Market Design for HCI: Successes and Failures of Peer-to-Peer Exchange Platforms

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ABSTRACT
This paper explores an HCI approach to designing markets, with a primary focus on peer-to-peer exchange platforms. We draw on recent work in economics that has documented how markets function, how they can be evaluated, and what can be done to fix them when they fail. We introduce five key concepts from market design: thickness, congestion, stability, safety, and repugnance. These lend HCI an analytic vocabulary for understanding why markets may succeed or struggle. Building on prior empirical work, we apply these concepts to compare two well-known network hospitality platforms, Couchsurfing and Airbnb. As a second illustrative case, we use market design to shed light on the challenges experienced by smaller-scale peer-to-peer marketplaces for lending, renting, and selling physical goods. To conclude, we discuss how this kind of analysis can make conceptual, evaluative, and generative contributions to the study and design of exchange platforms and other socio-technical systems.

Author Keywords
Market design; matching market; sharing economy; platform economy; Airbnb; Couchsurfing; Sharetribe

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H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Markets pervade our lives: they are involved in the everyday purchase of goods and services, be it from a supermarket, a bazar, a farmers' market, or an online store. Less obviously, we encounter markets when we look for a job or apply to a school. Even the allocation of organ transplant donations to patients in need may be conceptualized as a market. Markets can take on many forms, some of which challenge our conventional understandings of what markets are, and some in which money plays little to no role [53]. Here, we focus on *matching markets* – markets where money is not the only determinant of who gets what, and where the market involves searching and wooing on both sides [53]. The purpose of this paper is to explore what HCI might gain from engaging with market design, a branch of economics that has been developed to work out how to conceive, operate and evaluate markets – and to fix those which are failing. In particular, we consider how market design can help us understand successes and failures of peer-to-peer exchange platforms.

We argue that markets are essentially social systems and when we design new collaborative platforms, we inherently adopt some assumptions about a social system – or create new social systems. The increasing emphasis HCI scholars have placed on crowdsourcing and peer-to-peer exchange brings the field's focus on interfaces and the collaborative uses of technology together with a range of socioeconomic concerns. This urges us to consider what our community might gain from working more closely with the field of economics. We propose market design as a productive point of engagement for such endeavours. Market design operates from the premise that *"[m]arkets are human artifacts, not natural phenomena*" [53]. This idea swims against prevailing cultural attitudes that, according to Dourish [8], frame the market as a naturally occurring phenomenon rather than a motivated social product. The departure from considering markets as natural mechanisms is crucial, since casting markets as human artifacts turns them into objects of design and critical scrutiny, and as such, more explicitly objects of study for HCI scholars. Since markets are often instantiated in a technological form, we see an opportunity for our community to take an active role in designing markets and intervening critically where they do not work fairly or effectively.

After scoping out what types of markets we focus on and reviewing how markets have been studied in HCI, we introduce market design and the five core technical concepts it offers: thickness, congestion, stability, safety, and repugnance. This paper engages market design solely

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on the conceptual level – as an analytical vocabulary that can support efforts to design, evaluate, and critically study markets. This conceptual application of market design can benefit HCI researchers by promoting shared language and by establishing stronger connections between our field and ongoing work in economics. To explore how the five concepts can help make sense of systems within HCI, we present two illustrative case studies: First, we consider network hospitality platforms Couchsurfing and Airbnb, examining how each has sought to tackle issues of allocation, search, and arrangement of connections to optimize outcomes for participants. Second, we consider smaller peer-to-peer marketplaces that enable the lending, renting, and selling of physical goods. Analysing these niche marketplaces helps make visible the efforts and choices that go into creating and fostering markets. We conclude with a discussion of how this kind of analysis can make conceptual, evaluative, and generative contributions to the study and design of peer-to-peer exchange platforms and other socio-technical systems.

WHY MARKETS?

From high-frequency trading to the auction trade of pollution permits, contemporary markets are almost always dependent upon computers. Journals such as ACM Transactions on Economics and Computation (TEAC) have focused on the intersections of economics and computer science. Still, it may not be immediately clear why the design of markets should be of interest to HCI. Nobel Laureate in economics, Alvin E. Roth, frames markets [53] as "*tools we use to organize ourselves, to cooperate and coordinate and compete with one another, and ultimately to figure out who gets what*". This suggests that markets have relevance to core concerns of HCI, such as coordinating effort and enabling collaboration. Where markets are embodied by technology, their technological design becomes one key determinant of how they operate.

HCI and CSCW encounter a host of problems of allocation and matching that the study of markets could illuminate. However, with its rich history of drawing from psychology and sociology, HCI has had fewer connections with economics. Economics is, of course, a diverse discipline, so this paper makes only a schematic start on what benefits HCI might draw from it. We focus on developments in market design, the branch of economics concerning itself with the design and evaluation of markets and their operation. Before introducing market design in more detail, we scope out in brief the kinds of market this paper addresses, as well as prior work on online markets, crowdsourcing, and peer-to-peer exchange platforms.

What kinds of markets?

The notion of a matching market, the type of markets that we focus on in this paper, is different from the common, classic definition of a *market* as the interaction of supply and demand for a particular good or service, resulting in exchange [35]. Markets are a diverse phenomenon: *Commodity markets* are typically considered impersonal and driven by price. *Matching markets*, on the other hand, are markets where money is not the only determinant of who gets what, where the participants care, sometimes deeply, about who they are dealing with, and the market involves searching and wooing on both sides [53]. These types of two-sided matching markets include cases we often do not think of as markets at all, such as school placement. The line between *"perfectly anonymous commodity markets and relationship-specific matching markets"* is not clear-cut, rather, the conceptualization is better thought of as a spectrum from pure commodity to pure matching [53].

A focus on matching markets (as proposed in [52,53,63]) allows us to consider a range of situations where *matching mechanisms* are relevant. Here, a central observation is that matching is one of the major things that markets accomplish. What we find particularly innovative about the work of Roth and his colleagues [53] is the pragmatic turn it takes in framing markets not as free-standing, naturally occurring systems, but rather as human artifacts which are actively designed and shaped. Markets take place on *marketplaces*. As two traditional examples, town squares and market halls can serve as venues where supply and demand meet. Increasingly, markets are implemented by creating a marketplace using a computer system [20] – and different Internet-based marketplaces are now some of the world's largest and fastest-growing businesses [53]. The market design perspective invites our critical engagement with the construction of markets, the rules that govern their functioning (which are often formalised into software), and the decisions of those involved. One recent point of connection between economics and sociology has been in the 'performative' work in the sociology of financial markets where financial institutions have been studied as a produced infrastructure, not least in cases where market infrastructure fails, or where it comes into conflict with other practices or infrastructures. Muniesa's notion of 'market devices' [45] takes a similar turn as market design in seeing markets as constructed artefacts (see also [37]).

Finally, we want to note that we do not argue that markets are a neutral phenomenon: their extension, regulation, or curtailment are all issues of open debate. The extension of markets into aspects of our lives is rightly controversial [3]: markets can produce unfair outcomes and increase inequality. Yet, contemporary societies need ways to tackle the basic configuration problems that markets attempt to solve – the allocation of scarce resources and the matching of exchange partners.

Online markets and HCI

What makes online markets special, and curious as socio-technical objects, is that they necessarily require very precise rules, as these need to be written into software [53]. As such, whatever the specifics of an online market, software plays a major role in starting exchange processes and enabling the market to function. This is analogous with

classic CSCW discussions of workflow systems where *"formalism makes it possible to embed the categorisation into a computer system [with] parts of this formalism […] entirely automated by the system."* [16]

Given the diversity of online marketplaces, it is no surprise that these systems have attracted the attention of the HCI community. Some key domains where markets have been deployed and studied include auctions and commodity markets (such as early research on eBay [48,49]) as well as game markets and virtual economies [35]. Further work has looked into business-to-business markets where an especially influential example is Kollock's study [26] on how online markets fail. The piece depicts how trust, reputation and social interaction are essential parts of market functioning, and how markets are prone to fail without them. Markets have been used to address more traditional HCI problems, too. For instance, research on spam has explored how markets for receiving and sending email could help combat this problem [22], (see also [21]).

Crowdsourcing and peer-to-peer exchange platforms

Crowdsourcing and peer-to-peer exchange platforms bring HCI's focus on interfaces and the collaborative uses of technology together with diverse socioeconomic concerns. In recent years, scholars have turned to study networked platforms that act as marketplaces for crowdwork, peer-to-peer exchange, and on-demand services. These studies have focused primarily on the motivations and experiences of those who participate in these types of markets and the dynamics between different stakeholders, including not only the purported peers but also the platforms themselves.

Crowdsourcing, and especially the Amazon Mechanical Turk marketplace, have been a central focus. For example, there have been efforts to improve workflows and aggregate contributions from crowdwork [27], to encourage high-quality contributions and engage experts to perform crowdwork [9,19], as well as to examine of how crowdsourcing systems could be used as an alternative to other mechanisms (such as appeals to altruism) in motivating user contributions and allocating tasks to different users [20]. A range of critical analyses of crowdworkers' experiences [15,17,24,40,41] have been followed by efforts to intervene in these markets in order to support workers and enhance their relationships with requesters: The most famous examples of these collaborative efforts between workers and scholars include *Turkopticon*, a system that allows workers to publicize and evaluate their relationships with employers, thus enabling workers to engage in mutual aid [25], and *Dynamo*, a platform to support collective action by workers through facilitating the forming and mobilizing of publics around pertinent issues [54]. There have also been efforts to design and build better alternatives from the ground up, such as the self-governed crowdsourcing marketplace *Daemo* [10].

Moreover, scholars have looked into markets for on-demand labour, such as Gigwalk and TaskRabbit, where the tasks that are provisioned are geographic in nature [61,62]. Perhaps the most controversial example of on-demand labour services is the 'ridesharing' platform Uber. Researchers have examined drivers' experiences and their work context, including their relationship to the algorithms the company uses to allocate rides [34], issues of information and power asymmetries [50], and changes in work practices and requirements for different types of labour [14,47]. A recent, ethnographic study of auto-rickshaw drivers in Bengaluru, India [2] expands the debate of on-demand mobility beyond North America and Europe by highlighting how the Ola app has done little to change the uncertainty and vulnerability that characterizes the drivers' daily professional life.

A further emphasis has been on platforms that act as peer-to-peer marketplaces, often bringing strangers together to exchange spaces, goods, and services in a way that has traditionally been confined to the realm of kinship, friendship or paid employment [55]. Here, network hospitality [43,44] has been a particularly active topic of study, shifting from explorations of non-monetary hospitality exchange via Couchsurfing [28,32,33,51,59] to more recent studies about monetizing network hospitality through Airbnb [23,29]. Another important focus for research on peer-to-peer exchange platforms have been time banks [5,18,56,57] – systems that allow the exchange of work time between participants. Moreover, research has considered different systems for peer-to-peer exchange in local communities [12,30,31,36,38,58] suggesting a number of challenges to participation and often reporting on stalling efforts to sustain these types of marketplaces.

MARKET DESIGN: FIVE KEY CONCEPTS

We now turn to introduce market design, the branch of economics guiding our thinking in this paper. As highlighted earlier, market design frames markets as human artifacts and takes them on as objects of design. Using this approach, market designers work with how large scale societal 'issues', such as school placement [1] and organ donations [53], are handled. Market design aims to solve problems that existing marketplaces have not solved by first creating rules that allow a market to function, and second, circumstances in which it is safe and beneficial for those participating in the market to follow the rules.

Market design has defined five key technical concepts that characterise how markets function: *thickness, congestion, safety, stability*, and *repugnance*. The first four can be understood as success conditions, necessary for effectively functioning markets. The fifth points to how markets can fail if they are considered morally unacceptable. These concepts let us analyse and better understand successes and failures of different markets. In this way, market design provides an analytic vocabulary to support efforts to design, evaluate, and critically study markets. We caution against taking this as an exposition of how the concepts are typically used in market design scholarship in economics.

We encourage readers, instead, to turn to Vulkan *et al* [63] for a thorough introduction to the concepts and their implemention in economics, including in formal models.

Thickness

The first key factor of a successful marketplace is getting enough participants to create a steady flow of transactions. While the notion of thickness resembles the idea of critical mass [39,42], it is not only a matter of mass – as in the raw number of participants – but of the number of potential matches. For example, for a two-sided market to work (such as when matching students to schools), a large enough proportion of both sides need to come together ready to transact with one another. Markets can suffer from an over-supply on one side (such as too many buyers in comparison to the number of sellers), or a lack of good enough matches to convince participants to stay in the marketplace (e.g., it is not enough for Airbnb guests that accommodation is on offer in their destination but rather there need to be some offers that match their preferences).

Thickness is, in part, a temporal issue. For a market to work effectively, many people need to participate at the same time [53]. One issue that can lead a thick market to 'unravel' and become thin is the temptation for participants to 'jump the gun' by transacting too early – either off the market, or by accepting a less desirable but early bid. Individuals may try to transact before their rivals are present and ready in the market, in hopes of benefiting from an early mover advantage. Another issue that can make the market thinner is the possibility that some participants choose to 'buck the market'. This means transacting outside of the matching system to get a better deal.

Congestion

While thickness is necessary for a market to succeed, achieving it, in turn, creates a new risk: *congestion* – a problem that arises when participants are not able to review relevant options in a timely manner [52]. Here, one can think of a crowded job market where employers get so many applications that there is no way for them to invite everyone for an interview, and where applicants respond to this by sending applications to even more employers in hopes of improving the odds of getting an invitation. This illustrates how congestion makes it difficult for participants to identify the best options and negotiate a deal (before someone else does), thus reducing the usefulness and reliability of the market.

Roth [53] notes that it is easy to underestimate the severity of congestion since "*most successful markets have found a way to deal with it, and most markets that can't deal with it fail to become big and thick enough for us to notice them.*" Congestion can result in frustration, suboptimal matches, or in participants leaving the market to pursue options outside of the marketplace. A successful market overcomes the problem of congestion so that participants can consider enough alternatives to arrive at beneficial transactions [52]. Congestion can be addressed by providing participants with sufficient time to consider options and, importantly, by making the process of transacting fast so that if a deal falls through, participants can seize alternative opportunities while they are still available [53].

Safety

For a market to function successfully, it is necessary that it is *safe* to participate in it. Safety, in market design, refers to having the market organised in such a way that participants can make decisions based on reliable information and state their preferences honestly without fearing that this would harm them. Safety is important for ensuring that participants will not resort to alternative courses of action, namely, transacting outside of the marketplace, or attempting to 'game the system' by acting strategically in the marketplace [52]. Also, when it is not possible to explore every opportunity, it is helpful if participants can signal not only how desirable they are as an exchange partner but also how interested they are in the transaction that is being negotiated. Both issues are important, because reliable and comprehensive information is key for coming up with successful matches.

Moreover, participants need reliable information about those with whom they consider transacting. Often, this is best achieved by sharing others' prior experiences, for instance in the form of an online reputation system. Yet, if it is costly or risky to provide such reputation information about others, participants will not do so, and the entire market will suffer from a lack of reliable signals. Roth [53] brings up eBay as an example: Early on, when feedback was not anonymous, some buyers and sellers might have benefited (or, in other cases, punished) each other by writing reciprocal (partially inaccurate) reviews. By limiting the supply of accurate information, these participants ended up hurting the market. Later, eBay changed its feedback process so that buyers could share dissatisfactory experiences without fearing retaliation. This led to improvements in how detailed and useful information about market participants was available.

Stability

A market is *stable*, as defined by Gale and Shapley [11], when there are no pairs of participants who are not matched together but "*would have mutually preferred to be matched to each other than to (one of) their assigned match(es)*". For example, when matching students to schools, both schools and students have preferences: students may wish to attend particular schools based on their location, quality, or specialization, and schools, overall, may want to compete over the best students (regardless of the criteria used to assess desirability amongst the pool of candidates). In this scenario, a stable allocation is one where "*no school and student not matched to one another would both prefer to be*" [1]. Ideally, the market can be organized so that it produces a stable outcome, that is, a result where no one can do better by transacting outside of the market.

Repugnance

On a somewhat different level of analysis, Roth [52] points out the repugnance of a transaction or a market as one constraint on market design. Repugnant transactions are transactions that "*some people want to engage in and that are objected to by people who may not themselves experience any direct harm*" if such transactions take place [53]. The reason for objection, then, lies not in practical self-interest, but in values and morals.

Repugnant transactions do not have to involve money, but sometimes the involvement of money is what turns an otherwise acceptable transaction into a repugnant one [53]. Roth [53] uses the term objectification to refer to the fear that the act of putting a price on certain things – and then buying or selling them – might move them into a class of impersonal objects to which they should not belong. Involving money can also bring up concerns about coercion (forcing those who are in a need for money to transact through desperation) or fears that markets could lead to a slippery slope towards a less altruistic and more self-interested society [53]. As an interesting counterpart for repugnant transactions, Roth [53] identifies *protected* transactions, that is, transactions that many promote "*in the sense that they are eager to protect others' rights to engage in [them], even if they don't wish to engage in [that type of transaction] themselves.*"

The repugnance of a market can be difficult to predict because it depends on context and on who is judging: A transaction that is repugnant in one place, or for certain people, may be acceptable in another setting, at another time, or to other individuals [53]. As new markets become possible, for instance due to new technology that makes previously difficult or costly transactions feasible, this may bring about new kinds of repugnance [53]. An often-cited example of repugnant transactions is the market for kidneys for transplantation – it is illegal in most countries and deemed morally unacceptable by many (but not all).

APPLYING MARKET DESIGN IN HCI: CASE STUDIES

These five concepts from market design give us a start on diagnosing issues that can arise with markets, and help us articulate what makes more successful markets work. To show how these concepts can be applied to HCI, and to explore how they might help us think about designing markets, we now use them to guide our analysis in two illustrative case studies in the domain of peer-to-peer exchange platforms: 1) network hospitality via Airbnb and Couchsurfing and 2) peer-to-peer marketplaces for physical goods. We draw on prior research in these domains as well as our own, ongoing engagement with founders of peer-to-peer marketplaces and Sharetribe (a company that provides a software solution for these types of marketplaces). We aim to illustrate applications of the market design concepts, not to make an empirical contribution in its own right.

Case 1: Network hospitality via Airbnb & Couchsurfing

We first look at network hospitality [44] as practiced via Couchsurfing and Airbnb. Both platforms facilitate connections between guests from around the world and hosts who are willing to make spaces available for them, be it in their homes or secondary properties. Airbnb lets hosts offer short-term rentals, supporting well-defined monetary exchange to compensate the hosts' efforts, but enabling also subsequent non-financial social exchange [29]. In contrast, Couchsurfing hosts offer a place to stay, sometimes literally just on the 'couch', without any exchange of money but with the expectation of generalised reciprocity.

A key role fulfilled by both platforms, then, can be understood as helping users solve a "matching problem": At any time, there are guests looking for accommodation, and hosts potentially offering it. As such, the two sides of the markets need to match together. Exchange platforms are tasked with mediating the negotiations about who transacts with whom, when, and under what conditions, although as we will see, platforms differ in how they go about servicing this role. As we would expect, given that Airbnb and Couchsurfing are the two most prominent examples of network hospitality, there is much that these platforms do right from a market design point of view. What kind of insights can market design give us into the relative success of these markets?

Thickness

From attracting newcomers and retaining experienced members, to nurturing and encouraging different kinds of contributions, incentivizing participation is a long-standing challenge for HCI. Efforts to motivate participation can be understood in market design terms as creating and sustaining thickness. At a glance, thickness resembles the idea of critical mass [39,42]. Indeed, one simple measure of a system's success is the number of users it manages to attract and retain as active participants over time.

Yet, thickness, as understood in market design, articulates that what matters is not just the number of participants, but rather attracting sufficient numbers of relevant types of participants so that they can transact with each other: Can hosts attract guests, and do guests succeed in finding a place to stay? To sustain interest in exchange activity through any given platform, there needs to be a sufficiently high potential of participants finding matches (or being matched together by the system) so that sought-after exchanges can take place.

While the numbers of hosts and guests do not need to be equal at any one time, too large a discrepancy will lead to failed efforts to participate and can result in people abandoning the marketplace. Couchsurfing runs the risk of becoming a thin market if the benefits for guests seem to be much larger and more apparent than those a host derives. While the use of money helps to balance out this tension on Airbnb, a central way for Couchsurfing to counteract them is the fostering of generalised reciprocity: those who have

benefited of accommodation free-of-charge are expected to contribute back to the community. Encouraging participants to alternate between hosting and guesting, improves thickness (in terms of the number of potential matches) without necessarily increasing the sum total of participants.

Congestion

The success of hospitality platforms hinges, in part, on how well they overcome the problem of congestion: how do they manage to help participants to consider their alternatives and arrive at satisfactory transactions in a timely manner? Our comparison of Couchsurfing and Airbnb illustrates differences in how the two have addressed the problem of congestion (a challenge that can only arise once a market is thick enough for participants to be able to find matches).

When attempting to book accommodation via Airbnb, upon locating a suitable space, the guest asks the potential host whether they can rent out the place at the desired time. The host, then, needs to reply before the renter can request another property (or else they might end up with multiple bookings when they only wanted one). This keeps potential renters from flooding hosts with requests. Yet, this arrangement causes a bottleneck in that renters may need to contact multiple hosts, one after another, until they find accommodation that is available and fits their requirements. From the renters' perspective, waiting for response from one host means being blocked from negotiating other desirable alternatives – and these may get booked by other renters in the meanwhile. Airbnb has made several design decisions to improve the matching process to reduce congestion, such as directing renters to contact only one host at a time, and incentivizing hosts to reply quickly to all enquiries that they get. Moreover, Airbnb increasingly mitigates congestion with an Instant Book feature that hosts can enable to let guests make bookings without any back-and-forth.

Couchsurfing has chosen a different approach by actively advising potential guests to contact several hosts at once: "*When you find a few interesting potential hosts, carefully review their profile and send a Couchrequest for the dates you'll be there. We usually recommend sending about five Couchrequests. Make sure to personalize your messages and tell your host why you want to meet!*"[1] Here, emphasis is on interpersonal connection, with invitations to look for interesting hosts, personalise messages, and come up with reasons for why the guest wants to meet the host (something that is quite different from just wanting a place to stay free-of-charge). Encouraging guests to craft personal and detailed requests is aligned with the community's ideals of network hospitality, and, more practically, it may be necessary for improving the odds that guests can find a welcoming host. At the same time, though, this arrangement is prone to create congestion: Hosts risk being flooded with requests to the point that they will not respond promptly, and overlapping negotiations require coordinative effort, slowing down the matching process.

Safety and stability

The concept of safety is about participants being able to trust information shared on the market, along with feeling free to disclose honest information without fearing that it weakens their position. On both Airbnb and Couchsurfing, information about participants is mostly shared in the form of self-generated profiles and reviews written by others – the latter carrying more weight, in line with what warranting theory [64] leads us to expect. Establishing a good reputation, as recorded in one's profile, plays a critical role as a requirement for participation, and at least some Airbnb hosts share the understanding that a good reputation is key to increased earning opportunities [29].

However, in practice, reviews seldom give very reliable information, with the trend instead leaning toward 'perfect' reviews. Indeed, anything short of a praising review is read as negative (a challenge faced by earlier reputation systems of online markets, too, such as eBay [48,49]), and those taking part in hospitality exchanges may rather skip writing a review than post one that is critical. For example, Couchsurfing reviews have been found to be credible primarily as a count of the number of positive experiences rather than a balance between positive and negative [60]. As such, the opportunity to use the review system to make a market safe is somewhat lost. Similar issues exist on Airbnb, even after efforts to make the reviews more granular (instead of deploying only one, all-encompassing star rating) and redesigns that allow guests to give private feedback for hosts in addition to the public review.

While safety speaks to the role of information, the concept of stability concerns how participants may leave a market, trade outside of the market, or break commitments they make within the market. To maintain the thickness of a market, participants must be encouraged to continue exchanging via the platform, and given reasons to complete exchanges via the platform rather than disintermediating it by transacting directly with one another. The fact that platforms support the unacquainted finding and connecting with each other is a major benefit in this vein – while short-term rentals and homestays existed before online marketplaces, finding and organising them used to be more expensive, and more cumbersome.

When it comes to repeat exchange where the platform is not needed for establishing contact between unacquainted partners, further reasons to stay on the market may be needed to make it worthwhile for the exchange partners to transact via the platform (which typically takes a cut from all transactions it mediates). The financial assurances given by Airbnb can act as one such reason, in that any transactions taken off the site are considerably riskier, and indeed are one site where scammers have worked. One peculiarity, then, is that scammers, in some ways, help police Airbnb by discouraging disintermediation.

[1] http://www.couchsurfing.com/about/how-it-works/

Another concern of stability is that participants might renege on their deals. The binding nature of agreements on Airbnb imposes barriers to this for both hosts and guests. For Couchsurfing, the lack of monetary exchange between exchange partners means that disintermediation is less of a temptation since there are fewer advantages to transacting off the marketplace – the platform takes no commission for enabling hospitality exchanges. In the absence of the kinds of binding agreements made on Airbnb, there is little beyond community norms and reputation to push Couchsurfing participants to keep their agreements. A serious issue, then, is that hosts may cancel accommodation they had promised, guests may not show up as planned, or either may otherwise fail to fulfil their role.

Repugnance

Finally, the fifth concept we will discuss here concerns how markets are in some cases perceived as repugnant – and how this can result in political pressure to outlaw the market (or regulate it more strictly), or even a moral panic about the consequences of the market's existence. Clearly, Airbnb has attracted this type of criticism. The idea of renting one's own home for short-term visitors for profit – particularly when the resident is not present – has faced resistance, and can conflict with the notion of the home as a private domain. For many, there are aspects of one's life (such as your residence) that should not be commodified by trading it on a marketplace. There have been fewer arguments like this about Couchsurfing, a platform that supports seemingly similar hospitality exchanges, albeit without any money changing hands and with much more of an expectation that the exchange will involve not only a place to stay but also some socialising between the host(s) and the guest(s). While reactions to Couchsurfing hosts' reasons for offering accommodation free of charge range from curious to dubious, these do not typically take the form of an argument about repugnance.

Next to the presence or absence of monetary exchange (that can be seen to inappropriately commodify the domestic sphere), what might help to explain the difference is that there is tremendous variation within Airbnb as for the kinds of accommodation and the style of hosting that are on offer – while some of the activity is, indeed, similar in feel with Couchsurfing, other exchanges are very professionalised, resembling closely the hotel industry in that the spaces that are rented out are not excess spaces in a home but rather rooms or apartments that are continuously rented out for short-term stays. Many complaints surrounding Airbnb focus upon this latter variety of hospitality. This brings us to a second aspect of repugnance: the problem with short-term rentals displacing long-term residents (particularly in cities like San Francisco with a pre-existing, long-term housing crisis). The concern, here, is obviously not that a monetary market in rental housing would be repugnant per se, but rather that the desirability of short-term visitors vis-à-vis local, tax-paying, long-term residents has an unwanted, unfair impact on cities, and especially their less affluent residents. Short-term rentals have been blamed for inflating the price of housing, and some worry that Airbnb will become regarded as an example of a business model that "cuts out the middle man" with problematic consequences.

Case 2: Peer-to-peer marketplaces for physical goods

Market design lets us unpack some of the necessary features of successful marketplaces. Each concept brings up criteria regarding the involvement and participation of market actors, as well as mechanisms required to support the matching of exchange partners. Having considered one of the more successful niches of 'the sharing economy', we now turn to examine a set of peer-to-peer exchange platforms that have experienced, so far, more halting success: peer-to-peer marketplaces for physical goods. Those promoting the purported sharing economy [6,13] have been persistently fascinated with these types of peer-to-peer marketplaces, but empirical studies of co-use and redistribution of physical goods, especially when organised locally [36,58], have included accounts of difficulties in gaining sufficient thickness [30]. (This is similar to other types of peer-to-peer exchange platforms, like time banks, where balancing what is offered and what is in demand is challenging [57]). Clearly, there are significant, unresolved barriers to success in this domain, at least when contrasted with the relative success of network hospitality. Can market design help us identify and understand such challenges?

Thickness

Getting people to join a niche marketplace for exchanging physical goods can be challenging. There are, after all, plenty of options on where to buy and sell items, ranging from shops and flea markets to large online systems like Craigslist. The first solution to the problem of thickness, then, is that a marketplace must somehow outperform its alternatives to attract participants. We will not dwell on this challenge as a source of failure, as it is well-established that any new market needs to overcome it.

The notion of thickness highlights that growing a user base successfully means bringing in the right kinds of actors so that participants can find suitable exchange partners. The case of peer-to-peer marketplaces for physical goods helps us see why timing is essential in accomplishing this goal. First, signs of activity are an important indicator of the vitality and credibility of a peer-to-peer marketplace. Prior studies on local peer-to-peer exchange [30,58] depict how newcomers may withhold participation in the absence of social proof, waiting for others to "get the engine started." This points to a need to bootstrap marketplaces with a small group of committed participants, similarly as recommended in literature on social navigation [7] that highlights how visible actions of other users can inform understandings of what is appropriate and make a new online space feel alive and inviting. Sharetribe, whose platform aspiring peer-to-peer marketplace founders can use to set up a marketplace, echoes this, encouraging those setting up a two-sided

market to first ensure that there is supply before worrying about demand: *"[T]he best way to solve a marketplace's chicken and egg problem is to seed the marketplace. You should focus on signing up your providers and getting them to list their products or services."*[2]

Next to the actual thickness of a marketplace, perceptions matter. Consider Kitsplit (kitsplit.com), a camera rental marketplace. While only a fraction of the cameras and lenses listed on the marketplace may be relevant for any one person (or available at a given time), seeing that there are many things on offer makes the market appear thick. This acts as a signal of vitality that can attract further users to the market. Signs of successful exchanges are highly important for any peer-to-peer marketplace: they encourage newcomers and other hesitant individuals to participate.

Moreover, since thickness is a matter of the number of potential matches, likelihoods for completed exchange are higher if participants can swap sides in the marketplace. As seen in the case of network hospitality, encouraging participants to move between the different sides of the markets can, thus, be an effective way to improve thickness. In the case of Kitsplit, many participants occupy both sides quite naturally: They own specialised camera gear that they can rent out while they are not using it themselves, making some extra money, but they can also rent tools that they need only occasionally, avoiding the need to own these themselves. This dynamic has allowed the marketplace to make successful matches from early on, while still in the early stages of growing its user base and inventory.

In local peer-to-peer marketplaces, such as the Kassi system used on a Finnish university campus [31,58], participation is more open-ended than in the typical scenario of network hospitality. This means that there is potential to bring about exchanges that are not actively sought for but might be attractive once the opportunity appears. An interesting example of how thickness may improve in this setting, without necessarily adding to the number of registered users, is that some Kassi users were found to look for goods, such as sports gear, not only for themselves but also others in their social groups [31]. If users are willing to (or can be incentivised to) browse offers and requests not only with their own needs and interests in mind, but also with an eye out for what could be useful for a friend or family member, the odds of successful matching improve.

Congestion

If a peer-to-peer marketplace succeeds in achieving some thickness, it is then likely to run into issues of congestion. Facilitating participants' efforts to negotiate and complete exchanges can be a struggle for these types of marketplaces – while they can effectively help buyers and sellers to find each other, participants often still need to tackle some aspects of the exchange on their own.

Here, we can consider as an example Brisbane's Attire (www.brisbanesattire.com), a peer-to-peer marketplace for renting and trading designer dresses locally. While the marketplace has experienced some success in bringing interested participants together to establish the market and enable the discovery of potential matches, the key challenge related to selling and buying clothing remains unsolved: there is no way to try out the dresses online. Participants must rely on size information and pictures to judge whether an item is a match with their needs, or else set up an in-person meeting for fitting. Here, the hassles and delays related to coordinating trying out dresses to see if they fit the buyer (and a deal could be made) are a central source of congestion, making transacting slow and laborious. Moreover, it is hard to ensure that both parties follow through on such coordinative arrangements, or even communicate if they have lost their interest. There, then, remains the risk that negotiations do not result in an exchange, and participants find themselves having lost time and alternative opportunities. While these are largely issues that need to be resolved by the exchange partners, platforms can, to an extent, design their processes to lessen some of these concerns, for instance, by assuring exchanges as a trusted third party who can help resolve eventual conflicts.

As another example of congestion, Maggie's Kids' Market (maggieskidsmarket.com), a peer-to-peer marketplace for second hand children's clothing, was having difficulty in retaining participants since they found it burdensome to list items, wait for someone to get in touch about buying them, and only then coordinate the completion of the exchange – even though the marketplace had the functionality in place to process payments and handle shipping. Because of the perceived slowness of transacting via Maggie's marketplace, and to improve their odds of finding a match quickly, participants sometimes listed clothes concurrently both on the marketplace and on local Facebook groups for buying and selling clothing. This meant that by the time a potential buyer got in touch about a listing via the marketplace, the item might already have been sold via Facebook. While waiting to find out about this, the buyer was losing valuable time to negotiate alternative deals.

The challenges of Maggie's marketplace illustrate, first, congestion driving sellers to act in a way that leads to the sharing of outdated information in the marketplace, and subsequently, buyers suffering of congestion due to such information. As pointed out in prior research on local peer-to-peer exchange [31], the smoothness of exchange processes is key for making participation meaningful. That, in turn, is central to keeping participants from transacting off the market. This brings us back to the notions of safety and stability, and the question of disintermediation.

[2]https://www.sharetribe.com/academy/how-to-build-supply-marketplace/

Safety and stability

When it comes to peer-to-peer marketplaces for exchanging physical goods, the challenge of participants going off the market are significant. These were already hinted at above in our discussion of Maggie's Kids' Market and Brisbane's Attire where the geographically local nature of exchange made the cost of meeting in-person relatively low.

First, participants may be reluctant to return to an online system to complete a review after an in-person exchange, as was reported in an early study of the Kassi system [58]. These "invisible exchanges" weaken access to reliable information about participants' reputation (as established through prior exchanges) as well as the vitality of the marketplace. In market design terms, they deteriorate the safety of the market as they make it harder for participants to assess whether they want to take part and with whom they would like to collaborate.

Second, in local settings, participants may be reluctant to use a peer-to-peer marketplace for anything other than the discovery of matches. Both peer-to-peer marketplaces for clothing had encountered this problem of disintermediation: Participants would use the site to post listings, and search for them, but they would complete eventual exchanges in person, without using the marketplace's transaction process or payment system. Paying in cash might, of course, be simply less of a hassle for the participants (pointing at the need to design better ways to manage payments online), but it does allow participants to avoid paying a commission to the marketplace, as well – cutting out the middle man. This type of behaviour hinders the chances that a marketplace becomes sustainable over time but it is not difficult to imagine how participants might not worry about (or even recognize) such outcomes if there is an immediate benefit for them in transacting outside of the marketplace.

Repugnance

Largely, our examples of peer-to-peer marketplaces for physical goods have been of a small enough scale that they are perhaps less prone to be deemed repugnant than the more visible and more heavily debated cases of network hospitality. While some might be reluctant to buy second hand goods themselves, and maybe even look down on those who do, this aversion rarely takes the form of an argument about repugnance – it is not a question of it being morally unacceptable for others to redistribute used things they no longer need or to co-use valuable tools.

This is not to say, though, that there would not be cases of peer-to-peer marketplaces being deemed repugnant. One needs only consider the case of Silk Road, an online marketplace for drugs, to see how arrangements that share many features with the marketplaces we have discussed here (such as ratings, reputation, and the hurdles of delivery) can raise serious moral concerns and provoke calls for reconsidering existing laws and policies to stop and disband their functioning [4].

DISCUSSION

Conceptual work can be powerful in supporting how we understand new domains and new sets of problems. Our examples illustrate how the market design concepts can help us to divide up some of the challenges that peer-to-peer exchange platforms face, and offer a set of minimum substantial criteria that any market needs to meet to achieve some success. Drawing on the analytic vocabulary that we have introduced from market design to HCI, we draw out three discussion points: the first concerns the *conceptual* contribution that market design concepts can make, the second is their *evaluative* role in helping us assess markets in terms of their effectiveness but also in line with the values important for our designs, and last, we consider a *generative* role the concepts can play by opening up possibilities for how we can design markets.

Conceptualising markets

An analytic vocabulary allows us to name both emerging and familiar phenomena, thus making it easier to address them with increased conceptual clarity. Market design gives us a set of concepts that are useful in understanding how participants can come together for different types of exchange, and what kind of problems they might encounter based on how a marketplace is arranged. The concepts of thickness, congestion, safety, stability, and repugnance help us scrutinize diverse collaborative arrangements that can be conceptualised as markets. It is not that all collaborative systems make sense in these terms but that considering whether a system can be approached through this lens can reveal new perspectives to it.

In discussing peer-to-peer marketplaces for physical goods, we saw how they can struggle to solve problems of thickness and congestion. By naming common problems, we can understand better the high failure rate of online systems. While it is a truism that many online forums fail due to scarce participation, approaching this in terms of thickness gives us a more granular view of the problem than the notion of critical mass: shifting evaluative focus from the number of users to the number of potential matches gives us added insight to failures and possible means of solving them (such as encouraging participants to take on several roles). As another example, the notion of congestion sheds light on the problems of participants being 'blocked' from alternative courses of action, and helps explain why, for example, the time at the end of an eBay auction can be so fraught as a seller is blocked from accepting competing offers while waiting for the buyer to pay up.

Evaluating markets

Another contribution that market design can make in HCI is clarity in regarding markets as constructed, human artifacts, which can be designed in different ways. This leads us onto important questions of evaluating systems. By splitting apart success criteria of markets, we can evaluate different aspects of systems to understand where they fail and succeed. This may, then, allow for making evaluations on an empirically richer basis. Market design allows us to

identify issues that hinder the effectiveness of a market. Yet, once this analysis has been done, we can then return to considering the trade-offs that improving the effectiveness of a market can entail.

For example, differences in how Airbnb and Couchsurfing handle congestion can be seen not only as a matter of one being more effective than the other, but also as designs that foster different social qualities in the hospitality exchanges that the two platforms facilitate. At a glance, one might conclude that Airbnb has simply been more successful in solving the problem of congestion. While there may be some truth to that assessment, we argue that considering the issue solely as a matter of efficiency is insufficient. Parigi and State [46] have pointed out that technology can increase the ease of establishing interpersonal connections with strangers while, simultaneously, diminishing the bonding power of such experiences. The authors originally depicted this process of disenchantment in the context of the rising popularity of Couchsurfing between 2003 and 2011. Here, we deploy it as an example of how congestion, when it necessitates more back-and-forth between hosts and guests, can somewhat surprisingly foster interpersonal outcomes, such as trust and sociable encounters. A platform such as Couchsurfing, then, might choose to prioritise such outcomes, even at the cost of suboptimal effectiveness, if they align with the community's values. The most effective solution may not be the one that best serves the values of a marketplace. Market design concepts gives us the means to discuss how platforms are not powerless to make value choices and shape the outcomes among peers who transact on the market they have created.

Repugnance is another important concept for evaluation. Conceptualising collaborative arrangements as markets, even when markets do not need to entail any monetary exchange, can lead to monetary evaluation of goods some deem unfit for being considered in such terms. Concerns about objectification, coercion, and a moral slippery slope are considerations that can inform a range of value judgements that must be made – more or less intentionally – not only by designers and market participants but also by society as it seeks to make sense of and regulate online marketplaces, such as Airbnb or more labour-focused on-demand services like TaskRabbit and Uber.

Generating ideas for the design of markets

Lastly, we argue that market design concepts can be drawn upon as a resource for design ideas. While any design implications need to relate to the specifics of a particular market, it is worth discussing some examples of design avenues these concepts suggest. We have illustrated how having participants transact in ways more diverse than just their initial role can improve thickness: buyers can also act as sellers (as on Kitsplit), hosts can become guests, too (as is already common on Couchsurfing and Airbnb), and so on. Beyond thinking what encouraging users to contribute in multiple roles might look like in different systems, this can be taken as an opportunity to design in a way sensitive to the temporal aspects of markets. For example, we might think of features that act as something of a surge mechanism for hospitality exchange: hosts might be prompted to consider renting out on dates that they have not made available if there is a temporal lack of supply. Further opportunities for improving thickness arise from the tendency of some to browse a marketplace with both their own and others' needs in mind. Design, here, could embrace this emergent practice by making it easier for regular users to propose potential matches to their friends and, by doing so, possibly pull them into the market.

As for safety, we can think more closely about the veracity of information shared on online forums, the incentives to give such information, and what information would be most useful for participants. Markets might at times be served better if reviews focused on qualitative descriptions instead of evaluations. Framing reviews less as assessments of individual participants and more as a matter of sharing exchange experiences might help focusing on what went well, what can be improved, and what others should take into consideration as they go about their own exchanges.

CONCLUSIONS

Quoting Roth [53], it is our conviction that *"[a]s we start to understand better how markets and marketplaces work, we realize that we can intervene in them, redesign them, fix them when they're broken, and start new ones where they will be useful."* We have made the case that the analytic vocabulary of market design can facilitate efforts within HCI to approach markets as objects design and critical scrutiny. First, our illustrative case studies exemplify how market design concepts can help articulate understandings of markets, and examine their successes and failures. Second, the concepts can be used as an evaluative tool for assessing and reflecting on design choices not solely in terms of their efficiency, but also their implications for social interaction and the fairness of outcomes. Third, we have brought up the generative potential of the market design vocabulary. Considering the design of marketplaces as socio-technical systems – a task that requires us to look beyond immediate user interfaces – is an important part of our broader efforts of designing technologies which both fulfil their function while being effective and enjoyable. Just as we need to understand social relationships and interpersonal communication to design successful, or provocative, social media systems, insight into markets can help us create effective yet socially acceptable mechanisms for allocating resources and matching people.

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