. for tracking transactions).

Muñoz and Cohen [12] score 36 existing P2P or sharing economy services (such as Airbnb, Etsy, Bla Bla Car and Task Rabbit) on these dimensions. To make the comparison with P2P energy trading, an automated check was made (using Microsoft Excel) on whether the score on each dimension for each service fell within the range assigned for P2P energy trading. If it did a 1 was assigned, and if not a 0, and these were tallied for each service. Since each service is scored on seven dimensions, this means that a service with a tally of 7 matched P2P energy trading on all dimensions, a service with a tally of 4 matched P2P energy trading on four dimensions, and so on – the higher the tally, the greater the commonality between the service and P2P energy trading.

A second criterion for deciding which service(s) from other sector(s) to focus on was quantity of existing research. As the of the review was to supplement the existing extremely limited body of evidence of social impacts of P2P energy trading, it was important that other examples drawn upon were relatively well-researched. Therefore, for each service showing a high degree of commonality with P2P energy trading (or achieving a tally of 6 or 7), a basic search was conducted on the bibliographic database Scopus for research articles featuring the name of each service in their title. The results of this exercise (see Appendix 1), show a very clear predominance of research on Airbnb, with over 400 papers specifically focusing on it. Initial inspection of the limited number of results for other services suggested that many did not consider distributional impacts. The decision was therefore taken to focus the review on Airbnb.

Briefly, Airbnb is an online, peer-to-peer accommodation platform that allows 'hosts' to list rooms and properties as accommodation that can be booked by guests. Founded in 2008, it operates globally and is valued at around US$26 billion [16]. There are face similarities between Airbnb and models that could be categorised as P2P energy trading, but also important differences. These are discussed further in section 4, but are briefly introduced here for context.

Like P2P energy trading, Airbnb requires there to be some providers (offering accommodation, electricity, flexibility, etc.) and consumers (guests, electricity users) who transact between each other. Being a provider requires access to assets in the form of space (for Airbnb) or generation, storage, flexible loads, etc. (for P2P energy trading). Transactions are coordinated via a digital platform, and all users must join the platform in order to participate. However, Airbnb transactions tend to refer to one-off stays, while electricity trades are likely to be conducted over an ongoing basis with multiple providers/users simultaneously. Contact between Airbnb hosts and guests in often direct and sometimes in person; in the energy case, such contact is likely to be more restricted (although this depends on the model).

2.2   Realist review

The review followed realist principles in some, but not all, respects. Most notably, for reasons described above, the focus was exclusively on Airbnb, rather than iteratively pursuing lines of inquiry in a range of areas to substantiate context/mechanism/outcome associations. A simple search strategy was employed. A single search was conducted on each of the bibliographic database Scopus and Web of Science for all articles with the word "Airbnb" appearing in their title, abstract or keywords. The searches were conducted on 3 March 2020 and 17 August 2020 and returned 821 and 833 hits respectively. Google searches yielded relevant academic papers already identified in the databases searches, but no additional relevant grey literature (non-peer-reviewed journal/conference publications) within the first ten pages of search results.

Bibliographic details of all hits were downloaded and stored in the systematic review software EPPI-Reviewer 4. An automatic deduplication function was employed, indication a high degree of crossover between the two databases. Sources were then screened by the author against the following inclusion criteria, first on the basis of title/abstract, then on full text:

- In English.
- Contains empirical or model-based evidence, or reasoned conceptual/theoretical consideration, of impacts of distributional impacts of Airbnb.

The following exclusion criteria were applied because for reasons of transferability to the case of P2P energy trading:

- Primarily concerned with psychological aspects of motivation to use Airbnb, without consideration of differential impacts on different population segments.
- Primarily concerned with impacts of Airbnb on local property/rental prices. While this is an important economic/social impact of Airbnb, it was not considered to be directly relevant to the case of P2P energy trading (for more discussion of this, see section 4).
- Primarily concerned with tourism-related considerations (e.g. covering subjects such as 'adventure-seeking' guests).

Details on the following characteristics were extracted from each included source: location; urban/rural focus; method; key findings; recommendations. A basic quality/relevance assessment was also conducted based on the author's subjective judgment combining relevance and rigour (see [4]).

The extracted details of all remaining studies were imported into the qualitative analysis software NVivo 11 and subject to thematic analysis, with codes being assigned to similar findings, and conceptually similar codes being grouped into overall themes [17]. The codes and themes employed are included in Appendix 2. For each main 'findings' theme, a short evidence statement was written summarising the state of the evidence relating to that theme, reflecting factors such as the consistency of findings, hypothesised mechanisms, and possible explanations for differences based on context. These statements form the basis of the findings set out in narrative form in the next section. Finally, the transferability of each of the key findings to the context of P2P energy trading was considered on the basis on contexts, mechanisms, and outcomes according to the logic of realist synthesis.

3   Results and discussion

3.1   Study characteristics

The flowchart in Figure 1 presents an overview of the review process, with the number of documents included at each stage.
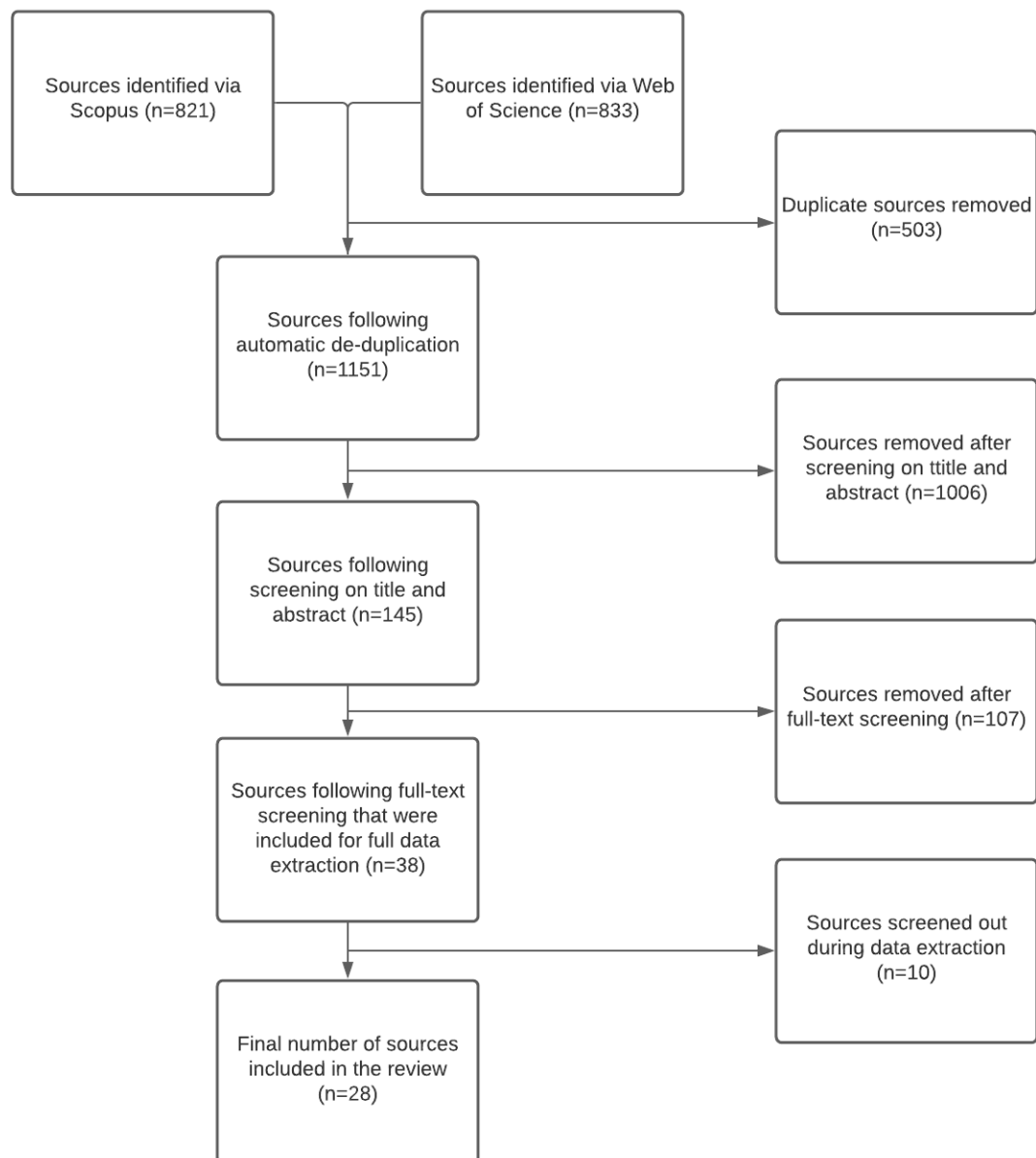

Figure 1: Flowchart of review process, with numbers of sources included at each stage.

Figure 2 shows how the included studies broke down in terms of country coverage, method, urban focus and relevance rating. The majority of studies were focused on the USA, urban areas, and used secondary data analysis approaches, such as open datasets on Airbnb listings or based on website scraping. All but one of the studies had a publication date in or after 2016. A full list of the included studies appears in Appendix 2.
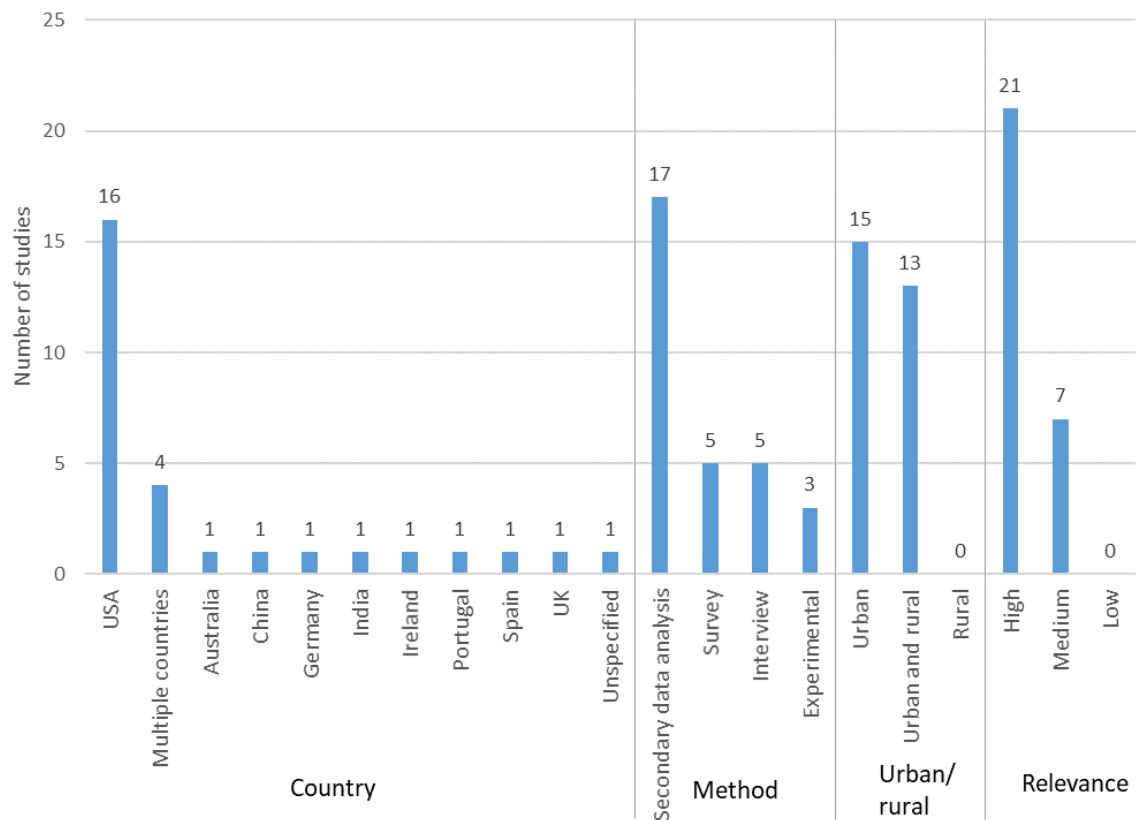
Figure 2: Main characteristics of included studies. Please note that a single study may be included against more than one category, for example where more than one methods are employed.

3.2   Evidence on hosting

An Airbnb host is the equivalent of a prosumer in a P2P electricity scheme – that is, they are in a position to supply a service (accommodation or electricity), not simply use it. Without these suppliers, the platforms could not operate. Hosts, like prosumers, are also distinct from service consumers because they stand to generate an income from the service they provide. They are therefore also uniquely positioned to benefit from sharing economy models, whether in accommodation or energy. This section presents evidence on the propensity of different population segments to be Airbnb hosts, and discusses the factors that have been suggested to affect this. Section 4 considers whether and how these findings might be expect to transfer to the energy domain.

Outcomes

The main dimensions of difference considered across multiple studies in the review (in order of number of studies featuring them) were host affluence, education, race/ethnicity, employment, age, gender, and tenure. A number of other factors were examined in individual studies. The main contextual factor uncovered was location. The most frequently employed method for studies focusing on host characteristics was secondary data analysis or website scraping. Often host characteristics were inferred on an area basis, meaning individual host characteristics could be different, and this was often cited as a limitation of the approach. Such studies also tended to rely on identifying correlations between hosting levels and area characteristics, meaning that while mechanisms explaining uptake may be suggested, they were often not directly tested.

Evidence on associations between affluence (on a range of measures) and Airbnb hosting was mixed. Across 15 studies, some found greater hosting prevalence in more affluent areas or households, while others found the inverse – and some found both or neither, depending on area studied. (Because of the number of studies considering this and other factors, individual citations are not included here but summarised for all main factors in Table 2 at the end of this sub-section.) Where there was greater prevalence of less affluent hosts, this tended to be in areas that were desirable for reasons such as proximity to tourist/cultural hotspots, city centre, or transport. There was some evidence of positive association between income, house value and listing price per night [18]. Studies sometimes stated that the economically rational expectation would be for less affluent households to be more likely to engage in hosting, since the revenue generated would have greater marginal benefit (e.g. see [19]). Where this was not the case, suggested explanations included more affluent hosts having access to space to rent out [20] and the availability of internet connections [21], and being more likely to live in areas desirable to guests [18]. There was some evidence that less affluent hosts are more likely to list rooms, while hosts in more affluent areas list entire dwellings [22]. An interview study highlighted the attraction to hosts, especially better off ones, of having a second income that was novel and enjoyable [23].

Across 10 studies that considered host education level (again usually on an area basis), there was quite consistent evidence of higher levels of hosting in more highly educated hosts or areas, although in some cases no significant association with education level was found. In certain circumstances (again related to location), there was evidence from one study of higher hosting levels in areas with lower education levels [24]. There was little speculation as to reasons underpinning the association between education and hosting, although Jiao and Bai [18] refer to previous research [25] suggesting that ability to interact with (i.e. list a property on) the platform is important. Schor [23] suggests that "platforms have been able to destigmatize the types of tasks and work they organize people to do" (p275), making these tasks more attractive where they would otherwise be "considered demeaning or degrading for people with their levels of education and accomplishments" (p275).

Evidence of associations between ethnic minority status and hosting was mixed and context specific. Across nine studies, some found differences in hosting levels associated with ethnicity (mainly on area basis), while others did not. Where there were differences, more studies found a higher propensity to host in areas with more White residents. Differences between different cities within the same study were detected (e.g. [26,27]). One multi-country study highlighted an association between lower affluence and ethnic minority status, and the association between this and lower levels of hosting [26]. A study which looked at foreign national status rather than ethnicity found greater propensity to host among this group, and also highlighted that this group tended to be younger, more highly educated, and live in well-connected areas [22].

Where studies measured host (or host area) employment status and/or type (seven studies), the evidence suggests that employment status either makes no difference to hosting levels, or that hosting is associated with being employed, especially in skilled, high value employment. It was suggested that there was a good fit between certain kinds of employment (including in finance, insurance and real estate) and hosting due to understanding of real estate, hospitality and the sharing economy, along with access to relevant services [28]. There was only one example of negative association between hosting and employment, which was thought to be due to hosting by students [22].

Regarding age, an association was consistently found (in most of seven studies) between being younger and increased propensity to host. Where this was not the case, this was speculated to be

due to factors like the expense of living in certain higher-hosting locations [28]. There was discussion of the 'digital divide' between older and younger people [21,26], with a suggestion that this could explain the difference in hosting – and also that this might be expected to diminish in future.

Evidence on associations between gender and hosting was mixed, with findings across five studies showing a greater propensity for males or females, or no difference, to be hosts. This may be an artefact of the secondary data analysis methods mainly used to study hosting characteristics, which are largely based on area data. Unlike for some characteristics such as affluence, age, and ethnicity, there is likely to be a much more even gender distribution from area to area, perhaps making gender differences in hosting more difficult to detect. An official release from Airbnb (not included in the review) notes that nearly 56% of hosts are women [29].

A number of other characteristics were considered either in single studies, or by only a single author team. Two studies by Quattrone [22,27] considered association between tenure type in cities and Airbnb hosting, finding that hosting was higher in areas where there were more rental properties. It was suggested that Airbnb hosting could be attractive as a supplementary income. Presence of children in the home was associated in two studies by Sarkar [28,30] with lower hosting levels, potentially because their presence means less spare space is available for hosting. One study [31] highlighted a previous finding from New York City by [32] that, while Airbnb hosts with multiple properties constitute just 6% of hosts overall, they account for 37% of total revenue.

Mechanisms

The main mechanisms thought be to drive associations between host characteristics and propensity to host have been highlighted in the relevant paragraphs. To summarise, one key driver is the possibility of a supplemental income, although sometimes the 'enjoyable' aspect of this income was valued more than the money itself [23]. Digital savviness was put forward as an explanation for higher uptake amongst younger, and possibly more highly educated, groups. In one case environmental motivations connected with the efficient use of housing space were cited [30]. The review did not focus on identifying the whole range of motivations for hosting. However, a number of studies focusing on host characteristics mentioned the forging of new connections as a key motivation [20,23,33], and word of mouth as a driver of uptake [20].

Context

The most important contextual factor associated with propensity to host was location. There was a consistent finding across eight studies of more hosting in locations likely to be attractive to visitors, such as those with points of cultural interest, good transport, beaches, universities, and jobs. Location interacted both positively and negatively with other host characteristics. For example, [18] found that people on lower incomes tended to live further from good transport links, diminishing the attractiveness of the location and seeing less hosting activity as a (suggested) result. On the other hand, location sometimes helped overcome factors which were otherwise rather strongly associated with hosting, such as the higher hosting levels identified in some low-education areas by [24]. Connections were highlighted between gentrification (e.g.[34]) or urban renewal projects (e.g. [24]) and hosting.

An additional mediating factor could be the choice available on Airbnb of listing an entire dwelling, a room in a shared house, or a room. [22], for example, found that listings for entire dwellings we more common in wealthy areas, while room listings were more common in educated but low income areas. The mixed evidence on the role of affluence could be accounted for by more affluent hosts letting our whole places, while less affluent hosts let out rooms. However, the analyses

employed in the studies make this hard to disentangle, since a listing of an entire dwelling in a less affluent area may, indiscernibly from the data, be the property of a more affluent owner living elsewhere.

Table 2 indicates the studies with findings supporting associations between the main characteristics discussed in this section and propensity to host, while Figure 3 summarizes the context/mechanism/outcome chains that were most consistently suggested by the evidence reviewed.

Table 2: Summary of studies finding certain characteristics to be associated with propensity to host. Note that some studies find effects in more than one direction (where, for example, they deal with more than one city).

| Category	Associated with more hosts	Studies
Affluence	Higher affluence indicators	[18–20,22–24,26,28,34–36]
	No difference	[21,27]
	Lower affluence indicators	[19,22,24,28,30,35]
Education	Higher education	[19,22–24,27,35]
	No difference	[21,28,30]
	Lower education	[24]
Race and ethnicity	Higher BAME	[22,27,28,30] (NB in Quattrone et al. 2016, the finding refers to foreign-born hosts, not BAME)
	No difference	[21,28,30]
	Lower BAME	[26–28,30,31,36,37] (NB in Marchecko 2019, the finding refers to earning level, not propensity to host.)
Employment	In employment	[19,22,23,31]
	No difference	[27,28,30]
Age	Younger	[21,22,26,27,31]
	No difference	[22,36]
	Older	[28]
Gender	Female	[26]
	No difference	[21]
	Male	[28,30]
Location	Attractive locations	[18,19,22,24,27,28,31,34]
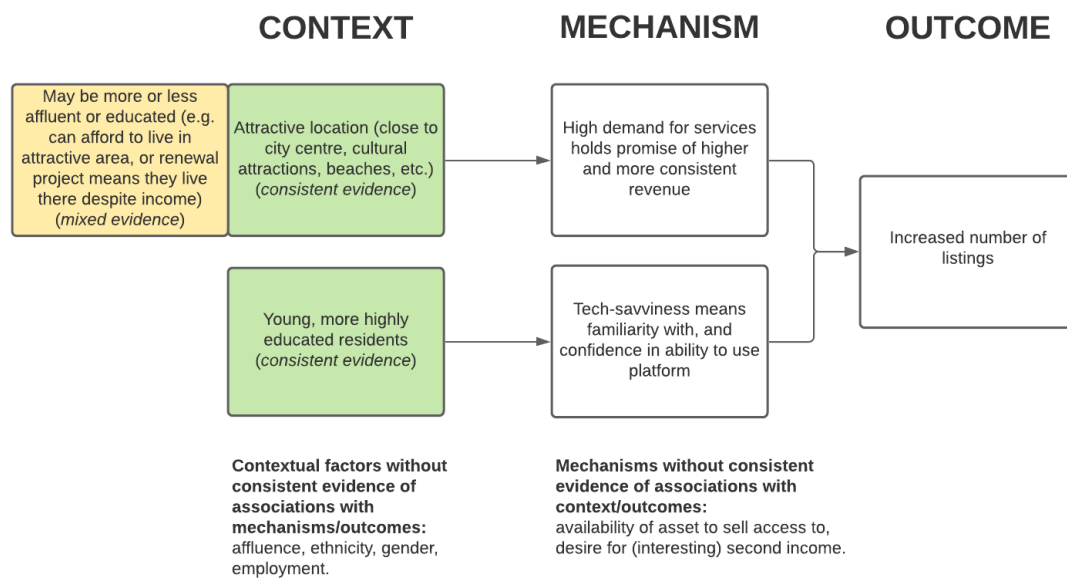
Figure 3: Main suggested context/mechanism/outcome chains for propensity to host.

3.3   Evidence on usage

This section of the paper considers evidence on usage of Airbnb as a guest, and the ways in which Airbnb hosts interact which may be associated with distributional impacts. This includes issues such as host earnings and acceptance of guest booking requests. The relevance to P2P energy trading is primarily around whether and on what terms prosumers and consumers might choose to trade. Again, the direct relevance of the evidence presented here to the case of P2P trading is discussed in section 4.

Outcomes

Similar dimensions of difference were considered in studies focused on guests and guest/host interactions as those on hosts, although with somewhat different frequency. In order of number of studies focusing on them, they were: gender, age, ethnicity, affluence, and a number of other factors mentioned in individual studies. Studies in this area drew on a broader mix of methods, with more experimental and survey work to complement secondary data analysis. While experimental studies have the potential limitation of lacking ecological validity, they do allow for more controlled variation in factors thought to affect guest/host interaction. Studies using secondary data are able to say less about guest than host characteristics, as the location of guests (and therefore their inferred demographic characteristics) are not readily available.

Evidence from the studies reviewed was limited on the propensity of males and females to be guests. One study [26] found that at least 60% of guests and hosts were female in the five cities across the world that they studied. They also cite a 2015 Airbnb report stating that 54% of guests are female [38]. Regarding booking behaviour, evidence was identified of both homophily and heterophily (i.e. preference for similarity and preference for difference respectively) with regard to host gender by guests. One study found that female guest-host homophily was primarily driven by affective (or 'feelings-based') trust [39].

There was evidence of impacts of interactions between gender and other guest characteristics in guest/host interactions. sexuality and gender discrimination. Ahuja and Lyons [40] showed more

discrimination against male homosexual couples (see later this section). Edelman et al. [41] demonstrates a wider race gap in host acceptance of booking requests in males than females, and Marchenko [37] shows Black female hosts earn less than Black males, and both much less than White males. There is experimental evidence of slightly lower trust by guests in male hosts [42].

Age was considered in a number of studies but, again, consideration of propensity to book by age was limited. There was evidence from two studies [21,26] that guests are more likely to be younger. Regarding booking behaviour, there was evidence from one study of higher levels of trust in older hosts [42].

Five studies focused on the role of race and ethnicity in booking behaviour and guest/host interactions. These studies present consistent evidence of poorer outcomes of Black, Asian and Minority Ethnic (BAME) groups, based on both actual usage and experimental data in a range of countries. An experimental study by Edelman et al. [41] found lower booking acceptance rates for guests with African-American-sounding names – an effect that persisted across ages and ethnicities of host. There was evidence of 8-10% lower listing prices for properties with Asian or Hispanic hosts [43], controlling for other factors. (Kakar suggests that "biased renters may be paying an 8–10% 'discrimination premium' for White rental units" (p39).) [36] found that the earning potential of African-American hosts on Airbnb was 12% lower than other hosts. There was also evidence of under-expression interactions between guests and hosts of different ethnic groups [26]. Edelman et al. [41] suggest that platforms such as Airbnb give greater potential for existing prejudices to be expressed in accommodation markets than other (e.g. hotel, non-P2P) models. They back up this claim by pointing to the absence of racial discrimination effects in their study amongst hosts who had previously accepted African-American guests.

There is little available evidence on relative affluence of Airbnb guests. One study [21] found that the most affluent users are less likely to user sharing platforms, including Airbnb (77% as likely). Where usage amongst less affluent users is not as high as expected, this may be due to lack of ability to access the platform (e.g. having internet subscription). One study found evidence that properties in high income areas received more reviews [35].

Other guest characteristics featured in single studies. In a study in Ireland, [40] found experimental evidence of discrimination against homosexual guests, particularly male couples. A study that considered guest education level found there to be no association with propensity to book on Airbnb [44]. There was some indication of a preference for married hosts [42].

Mechanisms and context

Again, the mechanisms thought to underlie some of the findings presented here have been included where relevant. In summary, there is mixed evidence on the roles of homophily and heterophily. This is perhaps explained by the suggestion in the previous section that a motivator to participate in Airbnb is to forge new connections, often with a degree of difference – but, according to [33], not too much difference. Also, [42] found that reputation was effective in overcoming homophily in guest-host interactions. Again, the propensity of guests to be younger was sometimes suggested to be due to digital savviness. Discrimination on the basis of race and sexuality has been suggested to be an extension of existing prejudices into the digital realm. Beyond this contextual point (i.e. the context of existing prejudice), there was little consistent evidence on the role of context in different outcomes. Again, this may be because guests' origins are harder to study on the basis of aggregated location data. Figure 4 shows the most consistently supported context/mechanism/outcome chain for this sub-section.
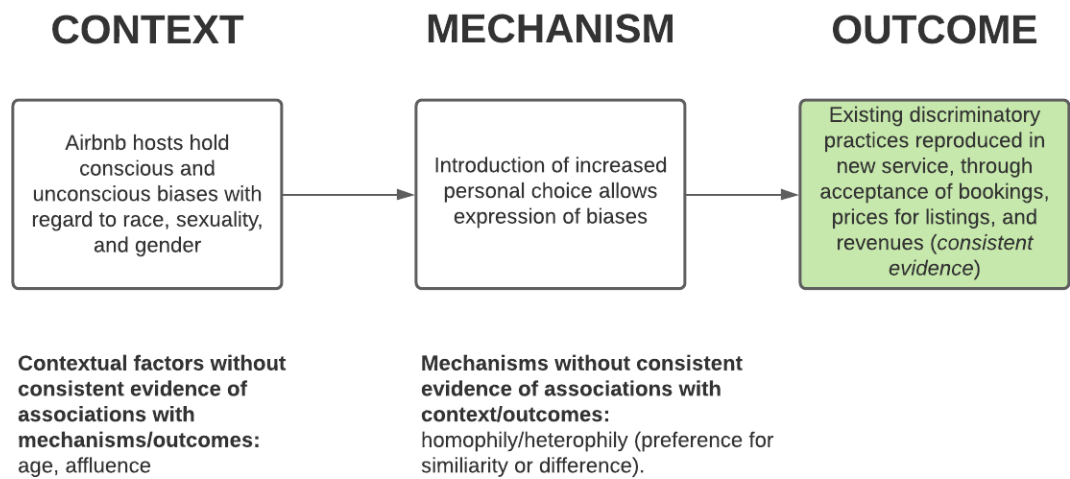
CONTEXT

Airbnb hosts hold conscious and unconscious biases with regard to race, sexuality, and gender

MECHANISM

Introduction of increased personal choice allows expression of biases

OUTCOME

Existing discriminatory practices reproduced in new service, through acceptance of bookings, prices for listings, and revenues (*consistent evidence*)

Contextual factors without consistent evidence of associations with mechanisms/outcomes: age, affluence

Mechanisms without consistent evidence of associations with context/outcomes: homophily/heterophily (preference for similiarity or difference).

Figure 4: Main supported context/mechanism/outcome chain for usage behaviour.

3.4   Identified recommendations

Many of the studies reviewed made recommendations for how distributional imbalances, discrimination, and other disadvantages might be addressed. These are useful to consider in case they might be applicable to P2P energy trading in certain forms. A number of broad classes of recommendation were identified, including those relating to platform design and functionality, data collection, participant targeting, and policy and regulation (along with a number of other recommendations that do not fit into these categories).

The most common single recommendation was the restriction of hosts' ability to accept or reject guests. Specifically, this means the adoption of the 'Instant Book' option of Airbnb, where guests are able to book a listing without prior host approval. The rationale for this recommendation is that it removes the potential for active discrimination against guests by hosts on the basis of characteristics such as race and sexuality. In July 2019, Airbnb announced that nearly 70% of its listings were bookable on this basis [45]. However, it should be noted that this measure does not have a direct impact on other possible forms of imbalance and discrimination, such a listing price differences by race, or guest booking choices.

A further, related, design recommendation is therefore to introduce elements of anonymization, such as concealing guest/host names and photos. The aim here is to mask characteristics until such a time as bookings are made, theoretically eliminating the potential for discrimination to occur on the basis of factors that might be apparent from these sources (such as race and gender). A drawback with both this and the Instant Book options are that they may be viewed as limiting the personal nature of Airbnb that is one of the characteristics that distinguishes it from more traditional accommodation options such as hotels and hotel booking sites.

Other platform design recommendations include the potential to offer feedback to hosts on the diversity of the guests they accept, potentially with incentives to promote greater diversity [26]. [36] suggests that simply giving hosts more information on and advice regarding diversity and fair pricing may be effective. [26] proposes that different payment options should be made available to avoid excluding guests without access to traditional bank accounts.

Several studies suggest that there should be more routine data collection and monitoring of diversity of use of the Airbnb platform. This is seen as especially important when countries of cities want to ensure that distributional impacts are minimised or the benefits of getting involved in a service like Airbnb are maximised. By monitoring where the service is used, and by whom, it may then be possible to promote uptake of Airbnb and similar sharing platforms in areas where they can provide some social benefits. [28], for example, found an underrepresentation of hosts in city areas they studied with high Asian and Hispanic populations. They suggest that better understanding the reasons this this, and potentially promoting home-sharing as both an additional income scheme and as a route to regeneration, could be considered. [18] also propose investment in neighbourhood improvements to increase the potential for home-sharing.

Many of the recommendations are concerned with how Airbnb and similar services should be regulated. There is concern that regulations which have applied in more traditional business models and no longer clear-cut in the sharing realm. Suggestions include area-based restrictions on short-term sharing rights [22], incorporating consideration of home sharing in long-term planning [28], audits of host and host behaviour characteristics [41], and more general restrictions and/or taxes to address impacts on tourism and rental markets that are outside the scope of this review.

4   Discussion

The findings presented so far all provide evidence of how different population sub-groups differ in their use of Airbnb, with some indications of the mechanisms associated with these differences. This section discusses the potential to apply insights from this review to the case of P2P energy trading, and thereby anticipate its possible distributional impacts. This is achieved according to the logic of realist synthesis, which suggests that similar outcomes might be expected when similar mechanisms operate in similar contexts.

4.1   Service provision

Figure 3 illustrated where there was most consistent evidence on the propensity to host on Airbnb. This was in two contexts: attractive locations, and areas with younger, more highly educated residents. Both of these contexts and mechanisms have analogues in the case of P2P energy trading.

More Airbnb listings were found in locations likely to be attractive to visitors, with the likely mechanism for this being the higher and more consistent revenue expectations such locations can bring. While not explicitly mentioned in the studies, other mechanisms could include greater awareness of Airbnb in such areas, and social norms supportive of its use. Not only is it more likely that operators will start P2P schemes in some areas than others (e.g. due to network conditions such as the presence of overloaded substations or cables), but incentives to participate in schemes in such areas are likely to be higher (e.g. rewards for offering flexibility around times of constraints). Conditions concerning awareness and social norms in such circumstances are likely to be similar to attractive Airbnb locations. The consistent, real-world evidence from the Airbnb case suggests that participation as a service provider in P2P energy trading will be higher where there is higher demand for such services.

There was consistent evidence of more Airbnb listings in areas with younger, more highly educated residents, with a main proposed mechanism for this being confidence and ability with digital technologies. There is other evidence of such a 'digital divide' privileging these groups (e.g. [46,47], although the divide is narrowing. Other explanations are possible, such as younger people being more in need of a second income, or being more open to home-sharing experiences. However, most of the findings controlled for indicators of affluence. Like Airbnb, the vast majority of P2P energy

schemes being trialled today are based around digital platforms and interfaces. These require both a certain level of skill, interest, and familiarity to use, and access to technology such as computers/smartphones and internet connections to operate. Based on this similarity, evidence from Airbnb provides reasonable confidence that younger, more educated people will have a greater propensity to act as a service provider in P2P energy trading – at least in its earlier incarnations.

The Airbnb review found mixed evidence on the role of affluence in participation as a host. Where there was greater prevalence of hosting in less affluent areas, this was often because the areas were attractive visitor locations. If translated directly to the case of P2P energy trading, this suggests that P2P schemes operating with higher incentives (e.g. in more highly constrained areas of the network) could see greater participation as a service provider from less affluent households. P2P schemes operating in areas where the direct incentives are lower (e.g. where there are no network constraints but a scheme has been set up to support a community energy project) may therefore be less likely to see participation as a service provider by less affluent or less educated households.

The role of affluence in service provision could also be mediated by the services it is possible to sell. On Airbnb, hosts can offer an entire dwelling, a spare room, or a spare bed. This means that participation as a host is open to a wide variety of people with different resource levels. Most P2P energy schemes are based around the sale of electricity, which can only be offered by households with access to generation – who may be more likely to be affluent, although evidence is mixed (e.g. [48–50]. However, if participants are able to offer services such as flexibility based on existing home appliances, then the barrier to entry (similar to letting out a room on Airbnb) is lower – although so are the likely returns. There was not enough consistent evidence on other Airbnb hosting factors to make informed inferences to P2P energy trading.

In summary, informed by substantial evidence from hosting on Airbnb, we might expect participation as a service provider in P2P energy trading to be higher in areas where the rewards are higher (e.g. network constraints), and by younger and/or more highly educated residents. Less affluent people are probably more likely to participate as service providers where the rewards are higher, although their ability to participate will depend on the services that can be traded. However, because the financial rewards of selling services in P2P energy trading are likely to be lower than for Airbnb, especially for flexibility services, other motivations to participate may become more prominent. If these inferences prove to be accurate, then older and less educated people, and less affluent people where incentives to participate are lower, are generally less likely to experience the benefits associated with being a service provider in P2P energy trading.

4.2   Service usage

There was little evidence of consistent associations between demographic characteristics and propensity to be a guest on Airbnb. However, this may be because it is harder for studies using secondary data to make inferences about guest characteristics. It is possible that findings on propensity to host on Airbnb could also apply to usage in general (and also in P2P energy trading), since similar mechanisms (e.g. tech-savviness) could be at work – but the evidential basis for this is weak.

The group of findings around which there was the most consistent evidence was the potential for discrimination on Airbnb on the basis of race, while there was also evidence of discrimination based on sexuality, both with interactions with gender. The proposed mechanism for this was the (new) choice afforded to accommodation providers to accept or reject guests based on these characteristics, offering a route for existing conscious or unconscious biases to be expressed. This was sometimes contrasted with traditional accommodation arrangements, with single hotels dealing

with many guests are thought to be less likely to engage in this kind of case-by-case decision. This was evidenced through higher rejection rates for guests with African American-sounding names, and lower listing prices and revenues for BAME hosts.

P2P energy trading also offers the novel opportunity for individual households to express choice over with which other individuals, and on which terms, they transact. There is no reason not to expect the same biases to exist in the population of energy system users as in the population of Airbnb users. If potential for individual choice were to be introduced to this system, and relevant characteristics were apparent (e.g. via names or photographs), it also seems reasonable to expect that these biases would be given expression. It is not necessarily the case that this level of disclosure of personal information would be the case, for data protection reasons. For example, trading may take place with unnamed individuals identified only on the basis of characteristics like general location. However, some level of personalisation is often framed as being a key selling point of such schemes [51,52].

4.3   Key study limitations

The key limitation of this study concerns the validity of inferring from evidence in one context (that of P2P accommodation) to another (that of P2P energy trading). This section discusses the key differences in contexts, and what this might means for transferability of findings. The first main difference is that Airbnb hosts have the potential to make quite substantial additional earnings, with a mean average of US$924 per month, and a median average of US$440 [53]. Meanwhile, estimated income from PV panels even with feed-in tariff subsidy in the UK averages £150 (approximately US$200) per year [54]. The earnings from selling flexibility services are likely to be considerably less. Even if the value of such services increased in future, revenue potential may therefore be substantially less motivating for P2P energy trading that hosting on Airbnb. Where revenue generation is a prime motivator for participation (perhaps likely to be relatively more common amongst less affluent service providers), this may mean lowered likelihood of involvement from such groups.

Another clear difference between Airbnb hosting and P2P energy trading is the level of personal interaction and physical labour that is generally envisaged. For Airbnb, the potential to meet new people was often a key driver of participation as a host, and an important component of the 'enjoyment' mentioned above. The extent to which such interaction is likely to occur in P2P energy trading is varied and, as yet, unclear. While driving community cohesion is a potentially attractive benefit of some schemes [55], data protection regulation means that sharing of information may be limited to generalities, and trading will often take place as a background function (unlike in Airbnb where there is regular direct contact between hosts and guests). P2P energy trading is likely to involve no, or limited, physical labour (restricted to changes to routines that may enable provision of flexibility). Some of the motivations to get involved in P2P trading are therefore likely to be different with, for example, a greater prominence of environmental motivations. Because making connections as a mechanism to drive participation as an Airbnb host was not clearly connected with any contextual factors, it is difficult to say what the implications of this difference could be. However, there is some evidence that level of physical interaction is not a driving factor in the findings on discrimination. [41], for example, found that discriminatory host behaviour did not differ between entire place and shared listings.

A third key difference is that the evidence on Airbnb all relates to the operations of single company with a single operating model. P2P energy trading on the other hand is likely to operate under a large diversity of models with the involvement of many different actors. Actors with a more explicit

social responsibility mission might be expected to be better placed, or do more, to actively engage groups which are underrepresented as service providers. However, the direction of this effect should not necessarily be expected to be for greater inclusion. Commercial companies with no explicit social agenda can be equally be expected to operate in this area. Also, the Airbnb website and platform is viewed as an example of very good user interface design in the industry [56,57], and the financial resources available to it to support the highest level of design and usability are substantial. Unless the platforms designed and/or employed by P2P schemes are as usable as Airbnb, there is a risk they could be even more exclusionary of non-tech-savvy users.

The effect of these differences is to increase uncertainty around the transferability of evidence from Airbnb to the case of P2P energy trading. However, the differences highlighted do not completely undermine any of the mechanisms by which outcomes were suggested to come about – the simply moderate the strength with which they might be expected to operate. For example, a model of P2P energy trading that offers less personal choice over who to trade with (e.g. whether a whole district is included in a scheme rather than whether individual participants are traded with) is likely less liable to discrimination. However, the risk is not entirely removed even in this case, since it is conceivable that existing prejudices could enter into participatory processes of deciding whom to include in a trading scheme.

A number of further limitations of the study should also be highlighted. Firstly, the review did not fully observe the realist review principle of iterative searching for new sources to substantiate the context/mechanism/outcome processes observed. This would have substantially added to the resources required to undertake the review, but would have allowed a wider range of evidence to be introduced to back up some of the inferences made to the case of P2P energy trading. Resource restrictions also meant that all screening and extraction was conducted by the author. To minimise bias in these processes, it is usually recommended to use two or more reviewers. The implication of this is that it is more likely that some potentially relevant studies or findings have been omitted. However, it is considered unlikely that sufficiently many studies or findings were missed to substantially change the main findings of the review.

5   Conclusions and recommendations

The main economic benefits of participating in P2P schemes in any sector come in two kinds: the ability to earn money as a seller, and to save money as a buyer. Participation also has the potential to bring wider benefits, such as new social relationships or a sense of empowerment in meeting low-carbon energy needs [55]. This study used a realist review of evidence on distributional impacts of the accommodation sharing service Airbnb to help anticipate how benefits and disadvantages might be distributed in P2P energy trading schemes. Such an approach has value because, while direct evidence on P2P energy trading is based on a limited number of small-scale trials, evidence on Airbnb is based on extensive real-world usage and experience. Inference from the case of Airbnb to P2P energy trading is made on the basis of similarities in the contexts and mechanisms at work.

On the basis of such inference, the benefits of selling services in P2P energy trading schemes would be expected to accrue disproportionately to those living in areas with network management challenges, who are younger and more highly educated. Households already in possession of (or able to acquire) generating technology such as PV panels are strongly positioned to benefit. Less affluent households may be expected to participate and benefit more in areas with network constraints than those without. However, this will probably be to a lesser degree on average than the more affluent, since they are more likely only be able to trade in less valuable services (such as provision of flexibility, compared to supply of electricity). Older and less educated people (who are

proportionally less likely to be tech-savvy), outside of areas of constraint, are likely to be at a relative disadvantage – although a shrinking 'digital divide' may reduce this disadvantage over time.

Less evidence is available on which demographic groups might be in a position to save money as buyers. To an extent the same mechanisms as for hosts (i.e. level of rewards for participation due to area, and tech-savviness) can be expected to apply here too, meaning the same groups could be advantaged or disadvantaged, although there is very limited evidential basis for this. The evidence also raised the prospect of discrimination on the basis of characteristics such as race and gender where there are high levels of individual choice over who to trade. Example findings included hosts being less likely to accept bookings from guest with African-American-sounding names, and lower listing prices and revenues for Black and Minority Ethnic hosts (sometimes with interactions with gender). This is thought to be a result of the 'importing' of existing biases that personalised P2P energy trading would enable.

A number of key differences between Airbnb and the case of P2P energy trading were identified. These were the different potential for direct physical interaction in Airbnb and P2P energy trading, the greater revenue potential in Airbnb, and the fact that Airbnb is a single commercial example of a P2P model while, in energy, the models/actors involved could be very diverse. However, the mechanisms identified by which distributional impacts are thought to arise are not fundamentally undermined by these differences, but moderated to different degrees.

The absence of consistent evidence of other distributional impacts on the basis of this review is not evidence of their absence. Some factors, such as health and disability, were not examined in the studies identified. Other factors, such as tenure, were only discussed in single studies or by single authors, and could have implications for ability to participate (at least as a provider) in P2P energy trading.

As set out in section 1, this study was motivated by a responsible research and innovation approach, which in part demands the anticipation of positive and negative impacts of innovations in order to inform research, future innovation, and regulation. It is to be expected that certain kinds of service offering will hold an implicit appeal to users with certain characteristics. For example, models which offer a high degree of manual control and technical detail are likely to appeal more to those with higher technical interest and ability. This will not inherently lead to unfair outcomes, so long as there is sufficient diversity of models (which offer similar benefits) to appeal to a broad and inclusive set of system users. Indeed, an increasingly user-centric approach to service design should be expected to increased diversity of offerings as there is more tailoring to the specific needs and demands of different user groups.

The problem comes if there is consistent alignment between certain characteristics and certain levels of benefit, especially if these align with existing inequalities within society. This review has highlighted a number of areas where there is a risk that this could be the case for P2P energy trading, as suggested by extensive evidence from a comparable service offering in the accommodation sector, Airbnb. To maximise fair societal outcomes as the energy market continues to decentralise and diversify, regulators must work with those offering services to ensure that the needs of as wide as possible a range of users continue to be met, and that as far as possible, new inequalities are not given room to emerge.

In this spirit, on the basis of this review, a number of recommendations are put forward for consideration by regulators and service operators. Most of these are informed by the recommendations captured from studies included in the review.

1. *Monitoring impacts*. Monitoring the characteristics of those who act as sellers and buyers in P2P trading will be key in tracking distributional impacts. While it is unlikely that participation would be expected to mirror the characteristics of the general population, monitoring would be able to identify groups who are consistently excluded and inform action either to promote participation, or provide advantageous alternatives. It should be noted that under some privacy legislation (such as the European Union's General Data Protections Regulation), characteristics such as racial or ethnic origin and sexuality are classed as 'special category data'. Their collection must be specifically justified, and they must receive special procession. The evidence identified from Airbnb is strongly suggestive that collection of such data is important, and could be reasonably required by regulators. Monitoring should ideally cover a wide variety of social dimensions of difference.

2. *Incentivising diversity*. Incentive systems could be used to reward or recognise those schemes that actively engage underrepresented groups. The form of such incentives is varied, but could include exemption from certain aspects of regulation (similar to exemptions for small suppliers in the UK from the Energy Company Obligation scheme on energy efficiency, which was put in place to lower the barriers to entry to the market), or league tables. More generally, regulation of such models is likely to have to be more outcomes/principles based, since prescribing specific regulation will be impossible for the diversity of P2P trading offerings that could be expected to emerge.

3. *Reasonable limits on trading choices*. It is clear that restricting choice over those with whom you can trade (and the terms of those trades) would address the potential for discrimination in P2P energy trading. It may be possible to retain personalisation features, such as a record of exactly who you have traded with, while preventing *a priori* selection of specific trading partners or terms (trading choices could be limited to general group characteristics, e.g. direct neighbours, local schools, etc., although this would not altogether eradicate the potential for discrimination on a group rather than individual basis).

4. *Diversifying trading potential*. The Airbnb option of listing not just entire places but also rooms and beds lowers the barriers to entry for hosts. P2P schemes that allow more services to be traded (or at least rewarded), such as flexibility or avoided consumption, would make participation as a service provider more widely accessible. Local authorities and other actors considering support for trading schemes in their areas should consider how accommodating the model is to service providers with access to different resources.

5. *Informed targeting*. The evidence suggests P2P schemes in areas where the network management demands are highest (e.g. where constraints are present) are likely to be more attractive to service providers from otherwise underrepresented groups, perhaps due to the higher incentives to participate. In such areas, introducing P2P schemes could therefore be an effective route to engagement with these groups, and associated benefits (so long as a sufficiently inclusive range of ways to participate are available, as per the previous recommendation).

The review is intended as a complement to, not a replacement for, ongoing research into the possible distributional impacts of P2P energy trading. In particular, studies which go further to consider recognition and procedural justice elements of transitions to more decentralised forms of energy provision (such as [58]) are to be welcomed. It is hoped that this review also demonstrates the potential of realist-informed methods to draw on evidence in other sectors and inform innovation and regulation in energy. There are areas where experience with alternative models is deeper and richer than it is in energy (for example "X-as-a-service" models, or principles-based regulation) where similar approaches could be fruitfully employed. Anticipating risks or unevenly

distributed benefits should not stifle innovation; conversely, it should be used to prompt innovation in fully inclusive service provision, and help make regulation more nimble when it comes to spotting and averting potential threats to fair outcomes.

6   Acknowledgements

7   Competing interests statement

The author has no competing interests to declare.

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Appendix 1

Table 3: Original scores assigned to sharing economy business models by [12]. In the shaded columns, 0/1 indicates whether or not the score falls in the range identified by the author as transferable to P2P energy trading (see section 2.1 for detail). Only services rated transferable on six or more dimensions are included. Also shown is the number of hits in Scopus for each service. Airbnb is highlighted.

	Raw scores							Transferable to P2P?								
	Governance	Mission	Resources	Funding	Interaction	Technology	Platform	Governance	Mission	Resources	Funding	Interaction	Technology	Platform	TOTAL	Scopus hits
Skill share	40	65	47.5	0	80	95	80	1	1	1	1	1	1	1	**7**	1
Kiva	50	100	20	70	65	90	85	1	1	1	1	1	1	1	**7**	21
Udacity	17.5	55	17.5	0	70	95	55	1	1	1	1	1	1	0	**6**	1
Maven	25	25	45	0	85	87.5	80	1	1	1	1	0	1	1	**6**	1
Musketeer	15	80	20	5	100	100	95	1	1	1	1	0	1	1	**6**	0

NON-PEER-REVIEWED PREPRINT: Anticipating distributional impacts of peer-to-peer energy trading

Kick Starter	30	85	20	0	100	95	87.5	1	1	1	1	0	1	1	**6**	8
Etsy	15	62.5	30	0	95	95	85	1	1	1	1	0	1	1	**6**	6
Vint	15	35	50	0	65	85	55	1	1	1	1	1	1	0	**6**	1
Airbnb	15	15	40	0	65	90	87.5	1	0	1	1	1	1	1	**6**	439
Share your meal	25	95	60	60	85	85	85	1	1	1	1	0	1	1	**6**	0
Vandebron	10	85	80	0	85	90	85	1	1	1	1	0	1	1	**6**	0
Sherpa Share	10	35	10	0	20	95	25	1	1	1	1	1	1	0	**6**	0
Task Rabbit	15	40	55	0	80	85	75	1	1	1	1	1	1	0	**6**	15
Upwork	10	40	45	0	100	97.5	85	1	1	1	1	0	1	1	**6**	8
Cargomatic	10	12.5	75	0	40	95	80	1	0	1	1	1	1	1	**6**	0

Appendix 2

List of studies included in the final review (these also appear in the full reference list of the article, but are presented separately here for clarity).

- Abrahao, B., Parigi, P., Gupta, A., Cook, K.S., 2017. Reputation offsets trust judgments based on social biases among Airbnb users. Proceedings of the National Academy of Sciences of the United States of America 114, 9848–9853. https://doi.org/10.1073/pnas.1604234114
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Appendix 3

Table 4: Codes used in thematic analysis of the included studies, with number of sources and specific references for each code.

Code	Sources	References
urban-rural	1	1
urban	15	15
any	13	13
hosting	0	0
hosting - affluence	15	39
more aff hosts	11	19
less aff hosts	6	12
same aff host	2	5
hosting - education	10	13
high ed hosts	6	8
same ed hosts	3	3
low ed hosts	1	1
hosting - ethnicity	9	17
less eth hosts	6	8
same eth hosts	4	5
more eth hosts	3	5
hosting - location reasons	8	19
hosting - employment	7	15
more emp hosts	4	6
same emp hosts	3	8
hosting - age	7	12
more young hosts	5	10
same young hosts	2	2
less young hosts	1	1
hosting - gender	5	5
male gen hosts	2	2
same gen hosts	1	1
female gen hosts	1	1
hosting - renting	3	6

Code	Sources	References
hosting - relationships (does this matter)	2	2
hosting - multiple hosts	2	2
hosting - digital savvy	2	4
hosting - green	2	3
hosting - children	2	3
hosting - norms	1	1
hosting - trust	1	3
hosting - build connections	1	2
location	0	0
USA	16	16
multiple countries	4	4
Ireland	1	1
Australia	1	1
germany	1	1
china	1	1
india	1	1
portugal	1	1
spain	1	1
UK	1	1
bulgaria	1	1
unspecified	1	1
recommendations	0	0
rec - regulation	8	10
rec - no choice	5	5
rec - platform design	5	5
rec - anonymisation	4	5
rec - predictive targeting	4	4
rec - norms	3	3
rec - monitoring	3	3
rec - attitude	1	1
rec - increase capacity	1	1
rec - partnerships	1	1
rec - risk	1	1
rec - feedback	1	1
rec - payment mode	1	1
rec - personalisation	1	1
rec - reward diversity	1	1
conflicting recs	1	1
quality and relevance	0	0
excellent	21	21
good	7	7
ok	0	0
method	0	0
secondary	17	17
case study	6	6

Code	Sources	References
survey	5	5
interview	5	5
experiment	3	3
other method	0	0
usage	0	0
gender	6	8
age	5	5
discrimination ethnicity	5	8
prefer same	2	4
norms	2	2
affluence	2	4
discrimination sexuality	1	3
reputation works	1	2
marital status	1	1
education	1	1
attitude	1	1
ratings	1	1
digital exclusion	1	1
trust	1	1
value	0	0
other codes		
importance of supply demand balance	1	1
inclusion-exclusion	1	1
development over time	1	1
earning levels	1	1