# Should Gig Platforms Decentralize Dispute Resolution?

**(Authors' names blinded for peer review)**

Online labor platforms provide freelancers the opportunity to work for clients on a project basis. However, disputes can occur as a result of the platform users' attempts to game the system, disagreement on the work quality or uncertainty of the quality outcomes. Traditionally, the dispute would then have to be mediated by the platform's dispute team, which is often viewed to be unhelpful or biased. However, there are emerging platforms that promise to resolve the dispute with a novel tribunal system and relegate dispute resolution to individual platform users through a voting mechanism. We are interested in examining the dispute resolution models used by both the traditional online platforms (i.e., the centralized dispute system) and the emerging online platforms (i.e., the decentralized dispute system). Our results suggest that the decentralized dispute system outperforms the centralized dispute system when the freelancer's skill level is sufficiently high, the client's quality standard is lower, or the task is associated with a lower degree of quality uncertainty. Thus, gig platforms should consider switching to the decentralized dispute system only if they are able to attest to the freelancers' skill level, or they cater to less strict clients or more standardized tasks. Moreover, the decentralized dispute system can be more appealing to policy makers because it can induce a more socially optimal quality level of the freelancer. In addition, we also find that the platform can further improve its revenue under the decentralized dispute system by charging dispute fees to both the freelancer and the client when the freelancer's skill level is moderately high.

*Key words*: gig economy, dispute management, quality contracting, online labor platforms, voting games, global games

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## 1. Introduction

Online labor platforms have grown tremendously over the years. Katz and Krueger (2019) found that the online labor platforms account for more than 90% of the net employment growth in the United States between 2005 and 2015. Some of the works hosted by the online labor platforms include: web design and marketing (e.g., Fiverr, Upwork and Freelancer.com), home services (e.g., TaskRabbit), micro "human intelligence tasks" such as image tagging and surveys (e.g., Amazon MTurk), and personal assistance for daily or ad-hoc needs (e.g., Fancy Hands). These online labor platforms are part of the larger "gig economy", where they utilize the idle time resource of the workers (freelancers) to contribute their expertise and give them opportunities to work. Freelancers often can work remotely and in their own free time. Therefore, it can be argued that such a model increases flexibility for businesses and enables connections between the most suitable work and the available freelancers. The recent COVID-19 pandemic has also driven 47% more employers to hire

freelancers from online labor platforms, as employers strive to adapt to remote work and find more flexible workers to match the changing business landscapes (Upwork 2020).

However, this ease of connections between clients and freelancers is not without any drawbacks. The lack of face-to-face interaction has brought about new challenges. Some of the common complaints in online labor platforms include: the gaming behavior of the platform users, the disagreement over the task assessment, and the uncertainty in the task outcomes. Hence, disputes can be a common occurrence in online labor platforms.[1] The resolution of these disputes normally rests upon the platforms as they take on the role of an arbiter.[2] Although the platform retains more decision-making power in this case, its arbitration may be biased towards a particular side due to a conflict of interest. We term such a dispute resolution method as the "centralized dispute system".

Moreover, there are also concerns about the quality of the freelancers' work as the skill level of the freelancers can be lower than the professional employees, and the majority of the online labor platforms do not have stringent screening processes. Due to the lack of quality assurance on the freelancer's work, online labor platforms typically draft clauses that allow the client to reject payment to the freelancer after the freelancer has completed the work. Such clauses can be found in most online labor platforms such as MTurk and Freelancer.com (Aloisi 2016). However, this leads to a potential contention for payment disputes as it may give clients a gaming incentive to free ride on the freelancer's work without paying for it.

Because of the doubts on the platform's arbitration on the disputes, there are emerging start-ups, such as Blocklancer, Origin, Coinlancer and Ethearnal, which promise to ensure fairer settlements for dispute cases with a novel tribunal system. These emerging platforms propose having a tribunal to decide on the disputes between clients and freelancers. Members of these new platforms will be allowed to participate in the tribunal to assess and vote on the dispute case. In the event of a dispute, a tribunal will be formed and the side which has the majority vote will win the dispute case. As such, the platform outsources dispute arbitration to the tribunal and crowdsources justice from its diverse members. Such emerging platforms believe that the majority rule is able to determine the "true" outcome more accurately (Blocklancer 2018). This is based on the idea that "diversity trumps ability" as declared by Hong and Page (2004) and validated experimentally by Krause et al. (2011). We term such a dispute resolution method as the "decentralized dispute system".

[1] See DeVault et al. (2019) for the common disputes and grievances in gig work. Other online platforms such as ecommerce platforms also report many disputes between the sellers and buyers. For example, Taobao handled about 2000 disputes per day in 2012 (Erickson 2014).

[2] Aloisi (2016) find that platform users usually are required to sign binding contracts that have pre-dispute arbitration clauses that reduce or exclude the likelihood of litigation, and the platform is usually the arbiter of the contract if any dispute arises. Even if the platform is not the arbiter, it can select an arbitrator which tends to act in its interest (Egan et al. 2021).

While the concept of "decentralized dispute system" once existed (e.g., the ecommerce giant eBay had previously adopted the "eBay Community Court" in 2007–2012), the lack of a more viable technology had limited the platform's ability to harness the masses to vote. Furthermore, an effective mechanism to incentivize participation of voters was not in place, and people were encouraged to participate on a voluntary basis solely for a sense of community contribution (van den Herik and Dimov 2012). To resolve these issues, the emerging platforms have utilized new technologies to operate the decentralized dispute system. Platform users are now incentivized to participate in the tribunal as they will earn a monetary reward if they have voted for the winning side of the dispute. Furthermore, these platforms randomly assign voters to individual dispute cases, so that the platform users who intend to participate in the tribunal do not know apriori which dispute case they will be assigned to. This helps minimize the possibility of voters colluding and ensures the fairness of the voting outcome. However, the monetary reward based on winning may also induce the voters to vote strategically in order to win rather than for justice. Thus, it is not clear whether strategic voting can effectively incentivize the quality improvement of the freelancer.

To assess whether such emerging platforms do have the advantage over traditional online labor platforms, we model and compare both the centralized and decentralized dispute systems. As such, we aim to answer the following research questions. First, when can the decentralized dispute system be more profitable for the platform, and why? Second, does the decentralized dispute system induce the freelancer to choose a quality level that is more socially optimal? Third, how should platforms adjust the fee structure when they switch to the decentralized dispute system?

We model a platform that facilitates the transaction between a client and a freelancer. The client offers a contract price to the freelancer and the freelancer decides on the quality of work. Upon receiving the work, the client has the right to reject payment to the freelancer, in which case the freelancer can initiate a dispute by paying the dispute fee to the platform. If the centralized dispute system is adopted, the dispute outcome will be determined by the platform. If the decentralized dispute system is adopted, a tribunal consisting of independent platform users will be formed to vote on the dispute case. Each member of the tribunal deposits a participation fee and those who have voted for the winning side will share the total deposits. Thus, each member votes strategically by taking into account the chance of winning, which we model using the global games framework. If the freelancer wins the dispute so that the client would have to pay the freelancer, or if the client accepts the freelancer's work in the first place, the platform extracts a percentage commission from the transaction price. Thus, the platform can earn revenues from two sources: 1) extracting commissions, and 2) charging dispute fees.

We find that under the centralized dispute system, the platform's conflict of interest in dispute resolution will result in a bias of ruling in favor of the freelancer. Because the platform will earn

the commission if the freelancer wins the dispute, it will set a lower quality standard to increase the winning probability of the freelancer. As a result, the freelancer is less incentivized to improve quality and the client is unwilling to offer a higher contract price. Under the decentralized dispute system, even though the members of the tribunal can vote strategically due to their interest to earn the monetary reward if they vote for the winning side, we find that as long as the voters are prevented from communicating with each other, the diversity of the voter pool can ensure a voting equilibrium such that a freelancer with a higher quality level will stand a higher chance of winning the dispute. More importantly, the tribunal's voting equilibrium eliminates the platform's bias under centralized decision making and results in a more stringent quality standard. Thus, to achieve the same winning probability, the freelancer will need to incur more cost to raise the quality level.

Given this key impact of decentralizing the dispute resolution, we characterize when a platform should use the decentralized dispute system, depending on the features of the freelancer, the client, and the task. First, we find that the decentralized dispute system is more profitable as long as the freelancer's skill level is sufficiently high. If the freelancer is sufficiently skilled to meet the higher quality standard under the decentralized dispute system, the client will be willing to offer a higher contract price and the platform will be able to extract more commissions. Furthermore, because dispute is less likely to occur with higher-skilled freelancers, the platform is less likely to earn the dispute fee and its revenue is primarily driven by the commissions. Thus, the decentralized dispute system is preferred in this case. By contrast, if the freelancer's skill level is insufficient, dispute is more likely to occur and the platform's revenue is more dependent the dispute fee. In this case, the higher quality standard under the decentralized dispute system will reduce the freelancer's willingness to pay for the dispute fee and make it more difficult for the freelancer to participate. Nevertheless, the centralized dispute system allows the platform to rule in favor of the freelancer. Thus, the freelancer is willing to pay a higher dispute fee, and the platform can better incentivize the participation of lower-skilled freelancers, who will be weeded out under the decentralized dispute system. Thus, the centralized dispute system is preferred in this case.

Besides accounting for the skill level of the freelancer, the platform may want to retain its control of the dispute resolution if the client is more likely to undervalue the freelancer's work. A stricter client would increase the likelihood of dispute and make it more difficult for lower-skilled freelancers to participate. Nevertheless, the centralized dispute system allows the platform to adapt to a lower quality standard and induce more lower-skilled freelancers to participate. Moreover, the platform should also be cautious about the nature of the tasks they cater to. We find that for the decentralized dispute system to outperform the centralized dispute system, the task cannot be associated with a high degree of uncertainty in the quality outcome. The task uncertainty can

further magnify the risk that a freelancer is exposed to. Nevertheless, under the centralized dispute system, the platform's bias in dispute resolution can protect the lower-skilled freelancer from the task uncertainty and improve freelancer participation. Our findings bear important implications for platforms. First, in order to reap the benefit from the decentralized dispute system, platforms needs to ensure the skill level of the freelancer pool (e.g., by using screening or certification, or providing training programs). Second, the decentralized dispute system is more likely to work well with standardized tasks (e.g., home services) where the task assessment is less uncertain rather than creative tasks (e.g., design work).

Our analysis also sheds light on how a platform should adjust its dispute fee structure when the decentralized dispute system is adopted. We find that the platform can further improve its revenue under the decentralized dispute system by charging dispute fees to both the freelancer and the client. In this case, if the freelancer initiates the dispute by paying the dispute fee, the client will automatically lose the dispute case if she does not follow up by also paying the dispute fee. This helps to reduce the incidence of disputes as the client will find it more costly to game the system by rejecting the freelancer's work on purpose. We further find that the platform should adopt such a double-sided dispute fee structure along with the decentralized dispute system when the freelancer's skill level is moderately high.

Furthermore, as the platform's bias limits the freelancer's incentive to improve quality, the freelancer chooses a quality level that deviates further away from the socially optimal level. This would lead to a loss of social welfare. By contrast, under the decentralized dispute system, the voting mechanism of the tribunal eliminates the platform's decision-making bias, and the freelancer is compelled to improve quality. Thus, the decentralized dispute system can give rise to a more socially optimal quality level. In addition, by relegating more decision-making power to the public, the platform is behaving more like a social planner. This could help resolve the criticism of online labor platforms not being a "true" sharing economy and create a long-term positive reputational effect for such platforms.

## 2. Literature Review

Our paper falls within the recent stream of literature on platform operations (see Benjaafar and Hu (2020), Chen et al. (2020b) and Hu (2021) for extensive lists of references related to platform operations). A number of papers have studied the optimal wage strategies of on-demand service platforms. Cachon et al. (2017), Guda and Subramanian (2019) and Hu et al. (2021) examine the influence of surge pricing on such platforms. Taylor (2018) studies the impact of delay sensitivity on the platform's optimal wages and prices. Bai et al. (2019) find that the ratio of wage to price should be higher during high demand periods. Hu and Zhou (2019) examine how the fixed commission contract affects a platform's revenue under various supply and demand conditions. Chen

et al. (2020a) study how competing platforms' bonus strategies can interact with their commission payment and impact their equilibrium profit and social welfare. Benjaafar et al. (2020) study the welfare of clients and freelancers under different wage schemes and regulations. Benjaafar et al. (2019) study a peer-to-peer product sharing platform's optimal rental price as well as the product ownership decisions of individuals with varying usage levels. In these papers, a common assumption is that the platform sets the wages for the freelancers. Our setting differs from these papers as in our model, the price is determined by a contracting process between the client and the freelancer, which is typical for online labor platforms.

There are papers in the economics literature that consider settings where the transaction price is determined by individual users rather than the platform (e.g. Caillaud and Jullien 2003, Hagiu 2006, Romanyuk and Smolin 2019, and Karle et al. 2020). However, we study a different issue of online labor platforms, which is the operational design of the dispute system. Furthermore, as the relationship between the client and the freelancer is different through the online labor platform as compared to traditional hiring, there are a number of empirical and experimental papers that focus on the user behavior on such platforms. For example, Chen and Horton (2016) find that freelancers on online labor platforms form wage reference points and react negatively when wages are cut, by reducing their outputs. Astashkina et al. (2018) find that the freelancers' flexibility in choosing their tasks can reduce the clients' satisfaction levels due to the presence of freelancer and client heterogeneity. Cullen and Farronato (2020) find that the supply of freelancers is highly elastic and the platform grows faster in cities where the clients and freelancers are located near each other and the tasks are homogeneous. Lin et al. (2018) find that the freelancers' reputation is more important for winning the bids for output-based contracts than those for input-based contracts. Horton (2019) study how displaying the freelancers' capacity to serve on their profiles can help to increase the market surplus of an online labor platform by improving the matching efficiency between the clients and freelancers. Based on an experiment on MTurk, Benson et al. (2020) find that clients with good reputation generally pay higher and have a lower chance of rejecting the payment to the freelancers. Barach et al. (2020) find that platforms can steer the clients towards certain freelancers by offering money-back guarantees or recommendations.

The quality contracting has been extensively studied in the supply chain management literature. This stream of literature typically considers a principal-agent framework and studies mechanisms to incentivize quality improvement of the agent. Such mechanisms include warranty or penalty contract (e.g., Balachandran and Radhakrishnan 2005, and Zhu et al. 2007), cost sharing contract (e.g., Chao et al. 2009), product inspection (e.g., Lee and Li 2018, Dong et al. 2016, and Mu et al. 2016), deferred payment (e.g., Babich and Tang 2012, and Rui and Lai 2015), supply chain traceability (Cui et al. 2020), quality target (e.g., Chen et al. 2017), and observability mechanism

(e.g., Beer and Qi 2021). The operations management literature has also investigated other levers in contracting, such as negotiation (e.g., Feng and Lu 2013, and Feng et al. 2015), two-part tariff (e.g., Hu and Qi 2018), and auction design (e.g., Duenyas et al. 2013, and Beil et al. 2018). In our setting, the contracting between the client and the freelancer is mediated by the platform, and we study dispute resolution as another mechanism to incentivize the freelancer's quality improvement.

Moreover, as the decentralized dispute system that we study for the emerging online labor platforms involves outsourcing the dispute resolution to the tribunal consisting of individual platform users, our setting is also related to the crowdsourcing literature. Terwiesch and Xu (2008) study the usage of tournaments to harness the optimal solution for an innovation contest from a population of independent agents. Körpeoğlu and Cho (2018) find that more entrants in an innovation contest may lead to increased competition, which may cause the entrants to exert higher effort to win the contest. Korpeoglu et al. (2019) study how the duration and award scheme of the innovation contest affect the productivity of the agents. Candoğan et al. (2020) study when the innovation contest organizer and the agents can benefit from the team submissions among agents. Marinesi and Girotra (2013) study the usage of the consumer crowd to gather information for product pricing and development. There are also papers that study crowdfunding (e.g., Belavina et al. 2020, Chakraborty and Swinney 2019a, and Chakraborty and Swinney 2019b), which can be considered as the crowdsourcing of investment. Different from all the above papers, in our decentralized dispute model, the tribunal's voting system crowdsources justice from the public.

To model the voting decisions of the tribunal, we draw references from the literature on voting games. Papers on voting games go as far back as in the 1950s, where Arrow (1951) and May (1952) find that the majority rule is able to treat all voters equally if there are only two candidates. Others study the strategy of voters and find that voters tend to vote strategically in equilibrium (Austen-Smith and Banks 1996, and Myerson 1998). Feddersen and Pesendorfer (1997) study the jury model in which each juror has a private signal of the defendant's guilt. Carlsson and van Damme (1993) and Morris and Shin (2003) study a class of games where players observe noisy signals of the true state, termed as "global games". Building on the framework of global games, Myatt (2007) investigates an electoral setting and shows that a unique threshold equilibrium exists. In operations management, Wang et al. (2020) apply the global games framework to study the interactions among firms under the setting where the regulator considers the proportion of firms that voluntarily adopt the new green technology before deciding on the regulation. In this paper, we apply the global games framework to model the voting outcome of the tribunal under the decentralized dispute system. To the best of our knowledge, our paper is the first to consider the crowdsourcing of justice to resolve dispute in online labor markets and the first to study the operational aspect of dispute management in such markets.

## 3. Model Setup

We consider a platform that facilitates the transaction between a client (her) and a freelancer (him). The platform's revenue consists of two components. First, the platform extracts a commission equal to $\gamma$ fraction of the transaction price, where $\gamma > 0$. In reality, the commission rate of online labor platforms is typically 10–20%. For example, the commission rate is 10% for Freelancer.com, 15% for TaskRabbit, and 20% for Upwork and MTurk. Since the commission rate is mainly governed by the industry norm, platforms have limited flexibility in choosing the commission rate freely. We assume that the commission is paid by the freelancer, i.e., the party who receives the payment.[3] Second, the platform charges a dispute fee $f \geq 0$, which is to be paid by the freelancer if he decides to initiate a dispute. In Section 7.3, we consider an alternative setting where the platform charges the dispute fee to both the freelancer and the client.

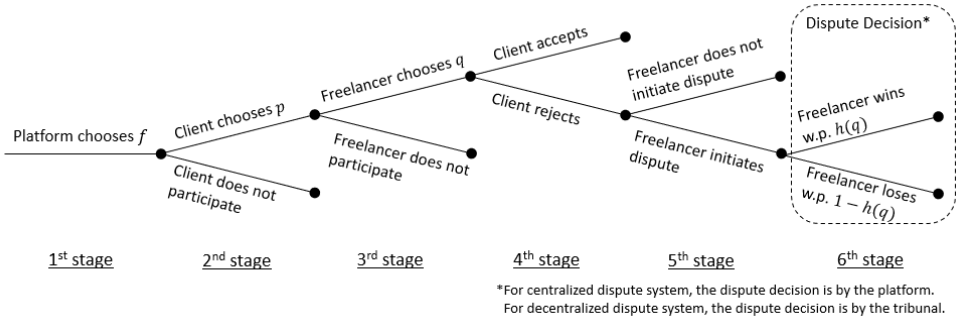


**Figure 1 Sequence of events for an online labor platform**

The sequence of events is depicted in Figure 1. The game starts with the platform first deciding on the dispute fee $f$. Given the platform's dispute fee, the client then offers a contract price $p$ to the freelancer. If the freelancer chooses to participate, he will choose his quality level $q \geq 0$ and deliver his work to the client. The freelancer incurs a convexly increasing effort cost, $\alpha q^2$, where $\alpha$ measures the efficiency of the freelancer (Ha et al. 2016). A freelancer with a smaller $\alpha$ can achieve the same quality at a lower cost, hence his skill level is higher (Banker et al. 1998). For example, a skillful graphic designer may be able to design a logo with ease because he is more familiar with professional software such as Adobe Photoshop, while a less skilled designer may have to familiarize himself with the software before embarking on the project properly, hence incurring a higher cost. We assume that $\alpha$ is public information since it is common practice for online labor platforms to have a reputation system for the freelancers, and a freelancer's skill level can be approximated

[3] Note that in reality, while it is common for platforms to charge the commission fee to the freelancer (e.g., Upwork and Freelancer.com), there are also platforms that charge the commission fee to the client (e.g., TaskRabbit and MTurk). It is easy to verify that our main insights carry through if we alternatively assume the commission is paid by the client because the client can adjust the price accordingly and transfer the commission to the freelancer.

by his rating and historical reviews (Jin et al. 2018). In our main model, we consider a setting where the quality of work is deterministic. In Section 7.2, we consider a model extension where the quality of work can be uncertain. Furthermore, note that because we consider a single freelancer in our main model, $\alpha$ would correspond to the skill level of the freelancer pool. In Section 7.4, we consider a model extension where the freelancer pool can have heterogeneous skill levels.

After the freelancer completes the task, the client decides whether to accept or reject the freelancer's work. Without loss of generality, we assume that the client's valuation of the work is equal to the work quality $q$. In Section 7.1, we consider a model extension where the client can have a different valuation than $q$. The transaction concludes if the client accepts the freelancer's work, in which case the platform will receive the commission fee $\gamma p$ and the freelancer will receive the payment $(1-\gamma)p$. If the client rejects the work by refusing to pay, the freelancer then decides whether to initiate a dispute by paying the dispute fee $f$.[4] This setting follows closely from most online labor platforms, such as Freelancer.com and MTurk, where the clients have discretionary power to decide whether the freelancer's work is worthy of getting paid. The dispute is on the entire contract price which would correspond to the commonly used fixed price contract, in which the platform only allows disputes on the entire contract.[5] The dispute resolution will be carried out by the platform under the centralized dispute system (Section 4), and will be carried out by the tribunal under the decentralized dispute system (Section 5). The freelancer will then have a probability of $h(q)$ in winning the dispute. We detail the dispute decisions in the subsequent sections.

To distinguish between the two dispute systems, throughout the rest of the paper, we use superscript "$*$" to represent the equilibrium of the centralized dispute system and superscript "$+$" to represent the equilibrium of the decentralized dispute system.[6]

## 4. Centralized Dispute System

In this section, we study the centralized dispute system. In this case, when a dispute is initiated, the dispute resolution will be carried out by the platform. In Section 4.1, we first delve into the dispute decision making process of the platform. Then, building on the platform's dispute decision, we

[4] We assume that the dispute fee is non-refundable regardless of whether the freelancer wins the dispute or not in the end. In reality, while certain platforms (e.g., Freelancer.com) allow the dispute fee to be refunded to the freelancer if the freelancer wins the dispute, others (e.g., Upwork and Blocklancer) charge non-refundable dispute fees. We find that our main results carry through if the dispute fee is alternatively assumed to be refundable.

[5] In practice, there may be options for the client to dispute on a fraction of the contract price, especially for time-dependent contracts. It is worth mentioning that the majority of the tasks in online labor markets are short-term small-scale projects which are more suitable for fixed price contracts. Based on the 2014–2016 dataset from Freelancer.com, Liang et al. (2016) find that the majority of projects use fixed price contracts. Furthermore, some platforms (e.g., Upwork and Freelancer.com) offer the option of milestone payments, in which case a dispute on a particular milestone can be carried out. Nevertheless, each milestone payment can be treated as a separate fixed price contract which the client and the freelancer have to agree on before the beginning of the work.

[6] The proofs for these results are available from the authors upon request.

proceed to analyze the subgame perfect equilibrium of the game between the client, the freelancer and the platform in Section 4.2.

### 4.1. Platform's Dispute Decision

Given that dispute occurs, the platform decides on the quality threshold $k$ that the freelancer's work should be evaluated on. If the evaluated quality is higher than the threshold $k$, the platform will rule in favor of the freelancer; otherwise, the platform will rule in favor of the client.[7] In reality, the platform's judgment can be affected by the concern for how close its judgment is as compared to the industry standard. A judgement that deviates from the industry norm can be heavily criticized and bring disrepute to the platform. Thus, to capture this consideration of the platform, we assume that the platform will incur a dis-utility if it deviates from the industry norm when making the dispute decision. We model the platform's dis-utility term as $-\theta(k-y)^2$, which is a quadratic function of the distance between the platform's threshold $k$ and the industry standard $y$. $\theta > 0$ is the degree of penalization when the platform deviates from the industry norm. Therefore, the platform's utility comprises two components. The first component is the monetary payoff from earning commissions and dispute fees, and the second component is the dis-utility if the platform deviates from the industry norm.

The platform receives a noisy signal of the freelancer's true quality level $x = q + \sigma\epsilon$, where $\sigma$ is the scaling factor and $\epsilon$ is the noise term that is uniformly distributed over $[-1, 1]$. This follows the standard model of subjective evaluation (e.g., Baker et al. 1994 and Levin 2003), where the true quality of work is known to the contracting parties (i.e., client and freelancer), but not to the third party evaluator (i.e., the platform). Therefore, the platform will rule in favor of the freelancer if $x \geq k$ and rule in favor of the client if $x < k$. Lemma 1 characterizes the platform's equilibrium quality threshold and the resulting winning probability for the freelancer.

LEMMA 1. *(i) Under the centralized dispute system, the platform's quality threshold is* $k^* = y - \frac{\gamma p}{4\sigma\theta}$.

*(ii) The probability of the freelancer winning the dispute is*

$$h^*(q) = \begin{cases} 0 & \text{if } q \leq k^* - \sigma, \\ \frac{q-y+\sigma}{2\sigma} + \frac{\gamma p}{8\theta\sigma^2} & \text{if } k^* - \sigma < q < k^* + \sigma, \\ 1 & \text{if } q \geq k^* + \sigma, \end{cases}$$

*which is increasing in* $q$*, and decreasing in* $\theta$ *and* $y$.

[7] Note that this is equivalent to modeling the platform's dispute decision as a binary variable $a \in \{0, 1\}$, where $a = 1$ represents the platform ruling in favor of the freelancer and $a = 0$ represents the platform ruling in favor of the client, as we can show that the platform's optimal decision is to rule in favor of the freelancer if and only if the evaluated quality is above a certain threshold.

Lemma 1 shows that the platform's quality threshold $k^*$ is always lower than the industry standard $y$, and is dependent on the magnitude of the commission fee (i.e., $\gamma p$). This implies that the platform, being the arbiter of the contract, has a conflict of interest in the dispute resolution. If dispute occurs and the platform rules in favor of the freelancer, it is able to earn the commission fee in addition to the dispute fee. Thus, the platform intentionally sets a lower quality threshold than the industry standard (i.e., $k^* \leq y$) to increase the winning probability of the freelancer. As a result, the probability of the freelancer winning the dispute comprises two components: 1) the probability that the platform's evaluated quality is above the industry standard $y$ (i.e., $\frac{q-y+\sigma}{2\sigma}$), and 2) a positive bias term that increases his chance of winning the dispute (i.e., $\frac{\gamma p}{8\theta\sigma^2}$). Furthermore, the bias term increases if the commission fee is higher, and decreases if the degree of penalization $\theta$ is higher.

In fact, the platform's inclination to let the freelancer win has been observed by clients that have gone through the dispute process (Tzezana 2015, Chris 2021 and Chen 2017). These clients warn that any arbitration rarely rules in favor of the client. Moreover, they complain that the unfair dispute resolution gives rise to freelancers relying on dispute to earn their profit, instead of putting in effort to improve their work quality. As our model highlights, such an issue is rooted in the platform's decision bias caused by the centralized mechanism of dispute resolution.

### 4.2. Contracting Equilibrium Under Centralized Dispute System

As we have obtained from Section 4.1, under the platform's dispute decision, the freelancer's winning probability is given by $h^*(q)$. Therefore, under the centralized dispute system, if both the client and the freelancer participate in the transaction, the freelancer's utility is given by

$$U_f = \begin{cases} -\alpha q^2 + h^*(q)(1-\gamma)p - f & \text{if client rejects and freelancer initiates dispute,} \\ -\alpha q^2 & \text{if client rejects and freelancer does not initiate dispute,} \\ -\alpha q^2 + (1-\gamma)p & \text{if client accepts,} \end{cases} \tag{1}$$

and the client's utility is given by

$$U_c = \begin{cases} q - h^*(q)p & \text{if client rejects and freelancer initiates dispute,} \\ q & \text{if client rejects and freelancer does not initiate dispute,} \\ q - p & \text{if client accepts.} \end{cases} \tag{2}$$

The platform's utility is given by

$$\Pi = \begin{cases} [h^*(q)(\gamma p + f) + (1 - h^*(q))f] - \theta(k^* - y)^2 & \text{if client rejects and freelancer initiates dispute,} \\ 0 & \text{if client rejects and freelancer does not initiate dispute,} \\ \gamma p & \text{if client accepts.} \end{cases} \tag{3}$$

We now use backward induction to find the subgame perfect equilibrium of the game between the client, the freelancer and the platform as shown in Figure 1. We assume that the platform users

choose the option that does not lead to dispute when they receive the same utility from another option that leads to dispute.[8] Proposition 1 characterizes the equilibrium under the centralized dispute system.

PROPOSITION 1. *(i) Under the centralized dispute system, there exist two thresholds, $\bar{\alpha}_c$ and $\underline{\alpha}_c$ (where $\bar{\alpha}_c \geq \underline{\alpha}_c$), such that transaction occurs if and only if $\alpha \leq \bar{\alpha}_c$, and given that transaction occurs, dispute occurs if $\underline{\alpha}_c < \alpha \leq \bar{\alpha}_c$ and does not occur if $\alpha \leq \underline{\alpha}_c$.*

*(ii) If $\alpha \leq \underline{\alpha}_c$, the platform's dispute fee is $f^* = \frac{(1-\gamma)(y+\sigma)}{1+\frac{\gamma}{4\sigma\theta}}$, the client's contract price is $p^* = \frac{y+\sigma}{1+\frac{\gamma}{4\sigma\theta}}$ and the freelancer's quality level is $q^* = \frac{y+\sigma}{1+\frac{\gamma}{4\sigma\theta}}$. Moreover, the platform's equilibrium utility is $\Pi^* = \gamma p^*$.*

*(iii) If $\underline{\alpha}_c < \alpha \leq \bar{\alpha}_c$, the platform's dispute fee is $f^* = \frac{(1-\gamma)^2\theta(2\alpha(y-\sigma)+1-\gamma)(\theta(1-\gamma)+2\alpha(\gamma-\theta(y-\sigma)))}{4\alpha(\alpha\gamma+(1-\gamma)\theta)^2}$, the client's contract price is $p^* = \frac{2\sigma\theta(2\alpha(y-\sigma)+1-\gamma)}{\alpha\gamma+\theta(1-\gamma)}$ and the freelancer's quality level is $q^* = \frac{(1-\gamma)\theta(2\alpha(y-\sigma)+1-\gamma)}{2\alpha(\alpha\gamma+(1-\gamma)\theta)}$. Moreover, the platform's equilibrium utility is $\Pi^* = h^*(q^*)\gamma p^* + f^* - \frac{\gamma^2(p^*)^2}{16\theta\sigma^2}$.*

Proposition 1 states that transaction only occurs if the freelancer's skill level is not too low (i.e., $\alpha \leq \bar{\alpha}_c$). Moreover, dispute can occur or not depending on the skill level of the freelancer. If the freelancer's skill level is high (i.e., $\alpha \leq \underline{\alpha}_c$), transaction occurs without dispute. In this case, the platform's utility comprises solely the commission revenue. A highly skilled freelancer is able to choose a quality level that is high enough to guarantee winning the dispute even if the platform receives a bad signal of his work quality. Recall from Lemma 1 that if $q \geq k^* - \sigma$, $h^*(q) = 1$. Hence, a highly skilled freelancer only needs to choose the lowest possible $q$ such that $h^*(q) = 1$ to avoid the dispute, so that he can earn the contract price with certainty without paying any dispute fee. Nevertheless, the freelancer only chooses to participate if the client's offered price is able to cover both the commission fee and the dispute fee (i.e., $(1-\gamma)p \geq f$). The freelancer will not participate if the client's offered price net of commission is less than the dispute fee, because if the client tries to game the system by rejecting the payment on purpose, the freelancer will not be able to afford the dispute. Thus, the client's equilibrium price satisfies $p^* = \frac{f^*}{1-\gamma}$, which indicates that the platform can use the dispute fee to nudge the client to offer a higher price to the freelancer.

As the freelancer's skill level decreases (i.e., $\underline{\alpha}_c < \alpha \leq \bar{\alpha}_c$), transaction occurs with dispute. Dispute occurs as it is not optimal for a lower-skilled freelancer to choose a sufficiently high quality level that can guarantee winning the dispute. Conversely, the client has a higher probability of winning the dispute. Hence, a rational client facing the possibility of winning the dispute should always reject the freelancer's work so that there is a chance that she does not have to pay the freelancer. Correspondingly, the freelancer stands a chance of earning the contract price only by

[8] For example, if $h^*(q) = 1$, the client will accept the freelancer's work instead of rejecting the work if the freelancer will subsequently initiate the dispute and win.

initiating the dispute. Hence, dispute occurs in equilibrium if the freelancer's skill level is low. In this case, the platform's utility comprises both the commission fee and the dispute fee, as well as the dis-utility due to deviating from the industry norm. Moreover, it is increasingly costly for a lower-skilled freelancer to participate due to the higher quality cost and lower winning probability for the dispute. Therefore, if the freelancer's skill level is too low (i.e., $\alpha > \bar{\alpha}_c$), the platform would not be able to incentivize the freelancer to participate.

## 5. Decentralized Dispute System

In this section, we study the decentralized dispute system. In this case, when a dispute is initiated, a tribunal will be invoked. Each member of the tribunal votes between the freelancer and the client, and the decision of the tribunal is based on the majority rule. In Section 5.1, we first introduce the setting of the voting game and delve into the voting decisions of the tribunal. Building on the voting equilibrium of the tribunal, we then proceed to analyze the subgame perfect equilibrium of the game between the client, the freelancer and the platform in Section 5.2.

### 5.1. Tribunal's Voting Game

We utilize the global games framework to model the voting game of the tribunal. Given that a dispute occurs, we assume that there is a continuum of voters, with a total mass of one, in the tribunal that decides whether to let the freelancer win the dispute case. Specifically, voter $i$ receives a private signal $x_i = q + \sigma\epsilon_i$, where $q$ is the true quality of the freelancer's work, $\sigma$ is the scaling factor, and $\epsilon_i$ is the noise term that is uniformly distributed over $[-1, 1]$. The signals, $x_i$'s, are independently drawn and represent the idiosyncratic valuations of each voter on the freelancer's work. For example, some voters can be more stringent and place less value on the freelancer's work. In line with the global games literature, we assume that the voters have a uniform prior on the true quality of the freelancer, such that each voter relies solely on the signal received to estimate the true quality of the freelancer's work. It is also important to note that these emerging platforms prevent communication among the voters by adopting the following measures: 1) each voter is allocated randomly to each dispute case and does not know apriori which dispute case he will be allocated to, 2) the platform does not establish any communication channels for the voters to communicate with each other, and 3) there is a limited time window for the voters to vote on the dispute case so that the chance to find and communicate with other voters in the same tribunal will be further reduced. This leads to an opacity in the composition of the tribunal, which helps to prevent collusion among voters and makes the global games framework applicable.

Each voter pays a participation fee in order to participate in the tribunal (i.e., gaining the right to observe the signal and vote). Consistent with the implementation of the new platforms, the total participation fees for a specific dispute case are then pooled together to form the total reward.

Note that this mechanism does not require the platform to infuse an additional monetary sum into the reward pool (i.e., the tribunal is self-funded), since the reward is an internal transfer of the fees among the voters. Voters who are part of the majority votes will be able to win an even share of the total reward. Without loss of generality, the participation fee of each voter is normalized to one as the reward is scaled proportionally by the magnitude of the participation fee.

Each voter is faced with the decision of voting for the freelancer or the client. Let $a_i \in \{0,1\}$ denote voter $i$'s decision, where $a_i = 1$ represents voting for the freelancer. Let $l$ denote the proportion of voters voting for the freelancer. We model the utility of voter $i$, $u_i(a_i, l)$, as follows:

$$u_i(a_i, l) = [\mathbf{1}_{l \geq 0.5} \frac{1}{l} a_i + \mathbf{1}_{l<0.5} \frac{1}{1-l}(1-a_i) - 1] - \xi[a_i \max(0, y - x_i) + (1-a_i)\max(0, x_i - y)]. \quad (4)$$

As Equation (4) shows, similar to the platform's utility, a voter's utility comprises two components. The first component is the voter's monetary payoff if voting for the winning side, which is the difference between the share of the total reward and the participation fee. For example, when the majority of the voters vote for the freelancer (i.e., $l \geq 0.5$), a voter will receive a reward of $\frac{1}{l}$ if he also votes for the freelancer (i.e., $a_i = 1$), and zero if he votes for the client (i.e., $a_i = 0$). The second component corresponds to the "guilt" component which may weigh on the voter's conscience if he does not let a worthy freelancer win and is weighed by a factor of $\xi$. As Equation (4) shows, the more the quality signal deviates from the industry standard, the greater the voter is concerned with the guilt component. The equilibrium of the voting game and the resulting winning probability for the freelancer are characterized in Lemma 2.

LEMMA 2. *(i) Under the decentralized dispute system, there exists a state-dependent Bayesian Nash equilibrium such that voter $i$ will vote for the freelancer if $x_i \geq y$ and vote for the client if $x_i < y$. Moreover, if $\sigma > \frac{2}{\xi}$, such an equilibrium is the unique equilibrium of the voting game.*

*(ii) The probability of the freelancer winning the dispute is*

$$h^+(q) = \begin{cases} 0 & \text{if } q \leq y - \sigma, \\ \frac{q-y+\sigma}{2\sigma} & \text{if } y - \sigma < q < y + \sigma, \\ 1 & \text{if } q \geq y + \sigma, \end{cases}$$

*which is increasing in $q$ and decreasing in $y$.*

Lemma 2(i) shows that the voter's equilibrium strategy is characterized by a single threshold on the signal received. Furthermore, this voting threshold is equal to the industry standard $y$. Thus, a voter will vote for the freelancer if he receives a quality signal higher than $y$ (i.e., $x_i \geq y$), and will vote for the client otherwise. Moreover, if the heterogeneity in the signals received by different voters is not too small (i.e., $\sigma > \frac{2}{\xi}$), this equilibrium is the unique equilibrium of the voting game. This implies that to achieve such an equilibrium, the platform should ensure that

the voters selected for the tribunal are sufficiently diverse. A diverse tribunal can guarantee that the voters follow a threshold policy based on the industry standard as it is harder for a voter to infer the signals received by other voters if $\sigma$ is large. As such, greater diversity in the tribunal can ensure the fairness of the tribunal. Furthermore, such a threshold policy has also been validated experimentally in voting games (Heinemann et al. 2004 and Heinemann et al. 2009). Thus, although the monetary reward can induce the voters to vote strategically, the voters can coordinate based on the publicly accepted industry standard in the absence of communication among them.

Lemma 2(ii) states that the voters are more likely to vote for the freelancer when the freelancer's true quality is higher. Collectively, the voters' voting strategies form a probability distribution on the voting outcome such that as $q$ increases, $h^+(q)$ increases. Hence, the strategic voting of the tribunal still preserves the freelancer's incentive to improve quality. Moreover, comparing the freelancer's probability of winning the dispute to that as given previously in Lemma 1, we observe that given the same quality level, the freelancer has a lower chance of winning the dispute under the decentralized dispute system. Under the decentralized dispute system, the freelancer is unable to take advantage of the platform's bias. Hence, the freelancer has to put in greater quality effort to achieve the same winning probability.

### 5.2. Contracting Equilibrium Under Decentralized Dispute System

As we have obtained from Section 5.1, under the equilibrium of the tribunal's voting game, the freelancer's winning probability is given by $h^+(q)$. Therefore, under the decentralized dispute system, if both the client and the freelancer participate in the transaction, the utilities of the freelancer and the client are similar to Equations (1) and (2) respectively with $h^*(q)$ replacing by $h^+(q)$. The platform's utility is given by

$$\Pi = \begin{cases} h^+(q)(\gamma p + f) + (1 - h^+(q))f & \text{if client rejects and freelancer initiates dispute,} \\ 0 & \text{if client rejects and freelancer does not initiate dispute,} \\ \gamma p & \text{if client accepts.} \end{cases} \tag{5}$$

Notice that if dispute occurs, the platform does not incur any dis-utility from the outcome of dispute resolution, because the quality threshold resulting from the voting game coincides with the industry standard (see Lemma 2). We now proceed to analyze the contracting equilibrium between the client and the freelancer as well as the platform's dispute fee decision. Proposition 2 characterizes the equilibrium under the decentralized dispute system.

PROPOSITION 2. *(i) Under the decentralized dispute system, there exist two thresholds, $\bar{\alpha}_d$ and $\underline{\alpha}_d$ (where $\bar{\alpha}_d \geq \underline{\alpha}_d$), such that transaction occurs if and only if $\alpha \leq \bar{\alpha}_d$, and given that transaction occurs, dispute occurs if $\underline{\alpha}_d < \alpha \leq \bar{\alpha}_d$ and dispute does not occur if $\alpha \leq \underline{\alpha}_d$.*

*(ii) If $\alpha \le \underline{\alpha}_d$, the platform's dispute fee is $f^+ = (1-\gamma)(y+\sigma)$, the client's contract price is $p^+ = y+\sigma$ and the freelancer's quality level is $q^+ = y+\sigma$. Moreover, the platform's equilibrium utility is $\Pi^+ = \gamma p^+$.*

*(iii) If $\underline{\alpha}_d < \alpha \le \bar{\alpha}_d$, the platform's dispute fee is $f^+ = \frac{(2\alpha(y-\sigma)+1-\gamma)(1-\gamma-2\alpha(y-\sigma))}{4\alpha}$, the client's contract price is $p^+ = \frac{2\sigma(1-\gamma+2\alpha(y-\sigma))}{1-\gamma}$ and the freelancer's quality level is $q^+ = \frac{1-\gamma}{2\alpha} + y - \sigma$. Moreover, the platform's equilibrium utility is $\Pi^+ = h^+(q^+)\gamma p^+ + f^+$.*

From Proposition 2, we can observe that the equilibrium under the decentralized dispute system can fall into three cases. First, if the freelancer's skill level is high (i.e., $\alpha \le \underline{\alpha}_d$), transaction occurs which does not lead to dispute. Second, if the freelancer's skill level is moderate (i.e., $\underline{\alpha}_d < \alpha \le \bar{\alpha}_d$), transaction occurs which leads to dispute. Third, if the freelancer's skill level is low (i.e., $\alpha > \bar{\alpha}_d$), transaction does not occur. This equilibrium structure is similar to that under the centralized dispute system. However, there are notable differences. As the tribunal's dispute decision follows the industry norm, the platform's bias is eliminated. The resulting differences in the equilibrium can be clearly seen by comparing Proposition 2 to Proposition 1 (e.g., the platform no longer incurs the dis-utility, $\frac{\gamma^2(p^*)^2}{16\theta\sigma^2}$, due to the deviation from the industry norm).

Recall that under the centralized dispute system, the platform's interest to earn the commission would lead to its decision-making bias of ruling in favor of the freelancer. This would cause the client to have reservations in offering a higher contract price to the freelancer, because an increased contract price would increase the platform's bias and thus create a counter force in the freelancer's willingness to choose a higher quality level. By contrast, the decentralized dispute system eliminates the platform's bias and raises the quality threshold for the freelancer to win the dispute. This results in the client being more willing to offer a higher contract price. Thus, the incentives of the client and the freelancer are in less conflict under the decentralized dispute system.

## 6. Value of Decentralization

As seen in Sections 4 and 5, the equilibrium outcome of the centralized and decentralized dispute systems can differ. In this section, we compare the two systems and derive insights regarding the type of markets that they cater to as well as the value of using the decentralized dispute system.

THEOREM 1. *(i) Transaction occurs in fewer cases under the decentralized dispute system (i.e., $\bar{\alpha}_d \le \bar{\alpha}_c$).*

*(ii) Dispute is prevented in fewer cases under the decentralized dispute system (i.e., $\underline{\alpha}_d \le \underline{\alpha}_c$).*

We start by comparing the thresholds on the freelancer's skill level that define when transaction and dispute occur, to gain a first understanding of how the decentralized dispute system can change the equilibrium structure. Theorem 1 states that the decentralized dispute system will reduce the

range of the freelancer's skill level $\alpha$ for transaction to occur, and will also reduce the range where dispute can be prevented. Recall from Section 4 that under the centralized dispute system, a platform's bias of being more inclined to let the freelancer win the dispute will arise because of its interest to earn the commission fee. Thus, a lower quality work is expected from the freelancer and correspondingly, it is less costly for the lower-skilled freelancers to participate under the centralized dispute system (i.e., $\bar{\alpha}_d \leq \bar{\alpha}_c$). The client is also more willing to compromise on the work quality since the platform is less likely to rule in her favor. This pushes the client to accept the freelancer's work and prevents dispute from occurring in more cases (i.e., $\underline{\alpha}_d \leq \underline{\alpha}_c$). Therefore, the platform's bias incentivizes participation and prevents dispute in more cases under the centralized dispute system.

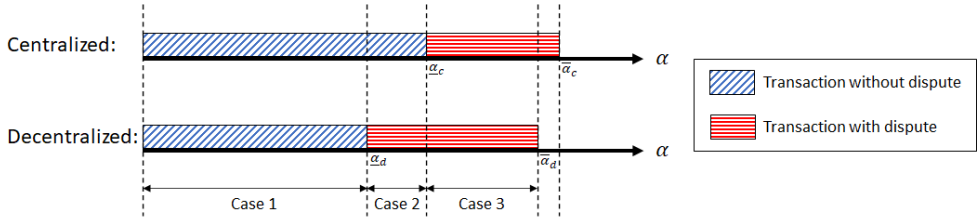


**Figure 2 The $\alpha$ thresholds of both the centralized and decentralized dispute systems.**

The comparisons of the $\alpha$ thresholds are illustrated in Figure 2. We define Case 1 as the scenario where no dispute occurs under both the centralized and decentralized dispute systems (i.e., $\alpha \leq \underline{\alpha}_d$), Case 2 as the scenario where dispute only occurs under the decentralized dispute system (i.e., $\underline{\alpha}_d < \alpha \leq \underline{\alpha}_c$), and Case 3 as the scenario where dispute occurs under both systems (i.e., $\underline{\alpha}_c < \alpha \leq \bar{\alpha}_d$).[9] We shall make references to these three cases for the rest of our discussion in this section, and focus on the scenarios where transaction occurs under both the centralized and decentralized dispute systems (i.e., $\alpha \leq \bar{\alpha}_d$). Theorem 2 summarizes the comparison of the equilibrium outcomes between the centralized and decentralized dispute systems.

THEOREM 2. *(i) There exists a threshold $\alpha_q$ (where $\underline{\alpha}_d < \alpha_q \leq \underline{\alpha}_c$) such that the equilibrium quality level is higher under the decentralized dispute system (i.e., $q^+ \geq q^*$) if $\alpha \leq \alpha_q$ or $\alpha > \underline{\alpha}_c$, and is lower under the decentralized dispute system (i.e., $q^+ < q^*$) if $\alpha_q < \alpha \leq \underline{\alpha}_c$.*

*(ii) There exists a threshold $\alpha_p$ (where $\underline{\alpha}_d < \alpha_p \leq \underline{\alpha}_c$) such that the equilibrium contract price is higher under the decentralized dispute system (i.e., $p^+ \geq p^*$) if $\alpha \leq \alpha_p$ or $\alpha > \underline{\alpha}_c$, and is lower under the decentralized dispute system (i.e., $p^+ < p^*$) if $\alpha_p < \alpha \leq \underline{\alpha}_c$.*

[9] We note that $\underline{\alpha}_c < \bar{\alpha}_d$ (hence Case 3 exists) if $\sigma > \bar{\sigma}$, where $\bar{\sigma} = \frac{\sqrt{(\gamma+2\theta y)^2+16\gamma\theta y}-\gamma+2\theta y}{12\theta}$; otherwise, Case 3 degenerates and the equilibrium regime can only be Case 1 or Case 2, or transaction does not occur under both systems at the same time.

*(iii) When dispute occurs under both systems (i.e., $\underline{\alpha}_c < \alpha \leq \bar{\alpha}_d$), there exists a threshold $\alpha_f$ (where $\underline{\alpha}_c < \alpha_f \leq \bar{\alpha}_d$) such that the equilibrium dispute fee is higher under the decentralized dispute system (i.e., $f^+ \geq f^*$) if $\alpha \leq \alpha_f$, and is lower under the decentralized dispute system (i.e., $f^+ < f^*$) if $\alpha > \alpha_f$.*

Theorem 2 states that when the decentralized dispute system does not change the equilibrium regime, such that either dispute occurs under both systems (i.e., Case 3) or dispute does not occur under either system (i.e., Case 1), the decentralized dispute system induces a higher quality level and contract price compared to the centralized dispute system. As we have seen, the decentralized dispute system eliminates the platform's bias of ruling in favor of the freelancer and raises the quality threshold for the freelancer to win the dispute. Thus, when dispute occurs under both systems (i.e., Case 3), the freelancer needs to choose a higher quality level under the decentralized dispute system. The elimination of the platform's bias also affects the freelancer's incentive to improve quality when dispute does not occur in equilibrium. In this case, the freelancer needs to factor in how stringent the quality standard is in the event of a dispute, in order to prevent dispute from occurring so that he would not have to pay the dispute fee. The platform's bias in the dispute resolution would make it easier for the freelancer to avoid the dispute and weaken the freelancer's incentive to improve quality. Thus, when dispute does not occur under either system (i.e., Case 1), the freelancer similarly needs to choose a higher quality level under the decentralized dispute system. In both cases, because the freelancer has the incentive to choose a higher quality level under the decentralized dispute system, the client is more willing to offer a higher contract price.

However, when the decentralized dispute system results in a different equilibrium regime compared to the centralized dispute system, it is possible for the decentralized dispute system to induce a lower quality level and contract price. In Case 2, dispute occurs under the decentralized dispute system but does not occur under the centralized dispute system. This means that the freelancer has to pay the dispute fee under the decentralized dispute system, which would limit how much effort cost he can expend to improve quality. Thus, in this case, the decentralized dispute system creates two effects on the freelancer's equilibrium quality level. While the freelancer's quality-improving incentive can be improved by the elimination of the platform's bias, his ability to improve quality is reduced because he also has to pay the dispute fee. We further find that when the freelancer's skill level is relatively low within Case 2 (i.e., $\alpha_q < \alpha < \underline{\alpha}_c$), the freelancer could not afford to expend sufficient effort to improve quality after paying the dispute fee, so the equilibrium quality level can fall below that of the centralized dispute system. Correspondingly, the client would offer a lower contract price under the decentralized dispute system. However, it is worth mentioning that this

does not always occur, as we find that if $\sigma \leq \bar{\sigma}$, then the equilibrium quality and contract price are always higher under the decentralized dispute system for all skill levels of the freelancer.[10]

We next turn to the platform's dispute fee. Theorem 2(iii) compares the equilibrium dispute fee between the centralized and decentralized dispute systems when dispute occurs under both systems (i.e., Case 3). The result shows that the equilibrium dispute fee is higher under the decentralized dispute system if the freelancer's skill level is relatively high (i.e., $\alpha \leq \alpha_f$), and is higher under the centralized dispute system if the freelancer's skill level is relatively low (i.e., $\alpha > \alpha_f$). As the freelancer's skill level decreases (i.e., $\alpha$ increases), his equilibrium quality level decreases and it would become increasingly difficult for the freelancer to win the dispute. In order to incentivize the freelancer to participate, the platform can reduce its quality threshold under the centralized dispute system, while it has no control over how the tribunal would judge the freelancer's work under the decentralized dispute system. Thus, as the freelancer's skill level decreases, his equilibrium probability of winning the dispute would decrease at a slower rate under the centralized dispute system. This indicates that a lower-skilled freelancer will have a greater advantage under the centralized dispute system and is hence willing to pay a higher dispute fee relative to the decentralized dispute system. Thus, when the freelancer's skill level decreases below a certain threshold (i.e., $\alpha_f$), the platform would be able to charge a higher dispute fee under the centralized dispute system.

THEOREM 3. *Suppose $\gamma \leq \frac{1}{3}$ and $\sigma \leq y$. There exists a threshold $\bar{\alpha}$ (where $\underline{\alpha}_d \leq \bar{\alpha} \leq \bar{\alpha}_d$) such that the platform's equilibrium utility is higher under the decentralized dispute system (i.e., $\Pi^+ \geq \Pi^*$) if $\alpha \leq \bar{\alpha}$, and is lower under the decentralized dispute system (i.e., $\Pi^+ < \Pi^*$) if $\alpha > \bar{\alpha}$.*

We next compare the platforms' equilibrium utilities under the two dispute systems. Theorem 3 characterizes, under the conditions of $\gamma \leq \frac{1}{3}$ and $\sigma \leq y$, that the platform can achieve a higher utility under the decentralized dispute system only when the freelancer's skill level is sufficiently high (i.e., $\alpha \leq \bar{\alpha}$).[11] Since $\underline{\alpha}_d \leq \bar{\alpha} \leq \bar{\alpha}_d$, the threshold $\bar{\alpha}$ can be achieved in Case 2 or Case 3, but not in Case 1.[12] This immediately indicates that when dispute does not occur under either system (i.e., Case 1), the platform is better off with the decentralized dispute system. If the freelancer's skill level is sufficiently high, dispute does not occur and the platform only earns the

[10] As $\theta$, the degree of penalization when the platform deviates from the industry norm in its dispute resolution, increases from zero to infinity, $\bar{\sigma}$ decreases from $y$ to $\frac{y}{3}$.

[11] We note that the conditions in Theorem 3 are unlikely to eliminate scenarios which are practically relevant. First, a commission rate higher than $\frac{1}{3}$ is uncommon for online labor platforms. Second, given that the quality signal follows a uniform distribution over $[q-\sigma, q+\sigma]$, $\sigma \leq y$ ensures that if the freelancer's quality level is equal to the industry standard $y$, the signal received by the platform or the voters are non-negative. Moreover, based on numerical studies where these conditions are not imposed, we can show that the result from Theorem 3 carries through.

[12] Furthermore, if $\bar{\alpha}_d < \alpha \leq \bar{\alpha}_c$, transaction only occurs under the centralized dispute system, hence the centralized dispute system dominates the decentralized dispute system in this case. Thus, our result of comparing the two systems extends to the region beyond $\alpha \leq \bar{\alpha}_d$.

commission fee. As discussed previously in Theorem 2, the elimination of the platform's bias under the decentralized dispute system results in a higher quality threshold, which can induce a higher quality level and a higher contract price. Thus, the platform can extract a greater commission fee under the decentralized dispute system.

If the freelancer's skill level is not sufficiently high, dispute can occur (i.e., Cases 2 and 3). When dispute occurs, the platform's revenue structure changes to one that depends on both the dispute fee and the commission fee. The platform is guaranteed to earn the dispute fee as long as dispute occurs, but only earns the commission fee if the freelancer wins the dispute. Depending on the skill level of the freelancer, the platform can extract more surplus from the participants through different means. When the freelancer's skill level is relatively high, he would be able to win the dispute with a high probability. This indicates that the platform will earn the commission fee with a high probability, hence its revenue is more dependent on the commission fee. Because the decentralized dispute system can induce the client to offer a higher contract price, the platform can earn a higher commission under the decentralized dispute system, and hence the decentralized dispute system would make the platform better off. By contrast, when the freelancer's skill level is relatively low, he can only win the dispute with a low probability. This indicates that the platform has to rely more on the dispute fee. As we have seen in Theorem 2, the platform's bias to rule in favor of the freelancer would create a greater advantage for lower-skilled freelancers, which enables the platform to charge a higher dispute fee under the centralized dispute system. Thus, the centralized dispute system would make the platform better off in this case.

Therefore, the decentralized dispute system can only benefit the platform when the freelancers' skill levels are sufficiently high. With higher-skilled freelancers, the platform would be able to utilize the tribunal to improve the incentive structure of participants and extract more commissions. However, with lower-skilled freelancers, the platform would benefit from retaining the decision-making power to arbitrate disputes to itself. By doing so, the platform can set a lower quality standard for lower-skilled freelancers and extract more dispute fees from them; whereas under the decentralized dispute system, the more stringent quality standard set by the tribunal would make it disproportionately more costly for the lower-skilled freelancers to participate and more of them can be weeded out (i.e., when $\alpha > \bar{\alpha}_d$).

The results suggest that different types of dispute resolution systems can cater to different market segments. The decentralized dispute system is more suitable when the freelancer pool is higher-skilled, while the centralized dispute system is more suitable when the freelancer pool is lower-skilled. Therefore, for the emerging platforms (e.g., Ethearnal and Blocklancer) to succeed with the decentralized dispute system, it is important to ensure the skill level of their freelancer pool, for example, by adopting a stricter screening and certification process, or providing proper

training to the freelancers. Meanwhile, the freelancers' skill levels may also improve over time for the traditional platforms (e.g., Upwork and Freelancer). This can be achieved by providing better training to the freelancers, such as by partnering with online learning platforms (e.g., Coursera or Udemy), or recognizing certain industry certifications.[13] Moreover, the majority of the tasks in companies have been shifting to a project-based structure, under which companies can utilize external workforce who are able to work remotely (Claussen et al. 2018). Thus, the freelancer market is expected to grow and more professional employees will utilize the online labor platforms (Katz and Krueger 2019). Such an influx of professional employees may increase the overall skill level of the freelancer pool. As a result, it may become optimal for these platforms to switch to the decentralized dispute system in order to reap greater benefits.

Lastly, the traditional online labor platforms are often criticized for not being a "true" sharing economy (Pasquale 2015). They are found empirically to behave like a monopoly or monopsony instead (Dube et al. 2020), as they have substantial autonomy to dictate the contractual terms while having limited liability (Ranchordas 2015). By decentralizing the dispute resolution, the platform is relegating more decision-making power to the participants of the sharing economy. Hence, a more ideal sharing economy may be achieved, where the platform functions less like a monopoly. Furthermore, it is worth mentioning that the social welfare in our model is $q - \alpha q^2$ and the socially optimal quality level is $\frac{1}{2\alpha}$. Comparing Propositions 1 and 2, it is easy to see that given the same equilibrium regime, the equilibrium quality level under the decentralized dispute system is closer to the socially optimal level. For example, when dispute occurs, under the decentralized dispute system, the platform's equilibrium utility is $\Pi^+ = h(q^+)\gamma p^+ + f^+$, which can be equivalently expressed as $q^+ - \alpha(q^+)^2$, the same form as the social welfare. This indicates that the voting mechanism of the tribunal would induce the platform to internalize the quality improvement cost of the freelancer, so that the platform's incentive is more aligned with the social planner. This allows a more socially optimal quality level to be induced. By contrast, under the centralized dispute system, the platform's equilibrium utility can be equivalently expressed as $q^* - \alpha(q^*)^2 - \frac{\gamma^2(p^*)^2}{16\theta\sigma^2}$, a different form from the social welfare. Thus, the platform's conflict of interest in dispute resolution distorts its incentive from that of the social planner, and causes the quality level to deviate further away from the socially optimal level.

## 7. Extensions

In this section, we explore four model extensions. In Section 7.1, we consider an extension in which the client has a different quality standard than the freelancer. In Section 7.2, we consider

[13] Upwork encourages its freelancers to obtain verifiable certifications such as Adobe, Oracle or Red Hat certifications. Freelancer.com has internal examinations for the freelancers to take, from programming to language tests.

an extension in which the quality outcome is uncertain. In Section 7.3, we consider an alternative dispute fee structure where the dispute fee can be charged to both the freelancer and the client. In Section 7.4, we consider the case with heterogeneous freelancers. In all extensions, we present the main result of comparing platform utilities under the centralized and decentralized dispute systems, and focus on the scenario where transaction occurs under both systems.

### 7.1. Disagreement on Quality

In our main model, we have considered the case where the client and the freelancer have the same valuation on the work quality. However, client may disagree with the freelancer on the work quality as she may have a different standard in judging the work quality. This has led to certain freelancers complaining that their works are undervalued (Ventura 2019). Since the different quality standards between the client and the freelancer can be another factor that leads to disputes, we now investigate how it can affect the platform's optimal choice of the dispute system. To model the difference between the client's and the freelancer's valuations on quality, we let the client's valuation of the freelancer's work be $\phi q$ instead of $q$, where $\phi \geq 0$ corresponds to the differential in the quality standard between the client and the freelancer. Thus, the client values the work more than the freelancer if $\phi > 1$ and less if $\phi < 1$, and our main model is equivalent to $\phi = 1$.

THEOREM 4. *Suppose $\gamma \leq \frac{1}{3}$ and $\sigma \leq y$. When the client values quality differently than the freelancer, there exists a threshold $\bar{\phi}$, which is increasing in $\alpha$, such that the platform's equilibrium utility is higher under the decentralized dispute system if and only if $\phi \geq \bar{\phi}$.*

Theorem 4 states that the decentralized dispute system works better if the client values the freelancer's work higher (i.e., $\phi \geq \bar{\phi}$). When the client has a stricter quality standard (i.e., $\phi$ is smaller), the freelancer has to put in more quality effort. As we know from the main model, the tribunal voting will make it increasingly more costly for lower-skilled freelancers to participate under the decentralized dispute system. If the client has a stricter quality standard, dispute will be more likely to occur, hence making it even more costly for lower-skilled freelancers to participate under the decentralized dispute system. By contrast, under the centralized dispute system, because dispute resolution is controlled by the platform, the platform is able to temper the client's quality standard by adjusting its quality threshold in dispute resolution, and protect the lower-skilled freelancers when the client has a stricter quality standard. Hence, the platform should only adopt the decentralized dispute system if the client is more compromising on the work quality (i.e., $\phi \geq \bar{\phi}$). Moreover, the decentralized dispute system is more likely to be the preferred system (i.e., $\bar{\phi}$ is lower) if the freelancer is higher-skilled (i.e., $\alpha$ is smaller). Thus, our previous finding that the decentralized dispute system performs better with higher-skilled freelancers continues to hold.

The result suggests that when choosing the appropriate dispute system, platforms should also take into consideration the type of clients that they are catering to. If the client pool tends to be less strict on the work quality and does not undervalue the freelancer's work, the platform can relegate the control of dispute resolution to the crowd and adopt a decentralized dispute system. However, if the client pool tends to undervalue the freelancer's work, tribunal voting will not be as effective and the platform is better off retaining the control of dispute resolution to itself.

### 7.2. Uncertain Quality

In our main model, we have considered the case where the freelancer's quality outcome is deterministic. Such a setting would correspond to tasks that are more standardized. For example, for a house-cleaning task, if the freelancer chooses to put in more effort, such effort can be directly translated to a cleaner house. Nevertheless, other types of tasks can have less deterministic outcomes. Platform users have commented that creative works (e.g., business naming), which are less deterministic in nature, can experience more disputes or payment rejections (Luchies 2015). The remote nature of freelancing work can also lead to misunderstanding of task objectives and make the task outcomes more uncertain for the freelancers. In this section, we study the setting where the realized quality level of the freelancer's work can be uncertain, to gain an understanding of how the platform's optimal dispute system should depend on the nature of the task being involved.

To model quality uncertainty, we introduce a probability $\beta \in (0, 1]$ such that the freelancer's realized quality is equal to his effort level $q$ with probability $\beta$ and zero with probability $1 - \beta$. Thus, $\beta$ measures the chance that the freelancer fails to meet the client's objective, which is realized after the project has been completed. A lower $\beta$ would correspond to a higher degree of quality uncertainty. Note that our main model is equivalent to $\beta = 1$.

THEOREM 5. *When the freelancer's quality is uncertain, if $\sigma \leq \bar{\sigma}$, the equilibrium quality level is always higher under the decentralized dispute system. Suppose $\gamma \leq \frac{1}{3}$ and $\sigma \leq \bar{\sigma}$. there exists a threshold $\bar{\beta}$, which is increasing in $\alpha$, such that the platform's equilibrium utility is strictly higher under the decentralized dispute system if and only if $\beta \geq \bar{\beta}$.*

Theorem 5 states that the decentralized dispute system is only better than the centralized dispute system if the degree of quality uncertainty is sufficiently low (i.e., $\beta \geq \bar{\beta}$). Recall that under the centralized dispute system, the platform tends to rule in favor of the freelancer because it can earn the commission fee if the freelancer wins the dispute. Thus, the platform can adapt to a lower quality threshold when the freelancer's realized quality is more likely to be inferior. In this respect, the platform's bias helps to create a cloak of certainty over the task to help the freelancer to participate, especially when the quality outcome is more uncertain. This makes the centralized dispute system the preferred system for the platform in this case. On the other hand, under the

decentralized dispute system, the platform relegates dispute resolution to the tribunal and cannot cater the tribunal's judging standard to the degree of quality uncertainty. Thus, the freelancer would face more risk when the quality is more uncertain and hence, would be less willing to participate. However, when the quality outcome is less uncertain, the decentralized dispute system can maintain its value of better incentivizing quality improvement, and is the preferred system. Furthermore, the decentralized dispute system is more likely to be the preferred system (i.e., $\bar{\beta}$ is lower) if the freelancer is higher-skilled (i.e., $\alpha$ is smaller). Thus, our previous finding that the decentralized dispute system performs better with higher-skilled freelancers continues to hold.

An inspection of the emerging platforms that are using the decentralized dispute systems shows that some of them are targeting creative tasks (e.g., graphic design, web development, and technical report writing), which tend to have a higher degree of uncertainty in the quality outcomes. However, our findings suggest that platforms should be cautious about outsourcing dispute resolution to the crowd when the task is associated with a higher degree of uncertainty. Thus, keeping the dispute resolution centralized can be a better way to deal with the uncertainties caused by the task.

### 7.3. Double-Sided Dispute Fees

In our main model, we have considered the case where the dispute will be initiated if the freelancer pays the dispute fee. Such a single-sided dispute fee structure is commonly used by online labor platforms (e.g., PeoplePerHour). Meanwhile, there are also online labor platforms that require the dispute fee to be paid by both parties in order for the dispute to be initiated. For example, Freelancer.com gives a four-day allowance for the other party to pay the dispute fee, before automatically closing the dispute in favor of the party that has initiated the dispute resolution by paying the dispute fee. While the double-sided dispute fee structure is not as commonly used as the single-sided dispute fee structure by traditional platforms, we are interested in understanding whether platforms can further benefit from switching to the double-sided dispute fee structure when they adopt the decentralized dispute system. In this section, we model the scenario of the platform charging dispute fees to both the freelancer and the client. Under this model, if the freelancer initiates the dispute by paying the dispute fee and the client follows up to participate in the dispute by also paying the dispute fee, the dispute will be initiated. However, if the freelancer initiates the dispute but the client decides not to pay the dispute fee, the freelancer will be automatically awarded a "win" and the client will then have to pay the freelancer the contract price.

THEOREM 6. *There exists a threshold $\tilde{\sigma}$ such that if $\sigma \leq \tilde{\sigma}$, the equilibrium quality level is always higher under the decentralized dispute system. Suppose $\gamma \leq \frac{1}{3}$ and $\sigma \leq \tilde{\sigma}$. When the platform can choose between single-sided or double-sided dispute fees, there exist a threshold $\tilde{\alpha}_d$ such that the*

*platform's equilibrium utility is higher under the decentralized dispute system if* $\alpha \leq \tilde{\alpha}_d$*. Furthermore, there exists a threshold* $\tilde{\alpha}_{dd}$ *such that if* $\tilde{\alpha}_{dd} < \alpha \leq \tilde{\alpha}_d$*, the optimal strategy is to use the decentralized dispute system with double-sided dispute fees.*

From Theorem 6, we observe that the decentralized dispute system remains better than the centralized dispute system when the freelancer's skill level is sufficiently high (i.e., $\alpha \leq \tilde{\alpha}_d$). Hence, our main result remains robust when the platform is allowed to choose which dispute fee structure to use under each dispute system. Theorem 6 further shows that when the freelancer's skill level is moderately high (i.e., $\tilde{\alpha}_{dd} < \alpha \leq \tilde{\alpha}_d$, where the additional subscript $d$ in $\tilde{\alpha}_{dd}$ denotes the double-sided dispute fee structure), the platform's optimal strategy is to combine the decentralized dispute system with the double-sided dispute fee structure. When the freelancer's skill level is very high, dispute does not occur in equilibrium under the decentralized dispute system. Nevertheless, with a double-sided dispute fee structure, it becomes more costly for the client to reject the freelancer's work because the client would have to pay the dispute fee if the freelancer initiates the dispute afterwards. Thus, the freelancer is able to choose a lower quality level while making sure that the client is unable to reject his work. Consequently, the client offers a lower contract price and the platform's utility is lower. Hence, the decentralized dispute system works better with a single-sided dispute fee in this case. However, when the freelancer's skill level is only moderately high (i.e., $\tilde{\alpha}_{dd} < \alpha \leq \tilde{\alpha}_d$), dispute occurs under the decentralized dispute system. In this case, by charging the dispute fee to both sides of the market, the platform has one additional source of revenue (i.e., the dispute fee charged to the client) over which it has direct control and becomes even less reliant on the commission revenue over which it only has indirect control. Therefore, the decentralized dispute system works better with double-sided dispute fees in this case.

Our results indicate that platforms can use double-sided dispute fees to cater to the freelancer market with intermediate skill levels when adopting the decentralized dispute system. This bears an important implication for platforms as platforms that intend to adopt the decentralized dispute system can consider first using the double-sided dispute fee structure as a transitional step when the freelancers' skill levels are not sufficiently high. However, as the freelancers become more proficient, the single-sided dispute fee structure can be considered.

### 7.4. Heterogeneous Freelancers

We close this section by showing that our main insights can be robust when the model allows for heterogeneous freelancers. We now consider a model where $\delta$ proportion of freelancers are high-type with skill level $\alpha_h$ and $1-\delta$ are low-type with skill level $\alpha_l$, where $\alpha_l > \alpha_h$. Thus, a higher $\delta$ corresponds to a more skilled freelancer pool. We find that the platform generally performs better under the decentralized dispute system if the skill level of the freelancer pool is sufficiently high.

We are able to show the existence of a threshold $\bar{\delta}$ such that the decentralized dispute system works better if and only if $\delta \geq \bar{\delta}$. Thus, the result indicates that the decentralized dispute system performs better when the average skill level of the freelancers is higher, which is consistent with our main finding.

## 8. Conclusion and Discussion

In this paper, we study how an online labor platform should manage the dispute between the client and the freelancer. Our model captures three reasons for dispute to arise: gaming incentives of the platform's users, disagreement over the quality standards, and uncertainty in the quality outcomes. Motivated by recent industry practice, we compare two types of dispute systems for online labor platforms: the centralized dispute system and the decentralized dispute system. Our results provide a comprehensive view of how platforms should choose the optimal dispute resolution system based on the features of the freelancer (how skillful he is), and the task (how uncertain its outcome is).

We show that the decentralized dispute system performs better than the centralized dispute system only when the freelancer pool is highly skilled. This bears several important managerial implications. First, the new platforms that are adopting the decentralized dispute system should ascertain the skill level of the freelancers first. They can consider using proper screening and certification processes, or providing training to improve the freelancers' skill level. Second, the traditional platforms such as Upwork and TaskRabbit may be using the right strategy in using the centralized dispute system as the current freelancers may not have been as well trained as full-time professionals. However, as the freelancers become more proficient with their work and more professional employees migrate to online labor platforms, one may expect the skill level of the freelancer pool to increase. In addition, we find that the value of the decentralized dispute system can be enhanced when the client's quality standard is lower, or when the task is associated with a lower degree of quality uncertainty.

There are also other non-monetary factors to consider before adopting the decentralized dispute system. Platforms that have concerns over the fairness of the dispute system affecting their reputation and users' participation rates should consider adopting the decentralized dispute system. The decentralized dispute system is able to offer a fairer dispute judgment as the decentralized dispute system is able to remove the platform's bias, which may be more acceptable to the general public. In addition, platforms have grown to be powerful and the public is often apprehensive of the platforms' sweeping authority (Herman 2017). As such, the emerging platforms' proposal to decentralize the dispute resolution process may be a more appealing approach that can reduce the negative connotation of the platform. Furthermore, our results show that the platform's incentive can be better aligned with the social planner after decentralizing the dispute resolution. The principle of a true "sharing economy" requires the platform users to be empowered to make decisions.

The recent tightening of regulations has compelled online labor platforms to relegate more decision-making power to the platform users so that they can retain the status of being part of the "sharing economy", where certain commercial and labor laws do not apply.[14] Hence, the decentralization of dispute resolution can help the platform to achieve an "ideal sharing economy" with greater user empowerment and fairer dispute arbitration. Nevertheless, the platforms have to be cautious about the potential increase in friction between the clients and the freelancers when they adopt the decentralized dispute system. They would need to devise robust systems to handle the possible increase in the dispute load.

This paper could serve as a first step in understanding the operational aspect of dispute management for online labor platforms. We hope our work could trigger future research in this domain. For example, to gain some baseline insights into the value of decentralizing the dispute resolution, we have focused on the case where the quality level of the freelancer is verifiable. When quality is unverifiable, a moral hazard issue may arise. Thus, one future research direction could be understanding whether the decentralized dispute system can be more effective in mitigating moral hazard as compared to the centralized dispute system. Moreover, it would also be interesting to empirically study the reputational effects of the decentralized dispute system over the long term.

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[14] The "California Assembly Bill 5", which was in force in California state in January 2020, seeks to classify drivers of Uber and Lyft as traditional employees due to the substantial amount of control these platforms have over the drivers, such as pay, choice of clients and service levels. However, the drivers are currently exempted from the bill due to "California Proposition 22".

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