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Research article

Responsible users and platform competition: A computational model

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ABSTRACT

Corporate Social Responsibility (CSR) is an increasingly important topic in business, especially in the context of digital platforms where consumers and policymakers care about the social responsibility of platforms. This paper introduces the concept of responsible users, defined as users who make decisions considering their CSR preferences in platform settings. However, how responsible users may affect platform strategic behavior and competition is unclear. Therefore, we propose a computational model of platform price competition that considers the presence of responsible users. We find that CSR preferences have pro-competitive effects that reduce prices and profits in equilibrium. However, this effect depends on how large CSR preferences can be. We also explore several market asymmetries and clarify their implication for platform price structures and profits. Furthermore, we find that it only matters that users express their CSR preferences, regardless of how those preferences are generated. By integrating the responsible user concept into platform competition, our work contributes to both platform competition and CSR literature. We discuss practical implications for platform users and managers and future research opportunities.

1. Introduction

Corporate Social Responsibility (CSR) is an increasingly important topic in business. Industry surveys and reports suggest that consumers prefer doing business with companies that act responsibly in economic, social, and environmental matters [1–4]. CSR positively impacts purchase intent [5,6] and willingness to pay [7], and it promotes consumer loyalty [8]. Moreover, CSR provides opportunities for competitive advantage, risk reduction, and legitimacy [9–11].

CSR-related issues are significant in the context of platforms because of the prevalence of platforms in the economy [12] and the power that many of those platforms possess [13,14]. Well-known platform firms like Apple, Google, and Amazon are expanding their CSR efforts [15,16]. At the same time, social media platforms, such as Facebook and Twitter, are associated with the spread of misinformation and fake news [17,18] that may contribute to the formation of echo chambers that fragment society [19], but also with addictive use, and mental health disorders, especially amongst adolescents [20]. Platforms may also take advantage of the AI feedback loops [21,22], which raises several user challenges, including privacy and surveillance, manipulation of user behavior, and bias in decision-making. Other social issues include workers' rights [23], loss of control, unemployment [24], and AI ethics [25,26].

Those examples suggest that in many platform settings, CSR issues are significant, and platform users may take into account their

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CSR preferences when making platform participation decisions. We call these consumers responsible users. For instance, when adopting contact-tracing apps, users take into account social considerations such as the risk of mass surveillance [27]. However, mainstream platform competition models do not consider responsible users [28–33]. Our work aims to fill that research gap by integrating user CSR preferences into platform competition.

We propose an agent-based economic model of platform competition in the presence of responsible users. In our model, users joining a platform consider the platform's impact on their community, measured by the average surplus created by the platform on the user's side. Our primary objective is to understand whether and how responsible users matter in the context of platform competition. Then, we could identify lessons for platforms and their managers. Therefore, our research question is: What is the impact of responsible users on platform competition?

To answer the research question, we run a set of computational experiments to see how responsible users (CSR preferences) affect platform prices (membership fees) and profits using the well-known Armstrong model of platform competition, which allows us to consider how user tastes, network effects, and prices interact with CSR preferences. We show that the presence of responsible users has significant implications for platform competition. We find that responsible users generate additional competitive pressure that reduces platform prices and profits. In other words, CSR preferences are pro-competitive. Moreover, the pro-competitive effect depends on the strength of the CSR preferences. Our findings highlight a new mechanism that justifies low prices in platform markets. Traditionally, low prices were justified as a consequence of network effects or as introductory prices. Our results highlight that the presence of responsible users can be another source of pro-competitive effects. However, we also find that when combined with prior advantages that lock-in some consumers (e.g., incumbency, platform focality, or dominant positions), CSR activities can lead to entrenching the position of those platforms with the advantage, making winner-take-all equilibria common.

The next section provides a research background, followed by a description of our model. Section 4 provides the results of the computational experiments, followed by model extensions. Section 6 discusses theoretical and managerial implications, and future research opportunities, and the last section concludes.

2. Theoretical background

We discuss the CSR and platforms literature to clarify essential concepts and issues that provide the background for this research. We also explain the Armstrong model of platform competition upon which our computational model is based.

2.1. CSR, user CSR preferences, and modeling CSR effects

CSR is a form of business self-regulation that aims to contribute to societal goals by creating shared value while making profits [34, 35]. Empirical research on the link between CSR and firm performance finds mixed results and highlights the need for more research to understand that relationship [36–38]. For instance, some papers report positive effects of CSR activities on firm performance, while others find the opposite effect. Other empirical work finds that competition matters [39] and that consumers have heterogeneous CSR preferences [40,41]. Recent empirical research explores stakeholder preferences for CSR [42] but the literature is also divided on the results between stakeholder preferences and their impact on performance. We adopt a similar terminology, focusing on user preferences for CSR because users are the main stakeholders in platform contexts, as we explain in the next section. The platform users who consider CSR in their platform decisions are called responsible users, and this concept is formally defined in the next section.

Although there is extensive literature on CSR, only a few papers provide guidance on the theoretical relationship between CSR and firm performance [43]. studies CSR using a stylized game-theoretic approach. They assume that CSR-compliant operations are costly, and they find that they will be implemented either when the cost premium is sufficiently low or when the risk of exposure to the public is sufficiently high [44]. proposes a game-theoretic all-pay auction model of integrating sustainability into the business model. Their simulations explore the role of the sustainability market potential (what percent of the market becomes sustainability market) and asymmetric firms [45]. analyze the diffusion of CSR in an evolutionary game. They assume that a socially responsible firm gives up some of its profit, but consumers have higher reservation prices for the products of socially responsible firms. They find that all firms adopting CSR is a stable equilibrium when the cost of socially responsible activities is sufficiently low. An increased industry size tends to give mixed oligopolies [46,47]. consider the competition of two firms with different marginal costs. They assume that the level of CSR is the firm's weight on consumer surplus in its objective function. They show that the more efficient firm chooses a higher CSR level and strengthens its dominant position. If CSR has sufficiently large fixed costs, only the more efficient firm adopts CSR. They also note that incorporating consumer surplus into the firm's objective function is a standard way to model CSR in several articles, but other articles model CSR as a means of vertical product differentiation. A recent article considers the effects of firms' ESG-related investments [48]. However, there is a lack of articles addressing the impact of user CSR preferences on platform prices and competition. In addition, there is a lack of theoretical work to help explain the contradictory empirical evidence on firm performance. Our paper proposes a new way to address these issues by explicitly considering user CSR preferences in a formal model.

2.2. Platforms, platform competition, and platform responsibility

A digital platform provides an infrastructure that facilitates the interaction between multiple groups of agents. A platform considers the cross-side network effects between the sides and sets prices to maximize its profit [29–32,49]. The platform may charge both sides, let one side access the platform for free, or set an asymmetric price structure. To determine the correct price structure, the platform faces a coordination (chicken-and-egg) problem: agents from one side are unwilling to join the platform unless agents from the other side are already on the platform, and the price set on one side influences the price on the other sides. Technology firms that offer platforms such as Apple, Google, Amazon, Alibaba, Tencent, Uber, and AirBnB provide excellent examples of firms leveraging platform strategies to disrupt traditional industries and dominate new markets [12,50–52]. Firms that offer platforms are called platform firms, and competition between platform firms is defined as platform competition. Several issues arise in that context, such as network effects, governance, openness, multihoming, quality of complements, and innovation [53–56].

However, the impact of user CSR preferences (expressed by responsible users) on how platforms compete is underexplored and is the main focus of this paper. In platform markets, responsible users may play a crucial role compared to other markets because their decisions influence the decisions of others elsewhere in the market. For example, users' decisions about joining specific platforms may influence developers or content creators. This interplay of decisions creates a complex web of effects whose consequences are not clear a priori. As discussed in the introduction, platforms are associated with several issues that affect users and their behavior. Social media platforms are associated with the spreading of misinformation that affect society, addictive behavior, and mental health issues. Other AI-driven platforms may be associated with loss of privacy, biased decisions, unemployment, and inequality. Some users may disapprove these consequences and act according to their social preferences by leaving the markets, which may lead to dissatisfaction and migration between platforms, resulting in platforms introducing changes to their internal policies. As a result, several authors have called for a responsible platform economy [57–59]. Indeed, governance of and by platforms is a significant business and policy challenge that has attracted considerable attention [60–63], raising self-regulation [64] and regulation issues [65–67]. On the other hand, platforms can create shared value [68], aid development [69], and support sustainability [70]. Platforms for the common good [71] can maximize social impact by enabling the interactions of multiple stakeholders. Other papers discuss user sensemaking and AI explainability in algorithmic media platforms [72–74]. All those platform issues are also related to the emerging literature on corporate digital responsibility (CDR) that studies CSR issues with a primary focus on technology and its implications for society and the environment [75–78]. This work is also related with research on responsible digitalization [79], as firms design platforms and other sustainable business models to maximize the impact of their digital transformation strategy [80].

Our main addition to the literature is a way to incorporate user CSR preferences and then analyze the implications for platform competition and social responsibility platforms using computational experiments. The social responsibility of platforms is a vast and complex topic [81], therefore, we focus on how platforms respond to responsible users, and show that this is a significant issue in a formal model. However, in the discussion section, we also identify other issues that provide future research opportunities.

2.3. Armstrong model of platform competition

Our research builds on the (Armstrong, 2006) model of platform competition, a seminal model that examines platform price competition, providing the foundation for several other papers [82,83]. The Armstrong model assumes that two groups of agents (or sides) need each other and two platforms intermediate between them (e.g., Uber and Lyft). We denote each group of agents as Side 1 and Side 2 (e.g., drivers and riders) and assume that they have a normalized population size of one. The terms agent, platform user, and user are synonyms in this context. Users decide which platform to adopt based on price (participation or membership fees), mismatch costs (tastes), which are assumed to be uniformly distributed by $y \sim U[0,1]$, and network effects (number of agents on the opposite side using the platform). All agents on both sides choose one of the platforms (i.e., the market is covered).

This generic model can represent a variety of platform competition cases, such as ride-sharing platforms connecting drivers and riders, streaming platforms connecting content creators and watchers, or gaming platforms connecting gamers and developers. Formally, the expected utility of an agent on the side i from joining the platform-k is

$$u_i^k = v + \beta_i n_j^k - t\left|y - l^k\right| - p_i^k, i = 1, 2;\ j \neq i \tag{1}$$

where n_j is the number of agents on the other side, β_i reflects the strength of the cross-side network effect on side i, p_i^k is the participation price that agents on side i pay when joining the platform k, and v represents the intrinsic value. Parameter t represents a mismatch cost that captures how costly it is for i-agents to use a platform that does not perfectly fit their tastes. A small t value implies a low level of differentiation, thus, high competition intensity. The model assumes both platforms are symmetric and the only difference between them is that they are located (l^k) at the extremes of the interval [0,1]. Given these utility functions, side-i demand for platform k is as follows:

$$n_i^k = \frac{1}{2} + \frac{p_i^k - p_i^{-k} + \beta\left(n_j^k - n_j^{-k}\right)}{2t} \tag{2}$$

Each platform faces this demand and sets prices to maximize profits:

$$max_{p_i^k, p_j^k} \pi^k = \left(p_i^k - c_i\right)n_i^k + \left(p_j^k - c_j\right)n_j^k \tag{3}$$

where c_j is the marginal cost on each side, that we assume zero for simplicity. In this situation, platforms set prices simultaneously and, in equilibrium, prices and profits are:

$$p_i^k = t - \beta_j \tag{4}$$

$$\pi_i^k = t - \frac{\beta_1 + \beta_2}{2} \tag{5}$$

in summary, the Armstrong model formally defines how two platforms, like Uber and Lyft compete, and characterizes the outcome (prices, profits, etc.) as a function of the model parameters (network effects, costs, etc.). Although the model considers only two platforms, and the number of platforms could be higher, it does not influence the central intuitions as the number of platforms has an effect similar to reducing the mismatch costs ("t").

In this paper, we want to understand how adding responsible users transforms platform competition and the equilibrium prices and profits. In the next section, we explain how we modify the Armstrong model to achieve our objective, and then we present and discuss our results.

3. Computational model

Our model follows the specification of the Armstrong model with the addition of a term μ that captures the CSR preferences of platform users. Formally, the user utility function is:

$$u_i^k = v + \mu + \beta_i n_j^k - t\left|y - l^k\right| - p_i^k, i = 1, 2;\ j \neq i \tag{6}$$

in this specification, $\mu = \min\left(\mu_i^k, M\right)$, where M is the CSR preferences ceiling discussed below. The term $\mu_i^k = \frac{CS_i^k}{n_i^k} = \frac{\int^{n_i^k}\left(v + \beta_i n_j^k - t\left|y - l^k\right| - p_i^k\right)\partial y}{n_i^k}$ represents the average welfare generated on the side *i* by the platform *k*. This means that an agent considers the average impact of the platform on the community of agents on its side. For example, in the case of Uber and Lyft, it implies that drivers care about how the platform treats other drivers, and riders care about how the platform treats other riders. All else being equal, agents prefer the platform that creates more surplus for other agents on their side.

Adding the user CSR preferences in the utility function creates a kind of vertical differentiation that is generated by internalizing others' welfare. Note that this model feature creates an additional positive feedback loop that resembles a direct network effect since the larger the surplus on one side, the more value the platform has for that side. However, in contrast with network effects, what drives the CSR preferences is not the number of agents on that side of the market, but the surplus enjoyed by agents on that side. In this situation, a platform faces a trade-off between profiting from current memberships or letting agents enjoy a higher surplus, which increases their willingness to pay. Therefore, a reduction of the membership price has three channels through which influences agents, (a) directly via the price, (b) indirectly via network effects, and (c) indirectly via the increased value due to CSR preferences. This last item is the novelty of our approach, whose influence on how platforms compete in prices is unknown.

3.1. *Definition of the user CSR preferences ceiling*

The user CSR preferences ceiling M is the maximum value that CSR preferences can add to the utility of a user. We assume M is greater or equal to zero, and at the lowest level of this ceiling $M = 0$, users have no CSR preferences, and the model is identical to that of (Armstrong, 2006). Users of a particular side have CSR preferences when $M > 0$, and those users are called responsible users.

As already defined, the user CSR preferences capture how much users care about how the platforms treat other users on the same side of the platform. However, users care about several other platform aspects defined in the utility function. Therefore, the user CSR preferences ceiling is used to ensure that the CSR preferences value does not increase forever. Users care about how platforms treat other users but up to a ceiling. The power of the simulation approach is that it allows us to examine what happens when that ceiling's value is low, medium, high, or no-limit, capturing a variety of real-life market scenarios.

From the perspective of the platform, the ceiling can be interpreted as the maximum attainable improvement in user willingness-to-pay that a platform can achieve through its CSR practices. In this sense, a market with a large ceiling is one in which platforms can significantly affect the user utility via CSR practices. Platform users may positively value platforms doing business with local companies, but increased reputation or willingness to pay may not grow forever. There is a saturation point at which all the benefits of CSR practices are achieved, and further firm efforts may benefit other stakeholders, but they will not increase the user willingness to pay.

3.2. *User demand and platform pricing*

In this symmetric framework, platform-*k* demand on side-*i* is as follows:

$$n_i^k = \frac{1}{2} + \frac{p_i^k - p_i^{-k} + \beta\left(n_j^k - n_j^{-k}\right) + \min\left(\mu_i^k, M\right) - \min\left(\mu_i^{-k}, M\right).}{2t} \tag{7}$$

Note that the demand depends on the CSR preferences. Additionally, demands present cross-network effects, which introduce an additional complexity that makes the model not solvable analytically. Therefore, we adopt a price competition algorithm that simulates the platforms' strategic behavior [84]. The price competition algorithm encompasses an agents' algorithm and a platforms' algorithm, outlined in Fig. 1. The computational model considers the agents' behavioral rules (utility functions), and platforms set fees following a gradient-like pricing rule that takes these behaviors into account. Side 1 and Side 2 agents choose the platform that maximizes their utility functions, and platforms evaluate the impact on their profits of a small change (0.05) in fees. If that change is profitable, they will increase or decrease fees. If not, they will maintain the current fees. Platform profit is the sum of the revenues from Side 1 and Side 2, formally $\pi^k = n_1 * p_1 + n_2 * p_2$. In this setting, platforms behave as fully informed and rational companies that contemporaneously choose the best action to improve their profits. Each run of the price competition algorithm (Fig. 1) is one iteration.

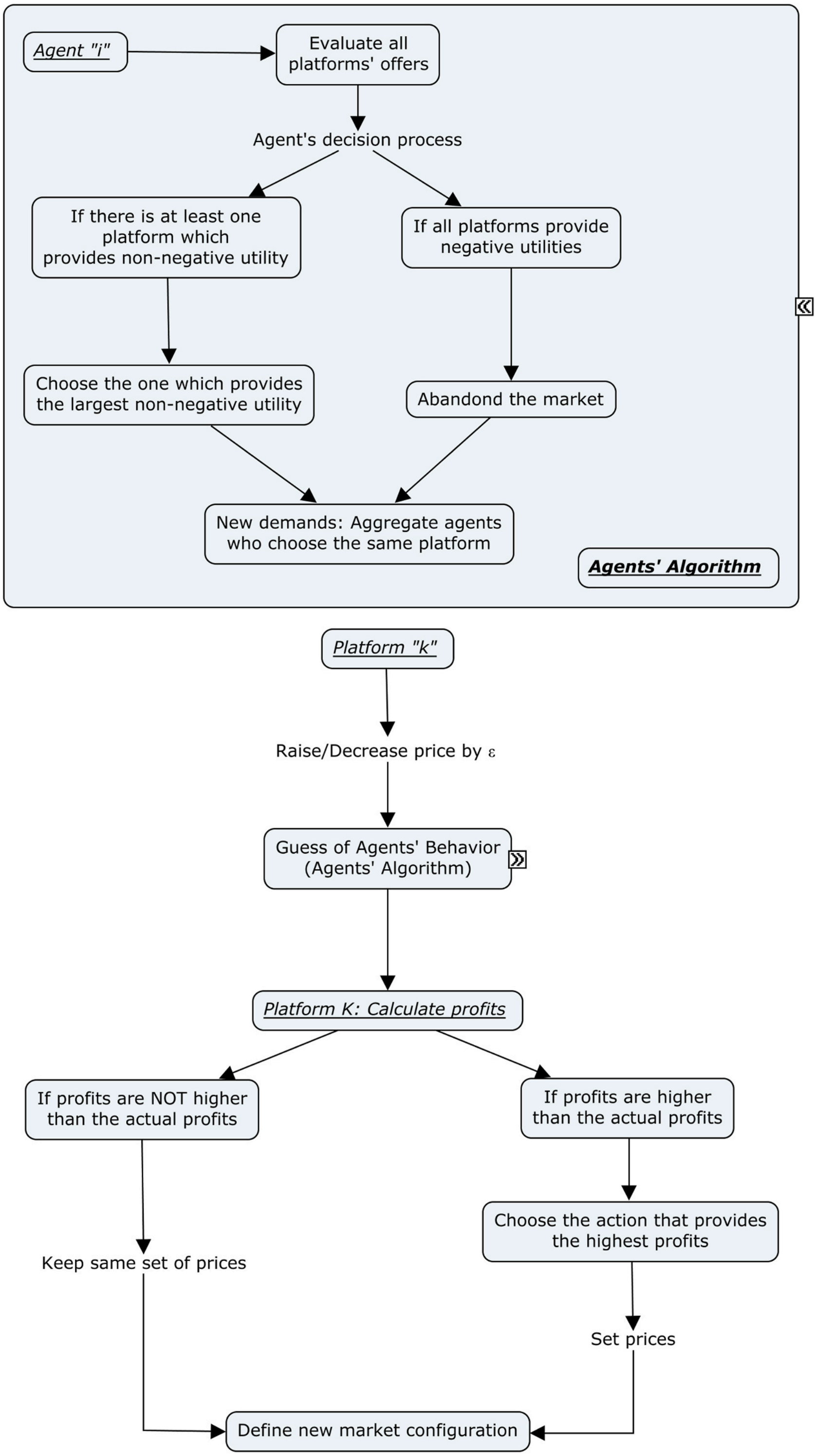

Fig. 1. Decision Processes of users (agents) and platforms.

In all cases, we run the model 400 times, enough to reach a stable equilibrium.

4. Computational experiments

We present the main computational experiments focusing on the effects of user CSR preferences (responsible users) on platform competition. First, we explore the effects of responsible users in a symmetric environment. Then, we explore an asymmetric setting in which only users on one side are responsible. In addition, we examine some model extensions that capture several dimensions of platform heterogeneity. We performed all experiments considering the entire parameter universe and 5 % changes in the three primary parameters (network effect, mismatch cost, and user CSR preferences ceiling). However, our presentation of results focuses only on a subset of cases since many parameter combinations provide similar intuition. Table 1 summarizes the specific parameter values used in the results that follow. The criterion for choosing these values is that they are representative of an area with similar results.

4.1. Responsible users on both sides

The user CSR preferences ceiling reflects the relevance that responsible users can have in influencing the willingness-to-pay or purchase intention. At the lowest ceiling level, users have no CSR preferences, equivalent to the (Armstrong, 2006) model. As we increase the ceiling, responsible users play a more significant role.

In Fig. 2, we depict levels of CSR preferences ceilings in columns and levels of mismatch costs in rows, respectively. In this way, if we move horizontally, we can observe the impact of changing the mismatch cost (the smaller the cost, the higher the competition intensity). If we move vertically, we can observe the impact of changing the user CSR preferences ceiling.

We observe that, in all cases, prices are equal to or lower than the Armstrong model prices (theoretical prices). This result highlights that CSR creates additional competitive pressure that keeps prices low. As platforms create CSR value that is captured by users, their utility increases and attracts more users, whose utility is also increased due to network effects and the surplus created by the extra interactions. As long as these effects are present, a price cut has a greater impact than in the Armstrong model. In other words, the presence of responsible users is pro-competitive.

Fig. 2 shows that the higher the CSR ceiling, the more intense the competition, while the higher the mismatch cost, the less intense the competition (theoretical prices are higher). In this regard, separating mismatch costs and CSR effects is beneficial because the two effects may co-occur, which also may explain some of the conflicting results in the empirical literature. For example, many firms announce their CSR projects or initiatives as marketing campaigns. These actions have a dual effect, creating a point of differentiation from competitors and, for some users, increasing their willingness to pay due to CSR preferences. However, CSR preferences call for price reductions, while mismatch costs call for price increases. The interest of firms in simultaneously generating both effects is because the greater willingness to pay generated by CSR preferences leads to fiercer competition, which reduces prices. However, by increasing mismatch costs, platforms can isolate competitors and benefit from the increased willingness to pay.

Another effect to consider is what happens when we reach the CSR ceiling (i.e., when the benefits of CSR for users disappear). Fig. 3 shows that when the ceiling is reached, the market loses the pro-competitive effect, and prices tend to rise. Nonetheless, they remain at or below theoretical levels. Note that, in Fig. 3, prices are declining or jumping quickly to a plateau. This jump is the effect of reaching the ceiling, which forces prices to converge to theoretical prices. More subtle is the simultaneous effect on welfare, which shows a kink at the same time that this price jump occurs. This is a reflection of the CSR preference ceiling, which limits the welfare that can be created in that market from that moment on. Therefore, once CSR preferences are satisfied or platforms cannot do better, the pro-competitive effects of responsible users disappear. They only last as long as the possibility of beating the competitor remains.

Fig. 3 shows two more interesting effects related to responsible users. On the one hand, as we increase the CSR ceiling, there is an increase in the welfare that is captured by both sides (see the first row, for instance). On the other hand, the larger the network effects, the more value the users can capture (see the first column). The latter effect contributes more to the creation of welfare, but the ceiling has a crucial role. For example, the first row shows that the platforms keep lower prices longer as we increase the ceiling. However, when we reach the ceiling, the welfare growth decreases, and platforms have the incentive to raise prices (bottom-right graph). Moreover, this situation becomes more evident in cases with ceilings going from medium to high. Therefore, combined with other

Table 1
Parameter values and scenarios.

Parameter & scenario		Values
Network effects	No Network	$\beta = 0$
	Low	$\beta = 0.25$
	Medium	$\beta = 0.5$
Mismatch Cost	Low	$t = 0.25$
	Medium	$t = 0.5$
	High	$t = 0.75$
	Maximum	$t = 1$
User CSR Preferences Ceiling	Low	$M = 0$
	Medium	$M = 50$
	High	$M = 100$
	No Limit	$M = 500$

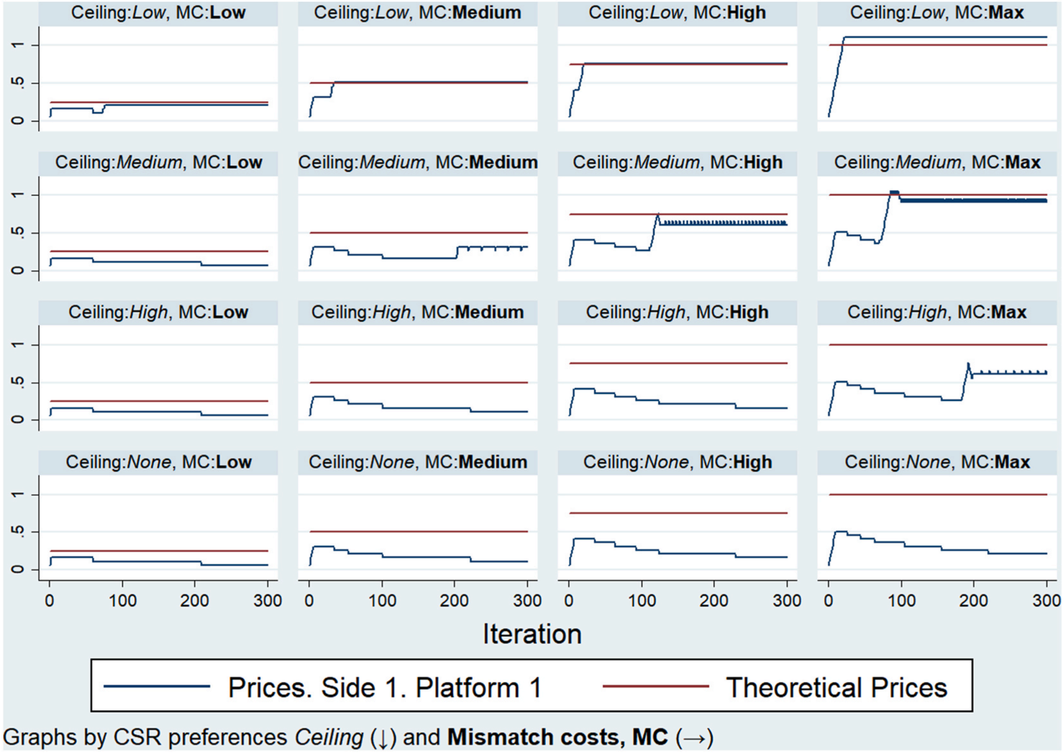

Fig. 2. Each panel shows prices with (blue) and without (red) CSR preferences for a combination of CSR preference ceiling and mismatch cost (represented by "Ceiling" and "MC") in a representative case ($\beta = 0$).

factors such as network effects, the CSR preferences ceiling (i.e., the saturation point of CSR preferences) can create the pro-competitive force described in the previous figures.

4.2. Responsible users on one side only

Platform sides may perceive the platform differently concerning CSR. For instance, in e-marketplaces, consumers may be willing to pay more if platforms support their communities, while sellers may be indifferent. To capture those situations, we run experiments in a market where only one side has responsible users or CSR preferences ($M > 0$) while the other follows the benchmark utility function and has no responsible users (Armstrong, 2006).

Fig. 4 compares the platform prices for Side 1 and Side 2. We observe that the effect of responsible users on how platforms set prices increases as mismatch costs and the CSR preference ceiling grow. Interestingly, despite the interrelationship between the sides, if only one side has responsible users, it does not influence the prices on the other side. This result indicates that CSR preferences are an endogenous quality parameter whose effect resembles a direct network effect. However, CSR preferences are self-reinforcing, which means that platforms must consider how their actions affect users and how users value the effect of those actions on their peers. More importantly, the effects of internalizing CSR preferences do not show spillover effects on the other side, like network effects. That implies that CSR activities may be limited in scope, which would explain why some studies have found no relationship between CSR activities and company performance, since such effects may be limited to a specific market with no spillover effects to others. This result also means that platforms only modify their behavior on the side with responsible users, everything else being equal.

Fig. 5 compares the platform profits with responsible users on only one side (asymmetric) and both sides (symmetric). We see that profits do not differ significantly. That result suggests that platforms internalize the asymmetries between the sides and set different prices for each side. The new price structure accommodates the asymmetry between the sides without eroding platform profits, which would explain the absence of relationship between CSR and performance in some works. This finding is further illustrated in Fig. 6, which compares platform profit from each side. When only one side has responsible users, this asymmetry affects the profit structure. In particular, the platform subsidizes the responsible users (side with CSR preferences) and profits from the other side.

5. Model extensions

In this section, we modify the original framework to address how robust the above insights are. We consider a setting where one platform has captive users (a small fraction of users consume the platform no matter what the competitor offers, which aims to represent incumbency, focality or dominant positions), alternative specifications of user CSR preferences (which aims to represent the

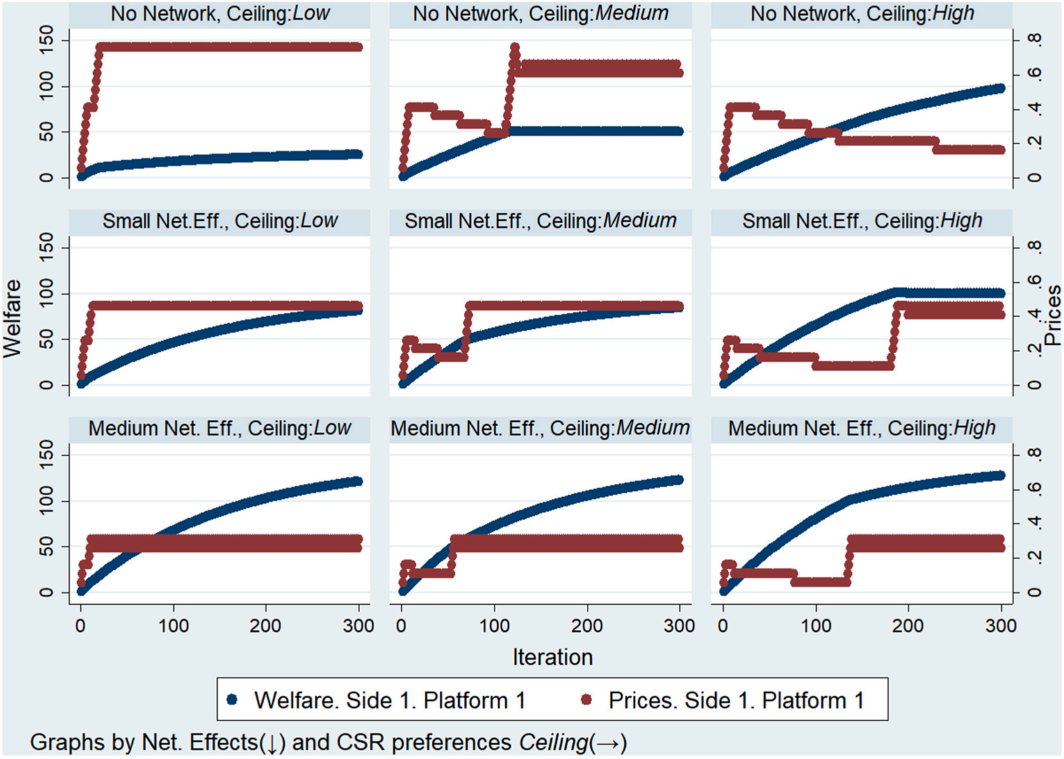

Fig. 3. User welfare and platform prices (Side 1 of Platform 1 is shown). Each panel represents a combination of network effects (β) and CSR preference ceiling (M).

possibility that users on one side may care about the welfare of different types of users), and asymmetric network effects (that represents cases in which riders care more about the number of drivers on the platform than the other way around, for example).

5.1. One platform has captive users

Since the presence of responsible users is pro-competitive, could other factors encourage firms to internalize CSR preferences? We consider that one platform has an advantage, such as captive users. In particular, 25 % of users on both sides will always choose platform 1 if it provides positive utility.

In such a setting, winner-takes-all becomes a typical outcome, as platform 1 captures the entire market. Fig. 7 depicts the market share of each platform. We observe that platform 1 market share is, on average, 90 % across all simulations, and in most cases, platform 1 captures the entire market. In contrast, without responsible users, such a result is unlikely and requires strong assumptions about the model parameters. That winner-take-all result highlights why it is in the interest of platforms to consider CSR. A firm with an advantage can capture the whole market if competitors cannot keep up. This result provides an alternative hypothesis to the empirical evidence highlighting a positive relationship between CSR and performance, since CSR could be used to improve previous advantages.

A straightforward extension of this analysis is to consider that users have different CSR preference ceilings depending on the platform. In this situation, the result is the same as described above. Any advantage that any platform may have that allows it to hold some users captive, whether by positioning, market structure, or internalization of preferences, facilitates a winner-take-all equilibrium.

5.2. Alternative user CSR preferences

In previous sections, we assumed that each side considers the average impact of the platform on the community of users of its side. For example, in the case of Uber and Lyft, this assumption implies that drivers care about how the platforms treat other drivers, and similarly for riders. However, it is also possible that some riders are concerned about how fairly the drivers are treated and thus show a greater willingness to pay when the platform proves fair treatment. In this section, we consider three cases that address this possibility. Formally, each case involves changes in how the user utility of platforms is determined. Table 2 summarizes the three new cases.

All previous intuitions hold in these three new cases. Moreover, we find no difference in how platforms set prices regardless of how CSR preferences are generated. Comparing Figs. 3 and 8, we see only minor differences that do not alter the intuitions. These results highlight that the presence of responsible users matters and not how the CSR preferences are generated.

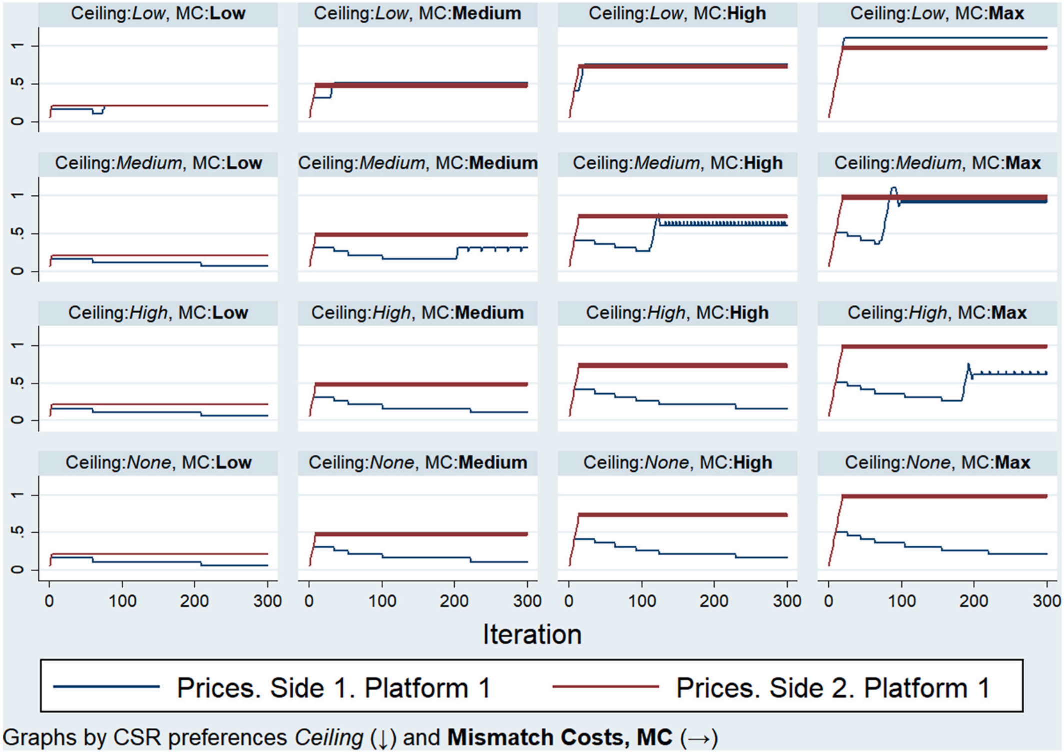

Fig. 4. Each panel shows the comparison of Platform 1 prices for Side 1 and 2 for different combinations of CSR preference ceiling, M, and mismatch cost, t (represented by "Ceiling" and "MC").

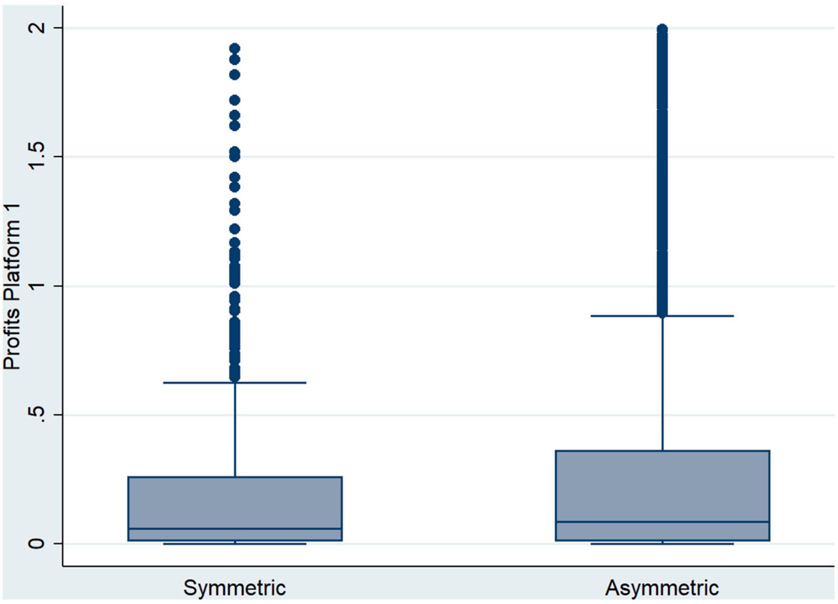

Fig. 5. Comparison of platform profits (symmetric vs. asymmetric CSR preferences case).

Nonetheless, the last result is likely influenced by two features of our theoretical framework. First, the theoretical model is symmetric, and even if we consider differences in how agents react, platforms react symmetrically. Second, network effects imply that even if there are differences in how CSR preferences are formed, riders consider the number of drivers on a platform and vice versa. Therefore, if riders only care about riders' welfare, they still care about the number of drivers on the platform and vice versa. This link

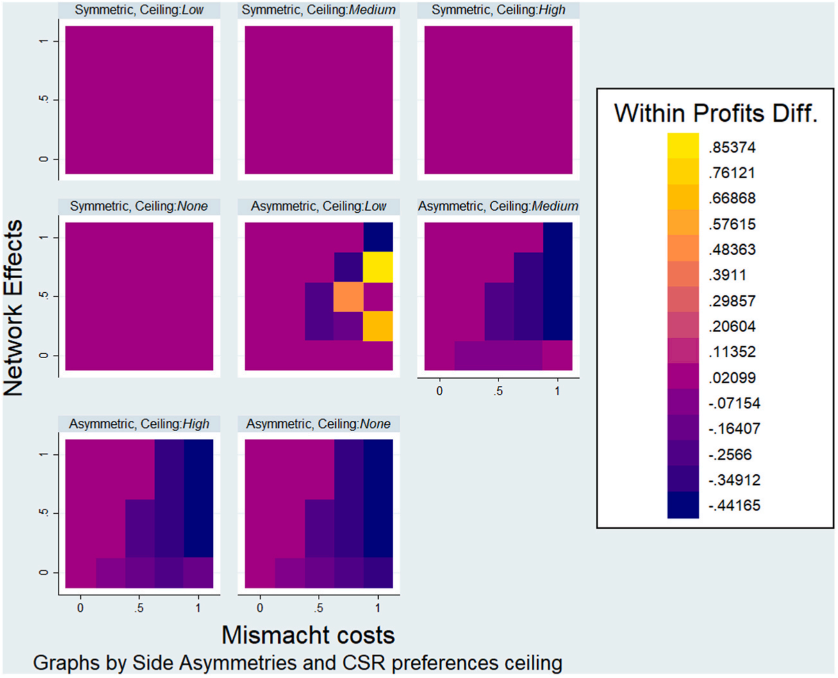

Fig. 6. Platform profit from each side. Each panel shows a combination of symmetric or asymmetric sides and CSR preference ceiling (represented by Symmetric/Asymmetric and "Ceiling").

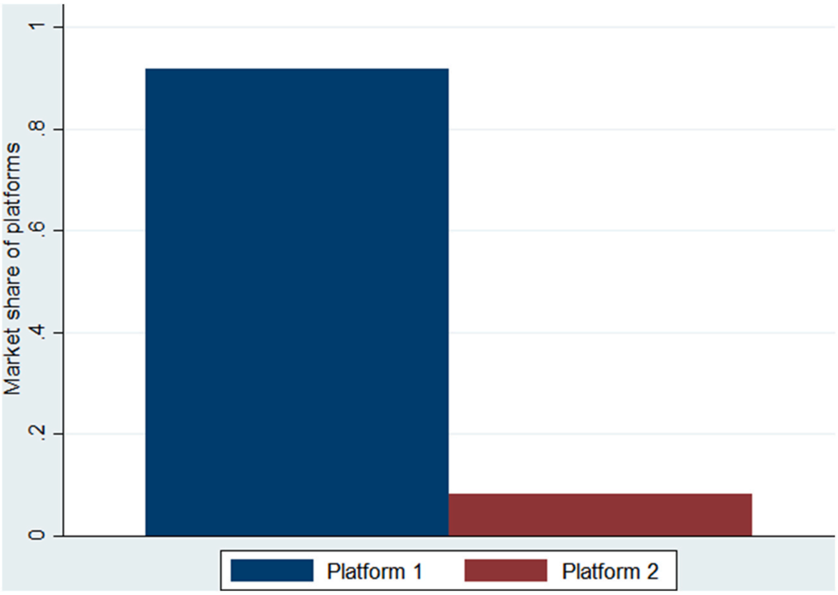

Fig. 7. Market share of platforms when platform 1 starts with 25 % of the market as captive.

Table 2
Alternative user CSR preferences specifications.

Alternative user CSR preferences μ	Intuition (Ride-sharing platform, e.g. Uber)
Users consider the average impact of the platform on the community on the *opposite* side	Riders care about drivers only
Users consider the average impact of the platform on the community on all sides	Riders care about riders and drivers
Users consider the average impact of the platform on all sides, but agents on the other side only care about their community.	Riders care about riders and drivers, but drivers care about drivers only

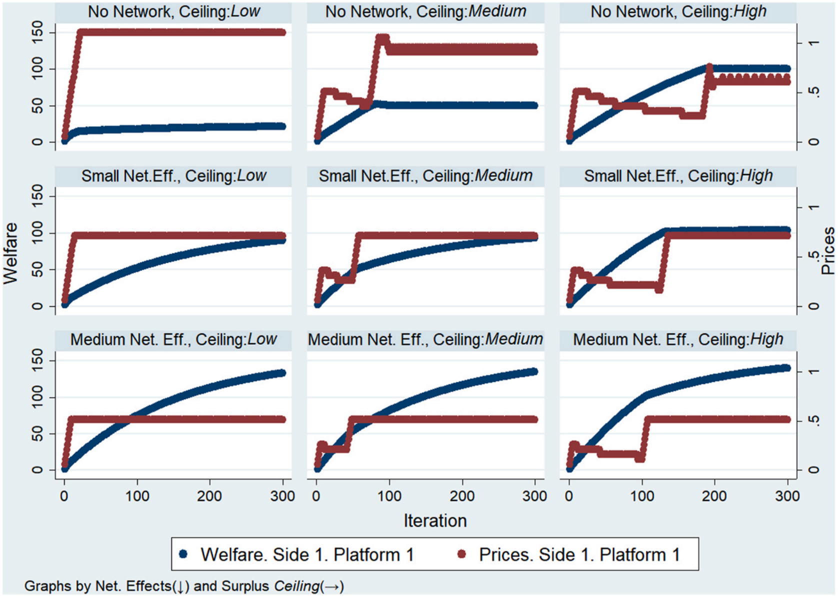

Fig. 8. Welfare and prices with cross-side CSR preferences. Each panel represents a combination of network effects (β) and CSR preference ceiling (M).

between the sides makes it easier for each side to internalize the preferences of the others. Therefore, including cross-side CSR preferences leads to a complex relationship of interlinked effects but does not dramatically alter the results.

Note that the influence of alternative CSR preferences is limited to speeding up the welfare creation process on each side, as illustrated when comparing Figs. 3–8. In this sense, the effects of CSR on prices or competition do not change, only the speed with which these effects trigger changes.

In summary, regardless of how user CSR preferences are formed, they are a pro-competitive force that reduces prices and profits while benefiting users. Therefore, as more platforms adopt CSR practices, competition is expected to increase and benefit consumers. However, we must also be careful as one platform may capture the entire market and raise prices, eroding the positive effects on consumers.

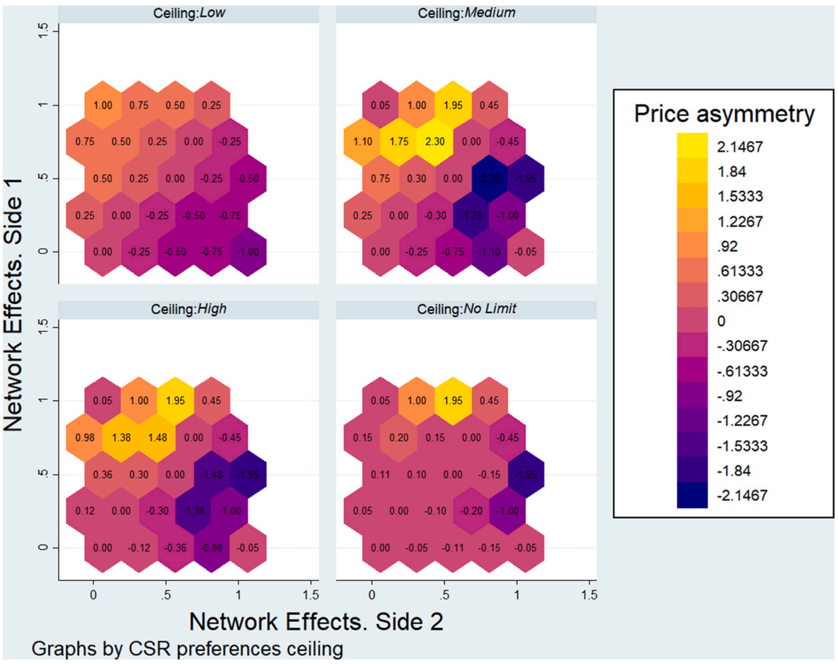

Fig. 9. Asymmetry between Side 1 and Side 2 prices. Each panel depicts a different CSR preference ceiling, M (Low, Medium, High, or no limit).

5.3. Asymmetric network effects

A common feature of digital platforms is that some users value the presence of others differently. For example, during a storm, riders may care more about available drivers than the other way around. Asymmetric network effects matter as platforms tend to subsidize one side and profit from the other, setting an asymmetric price structure. Since CSR preferences are pro-competitive, how do they affect the platform price structure in the presence of asymmetric network effects?

We find that the price structure asymmetry can increase or decrease depending on the strength of the network effects and the user CSR preferences ceiling. In the upper left case of Fig. 9, we have the original price asymmetry of the Armstrong model. In this case, the maximum asymmetry is one. However, in the rest of the cases, we observe that asymmetries can reach 2.3, which occurs in intermediate asymmetry cases. If the ceiling is medium, the price asymmetry becomes extreme for intermediate levels of network effect asymmetries. Platforms compete fiercely for the more valuable side, and CSR's pro-competitive nature reinforces the price asymmetry.

However, once we raise the ceiling, the price asymmetries are mitigated because platforms compete fiercely on both sides because of the pro-competitive effect of responsible users. Although price asymmetries still exist, they are not as extreme. In this situation, it is possible that the presence of responsible users can offset the influence of network effects. For example, when there is no ceiling and network effects are extreme on one side and non-existent on the other, the price asymmetry disappears because CSR preferences eventually become stronger than network effects.

From a managerial perspective, these results show that the internalization of CSR preferences creates feedback loops that can rival network effects. Therefore, it is crucial to recognize which is stronger for users, their CSR preferences, or the value of others in the network. The platform price structure depends on which effect is stronger as well as the impact on platform performance.

6. Discussion

We discuss theoretical and managerial implications and opportunities for future research.

6.1. Theoretical implications

The main contribution of this article is to model and analyze the impact of user CSR preferences (responsible users) on platform competition. Traditionally, platform competition models have remained agnostic about the role of CSR despite its increasing role in business. Our work shows that CSR can be a pro-competitive force that reduces prices and increases consumer surplus. The presence of responsible users translates into fiercer platform competition for those users.

Our main finding contrasts with the conventional observation that CSR actions could lead to higher prices. However, our work shows that such actions can be understood as two elements that offset each other: mismatch costs and CSR preferences. The former drives differentiation that softens competition, while the latter strengthens competition. The interaction between these two forces is the key to understanding why CSR can sometimes become a competitive advantage.

We also address how asymmetries between sides may affect competition. When each side values CSR differently, we find that platforms tend to reduce prices on the side that value CSR the most. This result highlights that the nature of CSR resembles a direct network effect or an endogenous quality parameter. A priori, we find that its impact is limited to altering the price structure (which side pays higher prices). This result highlights that the management of responsible users requires a differentiated treatment. CSR preferences are self-reinforcing and do not spill over to other sides in contrast to network effects. However, CSR preferences take into account what others do as network effects. These similarities and differences are key to understanding why CSR preferences should be studied differently from network effects and perceptions of quality.

Our work highlights that internalizing CSR preferences can erode profits by increasing competition. Nonetheless, we find that the pro-competitive effects can disappear once the CSR preference ceiling is reached. Moreover, our research finds that winner-take-all dynamics become common when one platform has an advantage over its competitors. Therefore, despite the pro-competitive nature of CSR, when firms are symmetric, heterogeneous platforms are likely to use it to conquer the market or as a barrier to entry.

Two additional model extensions consider alternative CSR preferences and asymmetric network effects. We find that our results are robust to the inclusion of other specifications of CSR preferences that include when one side cares about the welfare of other sides or when one side cares about the welfare of all sides. In all these cases, our central intuitions hold. Thus, the main lesson is that for price competition, it matters how users express their CSR preferences when purchasing, but it does not matter how they are generated. When we consider that some users value the presence of others differently, we find that CSR preferences can incentivize the price asymmetry, but the opposite is also likely. In particular, if there is scope for value creation through CSR activities, CSR preferences will likely outweigh the influence of network effects.

Methodologically, this article demonstrates the value of agent-based computational modeling [85–87] in understanding platforms as complex systems that give rise to complex competitive dynamics when CSR issues are considered. Future research could benefit from a broader adoption of simulation research and a complex systems approach [88–90].

6.2. Managerial implications

Our paper proposes a novel way to extend the platform competition literature by explicitly considering responsible users, those who have CSR preferences. A critical insight for platform managers is that they should carefully consider user CSR preferences on each side served by the platform. User CSR preferences intensify competition and lower firm profits. However, if one platform starts with an advantage, such as captive users, then winner-take-all outcomes are likely benefiting the platform with the initial advantage.

Managers should also consider the interaction between user CSR preferences and differentiation due to mismatch costs. A key finding of this work is that the platform's success depends on actively addressing CSR preferences and increasing differentiation from competitors. If platforms fail to do both, the increased willingness to pay created by CSR preferences may force platforms to compete fiercely. In this regard, a key recommendation for managers is to plan CSR strategies to address responsible users but isolate the competitor's influence. If enough differentiation is achieved, it can be a tipping factor in favor of platforms that embrace it. Thus, CSR provides an opportunity for competitive advantage but makes a platform vulnerable to winner-take-all dynamics. Therefore, managers should be aware of those complex dynamics and exercise caution. For specific numerical examples, we refer to the results section.

For platform users, one insight is that users have the power to determine competition outcomes as long as they express their preferences when making their platform participation decisions. Responsible use of platforms is not only about what a user does on a platform but also about what platform the user decides to join in the very first place. It is up to the responsible users to realize and use this power to stir platforms to more desirable competition outcomes. When a social media platform, for instance, causes harm to the community, responsible users should not participate in this platform. Users must act upon their preferences, not just talk about them or complain. In that case, platforms will respond to user preferences, and competition will lead to more socially desirable outcomes.

6.3. Limitations and future research

Our model is based on (Armstrong, 2006), which implies that the market is covered (all agents participate) and platforms are symmetric. Although we introduce some asymmetries, these are limited to what this model allows us to do. In this sense, future work could consider other frameworks that allow for growing markets and richer asymmetric environments. Another limitation of our analysis is that the platforms decide only on the level of participation fees. Future research needs to study the effects of other platform decisions, such as CSR-related positioning or investments and variations of platform competition, including competition in multiple dimensions or markets. Future work could also consider other variables influencing user CSR preferences. So far, we only consider agents that participate in the market (platforms and users), but non-market participants can be affected as well. For example, people who do not use social networks are indirectly affected by the spread of misinformation. Taking these effects into account is challenging, but raises an interesting field for future research. Modeling the CSR preferences of other stakeholders, such as platform complementors or local communities, could also add to our understanding of socially responsible digital platforms. Overall, the social responsibility of digital platforms is a vast and complex topic, and many theoretical and empirical studies will be needed to clarify all the dimensions, implications, and policy interventions.

7. Conclusion

This article proposes a computational model incorporating responsible users into a mainstream platform competition model. By integrating user CSR preferences into platform competition, the article contributes to platform competition literature and CSR literature. It shows that user CSR preferences matter and have significant implications for platform competition. It also shows how mismatch costs and network effects interact with user CSR preferences to determine competitive dynamics. Lastly, we offer practical implications for responsible users and platforms and identify future research directions.

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article and all the material to reproduce the results is explicitly mentioned.

CRediT authorship contribution statement

Evangelos Katsamakas: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **J. Manuel Sanchez-Cartas:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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