

# Utility Tokens as a Commitment to Competition\*

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## Abstract

We show that utility tokens can limit the rent-seeking activities of two-sided platforms with market power while preserving efficiency gains due to network effects. We model platforms where buyers and sellers can meet to exchange services. Tokens serve as the sole medium of exchange on the platform and can be traded in a secondary market. Tokenizing a platform commits a firm to give up monopolistic rents associated with the control of the platform leading to long-run competitive prices. We show how the threat of entrants can incentivize developers to tokenize and discuss cases where regulation is needed to enforce tokenization.

**Keywords:** Utility Tokens, Crowd-Funding, Blockchain, Financing.

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# 1 Introduction

Financial technology (FinTech) is promising to revolutionize the finance world. A key element in this vision is decentralization, aiming to break the market power of financial intermediaries and other large players in the financial industry. However, while FinTech focuses on increasing competition, the rise of technology in the economy at large is generating concerns of greater concentration of market power. Technology firms, such as Amazon, Meta, Uber, and AirBnB, control and operate online platforms with a large network of users, often buyers and sellers of goods and services.<sup>1</sup> Such platforms can lead to efficiencies because of network externalities — a ride-sharing platform can optimize ride scheduling and minimize wait times when everyone is using the same ride-sharing platform — but also open the door to rent seeking and monopolistic behavior by the firms that develop and operate them. It is well known in economic theory that such rent seeking and monopolistic behavior have the potential to eliminate the welfare gains achieved from network externalities.

In this paper, we show that a financial innovation from recent years — tokens on the blockchain — can provide a solution by creating a commitment device for firms that are running platforms to maintain competitive pricing and avoid rent seeking over time. The tokens we focus on are similar to “utility” tokens. These are tokens that serve as the medium of exchange between buyers and sellers who meet on a platform to trade goods or services. For example, the Filecoin token is the utility token associated with the Filecoin platform, an online marketplace for file storage.<sup>2</sup> Filecoin is a blockchain-based interface which allows users who need additional storage to rent this space using Filecoin tokens from users who have excess storage on their devices.

The motivation for introducing this and other utility tokens in practice has the spirit of the mechanism in our model — decentralizing and sharing surplus with users. The utility tokens in our model are indeed similar in some aspects to utility tokens used by platforms in practice. However, an important insight of our model is that a few key features are critical for utility tokens to serve the purpose of commitment to competition. While these key features can be found across different tokens in practice, they have not been consistently adopted. Hence, our analysis is normative, rather than positive. The paper provides theoretical guidelines for the future design of tokens and for the way they should be regulated. As such, while our model demonstrates the potential for tokenization to act as a commitment device for competition,

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<sup>1</sup>The case of a platform like Facebook run by Meta is more complicated, but has a similar spirit with a large network of advertisers and advertisees.

<sup>2</sup>See <https://filecoin.io>.

it does not imply that such commitment is the reason platforms have tokenized in the past.<sup>3</sup>

Our model describes a firm, which runs a platform where competitive providers of services (or goods) are matched with consumers. Consumers are heterogeneous in their valuations of the service. In a benchmark model, we show that the firm acts as a monopolist. It charges consumers more than the marginal cost of service provision and reimburses service providers exactly their marginal cost of service provision. The firm can thus earn a spread from each service exchange and can fully control the quantity and pricing of the service. The firm will therefore optimally set an equilibrium price and quantity resembling that of a monopolistic service provider, rationing service to some consumers with lower valuations of it, even though service providers are perfectly competitive. Hence, the production and allocation do not maximize the surplus from services.

We then introduce tokens into this framework, such that services on the platform have to be paid for with tokens. On a tokenized platform, and with a secondary market for tokens, the firm that operates the platform is effectively committed to give up pricing power over time and so competition is restored. With a common marketplace for tokens, service providers, who receive tokens in exchange for their services, can resell them directly to future consumers. The firm then faces competition both from consumers who bid up the price at which the firm can buy back tokens, and from service providers who bid down the price at which the firm can sell new tokens. The firm initially releases tokens to profit from trade on the platform, but each time it releases additional tokens, it increases the number of tokens that are sold in the future in the common marketplace, and consequently, the number of services exchanged on the platform, thereby generating competition for itself. Intuitively, in this case, we can think of the firm as having a limited stock of market power. Every time it wishes to monetize the platform, it has to create future competition for itself and uses up some of its market power. Our analysis of the dynamic framework characterizes how the platform optimally chooses to release tokens gradually, increasing the number of consumers who purchase the service over time. Eventually, enough tokens are released so that all consumers who value the service above its marginal cost of production are able to access the service, and so the equilibrium price and quantity reach levels that would occur in a competitive equilibrium.

This intuition highlights several critical features of utility tokens that are needed for the purpose of committing the platform to competition. First and foremost is the presence of a secondary market where service providers and consumers can trade the tokens. Without such

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<sup>3</sup>Other papers in the literature have put forth alternative reasons why firms can benefit from tokenization, see, e.g., Catalini and Gans (2018); Canidio (2018); Chod and Lyandres (2021); Chod, Trichakis and Yang (2022); Cong, Li and Wang (2020); Bakos and Halaburda (2019); Malinova and Park (2023); Li and Mann (2018); Sockin and Xiong (2023b); Lee and Parlour (2022); Gan, Tsoukalas and Netessine (2021); Gryglewicz, Mayer and Morellec (2021).

a secondary market, monopolistic behavior by the firm returns. This is because the firm in this case is the sole seller and the sole redeemer of tokens. As the sole seller of tokens, it has the power to charge consumers any price for a token, and as the sole redeemer of tokens, it has full discretion over how much to pay a service provider for a token. In equilibrium, the firm will charge consumers more than the marginal cost of service provision for each token and reimburse service providers at a price per token that is equal to their marginal cost of service provision. It will then choose the same monopolistic production and allocation of services, as without tokens.

In addition to the presence of a secondary market, three other features emerge as critical for tokens to restore competition. Two of them guarantee that the token is the only means of payment on the platform: The firm cannot charge consumers or providers any fees for accessing or using the platform and other than the transfer of token there cannot be any additional transfer between consumers and providers upon matching. These rules ensure that the firm has no way of earning continued rental income from tokens after it initially sells them. Another critical feature is that the service price is fixed in token units. This implies that each time the firm sells a token (or equivalently, a certain number of service units), it also sells the right to resell that same number of service units in the future. Thus, the fixed token-to-service price helps commit to the durability of tokens over time.

As we review in the paper, each one of these four features is part of the design of some utility tokens that have been introduced in practice. Yet, the four of them have not been implemented consistently together. Our analysis points to the importance of such implementation and so provides insights for future design and regulation of tokens. For example, Twitch, owned by Amazon and one of the largest live streaming platforms in the United States, has an in-app currency called Bits that users can buy at about 1.40 cents per Bit and use it to reward their favorite streamers. Streamers can redeem Bits for 1.00 cent per Bit.<sup>4</sup> Thus, Twitch as a sole redeemer of Bits is similar to a tokenized platform in our model without a secondary market. Our analysis suggests that establishing a secondary market for Bits trading would reduce rent seeking by the platform. The presence of a secondary market for token trading has been perceived by regulators as indication that tokens are securities and should be regulated accordingly. However, our paper shows that having a secondary market also has a critical purpose for achieving the goal for which tokens might have been introduced in the first place.

We extend our analysis to include two platforms. In the context of digital storage, one could imagine Dropbox or Google competing with Filecoin in providing a storage exchange. In the context of ride-sharing, everyone is of course familiar with Uber and Lyft and the

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<sup>4</sup>See <https://www.twitch.tv/bits>.

competition between them. A basic intuition would lead one to believe that competition across platforms is beneficial to welfare, as it helps reducing monopolistic rents. However, even though some network externalities can be achieved with multiple platforms, the basic premise behind such network externalities is that they can be better exploited if everyone is on the same platform. Going back to our examples, it is reasonable to assume that users cannot easily share their files with peers who are using a different cloud storage solution, and ride-sharing platforms cannot optimize rider-driver matches if they are not aware of what destination drivers are going to when completing a ride on a different platform. We model this by assuming that the benefit from consuming the service from a given platform increases in the number of people using this platform. Then, given our previous results on how a tokenized platform can achieve full competition, it follows that a single tokenized platform provides a higher surplus than when multiple platforms compete with each other to eliminate monopolistic rent-seeking. Intuitively, conditional on a particular pricing scheme, network effects make it efficient for all users to be on the same platform. By using tokens, competitive prices are achieved within a single platform, without resorting to competitive pressures across platforms. Therefore, a single tokenized platform can achieve the best of both worlds, unlike a solution with multiple platforms.

The analysis of competing platforms also helps us understand under what circumstances a firm operating a platform will have an incentive to tokenize it as a way of committing to competitive prices. This is an important question because we have shown above that tokenization promotes competitive pricing and achieves higher surplus, but at the same time it reduces the long-term profit of the platform. The question is then why would the platform initiate tokenization. We show that in the case of threat of competition from another platform, the incentive to tokenize can emerge naturally. If an incumbent platform operator is facing a threat of future entrants, it may indeed prefer to run a tokenized platform to deter entry. Moving to a tokenized platform serves as a commitment to transfer surplus to consumers later on, and so eliminates their incentives to move to a competing platform. In an alternative scenario, a potential entrant may choose to organize as a tokenized platform in order to attract users to move from the incumbent platform to its new platform.

Outside such scenarios, as we discuss in the paper, there are circumstances where the incentives to tokenize to commit to competition do not emerge organically, and in which regulation can help by requiring tokenization. Essentially, tokens are a tractable tool to bring competition. Regulators can rely on it instead of other less tractable or less desirable tools, and so regulation acts to enforce the token mechanism that can effectively ensure competition. For example, there has been an increased congressional focus on how best to regulate the

monopolies of firms such as Meta, Twitter and Amazon.<sup>5</sup> Some policy proposals recommend breaking up these companies.<sup>6</sup> However, this may be inefficient due to network effects as users benefit from many other users being on the same platform. Our paper demonstrates how the outcome of greater competition may come from tokenizing platforms.

We extend the model in a couple of other dimensions. First, our main model assumes a homogeneous service, mostly to keep things simple. This assumption is well suited for some types of services such as cloud storage but is less applicable to platforms in which consumers demand heterogeneous services. For example, for a ride-sharing platform, consumer demand may vary depending on peak/off-peak hours, distance, city of travel, etc. We thus extend the main model to a more general setting in which a platform allows the trade of heterogeneous services. We demonstrate that, as in the main model, the service exchange on the platform can be organized through a single utility token which allows the firm to give up market power over time. Eventually, welfare is maximized and at the competitive level. The key is to set prices of different services in token units based on an algorithm that accounts for factors, such as time, distance, and city of travel, in the ride-sharing example. The model then extends smoothly. Second, another important issue in real-world platforms, which we do not include in our main model for the sake of simplicity, is the uncertainty about demand over time. We extend the model so that a jump in demand may occur after the platform is initiated. We show that, even in such a case, the competitive outcome is achieved eventually in a tokenized platform.

An important question in assessing the role of tokens, as it emerges from our paper, is why they facilitate commitment that cannot be achieved in other ways. We argue that smart contracts on the blockchain, forming the basis for the tokens, play a crucial role in achieving commitment. In particular, the key parameters of the platform constitute the computer code that is developed by the firm initially. When the platform is launched, this code is released to and adopted by all users. If, in the future, the firm decides to make any changes to the platform's code, the majority of users need to reach a consensus and switch to running the new code. Since it is not in their interest to do so, commitment is maintained.

Many of the firms whose market power is a growing concern are centralized rather than decentralized "Fintech" companies. As such, a follow-up question is whether we can expect this commitment to be sustained if the platform is permission-based, and so changes in the code are under the control of the firm operating the platform. In such a case, regulation will be needed to supplement the token mechanism and ensure that it remains intact. As we

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<sup>5</sup>"Tech monopoly? Facebook, Google and Amazon face increased scrutiny," *The Guardian*, 3 June 2019.

<sup>6</sup>"Senator Elizabeth Warren Says 'It's Time To Break Up Amazon, Google And Facebook' — And Facebook CEO Mark Zuckerberg Fights Back," *Forbes*, October 2 2019.

argue above in discussing cases where platforms do not have an organic incentive to tokenize, regulation can act as a supplement to the token mechanism, making sure that it is followed. Given the tractability of this tool, demonstrated in our analysis, this is an easier way to regulate competition than other ways. Hence, the paper contains a message to regulators looking for the optimal way to regulate tokens. This has been an issue of great debate in recent years. The token sale market collapsed in 2019 following many regulatory concerns and cases of fraud. However, given the benefits shown in our paper, it can be revived by, for example, introducing a special regulatory regime for the issuance of utility tokens such as the “Token Safe Harbor” proposed by SEC commissioner Hester Pierce.<sup>7</sup> We provide discussion in the paper of the way smart contracts achieve commitment and when regulation is needed to enforce that.

**Related literature.** Our paper contributes to the nascent but rapidly growing literature that studies how firms and platforms can benefit from issuing tokens: Catalini and Gans (2018), Canidio (2018), Chod and Lyandres (2021), Chod et al. (2022), Cong et al. (2020), Bakos and Halaburda (2019), Malinova and Park (2023), Li and Mann (2018), Sockin and Xiong (2023b), Lee and Parlour (2022), Gan et al. (2021), Gryglewicz et al. (2021).<sup>8</sup>

Similar to our paper, Rogoff and You (2023) study secondary market tradability of tokens and conclude that non-tradable tokens result in higher revenues for a platform. However, their model is closer to a model of loyalty points, such as airline miles, since the platform is one-sided and provides the service itself rather than matching consumers and service providers. In contrast, we show that utility tokens, when tradable, never return to the platform and this creates commitment to competitive service provision in the long run.

In another related paper, Chod and Lyandres (2023) study competition between a tokenized platform pricing its goods in product tokens and a platform which prices the same goods in fiat. In their paper, a tokenized platform gains a second-mover pricing advantage vis-à-vis the platform pricing in fiat because the price of goods on a tokenized platform can be adjusted ex-post through the total number of tokens sold which affects the fiat price of tokens. In contrast, in our paper, tokenization causes the platform to gradually lose influence over the fiat price of tokens which generates commitment to long-run competitive pricing even in the

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<sup>7</sup>According to the proposal, entrepreneurs would be required to file appropriate disclosures but tokens would be exempt from federal securities laws for three years since the first token sale—the time needed to achieve a level of platform decentralization that is sufficient for tokens to pass the SEC’s securities evaluations. The proposal is available at <https://www.sec.gov/news/speech/peirce-remarks-blockress-2020-02-06>.

<sup>8</sup>The empirical literature on token issuance is also rapidly expanding, see, e.g., Davydiuk, Gupta and Rosen (2023), Adhami, Giudici and Martinazzi (2018), Amsden and Schweizer (2018), Boreiko and Sahdev (2018), Bourveau, De George, Ellahie and Macciocchi (2018), Deng, Lee and Zhong (2018), Fisch (2019), Roosenboom, Kolk and Jong (2020), Howell, Niessner and Yermack (2020), Lyandres, Palazzo and Rabetti (2022), Benedetti and Kostovetsky (2021).

absence of competition from other platforms.

Other papers study the economics of blockchains more broadly including the benefits and limitations of adopting cryptocurrencies as a means of payment: [Yermack \(2015\)](#), [Chiu and Koepl \(2022\)](#), [Abadi and Brunnermeier \(2018\)](#), [Budish \(2018\)](#), [Pagnotta \(2022\)](#), [Hinzen, John and Saleh \(2022\)](#), [Biais, Bisière, Bouvard and Casamatta \(2019\)](#), [Chiu and Koepl \(2019\)](#), [Saleh \(2021\)](#), [Easley, O'Hara and Basu \(2019\)](#), [Li and Mayer \(2021\)](#).<sup>9</sup> Complimentary to our paper is [Huberman, Leshno and Moallemi \(2021\)](#) who study how transaction fees incentivize miners to support the Bitcoin network and show that, in the long run, the network serves all users. Importantly, large miners are not able to affect transaction fees unilaterally. Although our focus is on utility tokens, we also show that a tokenized platform serves all consumers in the long run. We advance this result further by explicitly modeling competition between traditional platforms and comparing the outcomes to those delivered by a tokenized platform.

Relatedly, our paper contributes to a growing literature that highlights the commitment features of the blockchain technology. In [Cong and He \(2019\)](#), the blockchain helps overcome barriers to entry arising from information asymmetry and increases competition by allowing entrants to commit to delivering goods. In [Cong, Li and Wang \(2022\)](#), the blockchain enables commitment to dynamic token supply rules for a tokenized platform, which allows for optimal investment in platform quality over time. Similar to our paper, [Sockin and Xiong \(2023a\)](#) study decentralization of digital platforms that can be achieved through tokenization. In their paper, tokens allow a platform owner to commit to give up control over the platform through decentralized governance. In contrast, our focus is on how tokens can facilitate competitive pricing. While in [Sockin and Xiong \(2023a\)](#) tokenization can lead to reduced network effects due to removal of centralized subsidies that incentivize users to join a platform, in our setting, tokenization benefits network effects since competitive pricing can be achieved on a single platform.

Other work in the literature highlights different features of smart contracts. For example, [Brzustowski, Georgiadis-Harris and Szentes \(2023\)](#) model a durable goods monopolist who deploys smart contracts when trading with a buyer. In their paper, smart contracts do not provide commitment power because the contracts can be replaced without a buyer's consent in future. Instead, the main feature of smart contracts studied by [Brzustowski et al. \(2023\)](#) is that a contract can serve as a mediator between a seller and a buyer and, importantly, can hold information which is inaccessible to the seller. The paper shows that such contracts

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<sup>9</sup>See [Chen, Cong and Xiao \(2021\)](#) for an overview of the recent research into blockchain economics. See also [Hu, Parlour and Rajan \(2019\)](#), [Liu and Tsyvinski \(2021\)](#), [Hinzen, Irresberger, John and Saleh \(2019\)](#), and [Li, Shin and Wang \(2021\)](#) for empirical analysis of cryptocurrencies.



allow a seller to retain some market power.

Our paper is also related to the literature on durable goods monopolies originated by Coase (1972). This literature shows that, under some conditions, including a continuous infinite timeline and patient enough consumers, a durable goods monopolist charges competitive prices and immediately saturates the market due to competition with her future self. Similarly, in our paper, commitment to the tradability and durability of tokens creates competition for the firm in future token markets.<sup>10</sup> While in Coasian self-competition, the monopolist competes with their own future sales, in our model, the monopolist competes with past token sales. This feature of our model is similar to competition that a durable goods monopolist faces from a secondary market for used goods. An important difference is that the service purchased with tokens is non-durable and consumers demand the service in every period. Even though the token is durable, there is no inherent convenience yield from holding a token and consumers have to exchange the token for the non-durable service to obtain utility. This difference results in long-run competitive pricing in a finite horizon model even if agents are infinitely patient. This difference also implies that commitment to token supply would not help the firm extract more rents.<sup>11</sup>

Finally, our paper also relates to the work on the role of money in facilitating trade among agents (see Lagos, Rocheteau and Wright, 2017, for an overview). In these models, money is a good that does not have any intrinsic consumption value but it is used to facilitate trade when barter is inefficient. The models typically feature a double-coincidence of wants problem — i.e., when agents meet directly it is unlikely that one agent’s production good is another agent’s consumption good and vice versa. Money serving as a medium of exchange can help overcome the lack of coincidence of wants. In our framework, tokens are similar to “money” as they have no intrinsic value but are used only to exchange services on a platform. We differ in the underlying inefficiency that tokens help solve. We assume away the double coincidence of wants problem as a platform can match consumers with service providers ensuring that a match always results in a trade. In our model, the inefficiency arises due to the firm’s monopoly power over the matching technology since consumers and providers cannot meet outside the platform to trade directly. We show that this monopoly power is eroded over time due to tradability of tokens.

The rest of this paper is organized in the following way. In the next section, we set up and analyze the benchmark model. We discuss this model to highlight the main friction without utility tokens. In Section 3, we introduce the model with utility tokens and explain how tokens

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<sup>10</sup>In our model, as in Bulow (1982), if the durability and tradability of tokens is restricted the firm maintains market power. We discuss the importance of these features of tokens in Section 3.3 and the Appendix.

<sup>11</sup>Section 6 discusses the connection of our model with models of durable goods monopolies in more detail.

resolve the main friction. Section 4 introduces network effects and shows that a tokenized platform delivers a welfare superior outcome compared to competing platforms. This section also considers private incentives to adopt tokens. In Section 5, we extend the main model by introducing multiple service types and demand uncertainty. Section 6 discusses how smart contracts enable commitment to the parameters of the platform, how token price dynamics in the model relate to those observed in practice, and also relates our mechanism to those in models of durable goods monopolist. The last section concludes.<sup>12</sup>

## 2 Benchmark Model

We first set up a benchmark model without utility tokens and describe its equilibrium. In Section 3, we introduce tokens to the model and analyze how the equilibrium changes.

### 2.1 Model Setup

The model comprises of  $T$  periods. There are three types of agents: a long-lived firm that operates a platform which matches service providers and consumers, short-lived service providers who produce a service and can sell it on the platform, and short-lived consumers who value the service and can buy it on the platform. All agents are risk-neutral and have a common discount factor  $\delta \leq 1$ .

#### 2.1.1 Platform and Agents

The platform is initiated by the firm at the beginning of the first period,  $t = 1$ , and matches consumers with service providers in all periods  $t = 1, \dots, T$ . We assume that the service can only be purchased through the platform and there is no other way for service providers to match with consumers looking for the service.<sup>13</sup> This assumption is the key friction that allows the firm to earn monopoly rents in the benchmark model.

**Service providers:** Each period, a unit mass of service providers is born and can freely access the platform to sell their service. Service providers are short-lived — a provider born at period  $t$  can participate in the service exchange on the platform only at  $t$ . Their marginal cost of producing a unit of the service is  $c$ .

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<sup>12</sup>All proofs are in the Appendix. Appendices C and D are available online as the Internet Appendix.

<sup>13</sup>Matching, in this case, can be more sophisticated than consumers and service providers simply being able to meet. Matching can involve using the platform's technology to facilitate the provision of a service. For example, on a platform that connects users looking for taxi rides, matching involves mapping technology and optimization to connect each user with the closest driver. We also assume away the problem of platform leakage, i.e., a pair of a provider and a consumer who matched at least once on the platform cannot use any related information to meet outside the platform.

**Consumers:** Each period, a unit mass of consumers is born who each value only a single unit of the service. Similarly to providers, consumers are short-lived — a consumer born at time  $t$  can participate in the service exchange on the platform only at  $t$ .<sup>14</sup> There are  $N \leq T$  types of consumers. A consumer of type  $i$  values a unit of service at  $v_i \in [\underline{v}, \bar{v}]$ , where  $\delta \underline{v} \geq c$ .<sup>15</sup> Without loss of generality,  $v_i$  is decreasing in  $i$  with  $v_1 = \bar{v}$  and  $v_N = \underline{v}$ . The mass of type  $i$  consumers is equal to  $\alpha_i$  and  $\sum_{i=1}^N \alpha_i = 1$ . For convenience, we denote the mass of consumers who value the service weakly greater than  $v_i$  by  $L_i \equiv \sum_{j=1}^i \alpha_j$  with  $L_0 \equiv 0$ . We assume that consumers are deep pocketed and, as such, unconstrained in their ability to pay for the service.

**Firm:** In the benchmark model, the firm operating the platform intermediates trade between consumers and providers in each period. The firm charges consumers a price for being matched with and receiving a service from a provider while it pays providers a reimbursement to ensure service provision upon matching.

We denote by  $Q_t$  the mass of consumers matched in period  $t$  or, equivalently, the number of service units exchanged on the platform. We assume that the firm has to charge the same price  $p_t$  to all consumers for being matched. Since a consumer of type  $i$  purchases a unit of service in period  $t$  whenever  $v_i \geq p_t$ , the total consumer demand for the service is given by

$$d_t(p_t) = \begin{cases} L_i & \text{if } v_{i+1} < p_t \leq v_i \text{ for some } i \in \{1, \dots, N\}, \\ 0 & \text{if } v_1 < p_t, \end{cases} \quad (1)$$

where, for notational convenience, we define  $v_{N+1} \equiv 0$ .

On the other side of a match, the firm reimburses service providers  $r_t$  to ensure that a match results in a service exchange. We assume that providers face no costs of accessing the platform. Since providers' marginal cost is  $c$ , their participation constraint if they match with a consumer is

$$r_t \geq c. \quad (2)$$

When (2) holds, all service providers are present on the platform because access to the platform is free. However, not all of them may be matched with a consumer. In particular, if  $Q_t < 1$ , only a measure  $Q_t$  of service providers are matched with consumers.

The firm's profit in period  $t$  in the benchmark model is  $(p_t - r_t)Q_t$ . Each period  $t$ , the firm chooses  $Q_t$ ,  $p_t$ , and  $r_t$  to maximize this profit subject to the demand of consumers (1)

<sup>14</sup>We consider short-lived providers and consumers for ease of exposition. In the Appendix, we extend our main model to allow for these agents to be long-lived and show that the equilibrium of the model is preserved.

<sup>15</sup>This assumption ensures that there are gains from trade between lowest-type consumers and service providers in the model with tokens.

and the participation constraint of service providers (2). Given the consumers' step demand for the service (1), the firm's choice of  $Q_t$  uniquely determines the highest price  $p_t$  that it can charge consumers

$$p(Q_t) = v_i \quad \text{if} \quad Q_t \in (L_{i-1}, L_i] \text{ for some } i \in \{1, \dots, N\}, \quad (3)$$

which is the marginal consumer's value of service. Additionally, since service providers are competitive the firm optimally sets  $r_t = c$  so that their participation constraint (2) is just satisfied. Therefore, the firm's problem in period  $t$  can be written as

$$\pi^{m,t} \equiv \max_{0 \leq Q_t \leq d_t(p_t), p_t \geq 0, r_t \geq c} (p_t - r_t)Q_t = \max_{0 \leq Q_t \leq L_N} (p(Q_t) - c)Q_t, \quad (4)$$

and, thus, it reduces to the choice of the number of trades  $Q_t$  that the firm intermediates.

In the benchmark model without tokens, the firm's problem is identical in all periods  $t$  and, thus, the total profit over  $T$  periods is  $\pi^m \equiv \pi^{m,1} \sum_{t=1}^T \delta^{t-1}$ . In contrast, in our main model with tokens, the firm's decision at time  $t$  depends on the total number of tokens issued up till  $t$ .

## 2.2 Equilibrium Analysis

We first establish the equilibrium in the benchmark model.

**Proposition 1** (Equilibrium of Benchmark Model). *In the unique equilibrium of the benchmark model, the firm charges the same price in every period and only a fraction  $Q_t = L_{i_m} \leq 1$  of consumers is able to acquire the service. In particular, if  $L_{i_m} < 1$ , the competitive outcome, in which all consumers obtain the service, is never achieved.*

To provide the intuition for this result, we present the proof of Proposition 1 in the main text. To maximize its profit, the firm intermediates the maximum number of trades at a given price, i.e., it provides  $Q_t = L_i$  matches if the price is  $p(Q_t) = v_i$ , because  $v_i > c$  for all  $i$ . Thus, to solve (4), the firm chooses  $Q_t \in \{L_1, \dots, L_N\}$  and its problem becomes

$$\max_{Q_t \in \{L_1, \dots, L_N\}} (p(Q_t) - c)Q_t = \max_{i \in \{1, \dots, N\}} (v_i - c)L_i. \quad (5)$$

Each period, the firm trades off rents extracted from serving higher consumer types versus rents collected from serving a larger number of consumer types at a lower price. The solution,

$$i_m = \arg \max_i (v_i - c)L_i, \quad (6)$$

determines the marginal consumer type with value  $v_{i_m}$  that is served each period. Accordingly, in every period  $t$ , the firm intermediates  $Q_t = L_{i_m} = \sum_{j=1}^{i_m} \alpha_j$  units of service for the price  $p_t = v_{i_m}$  charged to consumers and pays  $r_t = c$  to service providers.

In the benchmark model, if  $i_m < N$ , only a fraction  $L_{i_m}$  of consumers is able to acquire the service every period. The remaining consumers are effectively priced out and are not able to obtain the service. Therefore, even though the firm does not produce the service itself, it acts like a monopolist who finds it optimal to exclude some consumers from the market. There are gains from trade between consumers and service providers that are not realized since excluded consumers who value the service above its marginal cost are not able to purchase it.

## 2.3 Key Friction

If consumers and service providers could meet with each other directly without the platform, the equilibrium price of the service and the quantity of it exchanged would be equal to those in a competitive market such that every consumer who values the service above its marginal cost of provision would be able to obtain the service.

The main friction of the model arises because consumers and service providers can only match with each other if they use the platform developed by the firm. The platform's exclusive matching technology generates monopoly power for the firm. Indeed, as we have shown above, the firm finds it optimal to restrict the supply of the service exchanged, or the number of matches, on the platform.

The matching technology is more likely to generate monopoly power if it provides users with utility benefits that are not easy to replicate outside the platform. For example, the platform might facilitate more efficient matching compared to random matching or the platform's users might enjoy some network benefits. Additionally, the platform's market power is likely to be greater if interactions between pairs of consumers and providers are non-repeated.<sup>16</sup>

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<sup>16</sup>For example, on a ride-sharing platform, the matching technology can facilitate matching riders with drivers who are close by. Even if a rider exchanges information with a driver to try to match without the platform in the future, such matching is unlikely to be efficient — the driver may not be available or nearby when the rider needs a ride. In contrast, a platform which matches customers with a handyperson in their area may struggle to retain users after facilitating the first match. Consumers and providers on such a platform can exchange contact details and more easily set up a recurring relationship through private channels.

### 3 Model with Tokens

We now introduce utility tokens to the model. We assume that, before the platform is launched, at the beginning of  $t = 1$ , the firm specifies a set of rules that govern how the platform will operate with tokens. Crucially, once the platform is operational, these rules cannot be changed by the firm unilaterally, which constitutes the firm's commitment.<sup>17</sup>

#### 3.1 Model Setup

As in the benchmark model, the platform is the only place where consumers can match with providers to exchange the service. However, under the rules, the firm cannot charge consumers or providers any fees for accessing or using the platform. Thus, in contrast to the benchmark, in this setup, consumers and providers do not make or receive any payments from the firm when using the platform to exchange the service.

The only means of payment allowed on the platform are tokens. In particular, in order to buy the service, a matched consumer has to pay tokens to her provider match. Any numeraire payments between consumers and providers are not permitted. Under the platform rules, the price of service in tokens is fixed — one token can be exchanged for one unit of the service.<sup>18</sup> Given these restrictions, to be able to pay for the service, consumers have to obtain tokens first. This gives rise to the demand for tokens and makes them valuable.

Although the firm is the only agent that can create tokens, it cannot restrict circulation of tokens among other agents. Specifically, tokens can be freely traded for numeraire in a common token market by any agent including the firm. In this market, the firm can trade its tokens with agents, consumers can buy tokens in order to exchange them for the service, while service providers, who may hold tokens they received as payment for their service, can sell tokens. Crucially, the firm cannot restrict trade in this market. We assume that the token market opens each period  $t$  before the platform exchange (see Figure 1). To summarize, the tokenized platform operates under the following set of rules.

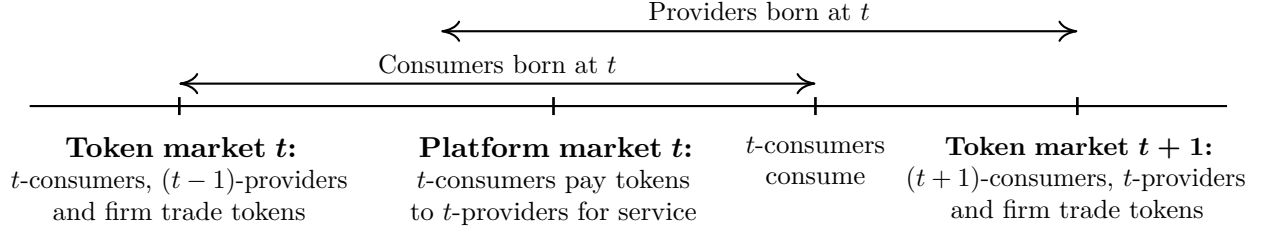
**Definition** (Platform Rules).

1. *Durable tokens can be traded by any agent in a common token market open to all agents.*

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<sup>17</sup>The implicit assumption is that the commitment to the rules is enabled through decentralization with blockchain technology — any changes to the rules have to be approved by the platform's users (e.g., as in Sockin and Xiong, 2023a). We discuss this commitment in more detail in Section 6.

<sup>18</sup>The price of one unit of service being equal to one token is without loss of generality. However, as we discuss below, it is important that the price is fixed. This feature is in line with other studies on product tokens (see, e.g., Chod and Lyandres, 2023; Cong and Xiao, 2021). This feature also creates token non-neutrality as in Sockin and Xiong (2023b) because a token's value to a user is determined by the consumption value of the service the token can be exchanged for rather than by the fiat value of the token. In Section 6, we discuss how smart contracts have been used to commit to this feature in practice.



**Figure 1: Sequence of events and lifespans of agents.** This figure shows the sequence of events during period  $t$  and the lifespans of short-lived consumers and service providers born at  $t$ .

2. Consumers and providers can freely match through the platform's technology. The firm cannot charge agents any fees for accessing or using the platform.
3. Tokens are the sole means of payment on the platform. No other payments can be made between consumers and providers upon matching.
4. The price of a unit of service is fixed in tokens.

Below we demonstrate that commitment to these rules leads to the gradual erosion of the firm's monopoly power and eventually results in the competitive outcome for the service exchange. In the Appendix, we show that while the four platform rules together deliver this outcome, relaxing any one of the rules returns some, or all, market power to the firm.

Finally, we need to make one more assumption in the finite-horizon model for tokens to be a credible medium of exchange.

**Assumption 1.** *Service providers born in period  $T$  can redeem their tokens with the firm at the end of this period for  $c$ .*

As explained above, consumers value tokens because they can be exchanged for the service. In turn, service providers accept tokens as payment for the service knowing that they can resell them in the token market. However, in the finite horizon model there is no token market after period  $T$ . Thus, to make tokens a credible medium of exchange, we need to assume that service providers can redeem their tokens with the firm at the end of the last period  $T$ .<sup>19</sup>

### 3.1.1 Consumers and Providers on Tokenized Platform

With a slight abuse of notation, we now denote by  $p_t$  the equilibrium price of a token in the token market. As we show below, in equilibrium each token purchased in period  $t$  is

<sup>19</sup>In the Appendix, we consider an extension of the model with an infinite horizon, where this assumption can be omitted as providers are always able to resell tokens in the token market of the following period. In this setting, there is also an equilibrium in which tokens do not have value as a medium of exchange due to the self-fulfilling nature of agents' beliefs. Such multiplicity of equilibria is a standard issue in the literature on fiat money (see, e.g., Samuelson, 1958; Wallace, 1980; Starr, 1989).



exchanged for one unit of service during the platform exchange in the same period. Thus,  $p_t$  can also be viewed as the price of the service in period  $t$  in numeraire. Before we describe how this token price is determined in equilibrium, we outline the strategies of consumers and providers on the tokenized platform.

**Consumers:** As in the benchmark, consumers born in the beginning of period  $t$  participate in the platform exchange market only once, at  $t$ . They first decide whether to buy any tokens in the token market at  $t$  and then exchange them for the service in the platform market. Finally, they exit after consuming any services obtained (see Figure 1). Our assumption that consumers are short-lived, in conjunction with the platform rules that do not allow any transfers between providers and consumers, implies that a consumer cannot benefit from the resale of tokens in the future. The only use of a token to a consumer is to exchange it for a service.<sup>20</sup>

Assuming that a token is accepted as payment for a unit of the service in the platform market at  $t$ , a consumer of type  $i$  purchases a token in the token market whenever her consumption value is weakly higher than the token price,  $v_i \geq p_t$ . Therefore, the total consumer demand for tokens is given by

$$d_t(p_t) = \begin{cases} L_i & \text{if } v_{i+1} < p_t \leq v_i \text{ for some } i \in \{1, \dots, N\}, \\ 0 & \text{if } v_1 < p_t, \end{cases} \quad (7)$$

which is identical to the demand for the service in the benchmark model (1). Because each short-lived consumer values only one unit of service, the maximum token demand is equal to  $L_N = 1$ . If consumers do not expect to be able to exchange a token for the service, they do not buy tokens.

Finally, because consumers exit before the token market at  $t + 1$ , tokens are worthless to them after the platform exchange at  $t$ . Therefore, all tokens purchased by consumers in the token market at  $t$  are transferred to providers in exchange for services.

**Service providers:** We assume that service providers are born after the token market in period  $t$  but can participate in the token market at  $t + 1$ . This allows providers to resell any tokens, that they obtain in the platform exchange market at  $t$ , in the token market at  $t + 1$ . After this token market, service providers exit (see Figure 1). Similarly to consumers, the assumption that providers are short-lived implies that they cannot buy tokens at  $t$  and, thus, they do not speculate in the token market.

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<sup>20</sup>In the Appendix, we consider an extension with long-lived consumers and providers. In this case, consumers and providers are able to speculate in the token market, i.e., agents might buy tokens to resell them in future periods rather than to exchange them for service. We show that speculation does not happen in the equilibrium.



As in the benchmark, service providers can access the platform freely. Conditional on being matched with a consumer in the platform market at  $t$ , a provider serves the consumer in exchange for a token, if the token resale price at  $t + 1$  is greater than the marginal cost of service provision  $c$

$$\delta p_{t+1} \geq c. \quad (8)$$

Otherwise, the provider rejects the service provision. As the firm repurchases all tokens for  $c$  at the end of the last period  $T$ , for notational convenience, we define  $p_{T+1} = \frac{c}{\delta}$ .

Below, we show that condition (8) is satisfied in our main model in all periods. Thus, consumers rationally expect to be able to exchange tokens for the service in all periods. Finally, because service providers born at  $t$  exit the economy after the token market at  $t + 1$ , they sell all their tokens in this market. This implies that all the tokens bought by consumers in the token market at  $t$  are sold by providers in the subsequent token market at  $t + 1$ .

### 3.1.2 Firm on Tokenized Platform

Given the platform rules that prohibit any fees for accessing or using the platform, the only way the firm can earn profit in the model is by trading tokens in the token market. In particular, each period  $t$ , the firm decides how many tokens  $q_t$  to sell in this market, where  $q_t < 0$  denotes a decision to buy back tokens. When making this choice, the firm considers the total number of tokens that it has sold up to date  $t$  and that are now owned by other agents  $Q_{t-1} \equiv \sum_{s=1}^{t-1} q_s$ , with  $Q_0 = 0$ . In the benchmark model, we used  $Q_t$  to represent the number of trades that the firm intermediates at time  $t$ . We choose the same notation here because our assumptions about consumers and providers imply that these agents do not hoard tokens and, therefore,  $Q_t$  is the total number of tokens that are exchanged for units of service in period  $t$ . As agents cannot short tokens  $Q_t \geq 0$ .

**Token price:** Because tokens are traded in the common token market, the firm trades  $q_t$  at the same equilibrium token price  $p_t$  as other agents. This price is given by the market clearing in the token market and, therefore, it incorporates the price impact of the firm's trades. Specifically, because service providers born at  $t - 1$  sell all their tokens  $Q_{t-1}$  in the token market at  $t$  and the firm trades additional  $q_t \geq -Q_{t-1}$  tokens, the total supply of tokens in this market is  $Q_{t-1} + q_t = Q_t$ . The equilibrium token price is then given by the price at which this supply clears the consumer demand for tokens (7)

$$d_t(p_t) = Q_t. \quad (9)$$

As the token demand is a step function, there can be multiple prices at which the market

clears when  $Q_t = L_i$  for each  $i$ . To uniquely pin down the market clearing price, we assume, without loss of generality, that the equilibrium price  $p(Q_t)$  is left-continuous.<sup>21</sup> This implies that the equilibrium price is the highest price that clears the market. Finally, if  $Q_t > 1$ , the total supply of tokens is greater than the maximum token demand. In this case, because providers selling tokens exit after the token market and have no further use for tokens, the price  $p(Q_t)$  falls to 0.<sup>22</sup> To summarize, the equilibrium token price  $p_t$  is given by

$$p(Q_t) = \begin{cases} v_i & \text{if } Q_t \in (L_{i-1}, L_i] \text{ for some } i \in \{1, \dots, N\}, \\ 0 & \text{if } Q_t > L_N. \end{cases} \quad (10)$$

**Firm's problem:** We can now write down the firm's profit. Each period  $t$ , given  $Q_{t-1}$  and anticipating that the current and future equilibrium token prices are given by (10), the firm chooses the token trading policy  $q_t$  to maximize the present value of its trading profits

$$\pi_t(Q_{t-1}) \equiv \max_{\{q_s\}_{s=t}^T} \sum_{s=t}^T \delta^{s-t} [p(Q_{s-1} + q_s) - \delta^{T-s} c] q_s \quad \text{s.t.} \quad Q_s = Q_{s-1} + q_s \geq 0, \quad (11)$$

where we account for the fact that the firm has to redeem tokens released in period  $s$  for  $c$  in the last period, i.e., in  $T - s$  periods. Note that the firm does not commit to the number of tokens sold in future periods, and therefore it is restricted only to time-consistent token issuance policies.<sup>23</sup> For any  $t' > t$ , the firm's trading policy  $q_{t'}$  has to maximize the present value of its trading profits going forward, i.e., solve (11) with  $t'$ . We can restate the firm's problem recursively as

$$\pi_t(Q_{t-1}) = \max_{q_t \geq -Q_{t-1}} \{ [p(Q_{t-1} + q_t) - \delta^{T-t} c] q_t + \delta \pi_{t+1}(Q_{t-1} + q_t) \}, \quad (12)$$

where  $\pi_{T+1} \equiv 0$ .

**Definition (Equilibrium).** *A subgame perfect equilibrium of this model is given by the number of tokens traded by the firm  $q_t = q_t(Q_{t-1})$  and the token prices  $p_t = p(Q_{t-1} + q_t)$  such that in*

<sup>21</sup>That is,  $\lim_{Q_t \uparrow L_i} p(Q_t) = p(L_i)$  for all  $i$ . Intuitively, the firm can choose  $q_t$  such that  $Q_t = L_i - \varepsilon$ , with arbitrary small  $\varepsilon$ , for which the market clearing price is unique,  $p(L_i - \varepsilon) = v_i$ . A different choice of the market clearing price when  $Q_t = L_i$ , e.g., the midpoint between  $v_i$  and  $v_{i+1}$ , will not affect our qualitative results although the surplus distribution would change.

<sup>22</sup>If providers and consumers are long-lived, the price falls to  $\delta^{T-t} c$  if there is excess supply of tokens. Indeed, long-lived agents can always redeem their tokens with the firm at the end of the last period for  $c$ . Note that, in either setting, with short- or long-lived agents, the firm is able to reabsorb excess token supply at zero profit because the discounted equilibrium price at  $Q_t > L_N$  is constant across periods  $t$ . As such, the effective sale price and the repurchase price of any excess tokens are the same.

<sup>23</sup>We discuss the value of time-consistent issuance policies in Section 6.1.3.

all periods  $t$ : i) the firm's trading policy maximizes its profit (11), ii) consumers and providers follow their optimal strategies given token prices, iii) the token market clears (9).

## 3.2 Equilibrium Analysis

We now determine the equilibrium in the general model setup, which lasts  $T$  periods and has  $N$  consumer types. We show that if the firm follows the platform rules it finds it optimal to gradually increase the supply of circulating tokens over time. In turn, this leads to the competitive outcome in the platform exchange market. To elucidate our results further, in Appendix B, we provide a detailed analysis of the model in an example with  $T = 2$  and  $N = 2$ .

To establish a unique equilibrium when  $T > N$  and  $\delta = 1$ , we introduce the following tie-breaking rule.

**Assumption 2** (Tie-breaking Rule). *If the firm is indifferent between trading a token in the current period  $t$  and postponing the trade of that token to some future period  $s > t$ , i.e., if the two strategies yield the same expected profit  $\pi_t(Q_{t-1})$ , the firm trades the token in the current period.*

Under this assumption, we can establish the following proposition.<sup>24</sup>

**Proposition 2** (Equilibrium of Model with Tokens). *In the model with tokens, there is a unique equilibrium, in which the total quantity of tokens released,  $Q_t$ , increases over time while the token price  $p_t$  decreases over time. With  $N$  different consumer types, the competitive outcome in the token market is achieved in exactly  $N$  periods if  $\delta = 1$ . If  $\delta < 1$ , the competitive outcome is achieved in at most  $N$  periods.*

When  $\delta = 1$ , the firm releases  $q_t = \alpha_i$  tokens in period  $t = i$ , where  $\alpha_i$  is the mass of consumers who have the highest value for the service among consumer types who have not yet obtained the service before this period. Specifically, at  $t = 1$ , the firm sells  $\alpha_1$  tokens and the resulting token price is  $p_1 = v_1 = \bar{v}$ . At  $t = 2$ , providers resell these tokens, received as payment for their service in the first period, and the firm sells additional  $\alpha_2$  tokens. As a result, the token price falls to the new level  $p_2 = v_2$ . This gradual release of tokens continues until period  $N$ , in which the firm sells tokens to the group of consumers who value the service the least and the token price falls to  $p_N = v_N = \underline{v}$ . By spreading the release of tokens over periods, the firm is able to maximize its profit. When  $\delta < 1$ , the firm discounts future revenues and may choose to sell new tokens to multiple consumer types in a given period.

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<sup>24</sup>All omitted proofs are in the Appendix.

Intuitively, the firm has a limited stock of market power when it commits to a tokenized platform operating under the platform rules. Whenever the firm wants to monetize the platform by selling tokens, it also necessarily creates competition for itself in future token resale markets. The firm competes both with service providers when selling additional tokens and with consumers when buying back tokens. Indeed, any tokens released by the firm will be subsequently resold by service providers. The more tokens the firm sells, the more future competition it faces from service providers and the less market power it has in the token markets going forward.

Moreover, the firm is not able to regain its market power by buying back some tokens because of competition from consumers. Because the token market is common, the firm has to do a buyback at a common equilibrium market price (10) set by the consumer demand, which makes token buybacks unprofitable. Effectively, the firm has to compete with consumers for tokens if it seeks to decrease the supply of tokens. The decrease, however, would imply higher equilibrium token price at which the firm does a buyback. This makes a buyback unprofitable because any future token price, which will be set by lower-type consumers once the firm decides to increase the token supply again, is no greater than the current price.

As a result, the firm can only profit from each token once, when it first sells the token. The firm therefore finds it optimal to sell tokens gradually, starting from the highest-type consumers and progressively selling to lower and lower-type consumers. As time passes, a competitive outcome is eventually reached in this market, in which all consumers who value the service above its marginal cost of provision are able to obtain a token and, therefore, the service.

### 3.3 Utility Tokens as a Solution to the Key Friction

As discussed in Section 2.3, the key friction of the model arises because consumers and service providers cannot match with each other directly to exchange the service. Instead, they must use the platform developed by the firm. This allows the firm to exercise monopoly power because it fully controls the platform and, therefore, can restrict the supply of the non-durable service.

When the service on the platform is exchanged through utility tokens, the supply of service is determined by the supply of tokens. Because every token can be used in all future platform markets, tokens are introducing durability in the trade of the non-durable service. Importantly, the real value of tokens does not depreciate over time — each token can be exchanged for one unit of the service in every period. Thus, when the firm sells tokens, it resembles a classic durable goods monopolist who has to compete in the resale market. As

we have shown above, as a result of this competition, the firm gradually increases the supply of tokens. Therefore, the firm slowly loses control over the platform market and the supply of service becomes unrestricted in the long-run, which resolves the main friction.

**Platform Rules:** The platform rules grant important features to utility tokens and are all necessary to achieve the competitive outcome in the long run. In Appendix C, we relax each rule one by one and show that doing so returns all, or some, market power to the firm. Below, we provide intuition for why each platform rule is important in eroding the firm's market power using the analogy of the firm as a durable goods monopolist.

The first rule specifies that there must be a common market for durable tokens, in which consumers, providers, and the firm can trade tokens with each other. Absent the common token market, the firm maintains complete control over the pricing of the service exchange on the platform. In this scenario, consumers can only buy tokens from the firm and providers can only redeem tokens with the firm. This allows the firm to regain all tokens each period and gives it full control over how many tokens are sold and, consequently, how much of the service will be exchanged on the platform. Essentially, the firm becomes a durable goods monopolist who can rent out their good each period. This scenario is equivalent to tokens being completely non-durable as each token can only be exchanged for a single service before it is returned to the firm. The firm therefore preserves its monopoly power and replicates the profit in the benchmark model.

The second rule, that the firm cannot charge agents any fees for using and accessing the platform, and the third rule, that no payments can be made between consumers and providers upon matching, prevent any extra transfers, direct or indirect, from the agents to the firm. As discussed above, in the absence of a common token market, the firm behaves similarly to a durable goods monopolist who rents out their good every period. In a similar vein, the second and the third rule prevent the firm from earning any continued rental income on tokens it has already sold.

Relaxing the second rule would allow the firm to earn these rents directly by charging providers or consumers access or transaction fees every time they exchange the service. Relaxing the third rule would allow the firm to earn these rents indirectly. Because service providers are competitive, every time they receive a token from a consumer, they would be willing to make a transfer to the consumer equal to their future surplus from the resale of the token. This would lead to higher token prices as, when purchasing a token, consumers expect to receive not only the value of the service but also the transfer from a provider. Consequently, the firm would be able to extract the value of all future transfers associated with a token when it first sells a token. While relaxing these two rules does not generally give the firm the ability to fully rent out the tokens, as is the case when there is no common

token market, it restores some market power to the firm. The firm essentially becomes a durable goods monopolist who continues to earn partial rents on goods they have sold.

The final rule specifies that tokens must allow transfer of the service between providers and consumers at a fixed exchange rate. This feature ensures that every time the firm sells a token — that grants consumers a unit of the service — a service provider will get to sell this token and, as such, a unit of service in the future. This feature imparts durability to the ability to exchange the service, even though the service itself is non-durable. If, instead, service providers were competing on how many tokens they require in exchange for service provision, the price of service in tokens would appreciate and, as a result, the quantity of service that each token buys would depreciate. In a sense, tokens become less durable and some market power would remain with the firm.<sup>25</sup>

### 3.4 Profits and Welfare

We now compare the firm’s profits and total welfare in the model with tokens to those in the benchmark model. To help distinguish the two scenarios, we refer to the platform in the benchmark model as a *monopolistic* platform and the platform in the model with tokens as a *tokenized* platform.

**Proposition 3** (Profit Comparison). *A monopolistic platform earns higher profit than a tokenized platform.*

When the firm operates a tokenized platform, it can profit from each token only once. With a monopolistic platform, on the other hand, the firm earns continued profits as it maintains its market power every period. Indeed, in this case, with full control over the market, the firm could choose the quantities and prices of the service to replicate those of a tokenized platform. However, the firm finds it more profitable to follow the monopoly strategy described in the benchmark model.

With tokens, competitive pricing, which maximizes the total per-period surplus is always achieved in the equilibrium. However, this outcome is reached only after some time. Due to the delay, the per-period surplus is lower under a tokenized platform relative to that under a monopolistic platform for the first  $i_m$  periods. Thus, if the monopolistic platform makes enough profit by providing a large mass of consumers with the service, i.e., if  $i_m$  derived in

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<sup>25</sup>In Appendix D.1, we also analyze a case in which a fraction of tokens is “burned”, withdrawn from circulation, during service exchange. In this case, market power returns to the firm in a similar way to the case when the fixed token-to-service price rule is relaxed. If the firm costlessly burns tokens, it effectively makes tokens less durable because some fraction of tokens cannot be exchanged for the service in the future.

(6) is high, the total welfare in the benchmark model may be higher. Formally, when  $\delta = 1$ , the following holds.

**Proposition 4** (Welfare Comparison). *The total welfare under a tokenized platform is higher than the total welfare under a monopolistic platform if the number of periods  $T$  is sufficiently high.*

The resale of tokens shifts surplus from the firm to consumers and service providers. As we discuss above, the platform rules ensure that the the firm can only profit from the sale of new tokens and all surplus from the resale of previously released tokens is entirely captured by consumers and providers. In contrast to the benchmark model, providers earn positive surplus because token prices are higher than the cost of service provision. In addition, consumers earn greater surplus once the token price falls below the monopolist's price.

If  $\delta < 1$ , the qualitative results are similar but there are two additional forces. On the one hand, the competitive outcome in the token market is reached sooner and, therefore, the total welfare is more likely to be higher under a tokenized platform. On the other hand, the discounted surplus from future periods contributes less to the total surplus and the initially higher price reduces welfare under the tokenized platform compared to that under the monopolistic platform.

## 4 Platform Competition

In the previous section, we show that the introduction of utility tokens to the platform can reduce monopolistic rents extracted by the firm. Another potential, and more traditional, mechanism of reducing rents is through competition between platforms. Below, we compare the relative efficiency of the two approaches in the presence of network effects by studying how the welfare under a tokenized platform compares to the welfare generated by two competing platforms that operate without tokens. In addition, we explore the firm's private incentives to tokenize the platform in the face of competition.

### 4.1 Competition under Network Effects

In this subsection, the two competing platforms are called *standard* as opposed to a *tokenized* platform of our main model. Here, we establish that, in the presence of network effects, a tokenized platform delivers higher total welfare than two competing standard platforms. Intuitively, if network effects are positive, it is efficient to exchange the service on a single platform. Although competition between platforms reduces their rents, it also implies that



consumers are spread across multiple platforms, which can lead to lower total welfare when network effects are significant. In contrast, by employing tokens, it is possible to obtain competitive prices on a single platform without splitting consumers between platforms. Therefore, a single tokenized platform delivers the highest total welfare in the long run.

**Network effects:** To model network effects, we assume that a higher mass of consumers on a platform leads to a higher value of a service unit for some consumers. For instance, the more riders and drivers that use a single ride-sharing platform, the easier it is to optimize matching efficiency and minimize waiting times for rides.<sup>26</sup> Taking cloud data storage as another example, sharing files with other users between multiple platforms might be less convenient than within the same platform. Moreover, maintaining multiple cloud storage accounts is costly financially and technologically if one has to maintain consistency of files across platforms.

In particular, a consumer of type  $i$  values a unit of the service on a platform  $j$  at

$$v_i + b_i(L^j), \quad (13)$$

where the network benefit  $b_i(L) \geq 0$  is a function on  $L \in [0, 1]$  and  $L^j$  is the mass of consumers on a platform  $j$ . We say that the platform exhibits network effects for consumers of type  $i$  if  $b_i(L)$  is strictly increasing. For other consumer types, we assume  $b_i(L) = 0$ .

As long as  $v_i + b_i(L_i)$  is decreasing in  $i$ , i.e., if the value of the marginal consumer on a platform with  $L_i$  consumers is decreasing in  $i$ , the addition of network effects does not change the conclusion of our main model. In the long run, after  $N$  periods, a tokenized platform operates at full capacity — the price in the token market is set competitively so that all  $N$  types of consumers are able to obtain the service. Therefore, as the total mass of consumers is equal to  $L_N = 1$ , the network benefit that a consumer of type  $i$  enjoys is equal to  $b_i(1)$ .

**Platform competition:** To model competition between two standard platforms we extend our benchmark model by adding a second platform. The two platforms are indexed by  $j = 1, 2$ . We assume that, each period  $t$ , the platforms simultaneously set prices  $p_t^j$  to consumers for being matched with providers and set reimbursement payments  $r_t^j \geq c$  to providers. For simplicity and to focus only on competition for consumers, we assume that  $r_t^1 = r_t^2 = c$  and that providers are present on both platforms. Consumers choose between the two platforms simultaneously after observing prices  $p_t^j$ . In the presence of network effects, consumers' utility

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<sup>26</sup>In many cases, having an account with more than one platform is not equivalent to being an active user on all of these platforms at same the time. For example, a ride-sharing platform usually attempts to connect a driver with the next rider within the same platform before they finish the first ride. This would be hard to implement on a second platform, even if the driver had an account with it, because the second platform would need to know when and where the first ride ends, which is the information available only to the first platform.



depends on the platform choice of other consumers. We, therefore, have to specify consumer beliefs about other consumers' choices after they observe the prices on the two platforms. We assume that all consumers believe that other consumers choose the platform with the lowest price, i.e., prices coordinate consumer choices. Otherwise, if the prices on the two platforms are the same, all consumers pick a platform at random.<sup>27</sup>

Under these assumptions, the two platforms effectively compete à la Bertrand by setting the price of the service. In the unique symmetric equilibrium, prices on the platforms are equal to the marginal cost of service provision  $p_t^j = c$ . Indeed, if this was not the case, one of the platforms would find it optimal to undercut the other platform's price. As in the case of the tokenized platform, all consumers are able to obtain the service. However, because the prices on the two platforms are the same, consumers optimally pick each platform with probability  $\frac{1}{2}$ , splitting evenly between the two. Therefore, the mass of consumers served by each platform is equal to  $L^j = 1/2$  and the network benefit that a consumer of type  $i$  enjoys is equal to only  $b_i(1/2)$ . Comparing the equilibrium masses of consumers served in the two scenarios, we obtain the following result.

**Proposition 5** (Welfare on Tokenized vs. Competing Platforms under Network Effects). *If the platform exchange exhibits network effects for some consumer types, the welfare under a tokenized platform in the long run (i.e., when a tokenized platform operates at full capacity) is higher than the welfare under two competing standard platforms.*

If network effects are absent, i.e., if  $b_i(L) = 0$  on  $L \in [0, 1]$  for all  $i$ , the two standard platforms achieve the same outcome and welfare as the tokenized platform in the long run. However, as long as network effects are positive,  $b_i(1) > b_i(1/2)$  for some consumer type  $i$ , the long run welfare generated by the tokenized platform is higher. Compared to the benchmark case of a monopolistic platform, rents are fully dissipated when platforms are competing. However, consumers are inefficiently split across platforms. In contrast, a tokenized platform can eliminate monopolistic rents while maintaining all consumers on the same platform and preserving network effects.

The setting above is an extreme case of price competition in which platform rents dissipate completely. The relative benefit of a tokenized platform compared to two standard competing platforms increases if the competition between the platforms is not perfect. For example, if

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<sup>27</sup>This assumption results in a unique symmetric equilibrium. If it is relaxed, there are 2 additional equilibria in which the prices on both platforms are the same but all consumers pick either the first or the second platform. We choose to focus on the symmetric equilibrium because, in the asymmetric cases, one of the platforms does not attract any consumers, which is likely not sustainable in practice in the long run and would force the platform to exit the market.

consumers cannot costlessly switch between platforms, or if platforms compete in a Cournot-like way by choosing the number of matches that they provide to consumers on their platforms each period rather than by directly competing on price. In these cases, consumers are still split between platforms but the oligopolistic rents do not dissipate fully. The two competing platforms still exclude some consumers from the market. Thus, compared to the case of perfect competition, the welfare is lower when the platforms engage in imperfect competition because some consumers are not able to obtain the service. In this setting, increasing the number of competing platforms can reduce oligopolistic rents further. However, more platforms would also lead to further declines in network effects. Therefore, in the presence of positive network effects, any number of competing platforms delivers lower welfare than that of a tokenized platform.

## 4.2 Incentives to Tokenize Platform

We now discuss the firm's incentives to tokenize its platform. As we have shown in our main analysis, the firm's profit is higher when it operates as a monopolist. Thus, it might seem that the only way to achieve the welfare-superior outcome of a tokenized platform is through a policy mandate. Contrary to this conclusion, in this section, we illustrate that the firm might have private incentives to operate a tokenized platform. Indeed, the firm can function as a monopolist only when it does not lose consumers to competition from other platforms. In contrast, tokenizing the platform could help prevent consumers from leaving to a competing platform. Thus, a firm may voluntarily choose to run a tokenized platform to prevent the entry of a potential competitor.

In this section, we assume that consumers and service providers choose between platforms based on the surplus delivered by the platforms. Intuitively, when users split across multiple platforms, there are losses in network effects which can be thought of as endogenous costs of switching between platforms. Therefore, a competitor successfully enters if the resulting market structure generates higher total long-run surplus for platform users.

We start the analysis by comparing consumer surplus in the scenario with a monopolist and in the scenario with two standard competing platforms.

**Proposition 6** (Consumer Surplus on Monopolistic vs. Competing Platforms under Network Effects). *If  $L_{i_m} > 1/2$  and if the platform exchange exhibits network effects for some  $i < i_m$  and, for some of these  $i$ ,  $b_i(L_{i_m})$  is sufficiently greater than  $b_{i_m}(L_{i_m})$ , i.e., if network effects are sufficiently stronger for higher-type consumers than for lower-type consumers, the consumer surplus on a monopolistic platform is higher than that on two standard competing platforms. Otherwise, the consumer surplus on a monopolistic platform is lower than that on*

*two standard competing platforms.*

With network effects, there are two opposing forces that affect consumer surplus on the monopolistic platform relative to the two standard competing platforms. On the one hand, competition between platforms reduces their rents which increases consumer surplus. In particular, consumer surplus increases because prices on the competing platforms are lower and because some consumers who were excluded from the service provision under the monopolist are able to obtain the service when platforms compete. On the other hand, a single monopolistic platform can generate higher network effects because consumers remain on the same platform instead of being split across two platforms. Thus, if the monopolist serves a sufficiently large mass of consumers and if the network benefits enjoyed by these consumers are sufficiently high, the benefit of the latter effect outweighs the cost of the former and consumer surplus on the monopolistic platform is higher than that on the two standard competing platforms.

First, we consider incentives to tokenize when the consumer surplus delivered by two competing platforms is higher than the surplus in the scenario with the monopolist. In this case, once the second platform is established, consumers will find it optimal to leave the monopolistic platform and join the competing platform.

The monopolist could try to deter entry by transferring some surplus to consumers. If the competition between platforms is imperfect, for example if platforms compete in a Cournot-like way, the surplus that consumers receive on competing platforms is lower and, thus, the transfer that needs to be made is lower. A sufficiently high transfer would allow the monopolist to retain consumers. However, the implementation of such a transfer might not be feasible.

The monopolist has two natural ways to implement the transfer of surplus to consumers. First, in the period in which a competing platform attempts to establish itself, the monopolist could transfer surplus to consumers by underpricing the service below its marginal cost. However, this option might not be feasible for a number of reasons. For example, if there are borrowing constraints, the firm cannot borrow against its future monopoly profit. Alternatively, the firm might not be able to reduce the price of the service below 0. Second, the monopolist could promise to consumers to lower prices in all future periods, even after the competitor fails and exits the market.<sup>28</sup> However, as we demonstrated in the benchmark model, the monopolist cannot credibly commit to keeping prices low in the long run if all consumers use its platform and there is no alternative. Therefore, a non-tokenized platform

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<sup>28</sup>The analysis of the the second channel, whereby the platform commits to give up surplus in the future through tokenization, distinguishes our paper from Chod and Lyandres (2023) who explore the first channel, whereby the platform gives up surplus by underpricing upfront.

might not be able to deter the entry of a competitor. When entry occurs, consumers split across platforms and, as a result, network effects decrease.

In contrast, a platform can credibly commit to keeping prices low in future periods through the adoption of tokens, and thereby deter entry of the competing platform. Indeed, in the long run, the welfare on the tokenized platform is maximized and completely captured by consumers and providers. Furthermore, in the early stages of its operation, a tokenized platform can give up even more surplus by speeding up the release of tokens. This would allow it to achieve the competitive outcome in fewer periods if it needs to surrender greater surplus to deter the entry of a competitor. Therefore, consumers and providers will not find it optimal to leave a tokenized platform in order to join a competing platform. Thus, a tokenized platform can deter the entry of a competitor in all periods, which preserves network effects.<sup>29</sup>

Next, we discuss incentives to tokenize when the consumer surplus delivered by two competing platforms is lower than the surplus in the scenario with the monopolist. In this case, the monopolist is not concerned about the entry of a competing platform as it would not be able to attract consumers. However, we can apply similar intuition to the problem of an entrant platform that considers its options for attracting consumers rather than retaining them. In this scenario, if the entrant operates a tokenized platform, it would deliver higher surplus to consumers and providers than a non-tokenized incumbent platform. Therefore, a tokenized platform can create a credible entry threat unlike a non-tokenized platform. In this case, the threat of entry by a tokenized platform can incentivize the monopolist to tokenize.

## 5 Extensions

In this section, we demonstrate that our main results remain qualitatively unchanged in two more general settings. First, we analyze the case when consumer demand is uncertain. Second, we consider the case when the platform allows the exchange of several types of services.

### 5.1 Demand Uncertainty

As discussed in the main analysis, our results for a tokenized platform rely on the assumption that the platform sets a fixed price in tokens at which the service can be acquired from

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<sup>29</sup>Note that tokenization by the incumbent deters entry even if the entrant platform was also to tokenize. The incumbent platform can always surrender more surplus by selling tokens faster such that consumers have no incentive to leave it for another tokenized platform. Such an entry threat may speed up the convergence to competitive pricing depending on when the threat materializes.

providers. A natural concern is whether this assumption poses any limitations if the demand for the service changes over time. For example, if the platform receives good reviews when it is initiated, the demand for the service might increase. In this subsection, we extend the setup to incorporate demand uncertainty and show that the general intuition of our main results is preserved. In the long run, the firm loses market power and the competitive outcome is reached.

Specifically, we assume that at  $t = 2$ , with probability  $\lambda$ , there is a one-time permanent jump in consumer demand. Formally, the mass of consumers that value the service at  $v_i$  increases from  $\alpha_i$  to  $\alpha_i(1 + \gamma)$  for all  $i \in \{1, 2, \dots, N\}$  and  $t \in \{2, 3, \dots, T\}$ . The mass of providers also increases commensurately to  $1 + \gamma$ . With probability  $1 - \lambda$ , no jump in demand occurs in which case the mass of consumers that value the service at  $v_i$  remains at  $\alpha_i$  for all  $i \in \{1, 2, \dots, N\}$  and  $t \in \{2, 3, \dots, T\}$ . We also assume that  $T \geq N + 1$  to allow enough time for the competitive outcome to be obtained.

In this extended setup, the competitive outcome in the token market is reached over time as in the main model. However, if the demand shock realizes at  $t = 2$ , this outcome might take longer to occur. Intuitively, at  $t = 2$ , the firm may prefer to delay selling tokens to the next group of consumers who have lower valuations for the service and instead first sell additional tokens to the newly added measure of consumers who have a higher value of the service.

For example, when  $\delta = 1$ , the firm optimally sells  $\alpha_1$  tokens to the highest-type consumers in the first period. In the second period, if the demand does not jump, the firm moves to the next consumer type, as in the main model, and sells  $\alpha_2$  tokens to consumers who value the service at  $v_2$ . However, if the demand jumps at  $t = 2$ , the firm instead sells  $\alpha_1\gamma$  tokens to the newly added highest-type consumers who value the service at  $v_1$ . The firm moves to lower type consumers only at  $t = 3$  and sells  $\alpha_2(1 + \gamma)$  tokens to consumers who value the service at  $v_2$ . This token release schedule increases the time it takes to reach the competitive outcome by one period relative to the case of no demand shock.

Formally, we show that the competitive outcome is still obtained in this extended setup. Define  $t^*$  as the period in which the competitive outcome is reached in our main model — if the probability of a jump in demand is 0.

**Proposition 7** (Equilibrium with Demand Uncertainty). *There is a unique equilibrium, in which the total quantity of tokens released,  $Q_t$ , increases over time while the token price  $p_t$  decreases over time. If the probability of a jump in demand is positive, i.e., if  $\lambda > 0$ , the competitive outcome is achieved after at least  $t^*$  periods.*

Importantly, no additional platform rules are required for the above result and the platform

rules that the firm must commit to are not contingent on the realization of the demand shock. Once the platform is tokenized at the beginning of  $t = 1$ , competitive pricing is achieved over time in a sub-game perfect equilibrium. Alternative commitment which achieves competitive pricing, including non-time-consistent strategies such as a direct commitment to the quantity of tokens released, would require the demand shock at  $t = 2$  to be contractible.<sup>30</sup>

In practice, one may expect that a token supply gradually increases over time because the pool of users on a platform grows as more users learn about the platform. Indeed, as the above result shows, in our setting, a jump in user demand causes more tokens to be released over a greater period of time. If more jumps in demand are added to the model, the token release would be even more gradual. Notably, the increased demand is not the only driver of the gradual release of tokens. As we show in the main model, the firm optimally sells tokens over time even without a growth in the user pool.

## 5.2 Multiple Service Types

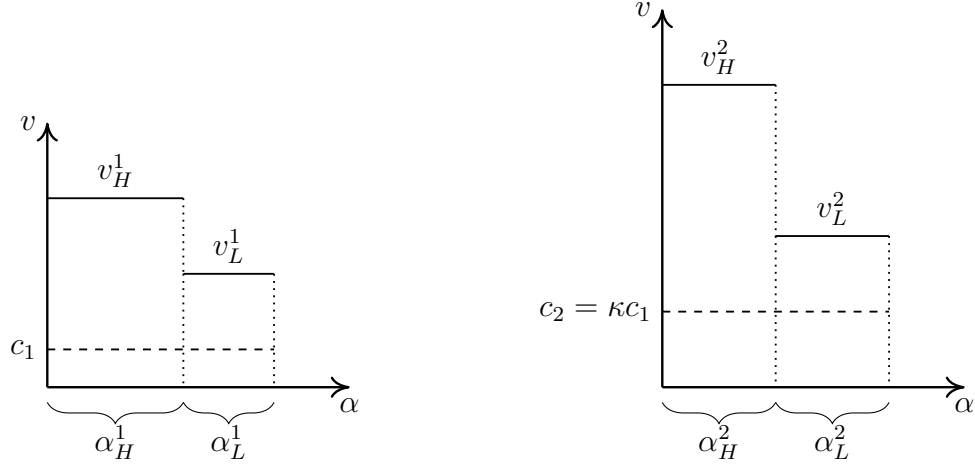
In our main analysis, we considered a platform that allows consumers and providers to exchange only one type of service. This setup is best suited for homogenous services such as cloud storage. However, in practice, platforms might seek to intermediate the exchange of multiple types of services. In this subsection, we show that our main results extend to the more general setting in which a platform allows trade of several types of services. We demonstrate that, as in the main model, the service exchange on the platform can be organized through a single utility token and that this enables the firm to give up market power over time. Eventually, the competitive outcome is obtained for each service.

In particular, suppose that the platform offers  $K$  service types which can be defined by their underlying parameters. For example, in a ride-sharing platform, one service type can be a ride in one city and another service type can be a ride in another city. In addition to a city of travel, the underlying parameters can be peak/off-peak hours, distance traveled, etc. A larger number of parameters will naturally span a larger number of service types. We assume that at any given time, there are multiple demand curves, each associated with a different service type.

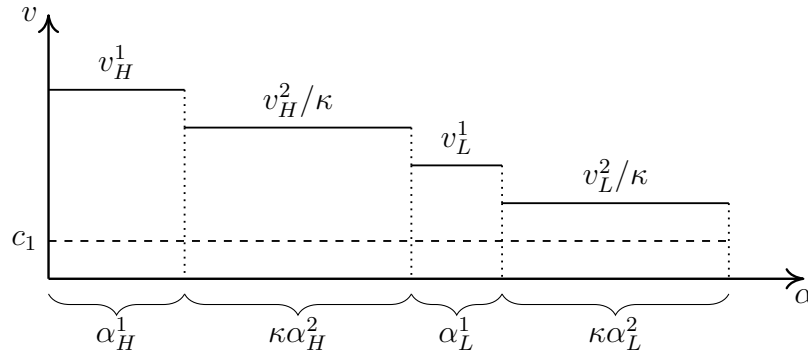
To illustrate how our main results obtain in this setting, we consider a case with  $K = 2$  different types of services and  $N_k = 2$  consumer types for each service. Denote by  $c_k$  the marginal cost of provision for the service of type  $k = 1, 2$  and, without loss of generality, assume that  $c_2 > c_1$ , i.e., the second service type costs more to produce for service providers. We define  $\kappa = \frac{c_2}{c_1}$  as the ratio of the two costs. For simplicity, we assume that consumer

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<sup>30</sup>We discuss the extent to which smart contracts can be used to foster commitment to time-consistent versus non-time-consistent token release schedules in more detail in Section 6.1.3.



**Figure 2: Consumer demands for two service types.** These figures plot consumers' inverse demand for the service type  $k = 1$  (left) and the service type  $k = 2$  (right). The providers' cost per unit produced is shown by the dashed lines.



**Figure 3: Aggregate consumer demand for tokens with two service types.** This figure plots aggregate consumers' inverse demand for tokens that can be used to purchase either of the two service types. The providers' cost per token is shown by the dashed line.

groups of the two service types do not overlap and that consumption preferences of each group have the same form as in the example. In particular, for each service type  $k$ , we denote by  $\alpha_H^k$  and  $\alpha_L^k$  the masses of consumers with service valuations of  $v_H^k$  and  $v_L^k$ , respectively (see Figure 2). Finally, if service providers can provide multiple services (for example, a short ride or a long ride in the same city) we assume that the platform fixes their relative prices in tokens to make them indifferent between which service they provide. Specifically, a unit of the service of type  $k = 1$  can be acquired on the platform for 1 token, while a unit of the service of type  $k = 2$  can be obtained for  $\kappa$  tokens. To implement this, the platform has to know the relative costs of the two services. This can either be directly specified in advance or the platform's algorithm needs to be able to dynamically evaluate the relative cost of each service type depending on the underlying parameters.

Under these assumptions, the two service demand curves can be aggregated into a single per-period demand curve for tokens (see Figure 3). Indeed, the maximum price that a consumer of type  $i = \{H, L\}$ , looking for the service of type  $k = 1$ , is willing to pay for a token is  $v_i^1$  and the total per-period token demand of such consumers is  $\alpha_i^1$ . Additionally, the maximum price that a consumer of type  $i = \{H, L\}$ , looking for the service of type  $k = 2$ , is willing to pay for a token is  $\frac{v_i^2}{\kappa}$  and the total per-period token demand of such consumers is  $\kappa\alpha_i^2$ . Thus, the maximum total token demand per period is  $1 + \kappa$ .

Given the single demand curve for tokens, the firm will follow the same strategy as in the main model and give up its market power over time. Specifically, since there are 2 consumer types and 2 service types, there are at most 4 unique token prices and, if  $\delta = 1$ , the firm releases all tokens in at most 4 periods. In the first period, the firm will sell tokens to the consumer type that can be charged the highest price for a token. In the second period, the firm will compete with service providers in the market for tokens and will sell tokens to the consumer type that can be charged the second highest price for a token. This continues until the total supply of tokens released reaches  $1 + \kappa$ . For example, given the demand in Figure 3, the firm sells  $\alpha_H^1$  for a price  $v_H^1$  in  $t = 1$ ,  $\kappa\alpha_H^2$  tokens for a price  $v_H^2/\kappa$  tokens in  $t = 2$ ,  $\alpha_L^1$  tokens for a price  $v_L^1$  in  $t = 3$ , and, finally,  $\kappa\alpha_L^2$  tokens for a price  $v_L^2/\kappa$  in  $t = 4$ .

This reasoning can be extended to arbitrary  $K$  and  $N$ . Suppose there are  $K$  possible service types that the platform's algorithm can evaluate and, for each service type  $k = 1, \dots, K$ , there are  $N_k$  different consumer valuations-types. Applying the result of Proposition 2, if  $\delta = 1$ , the firm will sell tokens strictly sequentially — only to one uni-dimensional type in a given period and it will take  $\sum_{k=1}^K N_k$  periods to get to the competitive pricing of tokens and, thus, the competitive allocation of services. However, if  $\delta < 1$ , time-discounting could speed up this process and the firm might sell to multiple uni-dimensional types in the same period.<sup>31</sup> Note that an alternative solution with multiple different service types could simply be to have  $K$  distinct tokens, one for each type of service. While this solution may lead to competitive pricing being achieved sooner, it may be impractical to implement in practice.

## 6 Discussion

In this section, we discuss some important features and applications of our model.

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<sup>31</sup>To determine how the firm sells tokens if  $\delta < 1$ , one has to solve explicitly the firm's recursive problem (see the proof of Proposition 2). For example, a sufficient condition for the firm to sell tokens to multiple uni-dimensional types in the same period is that there exist some  $i \in \{1, \dots, N\}$  and  $0 < k < N - i$  such that  $v_{i+k}(\alpha_i + \dots + \alpha_{i+k}) > v_i\alpha_i + \dots + \delta^k v_{i+k}\alpha_{i+k}$ .



## 6.1 Commitment through Smart Contracts

In our model, the commitment to competitive pricing through tokenization is enabled by the platform rules. One way to commit to these platform rules is by writing smart contracts on the blockchain.<sup>32</sup> In this case, the key parameters of the platform such as the price of the service in tokens, the token being the sole currency on the platform, and the permission to trade tokens in a secondary market constitute the computer code that is developed by the firm. The decision to utilize the blockchain implies that, when the platform is launched, this code is released to and adopted by all users who run it on their devices.

If the firm decides to make any changes to the platform's code once the platform is operational, it will not be able to do so unilaterally. Instead, for any changes to take place, the majority of users need to reach a consensus and switch to running the new code. The firm, therefore, needs to come to an agreement with the users on any changes to the platform rules. This need to achieve broad consensus enables commitment. This is similar to the commitment enabled by decentralized governance studied in [Sockin and Xiong \(2023a\)](#).<sup>33</sup>

In the following three subsections, we discuss the extent to which smart contracts can engender commitment to the platform rules. In Section 6.1.1, we provide examples of smart contracts that have been used in practice to commit to the key features of our tokenized platform. In Section 6.1.2, we discuss limitations of using smart contracts alone for commitment on centralized platforms. Finally, in Section 6.1.3, we discuss commitment to competitive pricing through alternative non-time-consistent token issuance policies and the requirements such commitment would impose on smart contracts.

### 6.1.1 Smart Contracts in Existing Token Market

To enable the commitment to competitive pricing, a tokenized platform in the model must be able to commit to the platform rules that specify the key features of utility tokens. In practice, although the features have not been consistently adopted together, different tokenized platforms have been using smart contracts to enforce commitment to each of these

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<sup>32</sup>In our paper, this commitment enabled by smart contracts decreases the platform's market power. However, commitment provided by smart contracts need not always be used to attenuate market power and instead, in other settings, can be employed to maintain market power. For example, in the case of a standard durable goods monopolist, quantity commitment through smart contracts may help preserve market power. Additionally, smart contracts may have other features that can help sustain market power (see, e.g., [Brzustowski et al., 2023](#)).

<sup>33</sup>It stands to reason that, without any bequest motives, short-lived consumers of our main model would be indifferent with respect to any changes to the platform rules that redistribute future surplus between future consumers and the firm. However, in Appendix D.2, we allow for long-lived agents and show that competitive pricing is obtained under the platform rules. Thus, because long-lived consumers value future surplus, they would not vote for changes to the code which would return market power to the platform. For more on decentralized consensus on blockchains, see [Cong and He \(2019\)](#).

features.

Many utility tokens are created with smart contracts that encode the first three platform rules stipulating that tokens are tradable in a common token market, that no access or transaction fees are paid to the creator of the platform, and that no payments in any currency besides the platform native token are made between agents on the platform. For example, Filecoin tokens are traded freely in secondary markets, buyers and sellers of storage on the Filecoin platform can only transact in Filecoin tokens, and these users do not pay any fees to the platform although some gas fees are paid to miners.<sup>34</sup> Other examples of utility tokens that have adopted some of these platform rules include Golem, Storj, and the Basic Attention Token.

Smart contracts have also been used to implement a fixed token-to-service rate. For example, Agrotoken has developed a number of tokens with a fixed value in underlying agricultural goods — SOYA, CORA, WHEA, SOYB, CORB. Each SOYA token, the first token created by the platform, is fixed to one ton of soybeans. The price of the token in USD is floating. This structure, in which the price of the token in numeraire is floating while the value of the token in terms of the units of the good/service is fixed, is similar to tokens in our model. As another example, a token called RealT ties the value of each token to a fixed ownership stake in a property.

Other papers in the literature that study the value of utility tokens also assume that tokens can be converted to goods or services at a fixed exchange rate — for example, [Li and Mann \(2018\)](#), [Malinova and Park \(2023\)](#), [Bakos and Halaburda \(2019\)](#), [Lee and Parlour \(2022\)](#) and [Chod and Lyandres \(2023\)](#). [Cong and Xiao \(2021\)](#) classify tokens that can be exchanged for a fixed amount of a product as product tokens. Notably, [Chod and Lyandres \(2023\)](#) discuss a number of platforms which use product tokens, including platforms for decentralized storage such as Sia, platforms for decentralized computing such as iExec, and platforms for virtual worlds such as Decentraland.

More generally, asset-backed cryptocurrencies and stablecoins use smart contracts to maintain a fixed exchange rate between tokens and associated assets. Additionally, [Cong and Xiao \(2021\)](#) also observe that all non-fungible tokens (NFTs) are inherently product tokens because each token is tied to a unique product. [Chod and Lyandres \(2023\)](#) also discuss how NFTs have been used to fix the price of products in tokens. Specifically, they give an example of how vintage South African wine has been auctioned through tokens where each token represents a claim to a given number of bottles.

The fixed token-to-service price creates token non-neutrality introduced in [Sockin and Xiong \(2023b\)](#) because a token's value to a user is determined by the consumption value

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<sup>34</sup>See <https://filecoin.io/>.

of the service the token can be exchanged for rather than by the fiat value of the token. [Sockin and Xiong \(2023b\)](#) give various examples of crypto platforms which exhibit token non-neutrality. In many of these cases, a fixed token-to-service rate contributes to creating the token non-neutrality. For example, Socios is a platform on which users can buy fan tokens which give them benefits for their sports team. Many of the tokens on the Socios platform provide a fixed amount of benefits such as voting rights on team decisions.

### **6.1.2 Limitations of Smart Contracts on Centralized Platforms**

For a decentralized, or a semi-decentralized platform, in which control rights are distributed amongst its many users, blockchain and smart contracts can help enforce the platform rules. Because the platform achieves the competitive outcome and maximizes its users' welfare under the platform rules, the users should be able to achieve broad consensus on preserving the rules.

For centralized platforms, in which control rights are concentrated, smart contracts alone may not be enough to enforce the platform rules. For example, if the platform is hosted on a permissioned blockchain, the platform's developers may be able to change the initial code unilaterally in the future. Alternatively, a centralized platform which owns proprietary matching technology, may simply be able to shut down the original platform and create a new version of the platform.

These cases might require other mechanisms to support commitment to the platform rules. One such mechanism is competition from other platforms. Our analysis in [Section 4.2](#) implies that a persistent threat of entry by a competitor can incentivize even a centralized platform to tokenize and maintain all the platform rules.

Another alternative could be regulation, which can play an important role in ensuring commitment to competitive pricing by enforcing the platform rules. Such a regulatory task should be feasible because all the conditions that are required by our platform rules should be observable and verifiable. Therefore, regulators could monitor any deviations from the platform rules and penalize them. Notably, this tractability could make such supervised tokenization a preferred option to regulate competition compared to other, less tractable, tools.

### **6.1.3 Commitment to Non-Time-Consistent Token Issuance Schedules**

In the equilibrium of our model, after the firm commits to the platform rules at the beginning of  $t = 1$ , the firm's choices are sub-game perfect in every subsequent period. In particular, the firm optimally increases the supply of tokens over time which leads to the competitive

outcome. As we discuss above, commitment to the platform rules can be enabled by encoding them in smart contracts. However, if smart contracts engender commitment, an important question that arises is why the firm should be limited to time-consistent choices after  $t = 1$ . For instance, to achieve the competitive outcome, the firm could encode an alternative, non-time-consistent token issuance policy directly in the rules.

Our main model has no uncertainty and the token demand in every period is deterministic. In this setting, commitment to an alternative non-time-consistent token issuance policy could be implemented. Importantly, such commitment alone would not be enough to reach competitive pricing and the firm may still need to adopt some of the other platform rules. For example, if the firm commits to the number of tokens sold in every period but transfers between agents on the platform are allowed, or there is no common token market, the firm recovers market power. Note that if all four platform rules are respected, additional commitment to an alternative non-time-consistent token issuance policy cannot increase the platform's profit. The reason is that, under the four platform rules, the token price in each period only reflects the one-period value of the service to the marginal consumer. Thus, committing to a non-time-consistent policy regarding future token issuance cannot increase the platform's profit in the current period.

In Section 5.1, we introduce demand uncertainty and show that, if the firm commits to the platform rules, competitive pricing is achieved regardless of whether a jump in demand realizes. Importantly, none of the platform rules adopted at the beginning of  $t = 1$  are state-contingent — they do not depend on the realization of the jump. In contrast, to achieve the same outcome through an ex-ante commitment to a token issuance schedule, the shock at  $t = 2$  would have to be contractible. In particular, the smart contract would have to stipulate ex-ante that the firm issues more tokens if a jump in demand occurs and the contract should be able to observe the shock ex-post to trigger the additional issuance. Even if such a shock is observable, implementation may not be feasible due to the oracle problem if the information about the shock has to be relayed to the smart contract from the outside of the blockchain.

This argument can also be applied to other non-time-consistent policies, for example, to a direct commitment to the price of the service. If there is uncertainty about the cost of service provision, such a commitment has to be state-contingent. In contrast, our proposed rules do not require the shock to be contractible. The initial adoption of the rules fosters time-consistent token issuance which leads to competitive pricing.

## 6.2 Empirical Predictions about Token Price Dynamics

In our main model, to illustrate the mechanism as clearly as possible, we assume that consumer valuations for the service are constant over time and that there is no change in or uncertainty about the matching technology underlying the platform. We show that in this setting, token prices decrease as the firm releases more and more tokens, gradually losing its market power. Thus, a sharp empirical prediction of our model is that, as the token supply increases or, equivalently, as the platform's user base increases, the token price decreases. We would therefore expect a negative relationship between token returns and the size of the platform.

This testable implication can help empirically distinguish our mechanism from the mechanisms in other models of tokenization and such analysis may be an interesting avenue for future work. For example, [Catalini and Gans \(2018\)](#) predict that venture returns are independent of growth in the token supply when tokenization is implemented with the goal of generating buyer competition. On the other hand, the model of [Cong et al. \(2020\)](#) suggests a positive relationship between a user base and the token price when the convenience yield of tokens increases with the user base. In practice, token prices are likely to have more complicated dynamics due to forces outside the model, e.g., uncertainty about platform fundamentals or the strength and type of network effects between users. [Sockin and Xiong \(2023b\)](#) develop a model with a tractable token price function capturing many of these features. As such, empirical tests of our model's implications should control for other factors that, according to the literature, could influence token prices.

Theoretically, to capture these dynamics more closely, our model can be modified along some dimensions. For instance, additional elements such as a shock that causes consumer valuations for the service to increase, perhaps, due to improved matching technology, can cause an increase in the token price. Specifically, in [Section 5.1](#), if the jump at  $t = 2$  was associated not with an increase in the consumer mass but with an increase in consumer valuations for the service, the token price between  $t = 1$  and  $t = 2$  could increase. While such shocks could give rise to more nuanced short-run and long-run price dynamics, they would not affect our main conclusion. Controlling for the demand shocks, tokenization would still lead to a decrease in monopoly power, as the user base grows, and a convergence to competitive pricing.

## 6.3 Parallels to Durable Goods Monopolist

In the model, commitment to the tradability and durability of tokens creates competition for the firm in future token markets. This mechanism is closely related to the literature on durable-

goods monopolies originated by Coase (1972). In this literature, under certain conditions, including a continuous infinite timeline and patient consumers, a durable goods monopolist charges competitive prices and immediately saturates the market due to competition with her future self. Specifically, if a monopolist is able to sell a durable good at a high price to high-value consumers in earlier periods, she is tempted to lower the price in subsequent periods in order to sell the good to low-value consumers. Anticipating lower prices of the good in subsequent periods, high-value consumers want to hold off buying in earlier periods hoping to purchase the durable good at a lower price in the future. This logic prevents the monopolist from charging high prices in earlier periods. In the limit, as the time between periods shrinks, the durable goods monopolist immediately saturates the market and charges competitive prices.

In the traditional literature on Coasian self-competition, the monopolist competes with their own future sales. The expectation that the price of a durable good will be lowered in the future forces the monopolist to lower prices initially. In contrast, in our model, the monopolist competes with past token sales. The more tokens the monopolist has already sold, the lower the market-clearing price for any new tokens sold.

This feature of our model is similar to competition that a durable goods monopolist faces from a secondary market for used goods, which are usually close substitutes for new goods. If the secondary market exists, a durable goods monopolist can lose market power even if some of the conditions required for Coasian self-competition are not met. In this case, the extent of the loss in market power depends on how quickly the good depreciates, as that determines its substitutability for new goods. In our model, tokens are perfectly durable because each token can be exchanged for one unit of the service at all periods in the future. The firm therefore competes with providers who are reselling a good that is a perfect substitute for new tokens the firm produces. Similarly, the competition the firm faces when buying back tokens is comparable to the competition that a durable goods monopolist would face from buyers if attempting to reacquire goods from the secondary market.

An important difference between our model and the models of durable goods monopolies is that the service purchased with tokens is non-durable and consumers demand the service in every period. This non-durability of the service, causes consumers, even if long-lived, not to delay purchasing tokens, unlike in the Coasian case, even if they expect the token price to fall in the future. Intuitively, although the token is durable, there is no inherent convenience yield from holding a token and consumers have to exchange the token for the non-durable service to obtain utility from tokens. In contrast, in the Coasian case, consumers get a convenience yield from using the durable good, for example a car, every period. Thus, in our model, high-value consumers do not have incentives to hold off buying tokens in earlier

periods when they know that the token price will decrease. Rather, they optimally purchase the service, through tokens, at a high price in earlier periods and, additionally, purchase the service at lower prices in subsequent periods. This implies that the firm does not immediately saturate the market with tokens but instead releases them slowly over time.

This difference also implies that, when selling tokens, the firm does not benefit from commitments that can increase the profit of a standard durable goods monopolist. In particular, a durable goods monopolist can benefit from commitment to a quantity or a price schedule. Indeed, if the monopolist could commit to not selling the good in subsequent periods for a lower price, high-value consumers would purchase the good in earlier periods for a high price, and thus the monopolist would be able to increase her profits. In contrast, in our setting, since consumers demand the service every period, the firm does not benefit from commitment to selling lower quantities in future periods. Similarly, in the models of durable goods monopolies, a finite horizon setting can benefit the monopolist because they can credibly delay the sale of goods till the last period. In our model, delaying token sales does not generate extra profit.

## 7 Conclusion

Decentralization is a key element of the FinTech revolution, aiming to break the market power of large players in the financial industry. However, while FinTech focuses on increasing competition, technology in other parts of the the economy is leading to concentration of market power. Due to network effects, many online platforms, which require a critical number of users to be operational, are natural monopolies and give rise to inefficient rent-seeking by their developers.

This paper shows that tokenization can allow firms who run two-sided platforms to give up market power and commit to competitive pricing. Moreover, in the presence of network effects, tokenization of a single platform can improve welfare even relative to competing platforms. We show that tokens can generate long-run competitive pricing even if demand on the platform is uncertain and if the platform sells many types of services.

In some cases, it is possible to generate private incentives for firms to tokenize. When such conditions do not arise, however, regulation may be needed to require large platforms to use tokenization. This leads to important policy implications. Our paper demonstrates that instead of breaking up large firms, which may be inefficient, tokenization may be an alternative way to limit their market power.

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## Appendix A: Proofs

*Proof of Proposition 2.* The proof proceeds in two steps. First, we prove that the firm does not buy back tokens in the equilibrium. As a result, the number of tokens in the market weakly increases over time while the equilibrium token price weakly decreases over time. Second, we prove that it is optimal for the firm to spread the sales of tokens over several periods to maximize its profit. In particular, if  $\delta = 1$ , the firm sells tokens over  $N$  periods.

First, observe that, since  $p(Q) = 0$  for any  $Q > 1$ , the firm never chooses  $q_t$  such that  $Q_t = Q_{t-1} + q_t > L_N = 1$  for any  $t$ . Indeed, in this case, the firm sells tokens for the price  $p(Q_t) = 0$  while increasing the number of tokens that have to be redeemed from providers. Therefore,  $Q_t \leq 1$  for all  $t$ .

We prove that there are no token buybacks by contradiction. Suppose the firm does its last buyback in the token market in period  $t$  by trading  $q_t < 0$  tokens. If  $t = T$ , then  $q_T < 0$  is not optimal since the token price  $p_T = p(Q_T) \geq v_N$  while the firm has to redeem all tokens from providers at the end of last period for  $c$ . Next, suppose the last buyback occurs in period  $t < T$ . Then, the total token supply at  $t$  in the token market is  $Q_t = q_t + Q_{t-1} \geq 0$ , where  $Q_{t-1}$  is the number of tokens sold by providers. The equilibrium token price at  $t$  is  $p_t = p(Q_t)$ , where  $p(Q_t)$  is given by (10). Consider any future period  $t' > t$ . The total token supply in this period is  $Q_{t'} = Q_t + \sum_{s=t+1}^{t'} q_s \geq Q_t$  because the firm does not buy back any tokens after period  $t$ , i.e.,  $q_s \geq 0$  for any  $s > t$ . The token price in period  $t'$  is  $p_{t'} = p(Q_{t'})$  where  $p(Q_{t'})$  is given by (10). Since  $p(Q)$  is weakly decreasing in  $Q$  and  $Q_{t'} \leq Q_t$ , we obtain

$$p_{t'} = p(Q_{t'}) \leq p(Q_t) = p_t. \quad (\text{A.1})$$

Thus, the price at which the firm buys tokens back is weakly higher than any future price at which the firm could sell them again. Therefore, the firm does not do the last token buyback, which, in turn, implies that there are no buybacks. Consequently,  $q_t \geq 0$  for all  $t$ .

Next, we find the optimal trading policy  $q_t(Q_{t-1}) \geq 0$  for the firm which solves (12) when  $\delta = 1$ . We first conjecture the profit function  $\pi_s(Q_{s-1})$  for any values  $s$  and  $Q_{s-1}$  and then verify that our conjecture is correct by solving (12) under the conjecture. Specifically, our conjecture is

$$\pi_s(Q_{s-1}) \begin{cases} = 0 & \text{if } Q_{s-1} = L_N, \\ = (v_i - c)(L_i - Q_{s-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j & \text{if } Q_{s-1} \in [L_{i-1}, L_i) \text{ and } N - i \leq T - s, \\ < (v_i - c)(L_i - Q_{s-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j & \text{if } Q_{s-1} \in [L_{i-1}, L_i) \text{ and } N - i > T - s. \end{cases} \quad (\text{A.2})$$

The conjecture is correct for the last period  $s = T$  because

$$\pi_T(Q_{T-1}) \begin{cases} = 0 & \text{if } Q_{T-1} = L_N, \\ = (v_N - c)(L_N - Q_{T-1}) & \text{if } Q_{T-1} \in [L_{N-1}, L_N), \\ < (v_i - c)(L_i - Q_{T-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j & \text{if } Q_{T-1} \in [L_{i-1}, L_i) \text{ and } N - i > 0, \end{cases} \quad (\text{A.3})$$

is the maximum profit in (12) with  $\delta = 1$  and  $t = T$ :

$$\pi_T(Q_{T-1}) = \max_{q_T \geq -Q_{T-1}} [p(Q_{T-1} + q_T) - c]q_T. \quad (\text{A.4})$$

Indeed, if

- (i)  $Q_{T-1} = L_N$ , then for any  $q_T > 0$ , the total supply  $Q_T = Q_{T-1} + q_T > L_N$  and, as a result, the token price is  $p_T = p(Q_T) = 0$ . Thus, the optimal  $q_T = 0$  and  $\pi_T(Q_{T-1}) = 0$ ;
- (ii)  $Q_{T-1} \in [L_{N-1}, L_N)$ , then if the firm chooses  $q_T \in (0, L_N - Q_{T-1}]$ , the token price is  $p_T = p(Q_T) = v_N$ . Otherwise, if  $q_T > L_N - Q_{T-1}$ , the token price is  $p_T = p(Q_T) = 0$ . Thus, the optimal  $q_T = L_N - Q_{T-1}$  and  $\pi_T(Q_{T-1}) = (v_N - c)(L_N - Q_{T-1})$ ;
- (iii)  $Q_{T-1} \in [L_{i-1}, L_i)$  and  $N - i > 0$ , because the firm has only one period left in which to sell tokens, it is not able to spread out their sales. Specifically, for any  $q_T \geq 0$ , we have

$$\pi_T(Q_{T-1}) = [p_T(Q_{T-1} + q_T) - c]q_T < (v_i - c)(L_i - Q_{T-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j.$$

Next, we prove that if our conjecture holds for period  $t + 1$ , it also holds for period  $t$ . Under the conjecture, applied to  $s = t + 1$ ,

$$\pi_{t+1}(Q_t) \begin{cases} = 0 & \text{if } Q_t = L_N, \\ = (v_i - c)(L_i - Q_t) + \sum_{j=i+1}^N (v_j - c)\alpha_j & \text{if } Q_t \in [L_{i-1}, L_i) \text{ and } N - i \leq T - (t + 1), \\ < (v_i - c)(L_i - Q_t) + \sum_{j=i+1}^N (v_j - c)\alpha_j & \text{if } Q_t \in [L_{i-1}, L_i) \text{ and } N - i > T - (t + 1). \end{cases} \quad (\text{A.5})$$

To determine  $\pi_t(Q_{t-1})$  we solve (12) with  $\delta = 1$ :

$$\pi_t(Q_{t-1}) = \max_{q_t \geq -Q_{t-1}} \{[p(Q_{t-1} + q_t) - c]q_t + \pi_{t+1}(Q_{t-1} + q_t)\} \quad (\text{A.6})$$

where  $\pi_{t+1}(Q_t)$  is given by (A.5). Now, if,

- (i)  $Q_{t-1} = L_N$ , then for any  $q_t > 0$ , the total supply  $Q_t = Q_{t-1} + q_t > L_N$  and, as a result, the token price is  $p_t = p(Q_t) = 0$ . By conjecture, we also have  $\pi_{t+1}(Q_t) = 0$ . Thus, the optimal  $q_t = 0$  and  $\pi_t(Q_{t-1}) = 0 + \pi_{t+1}(Q_t) = 0$ ;

- (ii)  $Q_{t-1} \in [L_{i-1}, L_i)$  for  $i$  such that  $N - i = T - t$ , then if  $q_t = L_i - Q_{t-1}$ , the total supply  $Q_t = L_i$  and the token price  $p_t = p(Q_t) = v_i$ . By conjecture, we also have  $\pi_{t+1}(Q_t) = \sum_{j=i+1}^N (v_j - c)\alpha_j$  because  $Q_t \in [L_i, L_{i+1})$  and  $N - (i + 1) = T - (t + 1)$ . Therefore, in this case, the profit is  $\pi_t(Q_{t-1}) = (v_i - c)(L_i - Q_{t-1}) + \pi_{t+1}(Q_t) = (v_i - c)(L_i - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j$ .

Alternatively, if the firm chooses  $q_t \in (0, L_i - Q_{t-1})$ , then  $Q_t \in [L_{i-1}, L_i)$  and subsequently  $p_t = p(Q_t) = v_i$ . By conjecture, we also have  $\pi_{t+1}(Q_t) < (v_i - c)(L_i - Q_t) + \sum_{j=i+1}^N (v_j - c)\alpha_j$  because  $Q_t \in [L_{i-1}, L_i)$  and  $N - i > T - (t + 1)$ . Therefore, in this case, the profit is  $\pi_t(Q_{t-1}) = (v_i - c)(Q_t - Q_{t-1}) + \pi_{t+1}(Q_t) < (v_i - c)(L_i - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j$ . The case when the firm chooses  $q_t = 0$  is similar since  $Q_{t-1} = Q_t$  but  $p_t = v_{i-1}$ .

Finally, if the firm alternatively chooses  $q_t > L_i - Q_{t-1}$ , then the total supply  $Q_t > L_i$ . Define  $k > i$  such that  $Q_t \in (L_{k-1}, L_k)$ . Then, the token price  $p_t = p(Q_t) = v_k < v_i$ . By conjecture, we have  $\pi_{t+1}(Q_t) = (v_k - c)(L_k - Q_t) + \sum_{j=k+1}^N (v_j - c)\alpha_j$  because  $Q_t \in [L_{k-1}, L_k)$  and  $N - k < T - (t + 1)$ . Therefore, in this case, the profit is  $\pi_t(Q_{t-1}) = (v_k - c)(Q_t - Q_{t-1}) + \pi_{t+1}(Q_t) < (v_i - c)(L_i - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j$ .

Overall,  $\pi_t(Q_{t-1})$  is maximized when  $q_t = L_i - Q_{t-1}$  and we obtain  $\pi_t(Q_{t-1}) = (v_i - c)(L_i - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j$ .

The case when  $Q_{t-1} \in [L_{i-1}, L_i)$  for  $i$  such that  $N - i < T - t$  is similar to the above. However, since  $N - i \leq T - (t + 1)$ , by the conjecture, the firm could delay the sale of tokens by choosing any  $q_t \in [0, L_i - Q_{t-1}]$  and still obtain the optimal profit  $\pi_t(Q_{t-1}) = (v_i - c)(L_i - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j$ . Thus, in this case, we can use the tie-breaking assumption that yields the unique choice of  $q_t = L_i - Q_{t-1}$ .

- (iii)  $Q_{t-1} \in [L_{i-1}, L_i)$  for  $i$  such that  $N - i > T - t$ , because the firm has fewer periods left than distinct consumer types, it is not able to spread out the sale of tokens perfectly. Specifically, for any  $q_t \geq 0$ , we have

$$\pi_t(Q_{t-1}) = [p(Q_{t-1} + q_t) - c]q_t + \pi_{t+1}(Q_{t-1} + q_t) < (v_i - c)(L_i - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j.$$

Therefore, we obtain

$$\pi_t(Q_{t-1}) \begin{cases} = 0 & \text{if } Q_{t-1} = L_N, \\ = (v_i - c)(L_i - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j & \text{if } Q_{t-1} \in [L_{i-1}, L_i) \text{ and } N - i \leq T - t, \\ < (v_i - c)(L_i - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c)\alpha_j & \text{if } Q_{t-1} \in [L_{i-1}, L_i) \text{ and } N - i > T - t, \end{cases} \quad (\text{A.7})$$

which proves that, if the conjecture holds for  $s = t + 1$ , it also holds for  $s = t$ . Thus, since the conjecture holds for  $s = T$ , it holds for all periods.

Applying this result to the firm's problem in period  $t = 1$ , the firm's optimal profit is  $\pi_1(0) = \sum_{j=1}^N (v_j - c)\alpha_j$  because  $Q_0 = 0$  and  $N - 1 \leq T - 1$ . In the unique equilibrium selected by the tie-breaking assumption, the firm optimally trades  $q_t = \alpha_i$  at the resulting token prices  $p_t = v_i$  for  $i = t = 1, \dots, N$ . While for all  $t > N$ ,  $q_t = 0$  and the token price is  $p_t = v_N$ . Therefore, the competitive outcome in which all consumers who value the service above its marginal cost is reached in  $N$  periods.

If  $\delta < 1$ , the future profits are not as valuable for the firm, so it may have an incentive to sell tokens to multiple consumer types in earlier periods because delaying token sales is now costly. In particular, to find the firm's optimal trading policy, one has to solve explicitly the firm's recursive problem, which is simplified to

$$\pi(L_{i-1}) = \max\{v_i\alpha_i + \delta\pi(L_i), v_{i+1}(\alpha_i + \alpha_{i+1}) + \delta\pi(L_{i+1}), \dots, v_N(\alpha_i + \dots + \alpha_N) + \delta\pi(L_N)\}, \quad (\text{A.8})$$

where  $\pi(L_N) = 0$  and the discounted cost of redeeming tokens in the last period is not part of the simplified problem because it is the same under any schedule. Starting from  $t = 1$  and  $Q_{t-1} = L_{i-1}$  with  $i = 1$ , if in equation (A.8), the solution is  $\pi(L_{i-1}) = v_i\alpha_i + \delta\pi(L_i)$ , then the firm sells tokens only to type  $i$  consumers in period  $t$ , i.e.,  $q_t = \alpha_i$ . Next, the firm proceeds to  $t + 1$  with  $Q_t = L_i$ . However, unlike in the case with  $\delta = 1$ , in equation (A.8), the solution could be  $\pi(L_{i-1}) = v_{i+k}(\alpha_i + \dots + \alpha_{i+k}) + \delta\pi(L_{i+k})$  for some  $k > 0$ . In this case, the firm sells tokens to  $k + 1$  consumer types, types  $\{i, \dots, i + k\}$ , in period  $t$ , i.e.,  $q_t = \sum_{j=0}^k \alpha_{i+j}$ . Next, the firm proceeds to  $t + 1$  with  $Q_t = L_{i+k}$ . In this case,  $p_t = v_{i+k}$  while  $p_{t-1} = v_{i-1}$ . Thus, if  $\delta < 1$ , the price might decline faster over time and the competitive outcome is reached in at most  $N$  periods.  $\square$

*Proof of Proposition 3.* The total profit of a monopolistic platform is the lifetime sum of one-period profits:

$$\pi^m = T\pi^{m,1} = T \sum_{j=1}^{i_m} (v_{i_m} - c)\alpha_j = T(v_{i_m} - c)L_{i_m}, \quad (\text{A.9})$$

where  $i_m$  is the marginal consumer type served by the platform, which is defined in (6).

The total profit of the tokenized platform is

$$\pi = \pi_1(0) = \sum_{i=1}^N (v_i - c)\alpha_i = \sum_{i=1}^N v_i\alpha_i - c. \quad (\text{A.10})$$

The monopolistic platform maintains greater market power and can always choose to replicate the trading policy that is optimal for the tokenized platform. In particular, the monopolistic platform achieves this by selling  $Q_t = \alpha_t$  tokens for the price  $p_t = v_t$  in periods  $t = 1, \dots, N$  and selling  $Q_t = 0$  in periods  $t > N$ , while still redeeming them from providers for  $r_t = c$  in each period. In this case, the firm's profit is  $\sum_{t=1}^T (p_t - r_t)Q_t = \sum_{i=1}^N (v_i - c)\alpha_i$  which should be smaller than  $\pi^m$ , the profit delivered by the optimal monopolistic strategy. Thus, the monopolistic platform earns a higher profit than the tokenized platform  $\pi^m > \pi$ .  $\square$

*Proof of Proposition 4.* The total welfare in the scenario with the monopolistic platform is the lifetime sum of its per-period profits and per-period surpluses of consumers who are able to obtain the service:

$$TS^m = T \sum_{j=1}^{i_m} (v_{i_m} - c)\alpha_j + T \sum_{j=1}^{i_m} (v_j - v_{i_m})\alpha_j = T \sum_{j=1}^{i_m} (v_j - c)\alpha_j, \quad (\text{A.11})$$

where  $i_m$  is the marginal consumer type served by the platform, which is defined in (6). Since the monopolistic platform charges the same token price  $p_t = v_{i_m}$  in every period, each term in the sum is a per-period surplus of the respective agent type multiplied by the total number of periods  $T$ .

The total welfare in the scenario with the tokenized platform, is the sum of platform's, consumers', and providers' surpluses:

$$\begin{aligned} TS^{tk} &= \sum_{j=1}^N (v_j - c)\alpha_j + \sum_{j=1}^N \sum_{i=1}^{j-1} (v_i - v_j)\alpha_i + \sum_{j=1}^N \sum_{i=1}^{j-1} (v_j - c)\alpha_i + (T - N) \sum_{i=1}^N (v_i - c)\alpha_i \\ &= \sum_{j=1}^N \sum_{i=1}^j (v_i - c)\alpha_i + (T - N) \sum_{i=1}^N (v_i - c)\alpha_i. \end{aligned} \quad (\text{A.12})$$

The sum of the first three terms represents the total surplus in the first  $N$  periods when the firm gradually releases tokens to consumers. Specifically, in period  $j$ , the firm releases  $\alpha_j$  tokens, in addition to the current outstanding stock of tokens  $Q_{j-1} = \sum_{i=1}^{j-1} \alpha_i$ , and the token price is  $v_j$ . In this period, the total surplus generated by consumers of type  $i < j$  is split between consumers and service providers while the surplus generated by consumers of type  $j$



is entirely captured by the firm.

Finally, the last term in the sum (A.12) is the total surplus from periods  $t > N$  when the token market reaches the competitive outcome, in which all  $N$  consumer types are able to obtain a token, and, thus, the service. At this time, the per-period surplus is maximized and is strictly higher than the per-period surplus under the monopolist who does not serve all consumers, which is the case when  $i_m < N$ .

Therefore, if  $T$  is sufficiently large, the total surplus under the tokenized platform is higher than that under the monopolistic platform since (A.11) is smaller than the last term in (A.12). Alternatively, if  $T$  is small and  $i_m$  is sufficiently close to  $N$ , the total surplus under the monopolistic platform can be higher since (A.11) can be larger than (A.12).  $\square$

*Proof of Proposition 5.* To prove the proposition, we first write out the long-run equilibrium outcomes under network effects in the two scenarios: with a tokenized platform and with two competing standard platforms. We then compare the welfare across these scenarios.

*Tokenized platform.* If  $v_i + b_i(L_i)$  is decreasing in  $i$ , the results of our main model apply to a tokenized platform. The only difference is that the market-clearing prices reflect the network effects. Specifically, when  $\delta = 1$ , the platform reaches the competitive outcome in  $N$  periods. For any  $t \geq N$ , the price of the token and, therefore, the service is  $p_t = v_N + b_N(L_N) = v_N + b_N(1)$ . The total per-period welfare in this scenario is

$$TS^{tk} = \sum_{i=1}^N (v_i + b_i(1) - c)\alpha_i = \sum_{i=1}^N (v_i + b_i(1))\alpha_i - c. \quad (\text{A.13})$$

*Two standard competing platforms.* If the two platforms compete by setting a price of the service to consumers as described in the text, there is a symmetric equilibrium. In this equilibrium, prices on the platforms are equal to the marginal cost of the service provision  $c$  and the mass of consumers on each platform is  $\frac{1}{2}$ . Thus, the total per-period welfare on the two platforms in this scenario is

$$TS^c = 2 \left[ \sum_{i=1}^N (v_i + b_i(1/2) - c) \frac{\alpha_i}{2} \right] = \sum_{i=1}^N (v_i + b_i(1/2))\alpha_i - c. \quad (\text{A.14})$$

Comparing the total per-period welfare in the two scenarios, we have  $TS^{tk} > TS^c$  as long as there is type  $i$  for which  $b_i(1) > b_i(1/2)$ , i.e., the platform exhibits network effects for consumers of type  $i$ .  $\square$

*Proof of Proposition 6.* In the scenario with the monopolistic platform and network effects, the firm solves  $i_m = \arg \max_i (v_i + b_i(L_i) - c)L_i$ , where, by assumption,  $v_i + b_i(L_i)$  is decreasing in  $i$ . The price of the service on the platform is  $p_t^m = v_{i_m} + b_{i_m}(L_{i_m})$ . Note that the monopolist serves weakly more consumer types if network effects are sufficiently large for some consumer types, i.e.,  $i_m$  is weakly higher than in the benchmark. In this scenario, the consumer surplus on the platform is

$$CS^m = \sum_{i=1}^{i_m} (v_i + b_i(L_{i_m}) - p_t^m) \alpha_i = \sum_{i=1}^{i_m} (v_i + b_i(L_{i_m}) - v_{i_m} - b_{i_m}(L_{i_m})) \alpha_i. \quad (\text{A.15})$$

The consumer surplus on two competing platforms is

$$CS^c = TS^c = \sum_{i=1}^N (v_i + b_i(1/2) - c) \alpha_i. \quad (\text{A.16})$$

Comparing the two, it is possible that  $CS^m > CS^c$ . The necessary condition is that  $L_{i_m} > 1/2$ , i.e., the monopolistic platform serves more consumers than each of the competing platforms. In addition, there should be network effects for some consumer types  $i < i_m$  and, for some of these  $i$ ,  $b_i(L_{i_m})$  needs to be sufficiently greater than  $b_{i_m}(L_{i_m})$ , i.e., networks effects are sufficiently stronger for higher-type consumers than for lower-type consumers. □

*Proof of Proposition 7.* The demand for tokens, the market clearing price and the firm's problem in the extended setup are given, as in the main model, by (7), (10), and (12). If the demand jump realizes at  $t = 2$ , we have  $L_i^{d=1} = L_i(1 + \gamma) = \sum_{j=1}^i \alpha_j(1 + \gamma)$  for all  $t \in \{2, 3, \dots, N\}$ . If the demand jump does not realize at  $t = 2$ ,  $L_i^{d=0} = L_i = \sum_{j=1}^i \alpha_j$  for all  $t \in \{2, 3, \dots, N\}$ .

Applying the results of Proposition 2, and replacing  $L_i$  with  $L_i^d$  for  $d = \{0, 1\}$ , the profit function for all periods  $t \geq 2$  when  $\delta = 1$  is,

$$\pi_t(Q_{t-1}) \begin{cases} = 0 & \text{if } Q_{t-1} = L_N^d, \\ = (v_i - c)(L_i^d - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c) \alpha_j & \text{if } Q_{t-1} \in [L_{i-1}^d, L_i^d) \text{ and } N - i \leq T - (t + 1), \\ < (v_i - c)(L_i^d - Q_{t-1}) + \sum_{j=i+1}^N (v_j - c) \alpha_j & \text{if } Q_{t-1} \in [L_{i-1}^d, L_i^d) \text{ and } N - i > T - (t + 1). \end{cases} \quad (\text{A.17})$$

We first evaluate  $\pi_2$  if the firm releases the same quantity of tokens as it does in the main model,  $q_1 = Q_1 = \alpha_1$ . If no demand jump realizes, the firm's optimal profit is  $\pi_2(Q_1) = \sum_{j=2}^N (v_j - c) \alpha_j$  because  $Q_1 = \alpha_1 = L_1^{d=0}$  and  $N - 1 \leq T - 1$ . If the demand jump

realizes, the firm's optimal profit is  $\pi_2(Q_1) = (v_1 - c)\gamma\alpha_1 + \sum_{j=2}^N (v_j - c)\alpha_j(1 + \gamma)$  because  $Q_1 = \alpha_1 = L_1^{d=1} - \gamma\alpha_1$  and  $N \leq T - 1$ .

Next, we prove that the firm optimally chooses  $Q_1 = \alpha_1$ . The firm's problem at  $t = 1$  is

$$\mathbb{E} \pi_1(0) = \max_{q_1 \geq 0} \{[p(q_1) - c]q_1 + \delta \mathbb{E}[\pi_2(q_1)]\}, \quad (\text{A.18})$$

The firm is unsure of whether or not the demand shock will materialize in the following period. If the firm chooses

- (i)  $Q_1 = \alpha_1$ . Then if no demand jump realizes at  $t = 2$ , the firm's total profit is  $\pi_1 = \sum_{j=1}^N (v_j - c)\alpha_j$ . If the demand jump realizes, the firm's total profit is  $\pi_1 = \sum_{j=1}^N (v_j - c)\alpha_j(1 + \gamma)$ . Thus, the firm's expected profit is  $\mathbb{E}[\pi_1] = \sum_{j=1}^N (v_j - c)\alpha_j(1 + \lambda\gamma)$ .
- (ii)  $Q_1 > \alpha_1$ . Define  $i^d \geq 1$  such that  $Q_1 \in (L_{i^d-1}^d, L_{i^d}^d]$ . Note that  $i^0 \geq i^1$ . The firm sells  $Q_1$  tokens for the price  $v_{i^0}$  at  $t = 1$ . Then, if no demand jump realizes at  $t = 2$ , the firm will optimally release  $L_{i^0}^{d=0} - Q_1$  tokens at  $t = 2$  and the corresponding market clearing price will be  $v_{i^0}$ . Thus, the firm's total profit is  $\pi_1 = (v_{i^0} - c)Q_1 + (v_{i^0} - c)(L_{i^0}^{d=0} - Q_1) + \sum_{j=i^0+1}^N (v_j - c)\alpha_j < \sum_{j=1}^N (v_j - c)\alpha_j$ . If the demand jump realizes, the firm will optimally release  $L_{i^1}^{d=1} - Q_1$  tokens at  $t = 2$  and the corresponding market clearing price will be  $v_{i^1}$ . Thus, the firm's total profit is  $\pi_1 = (v_{i^0} - c)Q_1 + (v_{i^1} - c)(L_{i^1}^{d=1} - Q_1) + \sum_{j=i^1+1}^N (v_j - c)\alpha_j(1 + \gamma) < \sum_{j=1}^N (v_j - c)\alpha_j(1 + \gamma)$ . Therefore, for the firm's expected profit at  $t = 1$ , we have  $\mathbb{E}[\pi_1] < \sum_{j=1}^N (v_j - c)\alpha_j(1 + \lambda\gamma)$ .
- (iii)  $Q_1 < \alpha_1$ . Then, if no demand jump realizes at  $t = 2$ , the firm's total profit is  $\pi_1 = \sum_{j=1}^N (v_j - c)\alpha_j$ . If the demand jump realizes, the firm's total profit is  $\pi_1 = \sum_{j=1}^N (v_j - c)\alpha_j(1 + \gamma)$ . Thus, the firm's expected profit at  $t = 1$  is  $\mathbb{E}[\pi_1] = \sum_{j=1}^N (v_j - c)\alpha_j(1 + \lambda\gamma)$ . Because  $\delta = 1$  and  $N \leq T + 1$ , the firm gets the same profit as it does when  $Q_1 = \alpha_1$ . Thus, in this case, we can use the tie-breaking assumption that yields the unique choice of  $q_1 = \alpha_1$ .

In the unique equilibrium selected by the tie-breaking assumption, the firm optimally trades  $q_1 = \alpha_1$ . The firm's expected profit at  $t = 1$  is  $\mathbb{E}[\pi_1] = \sum_{j=1}^N (v_j - c)\alpha_j(1 + \lambda\gamma)$ . If there is no jump in demand at  $t = 2$ , the firm chooses  $q_t = \alpha_t$  and the resulting token price is  $p_t = v_t$  for  $t \in \{2, \dots, N\}$ . For all  $t > N$ ,  $q_t = 0$  and the token price is  $p_t = v_N$ . Therefore, the competitive outcome in which all consumers who value the service above its marginal cost is reached in  $N$  periods. If there is a jump in demand at  $t = 2$ , the firm chooses  $q_2 = \alpha_1\gamma$ ,  $q_t = \alpha_{t-1}(1 + \gamma)$  and the resulting token prices  $p_t = v_{t-1}$  for  $t \in \{2, \dots, N + 1\}$ . For all  $t > N + 1$ ,  $q_t = 0$  and the token price is  $p_t = v_N$ . Therefore, the competitive outcome in which all consumers who value the service above its marginal cost is reached in  $N + 1$  periods.

From Proposition 2,  $t^* = N$ . Therefore, for  $\lambda > 0$ , the competitive outcome is obtained in at least  $t^*$  periods.

If  $\delta < 1$ , the future profits are not as valuable for the firm, so it may have an incentive to sell tokens to multiple consumer types in earlier periods because delaying token sales is now costly. For  $t > 1$ , we can apply the results from the proof of Proposition 2 for  $\delta < 1$ . In this case, the price could decline faster over time, i.e., there can be period  $t > 1$  such that  $p_t = v_{i+k}$  while  $p_{t-1} = v_{i-1}$  for some  $k > 0$ . Similarly, at  $t = 1$ , solving (A.18) with  $\delta < 1$ , the firm might choose to sell  $q_1 = \alpha_1 + \dots + \alpha_{1+k}$  for some  $k > 0$ . Thus, even if there is a jump in demand, at  $t = 2$ , the firm may prefer to release tokens to consumers who value the service at less than  $v_1$ .

□

## Appendix B: Example with $T = 2$ and $N = 2$

To illustrate the intuition behind our main results that a tokenized platform, operating under the platform rules, reduces the monopoly power of the firm and leads to the competitive outcome, we provide the analysis of an example, in which we set  $T = 2$  and  $N = 2$ . Thus, the platform operates for two periods and there are two types of consumers. We refer to the two consumer types as high-type ( $H$ ) and low-type ( $L$ ). Their respective values of the service are  $v_H$  and  $v_L$ , where  $v_H > v_L \geq \frac{c}{\delta}$ . Additionally, in most of our analysis, we assume that  $\delta = 1$  and only briefly discuss how results change when  $\delta < 1$ .<sup>35</sup>

**Benchmark Model:** As shown in Section 2.2, if the platform operates without tokens, the firm finds it optimal to sell the same quantity of service in all periods. In particular, it will choose  $q_1 = q_2 = \alpha_H$  units of the service, serving only high-type consumers, for a price  $p_1 = p_2 = v_H$  if

$$(v_H - c)\alpha_H \geq v_L - c. \quad (\text{B.1})$$

In this case, extracting the maximum rents from high-type consumers is more profitable than selling to both high- and low-type consumers. Thus, there is under-provision of the service. The firm's total profit over the two periods is  $2(v_H - c)\alpha_H$ . If condition (B.1) does not hold, the firm will optimally sell  $q_1 = q_2 = 1$  units of service, serving both types of consumers for a price  $p_1 = p_2 = v_L$ . Below, we focus on the more interesting case when (B.1) holds as this is when the firm's monopoly power leads to lower total welfare compared to a competitive market.

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<sup>35</sup>See Appendix D.4 for a complete analysis of the example with  $\delta < 1$ .

**Model with Tokens:** We now show that, when the firm operates a tokenized platform, i.e., when it commits to the platform rules, its monopoly power is gradually weakened. Importantly, while the firm is the only seller of tokens at  $t = 1$  when the platform is initiated, this is no longer the case at  $t = 2$ . Specifically, if the firm sells  $q_1$  tokens to consumers at  $t = 1$ , consumers exchange these tokens for the service in the same period. At  $t = 2$ , service providers, who received tokens from consumers in exchange for the service at  $t = 1$ , sell  $Q_1 = q_1$  tokens in the token market. Thus, the total token supply at  $t = 2$  is  $Q_2 = Q_1 + q_2$ . If the firm decides to sell additional tokens to consumers,  $q_2 > 0$ , it competes with providers in the common token market. Otherwise, if the firm decides to buy back tokens from providers,  $q_2 < 0$ , it competes with consumers in the common token market.

Given the service demand of the two consumer types (7), the equilibrium token price (10) as a function of the total token supply in both periods is

$$p(Q_t) = \begin{cases} v_H & \text{if } Q_t \in (0, \alpha_H], \\ v_L & \text{if } Q_t \in (\alpha_H, \alpha_H + \alpha_L], \\ 0 & \text{if } Q_t > \alpha_H + \alpha_L = 1. \end{cases} \quad (\text{B.2})$$

Additionally, because the platform operates for two periods, the firm is committed to redeem all tokens owned by service providers for  $c$  at the end of  $t = 2$ . Absent such a commitment, in a finite horizon model, tokens have no value after  $t = 2$  and, thus, cannot act as a credible medium of exchange.<sup>36</sup>

We can solve the firm's problem by backwards induction. In the last period, the firm maximizes its profit by choosing the number of tokens to trade  $q_2$  given the number of tokens sold by providers in the token market  $Q_1$

$$\pi_2(Q_1) = \max_{q_2 \geq -Q_1} [p(Q_1 + q_2) - c]q_2, \quad (\text{B.3})$$

where the price  $p(Q)$  is given by (B.2). Because  $p(Q) = 0$  for any  $Q > 1$ , the firm never sells tokens such that  $Q_1 > 1$ . Thus, given that  $Q_1 \leq 1$ , there are three possible cases: i)  $Q_1 = \alpha_H + \alpha_L = 1$ ; ii)  $Q_1 \in [\alpha_H, \alpha_H + \alpha_L)$ ; and iii)  $Q_1 \in [0, \alpha_H)$ .

Note that the firm does not buy back tokens in any of the three cases. Indeed, if  $q_2 < 0$ , the firm's profit is negative because the buyback price  $p(Q_1 + q_2) \geq v_L$  is greater than the price  $c$  at which the firm redeems tokens from providers at the end of the last period. Thus,

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<sup>36</sup>The absence of the commitment will cause service providers to refuse the provision of service at  $t = 2$ . This will cause the market for tokens to break down at the start of  $t = 2$  as consumers will not purchase tokens they cannot exchange for the service. This will further cause the market to break down at  $t = 1$  as service providers will know that tokens cannot be resold at  $t = 2$ .

the firm always chooses  $q_2 \geq 0$ .

Consider the first case when  $Q_1 = \alpha_H + \alpha_L$ . If the firm chooses  $q_2 > 0$ , the total supply  $Q_2 > 1$  and the token price falls to zero, which yields a negative profit. Thus, the firm's profit in this case is maximized at  $q_2 = 0$  and equal to  $\pi_2(Q_1) = 0$ .

Next, consider the second case when  $Q_1 \in [\alpha_H, \alpha_H + \alpha_L)$ . In this case, if the firm chooses  $q_2 \in (0, \alpha_H + \alpha_L - Q_1]$ , the total supply  $Q_2 \in (\alpha_H, \alpha_H + \alpha_L]$  and, subsequently, the token price  $p_2 = v_L$ . Otherwise, if the firm chooses  $q_2 > \alpha_H + \alpha_L - Q_1$ , the token price falls to zero. Thus, the firm's profit is maximized at  $q_2 = \alpha_H + \alpha_L - Q_1$  and equal to  $\pi_2(Q_1) = (v_L - c)(\alpha_H + \alpha_L - Q_1)$ . Intuitively, the firm sells the most tokens it can at  $p_2 = v_L$  before the price drops to 0.

Finally, consider the third case when  $Q_1 \in [0, \alpha_H)$ . In this case, if the firm chooses  $q_2 \in (0, \alpha_H - Q_1]$ , the total supply  $Q_2 \in (0, \alpha_H]$ . Subsequently, the token price is  $p_2 = v_H$  and the firm's profit is  $(v_H - c)q_2$ . Alternatively, if the firm chooses  $q_2 \in (\alpha_H - Q_1, \alpha_H + \alpha_L - Q_1]$ , then  $Q_2 \in (\alpha_H, \alpha_H + \alpha_L]$ . Subsequently,  $p_2 = v_L$  and the firm's profit is  $(v_L - c)q_2$ . Lastly, if the firm chooses  $q_2 > \alpha_H + \alpha_L - Q_1$ , the token price falls to zero. Therefore, in this case, the firm's optimal choice is  $q_2 = \alpha_H - Q_1$  if  $Q_1 < \overline{Q_1} \equiv \alpha_H - \frac{(v_L - c)}{(v_H - v_L)}\alpha_L$  and  $q_2 = \alpha_H + \alpha_L - Q_1$  otherwise. Notably, irrespective of the firm's choice of  $q_2$ , the firm's profit  $\pi_2(Q_1) < (\alpha_H - Q_1)(v_H - c) + \alpha_L(v_L - c)$ . Intuitively, the firm has just one period to sell tokens and is not able to capture both a higher price of  $v_H$  for the first  $\alpha_H - Q_1$  tokens and a lower price of  $v_L$  for the additional  $\alpha_L$  tokens. The firm either sells  $\alpha_H - Q_1$  tokens for the price  $v_H$  or  $\alpha_H + \alpha_L - Q_1$  tokens for the price  $v_L$ .

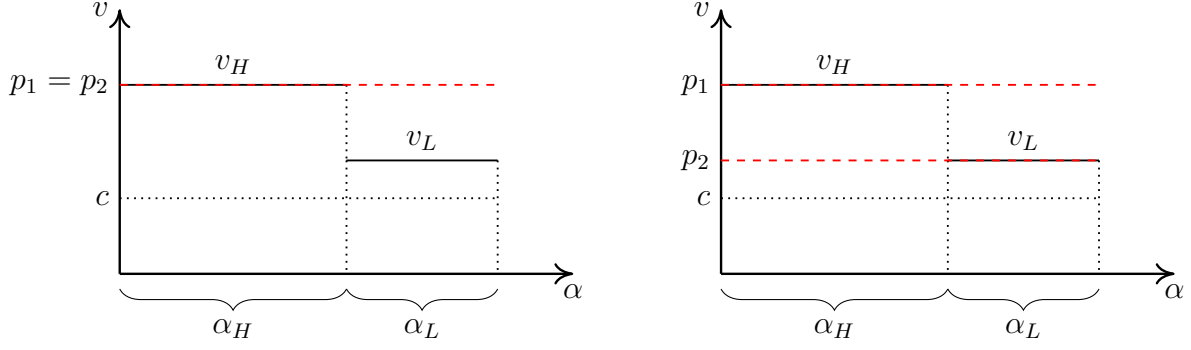
To summarize, the firm's optimal trading policy at  $t = 2$  as a function of  $Q_1$  is

$$q_2(Q_1) \begin{cases} = 0 & \text{if } Q_1 = \alpha_H + \alpha_L, \\ = \alpha_H + \alpha_L - Q_1 & \text{if } Q_1 \in [\overline{Q_1}, \alpha_H + \alpha_L), \\ = \alpha_H - Q_1 & \text{if } Q_1 \in [0, \overline{Q_1}), \end{cases} \quad (\text{B.4})$$

and the firm's optimal profit at  $t = 2$  as a function of  $Q_1$  is

$$\pi_2(Q_1) \begin{cases} = 0 & \text{if } Q_1 = \alpha_H + \alpha_L, \\ = (v_L - c)(\alpha_H + \alpha_L - Q_1) & \text{if } Q_1 \in [\alpha_H, \alpha_H + \alpha_L), \\ < (v_H - c)(\alpha_H - Q_1) + (v_L - c)\alpha_L & \text{if } Q_1 \in [0, \alpha_H). \end{cases} \quad (\text{B.5})$$

We can now consider the firm's decision in the first period. At  $t = 1$ , when choosing the number of tokens to trade  $q_1$ , the firm anticipates how this choice will affect its future trading profit  $\pi_2(Q_1)$ . The firm knows that  $Q_1 = q_1$  because all tokens purchased by consumers at



**Figure 4: Prices of service in the benchmark model and the model with tokens.** These figures plot service prices in the two periods (dashed lines) in the benchmark model (left) and in the model with tokens (right).

$t = 1$  are subsequently resold by providers at  $t = 2$ . The firm's problem is

$$\pi_1 = \max_{q_1 \geq 0} [p(q_1) - c]q_1 + \pi_2(q_1), \quad (\text{B.6})$$

where the price  $p(Q)$  is given by (B.2).

The firm's profit,  $\pi_1$ , is maximized if the firm chooses  $q_1 = \alpha_H$ , which yields a total profit over the two periods equal to

$$(v_H - c)\alpha_H + (v_L - c)\alpha_L. \quad (\text{B.7})$$

In this case,  $p_1 = v_H$  and, in the second period,  $q_2 = \alpha_L$  and  $p_2 = v_L$  (see Figure 4). With this strategy, the firm is able to spread the sale of tokens over the two periods such that it captures the maximum possible price of  $v_H$  for the first  $\alpha_H$  tokens and the maximum possible price of  $v_L$  for the additional  $\alpha_L$  tokens. Alternatively, if the firm chooses either  $q_1 \in [0, \overline{Q}_1)$ ,  $q_1 \in [\overline{Q}_1, \alpha_H)$ , or  $q_1 \in (\alpha_H, \alpha_H + \alpha_L]$ , its total profit  $\pi_1 < (v_H - c)\alpha_H + (v_L - c)\alpha_L$ . In these cases, the firm is not able to extract the maximum possible price for each additional token sold. In the former two cases, the firm sells too few tokens in the first period and, in the second period, it ends up in case iii) discussed above. In the last case, the firm sells too many tokens in the first period, capturing only the lower price of  $v_L$  for the first  $\alpha_H$  tokens.

The firm competes in the common token market both with service providers when selling additional tokens and with consumers when buying back tokens. Each time the firm wants to monetize the platform by selling additional tokens, it increases competition for itself with service providers who resell these tokens in subsequent periods. Over time, as the total quantity of tokens in circulation grows, competition from the token resale increases, reducing the price of tokens. Moreover, competition that the firm faces from consumers ensures that

the firm does not reacquire any tokens. If the firm decides to buy back some tokens it has to purchase them from providers in the common token market. Because consumers bid up the price for tokens in this market, such buybacks are unprofitable for the firm.

The competition that the firm faces from service providers and consumers, implies that the firm can only profit from each token once, because any released tokens will be subsequently resold by service providers but not the firm. Thus, in order to extract the maximum possible rent from each token, the firm gradually sells tokens, progressively lowering their price. Intuitively, we can think of the firm as having a limited stock of market power that eventually runs out. As a result, in the equilibrium, not every consumer is served at first but eventually, everyone who values the service more than its marginal cost will be able to obtain the service.

The resale of tokens shifts surplus from the firm to consumers and service providers. In the benchmark model, the firm as a monopolist obtains a surplus of  $(v_H - c)\alpha_H$  at  $t = 2$  by selling tokens to high-type consumers. With tokenization, the firm can no longer profit from sales to high-type consumers at  $t = 2$ . Instead, to make any profit at  $t = 2$ , the firm has to sell tokens to low-type consumers. As a result, at  $t = 2$ , high-type consumers enjoy a positive surplus of  $(v_H - v_L)\alpha_H$ . Additionally, service providers get to benefit from the resale of tokens, that the firm sold at  $t = 1$ , and obtain a surplus of  $(v_L - c)\alpha_H$ .

When  $\delta = 1$ , the competitive allocation of the service is reached in exactly two periods. When  $\delta < 1$ , the firm might choose to sell tokens to multiple consumer types at once, thus lowering the price faster. In the example, the firm prefers to release tokens to both consumer types at  $t = 1$  if  $v_L > v_H\alpha_H + \delta v_L\alpha_L$ . A smaller  $\delta$  can, therefore, speed up the process of getting to the competitive allocation of the service.



# Internet Appendix

## Appendix C: Platform Rules

In this appendix, we sequentially relax each of the platform rules and show that, in each case, the firm does not relinquish all market power. Thus, each rule is necessary for achieving the competitive outcome. For each rule, except the first, to illustrate the mechanism as clearly as possible, we work with the parameterized example of Appendix B (i.e.,  $N = 2$ ,  $T = 2$ ,  $\delta = 1$ ).

### C.1 Non-Tradable Tokens

We start by relaxing the first rule and consider what happens if tokens are made non-tradable, i.e., if there is no common market for tokens. In this case, the firm can replicate the outcome in the benchmark model and achieve the monopoly profit. Indeed, assume that there is no common market for tokens in which service providers, who have been paid in tokens for their service, can resell tokens directly to consumers. Then, providers' only option is to redeem their tokens with the firm in every period. Thus, the firm is the sole seller and redeemer of tokens.

As the firm gets back all tokens it sells in a period at the end of that period, the total supply of tokens in the token market is fully determined by the firm,  $Q_t = q_t$ . Thus, the firm can simply replicate the monopoly outcome by selling  $q_t = L_{im}$  tokens for a price  $p_t = v_{im}$  while redeeming the tokens at a price  $r_t = c$  in every period. Service providers accept tokens as payment for the service because the redemption price ensures that providers just recover their cost of service provision. Therefore, non-tradable tokens do not reduce the monopoly power of the firm.

### C.2 Fees charged by firm

We relax the second platform rule that the firm cannot charge consumers or providers any fees. In particular, we allow the firm to charge providers a transaction fee  $f_t$  per match. At the end of this subsection, we discuss how transaction fees map to other fees that the platform might charge, such as access fees.

With transaction fees, a provider serves a consumer in exchange for a token in the platform market at  $t$  if the token resale price at  $t + 1$  is greater than the sum of the marginal cost of service provision  $c$  and the transaction fee  $f_t$

$$\delta p_{t+1} \geq c + f_t. \quad (\text{C.1})$$

The firm's recursive problem is

$$\pi_t(Q_{t-1}) = \max_{q_t \geq -Q_{t-1}, f_t \leq \delta p_{t+1} - c} \{[p(Q_{t-1} + q_t) - \delta^{T-t}c]q_t + f_t[Q_{t-1} + q_t] + \delta\pi_{t+1}(Q_{t-1} + q_t)\}, \quad (\text{C.2})$$

where  $\pi_{T+1} \equiv 0$ .

The two-period example can be solved by backwards induction. At  $t = 2$ , service providers are not willing to pay any fees because each token is redeemed by the platform for  $c$ , i.e.,  $p_3 \equiv c$ . Therefore, the highest fee the firm can charge providers is  $f_2 = 0$ . Because the firm cannot charge any fees in the last period, its problem at  $t = 2$  is identical to its problem in the example of Appendix B. The firm's optimal choice of  $q_2(Q_1)$  as a function of  $Q_1$  is given by (B.4) and its optimal profit  $\pi_2(Q_1)$  as a function of  $Q_1$  is given by (B.5).

At  $t = 1$ , the firm chooses quantity  $q_1$  and fee  $f_1$  to maximize its profit  $\pi_1$ . Importantly, the firm's problem now differs from the problem in Appendix B. Specifically, the firm understands that its ex-post choice of  $q_2$  at  $t = 2$  affects the token price  $p_2$ , and therefore the maximum fee  $f_1 = p_2 - c$  that it can charge providers at  $t = 1$ . If providers expect next period's price to be  $p_2 = v_H$ , they are willing to pay a fee of  $f_1 = v_H - c$ , but if providers expect next period's price to be  $p_2 = v_L$ , they are only willing to pay a fee of  $f_1 = v_L - c$ . Thus, at  $t = 1$ , the firm solves

$$\max_{q_1 \geq 0} \left[ \underbrace{p_1(q_1) - c}_{\text{Token Sale Profit } t=1} + \underbrace{p_2(q_2(q_1) + q_1) - c}_{\text{Fee Profit } t=1} \right] q_1 + \pi_2(q_1). \quad (\text{C.3})$$

If the firm chooses  $q_1 = Q_1 = \alpha_H$  at  $t = 1$  (as it does in Appendix B with all of the platform rules), then  $q_2 = \alpha_L$  and  $p_2(\alpha_L + \alpha_H) = v_L$  and, thus  $f_1 = v_L - c$ . The firm's total profit over the two periods is

$$\underbrace{(v_H - c)\alpha_H + (v_L - c)\alpha_L}_{\text{Total Token Sale Profit}} + \underbrace{(v_L - c)\alpha_H}_{\text{Total Fee Profit}} = (v_H - c)\alpha_H + v_L - c. \quad (\text{C.4})$$

Relative to its profit in Appendix B, the firm is able to extract surplus from providers and earns extra profit of  $(v_L - c)\alpha_H$ . The firm's profit is higher but the competitive allocation is still achieved at  $t = 2$ .

However, the firm may prefer to choose  $q_1 = \overline{Q_1} - \varepsilon$  for arbitrarily small  $\varepsilon$ . In this case, at  $t = 2$ , the firm's optimal choice is  $q_2 = \alpha_H - Q_1 = \frac{v_L - c}{v_H - v_L}\alpha_L$  and  $p_2(\alpha_H) = v_H$ . Thus, at  $t = 1$ , the firm can charge a fee of  $f_1 = v_H - c$  generating a profit over the two periods of

$$\underbrace{(v_H - c)\alpha_H}_{\text{Total Token Sale Profit}} + \underbrace{(v_H - c) \left( \alpha_H - \frac{v_L - c}{v_H - v_L}\alpha_L \right)}_{\text{Total Fee Profit}}. \quad (\text{C.5})$$

Importantly, even though the firm earns less from token sales, it makes more revenue from transaction fees. In this case, the competitive allocation is not achieved at  $t = 2$ . Moreover, the total surplus with tokens is worse than if the firm operated as a monopoly because not all high-type consumers obtain the service at  $t = 1$ .<sup>37</sup> (C.5) is higher than (C.4) iff

$$(v_H - c) \left( \alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L \right) > v_L - c. \quad (\text{C.6})$$

**Mapping to Access Fees:** The model with provider transaction fees that are charged conditional on a match is equivalent to a model in which providers pay access fees that are charged by the firm before a potential match. The highest access fee that service providers are willing to pay accounts for the probability of not being matched. Specifically, at time  $t$ , a provider is willing to pay an access fee  $a_t$  that satisfies

$$Q_t \delta p_{t+1} \geq Q_t c + a_t, \quad (\text{C.7})$$

where  $Q_t \leq 1$  is the probability of matching with a consumer. Therefore, the model with transaction fees is analogous to one with access fees in which  $a_t = Q_t f_t$ . The firm's profit is the same in the two cases. In the former case, measure  $Q_t$  of service providers are matched with consumers and pay transaction fees  $f_t$  while, in the latter case, all service providers, measure 1, pay access fees  $a_t$ .

To summarize, if the firm does not adopt the second rule and can charge fees for using or accessing the platform, it is able to regain market power and extracts additional surplus.

### C.3 Transfers between Consumer and Providers

We relax the third platform rule by allowing transfers in numeraire between consumers and providers during service exchange. We denote by  $m_t$  the transfer from a provider to her consumer match in the platform market in period  $t$ . The provider serves the consumer in exchange for a token in this market, if the token resale price at  $t + 1$  is greater than the sum of her marginal cost  $c$  and the transfer  $m_t$

$$\delta p_{t+1} \geq c + m_t. \quad (\text{C.8})$$

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<sup>37</sup>Because the firm can earn at least  $(v_H - c)\alpha_H + v_L - c$  and we assume that  $(v_H - c)\alpha_H > v_L - c$  (i.e., in the benchmark, the monopoly outcome is inefficient), the firm does not sell to all consumers at  $t = 1$ . If the firm sells to all consumers at  $t = 1$ , the firm charges a maximum fee of  $v_L - c$  and obtains a profit of only  $2(v_L - c) < (v_H - c)\alpha_H + v_L - c$ .

We assume that providers offering the highest transfers are matched with priority to consumers. Otherwise, post-match, a provider has no incentive to offer a positive transfer to consumers. Therefore, competition between providers results in  $m_t = \delta p_{t+1} - c$ . In this case, in exchange for a token, consumers rationally expect to receive both a unit of service and a transfer  $m_t$  in period  $t$ . Thus, consumers are willing to pay  $m_t$  more for the same number of tokens compared to the main model.

The firm's recursive problem is given by (12), as in the main model. However, the demand for tokens and subsequently the market-clearing prices incorporate the transfers consumers will receive during the platform exchange.

The two-period example can be solved by backwards induction. At  $t = 2$ , service providers will not be willing to make any transfers because each token is reimbursed for  $c$ , i.e.,  $p_3 \equiv c$ . As a result,  $m_2 = 0$ . Therefore, consumer demand for tokens at  $t = 2$  is identical to the example in Appendix B and subsequently the market clearing price at  $t = 2$ ,  $p_2^{m_2}$ , as a function of token quantity is given by (B.2). The firm's optimal choice of  $q_2(Q_1)$  as a function of  $Q_1$  is given by (B.4) and its optimal profit  $\pi_2(Q_1)$  as a function of  $Q_1$  is given by (B.5).

At  $t = 1$ , the firm chooses  $q_1$  to maximize its profits,  $\pi_1$ . Importantly, the firm's problem at  $t = 1$  differs from the problem in Appendix B. Specifically, the firm understands that its ex-post choice of  $q_2$  at  $t = 2$  affects the token price  $p_2$ , and therefore the equilibrium transfers  $m_1 = p_2 - c$  between consumers and service providers at  $t = 1$ . If providers expect next period's price to be  $p_2 = v_H$ , they are willing to pay consumers a transfer of  $m_1 = v_H - c$ , but if providers expect next period's price to be  $p_2 = v_L$ , they are only willing to pay consumers a transfer of  $m_1 = v_L - c$ . Given the consumer demand, the market-clearing price at  $t = 1$  is given by

$$p_1^{m_1}(Q_1) = \begin{cases} v_H + v_H - c & \text{if } Q_1 \in (0, \overline{Q_1}), \\ v_H + v_L - c & \text{if } Q_1 \in [\overline{Q_1}, \alpha_H], \\ v_L + v_L - c & \text{if } Q_1 \in (\alpha_H, \alpha_H + \alpha_L], \\ 0 & \text{if } Q_1 > \alpha_H + \alpha_L = 1. \end{cases} \quad (\text{C.9})$$

At  $t = 1$ , the firm solves

$$\max_{q_1 \geq 0} [p_1^{m_1}(q_1) - c]q_1 + \pi_2(q_1). \quad (\text{C.10})$$

If the firm chooses  $q_1 = Q_1 = \alpha_H$  at  $t = 1$  (as it does in Appendix B with all the rules),  $m_1 = v_L - c$  and the market-clearing token price is  $p_1^{m_1} = v_H + v_L - c$ . The firm's total profit over the two periods is

$$\underbrace{(v_H + v_L - c - c)\alpha_H}_{\text{Token Sale Profit } t=1} + \underbrace{(v_L - c)\alpha_L}_{\text{Token Sale Profit } t=2} = (v_H - c)\alpha_H + v_L - c. \quad (\text{C.11})$$

Relative to the profit in Appendix B, the firm is able to extract surplus from providers and earns an extra  $(v_L - c)\alpha_H$ . The firm's profit is higher but the competitive allocation is still achieved at  $t = 2$ .

However, the firm may prefer to choose  $q_1 = Q_1 = \overline{Q}_1 - \varepsilon$  for arbitrarily small  $\varepsilon$ . In this case, at  $t = 2$ , the firm's optimal choice is  $q_2 = \alpha_H - Q_1 = \frac{v_L - c}{v_H - v_L}\alpha_L$  and  $p_2(\alpha_H) = v_H$ . Subsequently,  $m_1 = v_H - c$  and the market-clearing token price is  $p_1^{m_1} = v_H + v_H - c$ , giving the firm a profit over two periods of

$$\underbrace{(v_H + v_H - c - c) \left( \alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L \right)}_{\text{Token Sale Profit } t = 1} + \underbrace{(v_H - c) \left( \alpha_H - \alpha_H + \frac{v_L - c}{v_H - v_L} \alpha_L \right)}_{\text{Token Sale Profit } t = 2} \\ = (v_H - c)\alpha_H + (v_H - c) \left( \alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L \right). \quad (\text{C.12})$$

Importantly, a higher expected price for tokens at  $t = 2$  increases the firm's payoff from selling tokens at  $t = 1$  because consumers are able to receive a higher transfer from providers. In this case, the competitive allocation is not achieved at  $t = 2$ . Moreover, the total surplus with tokens is worse than if the firm operated as a monopoly because not all high-type consumers obtain the service at  $t = 1$ .<sup>38</sup> (C.12) is higher than (C.11) iff

$$(v_H - c) \left( \alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L \right) > v_L - c, \quad (\text{C.13})$$

which is the same condition as (C.6).

Notice that the equilibrium outcomes and the firm's profits are identical if the second rule or the third rule is relaxed. Intuitively, relaxing either rule allows the firm to extract, either directly or indirectly, the surplus that providers receive from the token resale.

## C.4 Flexible Service Price

We relax the final platform rule by allowing flexible pricing of the service, i.e., service providers can adjust how many tokens they require in exchange for the service. We denote by  $k_t$  the price in tokens a provider charges her consumer match in the platform market in period  $t$ . We assume providers asking for the least amount of tokens in exchange for the service are matched with priority to consumers. Otherwise, post-match, a provider has no incentive to offer a competitive price to consumers. Therefore, competition between providers results

<sup>38</sup>Because the firm can earn at least  $(v_H - c)\alpha_H + v_L - c$  and we assume that  $(v_H - c)\alpha_H > v_L - c$  (i.e., in the benchmark, the monopoly outcome is inefficient), the firm does not sell to all consumers at  $t = 1$ . Indeed, if the firm sells to all consumers at  $t = 1$ , the equilibrium transfer is  $m_1 = v_L - c$  and the market-clearing token price  $p_1^{m_1} = v_L + v_L - c$ , which gives the firm a profit of  $2(v_L - c) < (v_H - c)\alpha_H + v_L - c$ .

in  $k_t = \frac{c}{\delta p_{t+1}}$ . In the token market, consumers of type  $i$  are willing to pay at most  $\frac{v_i}{k_t}$  per token as they need to exchange  $k_t$  tokens for the service. The firm's recursive problem is given by (12), as in the main model. However, the demand for tokens and subsequently the market-clearing prices incorporate the number of tokens consumers need to exchange for the service on the platform exchange.

The two-period example can be solved by backwards induction. At  $t = 2$ , service providers demand  $k_2 = 1$  tokens because each token is reimbursed for  $c$ , i.e.,  $p_3 \equiv c$ . Therefore, consumer demand for tokens at  $t = 2$  is identical to the example in Appendix B and subsequently the market clearing price at  $t = 2$ ,  $p_2^{k_2}$ , as a function of token quantity is given by (B.2). The firm's optimal choice of  $q_2(Q_1)$  as a function of  $Q_1$  is given by (B.4) and its optimal profit  $\pi_2(Q_1)$  as a function of  $Q_1$  is given by (B.5).

At  $t = 1$  the firm chooses  $q_1$  to maximize its profits,  $\pi_1$ . Importantly, the firm's problem at  $t = 1$  differs from the problem in Appendix B. Specifically, the firm understands that its ex-post choice of  $q_2$  at  $t = 2$  affects the token price  $p_2$ , which in turn affects the amount of tokens  $k_1 = \frac{c}{p_2}$  service providers demand for the service at  $t = 1$ . Therefore, there are two cases: i) If providers expect next period's price to be  $p_2 = v_H$  (i.e., if  $Q_1 < \overline{Q_1}$ ), they ask consumers for  $k_1 = \frac{c}{v_H}$  tokens in exchange for the service. Each high-type consumer is willing to pay at most  $\frac{v_H^2}{c}$  per token and demands  $k_1 = \frac{c}{v_H}$  tokens, so that their total payment for the service is  $v_H$ ; ii) If providers expect next period's price to be  $p_2 = v_L$  (i.e., if  $Q_1 \geq \overline{Q_1}$ ), they ask consumers for  $k_1 = \frac{c}{v_L}$  tokens in exchange for the service. Each high-type consumer is willing to pay at most  $\frac{v_H v_L}{c}$  per token and demands  $k_1 = \frac{c}{v_L}$  tokens, so that their total payment for the service is  $v_H$ . Each low-type consumer is willing to pay at most  $\frac{v_L^2}{c}$  per token and demands  $k_1 = \frac{c}{v_L}$  tokens, so that their total payment for the service is  $v_L$ . Given consumer demand, the market-clearing price at  $t = 1$  is given by

$$p_1^{k_1}(Q_1) = \begin{cases} \frac{v_H^2}{c} & \text{if } Q_1 \in (0, \overline{Q_1}), \\ \frac{v_H v_L}{c} & \text{if } Q_1 \in [\overline{Q_1}, \alpha_H], \\ \frac{v_L^2}{c} & \text{if } Q_1 \in (\alpha_H, \alpha_H + \alpha_L], \\ 0 & \text{if } Q_1 > \alpha_H + \alpha_L = 1. \end{cases} \quad (\text{C.14})$$

At  $t = 1$ , the firm solves

$$\max_{q_1 \geq 0} [p_1^{k_1}(q_1) - c]q_1 + \pi_2(q_1). \quad (\text{C.15})$$

There are two relevant cases. First, if  $\alpha_H \frac{c}{v_H} < \overline{Q_1}$ , then if the firm sells  $q_1 = Q_1 = \alpha_H \frac{c}{v_H}$  at  $t = 1$ , service providers anticipate that, next period, the firm optimally sells  $q_2 = \alpha_H - Q_1$  tokens and the market clearing price is  $p_2(\alpha_H) = v_H$ . Providers therefore demand  $k_1 = \frac{c}{v_H}$

tokens in exchange for the service. By choosing  $q_1 = \alpha_H \frac{c}{v_H}$ , the firm sells to all high-type consumers at  $t = 1$  because each high-type consumer demands  $k_1 = \frac{c}{v_H}$  tokens. In this case, the firm replicates the monopoly profit over the two periods. Specifically, its profit is

$$\underbrace{\left(\frac{v_H^2}{c} - c\right) \alpha_H \frac{c}{v_H}}_{\text{Token Sale Profit } t=1} + \underbrace{(v_H - c) \left(\alpha_H - \alpha_H \frac{c}{v_H}\right)}_{\text{Token Sale Profit } t=2} = 2(v_H - c)\alpha_H. \quad (\text{C.16})$$

The competitive outcome is not reached and only high-type consumers obtain the service each period.

Second, if  $\alpha_H \frac{c}{v_H} \geq \overline{Q}_1$ , then if the firm sells  $q_1 \geq \overline{Q}_1$  at  $t = 1$ , service providers anticipate that  $q_2 = \alpha_H + \alpha_L - Q_1$  and  $p_2(\alpha_H + \alpha_L) = v_L$ . Therefore,  $k_1 = \frac{c}{v_L}$ . In this case, if the firm chooses to sell to all high-type consumers  $q_1 = \alpha_H \frac{c}{v_L}$  (as it does in Appendix B with all the rules), its total profit over the two periods is

$$\underbrace{\left(\frac{v_H v_L}{c} - c\right) \alpha_H \frac{c}{v_L}}_{\text{Token Sale Profit } t=1} + \underbrace{(v_L - c) \left(\alpha_H + \alpha_L - \alpha_H \frac{c}{v_L}\right)}_{\text{Token Sale Profit } t=2} = (v_H - c)\alpha_H + v_L - c. \quad (\text{C.17})$$

Relative to its profit in Appendix B, the firm is able to extract surplus from providers and earns an extra  $(v_L - c)\alpha_H$ . The firm's profit is higher but the competitive allocation is still achieved at  $t = 2$ .

However, if  $\alpha_H \frac{c}{v_H} \geq \overline{Q}_1$ , the firm may prefer to choose  $q_1 = Q_1 = \overline{Q}_1 - \varepsilon$  for arbitrarily small  $\varepsilon$ . In this case,  $q_2 = \alpha_H - Q_1 = \frac{v_L - c}{v_H - v_L} \alpha_L$  and  $p_2(\alpha_H) = v_H$ . Subsequently,  $k_1 = \frac{c}{v_H}$ . The firm's profit over the two periods in this case is

$$\underbrace{\left(\frac{v_H^2}{c} - c\right) \left(\alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L\right)}_{\text{Token Sale Profit } t=1} + \underbrace{(v_H - c) \left(\alpha_H - \alpha_H + \frac{v_L - c}{v_H - v_L} \alpha_L\right)}_{\text{Token Sale Profit } t=2} \\ = (v_H - c)\alpha_H + \frac{v_H}{c}(v_H - c) \left(\alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L\right). \quad (\text{C.18})$$

In this case, the competitive allocation is not achieved at  $t = 2$ . Moreover, the total surplus with tokens is worse than if the firm operated as a monopoly because not all high-type consumers obtain the service at  $t = 1$ . (C.18) is higher than (C.17) iff

$$\frac{v_H}{c}(v_H - c) \left(\alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L\right) > v_L - c. \quad (\text{C.19})$$

Notice that relative to the previous two rules, this condition is more likely to be satisfied than (C.6) because of the term  $\frac{v_H}{c} > 1$  multiplying the left-hand side of the equation.

With a flexible token-to-service price, the firm makes higher profit relative to the cases

in which the firm can charge fees or allows transfers during the platform exchange. Besides getting extra surplus from service providers, the firm also effectively reduces the durability of tokens. With a fixed token-to-service price, the total mass of high-type consumers the platform sells tokens to at  $t = 1$  and  $t = 2$  cannot be more than  $\alpha_H$ . In contrast, with a flexible token-to-service price, the firm can sell to more than  $\alpha_H$  high-type consumers in total over the two periods. Indeed, because each token buys less of the service at  $t = 2$  than at  $t = 1$ , the demand of high-type consumers at  $t = 2$  cannot be completely satisfied by providers reselling tokens and, therefore, these consumers have to buy additional tokens from the firm. This allows the firm to extract extra rents. Effectively, each token becomes less durable over time because it provides less of the service in future platform markets. This allows the firm to retain more market power.

## Appendix D: Additional Analysis

### D.1 Token Burning

In this section, we explore how potential token burning during the platform exchange, a feature of some blockchain platforms, affects our results. The main model allows the firm to buy back tokens in the common token market. In this section, we model token burning as distinct from such buybacks by allowing the firm to eliminate some tokens from circulation at *no cost*. Similar to the fourth platform rule, token burning can be viewed as a way to make tokens less durable — essentially, a certain fraction of tokens, which are burned, can no longer be exchanged for the service in future platform markets.

Specifically, we assume that a fraction  $1 - b_t$  of tokens is burned during each transaction between consumers and providers in the platform market. Although consumers pay providers 1 token to obtain one unit of the service, providers receive only  $b_t < 1$  tokens that they can resell in the token market next period. Thus, a provider is willing to exchange the service in the platform market if the resale price of  $b_t$  tokens at  $t + 1$  is greater than the marginal cost of service provision  $c$

$$\delta p_{t+1} b_t \geq c. \quad (\text{D.1})$$

Therefore, the highest burning rate the firm can set that satisfies providers' participation constraint is  $b_t = \frac{c}{\delta p_{t+1}}$ .

The firm's problem can be stated recursively as

$$\pi_t(Q_{t-1}) = \max_{q_t \geq -Q_{t-1}, b_t \leq \frac{c}{\delta p_{t+1}}} \{ [p(Q_{t-1} + q_t) - (\delta^{T-t} c) \prod_{s=t}^T b_s] q_t + \delta \pi_{t+1}((Q_{t-1} + q_t) b_t) \}, \quad (\text{D.2})$$



where  $\pi_{T+1} \equiv 0$ . There are two changes in the firm's problem compared to the main model. First, in the last period, the firm redeems only the tokens that remain outstanding after burning in all previous periods. Second, the total number of tokens carried from period  $t$  to period  $t + 1$  by providers is  $(Q_{t-1} + q_t)b_t$ .

To illustrate the mechanism as clearly as possible, we work with the parameterized example of Appendix B. This two-period model can be solved by backwards induction. At  $t = 2$ , each token is reimbursed for  $c$ , i.e.,  $p_3 \equiv c$ . Therefore, the firm cannot burn any tokens and  $b_2 = 1$ . Because the firm does not burn any tokens, its problem at  $t = 2$  is identical to its problem in the example in Appendix B. Consumer demand for tokens and the corresponding market clearing price as a function of token quantity is given by (B.2). The firm's optimal choice of  $q_2(Q_1)$  as a function of  $Q_1$  is given by (B.4) and its optimal profit  $\pi_2(Q_1)$  as a function of  $Q_1$  is given by (B.5).

At  $t = 1$  the firm chooses  $q_1$  and the burn rate  $b_1$  to maximize its profits  $\pi_1$ . Importantly, the firm's problem at  $t = 1$  differs from the problem in Appendix B. Specifically, the firm understands that its ex-post choice of  $q_2$  affects the token price  $p_2$ , and therefore the highest burn rate  $b_1 = \frac{c}{p_2}$  it can implement at  $t = 1$ . If providers expect next period's price to be  $p_2 = v_H$ , they are willing to keep  $b_1 = \frac{c}{v_H}$  fraction of tokens. If providers expect next period's price to be  $p_2 = v_L$ , they need to keep at least  $b_1 = \frac{c}{v_L} > \frac{c}{v_H}$  fraction of tokens. Consumer demand for tokens and the corresponding market clearing price as a function of token quantity is given by (B.2). The firm solves

$$\max_{q_1 \geq 0} [p_1(q_1) - c \cdot b_1(p_2(q_2(q_1) + q_1))]q_1 + \pi_2(q_1 \cdot b_1(p_2(q_2(q_1) + q_1))). \quad (\text{D.3})$$

There are two relevant cases. If the firm sells to all high-type customers at  $t = 1$ , i.e., if the firm chooses  $q_1 = Q_1 = \alpha_H$  at  $t = 1$ , the highest burn rate it can choose depends on whether or not  $\alpha_H \frac{c}{v_H} < \overline{Q}_1$ . First, if  $\alpha_H \frac{c}{v_H} < \overline{Q}_1$ , then service providers anticipate that next period the firm optimally sells  $q_2 = \alpha_H - Q_1 b_1$  tokens and the market clearing price is  $p_2(\alpha_H) = v_H$ . Providers therefore are willing to accept a burn rate of  $b_1 = \frac{c}{v_H}$  tokens. In this case, the firm's total profit over the two periods is

$$\underbrace{\left(v_H - c \frac{c}{v_H}\right) \alpha_H}_{\text{Token Sale Profit } t=1} + \underbrace{(v_H - c) \left(\alpha_H - \alpha_H \frac{c}{v_H}\right)}_{\text{Token Sale Profit } t=2} = 2(v_H - c)\alpha_H. \quad (\text{D.4})$$

The competitive outcome is not reached and only high-type consumers obtain the service each period.

Second, if  $\alpha_H \frac{c}{v_H} \geq \overline{Q}_1$ , then if the firm sells to all high-type customers at  $t = 1$ , service providers anticipate that  $p_2(\alpha_H + \alpha_L) = v_L$  and the firm has to choose  $b_1 = \frac{c}{v_L}$ . The firm's

total profit over the two periods is

$$\underbrace{\left(v_H - c \frac{c}{v_L}\right) \alpha_H}_{\text{Token Sale Profit } t=1} + \underbrace{(v_L - c) \left(\alpha_H + \alpha_L - \alpha_H \frac{c}{v_L}\right)}_{\text{Token Sale Profit } t=2} = (v_H - c) \alpha_H + (v_L - c) \quad (\text{D.5})$$

Relative to the its profit in Appendix B, the firm is able to extract surplus from providers and earns an extra  $(v_L - c) \alpha_H$ . The firm's profit is higher but the competitive allocation is still achieved at  $t = 2$ .

However, if  $\alpha_H \frac{c}{v_H} \geq \overline{Q}_1$ , the firm may instead prefer to choose  $q_1$  such that  $q_1 \frac{c}{v_H} = \overline{Q}_1 - \varepsilon$  for arbitrarily small  $\varepsilon$ . In this case, the firm can credibly set  $b_1 = \frac{c}{v_H}$  because its optimal choice at  $t = 2$  is  $q_2 = \alpha_H - b_1 Q_1 = \frac{v_L - c}{v_H - v_L} \alpha_L$  and  $p_2(\alpha_H) = v_H$ . The firm's profit over the two periods is then

$$\begin{aligned} & \underbrace{\left(v_H - c \frac{c}{v_H}\right) \frac{v_H}{c} \left(\alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L\right)}_{\text{Token Sale Profit } t=1} + \underbrace{(v_H - c) \left(\alpha_H - \alpha_H + \frac{v_L - c}{v_H - v_L} \alpha_L\right)}_{\text{Token Sale Profit } t=2} \\ &= (v_H - c) \alpha_H + \frac{v_H}{c} (v_H - c) \left(\alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L\right), \end{aligned} \quad (\text{D.6})$$

In this case, the competitive allocation is not achieved at  $t = 2$ . Moreover, the total surplus with tokens is worse than if the firm operated as a monopoly because not all high-type consumers obtain the service at  $t = 1$ . (D.6) is higher than (D.5) iff

$$\frac{v_H}{c} (v_H - c) \left(\alpha_H - \frac{v_L - c}{v_H - v_L} \alpha_L\right) > v_L - c, \quad (\text{D.7})$$

which is the same as (C.19).

Allowing the firm to costlessly eliminate tokens from circulation via burning is similar to the case of having a flexible token-to-service price on the platform. Here too, the firm makes higher profit because, besides getting extra surplus from service providers, the firm also effectively reduces the durability of tokens. Without burning, the total mass of high-type consumers, to which the platform sells tokens in  $t = 1$  and  $t = 2$ , cannot be more than  $\alpha_H$ . In contrast, with burning, the firm can sell to more than  $\alpha_H$  high-type consumers in total over the two periods. Indeed, because some tokens are burned between  $t = 1$  and  $t = 2$ , the demand of high-type consumers at  $t = 2$  cannot be completely satisfied by providers reselling tokens and, therefore, these consumers have to buy additional tokens from the firm. This allows the firm to extract extra rents. Effectively, tokens become less durable over time because a burned fraction of them cannot be used in future platform markets. This allows the firm to retain more market power.

## D.2 Model with Long-lived Agents

In this section, we extend the setup of our main model to allow for long-lived consumers and long-lived providers. We show that, the equilibrium established in the main model holds in this extended setup. For simplicity, we assume that  $\delta = 1$ .

**Long-lived agents:** We assume that a unit mass of consumers and a unit mass of service providers are born in the beginning of period  $t = 1$ . These agents are long-lived and can participate in the platform exchange market and the token market in all periods  $t = 1, \dots, T$ . Unlike in our main model, consumers can now sell tokens in any token market or exchange them in any platform market. This implies that consumers do not have to exchange all the tokens, which they buy in the token market at  $t$ , in the platform exchange market at  $t$ . Similarly, unlike in our main model, service providers can now buy and sell tokens in any token market. This implies that providers do not have to sell the tokens, which they receive as payment in the platform exchange market at  $t$ , in the token market at  $t + 1$ . Therefore, consumers and providers condition both their trading decisions in the token market at  $t$  and their exchange decisions in the platform market at  $t$  on token prices  $p_s$  in all periods  $s \geq t$ .

**Circulation of tokens:** As in the main model, we define the number of tokens traded by the firm in period  $t$  as  $q_t$ , where  $q_t > 0$  denotes a decision to sell tokens while  $q_t < 0$  denotes a decision to buy back tokens. Similarly,  $Q_{t-1} \equiv \sum_{s=1}^{t-1} q_s$  denotes the total number of tokens that the firm sold up to period  $t$  and that is now held by other agents. Because agents cannot short tokens, we have  $q_t \geq -Q_{t-1}$ .

In contrast to our main model, we now also have to track consumer and provider token holdings after the token and platform markets in every period. Define as  $Q_t^i$  the total number of tokens owned by consumers of type  $i$  after the platform exchange ends at date  $t$ , where  $Q_t^i \geq 0$ , and as  $Q_t^p$  the total number of tokens owned by providers after the platform exchange ends at date  $t$ , where  $Q_t^p \geq 0$ . Because all tokens sold by the firm up to period  $t + 1$  are held by consumers and providers, we have

$$\sum_i Q_t^i + Q_t^p = Q_t. \quad (\text{D.8})$$

We define as  $q_t^i$  the number of tokens bought (sold if  $q_t^i < 0$ ) by consumers of type  $i$  in the token market at period  $t$ , where  $Q_{t-1}^i + q_t^i \geq 0$  because consumers cannot short tokens, and as  $q_t^p$  the number of tokens bought (sold if  $q_t^p < 0$ ) by providers in the token market at period  $t$ , where  $Q_{t-1}^p + q_t^p \geq 0$  because providers cannot short tokens. The market clearing

condition in the token market is now

$$\sum_i q_t^i + q_t^p = q_t. \quad (\text{D.9})$$

We define as  $q_t^{e,i}$  the number of tokens exchanged by consumers of type  $i$  in the platform market, where  $Q_{t-1}^i + q_t^i - q_t^{e,i} \geq 0$  because consumers cannot spend more tokens than they own, and as  $q_t^{e,p}$  the number of tokens received by providers in the platform market. The market clearing condition in the platform market is  $\sum_i q_t^{e,i} = q_t^{e,p}$ . Finally, the evolution of token holdings for consumers and providers is

$$Q_t^i = Q_{t-1}^i + q_t^i - q_t^{e,i}, \quad (\text{D.10})$$

$$Q_t^p = Q_{t-1}^p + q_t^p + q_t^{e,p}. \quad (\text{D.11})$$

**Agents' decisions:** The trading decisions of consumers and providers in the token market,  $q_t^i$  and  $q_t^p$ , and their exchange decisions in the platform market,  $q_t^{e,i}$  and  $q_t^{e,p}$ , depend on all future prices. We define the sequence of future prices as  $p_{>t} \equiv \{p_{t+1}, \dots, p_T, p_{T+1}\}$  with  $p_{T+1} \equiv c$ .

First, consider agents' actions in the platform market at  $t$ . The number of tokens exchanged by consumers of type  $i$  in this market is  $q_t^{e,i} = \min\{Q_{t-1}^i + q_t^i, \alpha_i\}$  if  $v_i \geq p_s$  for all  $p_s \in p_{>t}$ . Otherwise,  $q_t^{e,i} = 0$ . Providers accept tokens as payment for the service if  $p_s \geq c$  for some  $p_s \in p_{>t}$ . Because  $p_{T+1} \equiv c$ , the provider's participation constraint is satisfied in all periods and they are willing to provide the service at any  $t$ .

Next, consider agents' actions in the token market at  $t$ . The demand of long-lived consumers of type  $i$  in the token market is

$$q_t^i = \begin{cases} \alpha_i - Q_{t-1}^i & \text{if } v_i \geq p_t \text{ and } p_t \geq p_s \text{ for all } p_s \in p_{>t} \text{ and } Q_{t-1}^i \in [0, \alpha_i), \\ 0 & \text{if } v_i \geq p_t \text{ and } p_t \geq p_s \text{ for all } p_s \in p_{>t} \text{ and } Q_{t-1}^i \geq \alpha_i, \\ -Q_{t-1}^i & \text{if } v_i < p_t \text{ and } p_t \geq p_s \text{ for all } p_s \in p_{>t}, \\ +\infty & \text{if } p_t < p_s \text{ for some } p_s \in p_{>t}, \end{cases} \quad (\text{D.12})$$

where we assume that, if consumers are indifferent between buying tokens in the current period or in some future period, they postpone the purchase to the future. Thus, consumers do not demand more than  $\alpha_i$  tokens unless they expect the token price to increase, in which case the demand is infinite. This implies that consumers do not accumulate in advance tokens that they plan to use in the future platform markets. The demand of long-lived providers in

the token market is

$$q_t^p = \begin{cases} -Q_{t-1}^p & \text{if } p_t \geq p_s \text{ for all } p_s \in p_{>t}, \\ +\infty & \text{if } p_t < p_s \text{ for some } p_s \in p_{>t}, \end{cases} \quad (\text{D.13})$$

where we assume that, if providers are indifferent between selling tokens in the current period or in some future period, they conduct the sale in the current period.

**Firm's problem:** The firm's problem is given recursively by

$$\pi_t(Q_{t-1}^1, \dots, Q_{t-1}^N, Q_{t-1}^p) = \max_{q_t \geq -Q_{t-1}^p} \{[p_t - c]q_t + \pi_{t+1}(Q_{t-1}^1, \dots, Q_{t-1}^N, Q_t^p)\}, \quad (\text{D.14})$$

where  $\pi_{T+1} \equiv 0$  and  $p_t$  is the market clearing token price that is consistent with the firm's future token issuance policy and, thus, future prices.

**Equilibrium analysis:** As in our main model, we can find the equilibrium by backward induction and show that the token price weakly decreases with time. In the equilibrium, agents do not have incentives to hoard tokens. In any period  $t$ , consumers do not buy more tokens than they need for service consumption, i.e.,  $q_t^i \leq \alpha_i$ , because any tokens, that are bought at  $t$  and that are not exchanged in the platform market at  $t$ , can only be resold for a weakly lower price  $p_s$  at some time  $s > t$ . Consumers also do not accumulate in advance tokens that they plan to use in the future platform markets as such tokens can be bought in the future for a weakly lower price. Similarly, providers do not hoard tokens that they receive from consumers at  $t$ , but instead sell them at the earliest opportunity — in the token market at  $t + 1$ , i.e.,  $q_t^p = -Q_{t-1}^p$ .

Intuitively, the price cannot increase in equilibrium because the price of tokens in the last period is pre-determined by the firm's commitment to redeem tokens for  $c$ . This implies that agents do not speculate in the token market in the last period, so the price of tokens in the last period is determined by the value of service consumption. In turn, this implies that agents do not speculate in the token market of the previous period and, thus, the price of tokens in this period too is determined by the value of service consumption. Applying this argument to all previous periods, agents do not accumulate tokens in order to resell them in future token markets but only trade them to exchange them for the service. Thus, the token price weakly decreases with time as more tokens are sold by the firm.

Formally, because the firm redeems all tokens at the end of the period for  $c$ , i.e.,  $p_{T+1} \equiv c$ , the equilibrium token price at any period  $t \leq T$  is such that  $p_t \geq c$ . Consider agents' actions in the last period  $t = T$ . The firm does not buy any tokens in the token market if  $p_t > c$  and is indifferent if  $p_T = c$  because the firm can redeem all tokens at the end of the period for  $c$ .

Providers sell any tokens that they have  $Q_{T-1}^p$  if  $p_T \geq c = p_{T+1}$  because they do not have any consumption value to them. If consumers of type  $i$  already have tokens,  $Q_{T-1}^i \geq \alpha_i$ , they keep at most  $\alpha_i$  tokens, i.e., one token each, and sell any other tokens because any additional tokens do not have consumption value to them.

Therefore, there are two cases. i) If  $Q_{T-1}^i > \alpha_i$  for all  $i$ , both consumers and providers are only willing to sell tokens and, as a consequence, the token price  $p_T$  falls to  $c$ . ii) Otherwise, if there is a subset of consumers types  $J_T$  who have less than  $\alpha_j$  tokens, i.e.,  $Q_{T-1}^j < \alpha_j$  for all  $j \in J_T$ , they would be willing to buy tokens to exchange for consumption. In this case, if the supply of tokens from other agents,  $-\sum_{i \notin J_T} q_t^i - q_t^p + q_t$ , is higher than the maximum demand of agents in  $J_T$ ,  $\sum_{j \in J_T} (\alpha_j - Q_{t-1}^j)$ , the equilibrium price  $p_T$  falls to  $c$ . Otherwise, the equilibrium price  $p_T$  is equal to the value  $v_{j_T}$  for some  $j_T \in J_T$  such that the total demand from all higher-type agents in  $J_T$  is equal to the total supply,  $\sum_{j \in J_T, j \leq j_T} (\alpha_j - Q_{t-1}^j) = -\sum_{i \notin J_T} q_t^i - q_t^p + q_t + \sum_{j \in J_T, j > j_T} Q_{t-1}^j$ , where the last term is the supply from all lower-type agents  $j$  in  $J_T$  who prefer to sell their tokens at the price  $v_{j_T}$  because it is higher than their valuation of the service,  $v_{j_T} > v_j$  for any  $j > j_T$ . Therefore,  $p_T = c$  if agents accumulated more tokens than what is needed for one period service consumption, i.e.,  $Q_{T-1} > 1$ . Or, if  $Q_{T-1} \leq 1$ ,  $p_T = v_{j_T}$  for some  $j_T \in J_T$ .

Stepping one period back, we can show that the price  $p_{T-1} \geq p_T$ . In particular, if  $Q_{T-2} > 1$  the above argument can be applied to show that  $p_{T-1} = c$ . Otherwise, if  $Q_{T-2} \leq 1$ , we have  $p_{T-1} = v_{j_{T-1}}$  for some  $j_{T-1} \in J_{T-1}$ . Importantly, it cannot be that  $p_{T-1} = v_{j_{T-1}} < p_T = v_{j_T}$  because, in this case, agents would be willing to buy tokens at  $T-1$  to resell them in  $T$ . This would imply that the total number of tokens carried into period  $T$  would be  $Q_T > 1$  and, thus,  $p_T = c$ . As a result, we have  $j_{T-1} \leq j_T$ .

Applying the above arguments for all periods  $t \leq T-2$ , it follows that the price weakly decreases over time, i.e.,  $p_{t-1} \geq p_t$  for all  $t$ . Either, if  $Q_s > 1$  at some period  $s$ , the price falls to  $c$  and stays at  $p_t = c$  for all  $t \geq s$ . Or, if  $Q_s \leq 1$  for all  $t$ , the price is  $p_t = v_{j_t}$  such that  $j_{t-1} \leq j_t$ . In this case, as the token price weakly decreases, consumers do not buy more than one token per period because they can enjoy only one unit of service per period. This also implies that the consumer and producer demand are the same as in our main model for any  $p_t \geq c$ . As we have shown previously, in this case, the firm optimally sells tokens such that the second case is achieved, i.e., the firm does not release more than  $L_N = 1$  tokens and  $Q_t \leq 1$  for all  $t$ . Moreover, the firm sells tokens gradually such that  $j_t = i$ , i.e.,  $q_t = \alpha_i$  and  $p_t = v_i$ , for  $i = t = 1, \dots, N$ . Then, for all  $t \geq N$ ,  $q_t = 0$  and the number of circulating tokens is  $Q_t = 1$  with  $p_t = v_N$ . Therefore, for consumers,  $q_t^i = q_t^{e,i} = \alpha_i$  for all  $t \geq i$  and  $Q_t^i = 0$  for all  $t$ . And, for providers,  $q_t^p = -Q_{t-1}$ ,  $q_t^{e,p} = Q_t$  and  $Q_t^p = Q_t$  for all  $t$ .

### D.3 Model with Infinite Horizon

In this section, we extend our main model with tokens to allow for an infinite horizon. The results already established in the paper hold for any arbitrarily large  $T$ . They rely on Assumption 1 that guarantees that providers can redeem their tokens with the firm for  $c$  at the end of the last period. This assumption makes tokens a credible medium of exchange in all periods. Indeed, at  $t = T$ , because providers know that tokens can be redeemed at the end of the period for  $c$ , their participation constraint (8) is satisfied and they are willing to accept tokens from consumers as payment during the platform exchange at  $t = T$ . Then, because consumers know that tokens can be exchanged for the service at  $t = T$ , consumers find tokens valuable and buy them for  $p_T$  in the token market at the beginning of  $t = T$ . This, in turn, implies that tokens can serve as a medium of exchange at  $t = T - 1$ . Indeed, because providers know that tokens can be resold for  $p_T > c/\delta$ , their participation constraint (8) at  $t = T - 1$  is satisfied and providers are willing to accept tokens as payment during the platform exchange at  $t = T - 1$ . Applying backward induction in this manner to all periods, we can show that tokens are a credible medium of exchange, i.e., both consumers and providers believe that they are valuable in all periods.

The primary difference of the infinite horizon setting from our main model is the absence of Assumption 1. In this case, the beliefs of agents about the value of tokens are not supported by the ability of the last period providers to redeem tokens with the firm for numeraire as described above. Instead, the beliefs can be self-fulfilling, which leads to multiple equilibria. Such multiplicity of equilibria is a standard issue in the literature on fiat money (see, e.g., Samuelson, 1958; Wallace, 1980; Starr, 1989). Like fiat money, tokens do not have intrinsic value in our setting and are only valuable if they can be exchanged for the service.

In the model with the infinite horizon, there exists an equilibrium in which tokens are not a credible medium of exchange and  $p_t = 0$  for all  $t$ . Specifically, if providers at some period  $t$  believe that they can resell tokens in the token market at  $t + 1$  only for  $p_{t+1} = 0$ , their participation constraint (8) is violated, and they do not accept tokens as payment during the platform exchange at  $t$ . This implies that consumers do not find tokens valuable in the beginning of  $t$  and  $p_t = 0$ , which subsequently unravels the beliefs of providers at  $t - 1$ . Going backwards, the beliefs of providers and consumers unravel and  $p_s = 0$  for all periods  $s \leq t$ . This implies that the firm cannot sell any tokens in periods  $s \leq t$ . Therefore, there is an equilibrium in which no tokens are sold and consumers believe tokens cannot be exchanged for the service while providers believe that they cannot resell tokens.

There is also an equilibrium similar to that of our main model in which the firm releases tokens gradually over time and the competitive outcome is obtained in at most  $N$  periods. If  $\delta = 1$ , this equilibrium can be supported by providers' and consumers' beliefs that, for

any period  $t > N$ , the token price is  $p_t = v_N$  and that, for any period  $t \leq N$ , the token price is  $p_t = v_t$ . Under these beliefs,  $p_t > c/\delta$  for all  $t$  and, thus, providers' participation constraint (8) is satisfied in all periods. Therefore, at any  $t$ , expecting to resell tokens at  $t + 1$  to cover the cost of service provision, providers accept tokens as payment for the service. Because consumers believe that providers accept tokens in exchange for the service, their token demand is given by (7) for all  $t$ . This implies that the market-clearing price in any period is given by (9).

In this case, the firm's problem is similar to the one solved in our main model except the firm does not have to redeem tokens at  $c$  in the last period. This change to the firm's problem does not affect the optimal token release schedule and the firm sells tokens over  $N$  periods. Indeed, in our main model, the firm sells tokens as long as the total number of tokens released is weakly smaller than the maximum consumer demand,  $L_N = 1$ . Because the total cost of redeeming tokens is incurred in the last period, this cost depends on the total number of tokens sold but not when tokens are released. The redemption cost therefore does not affect the firm's optimal timing of token sales. In the infinite horizon model, without the cost of redeeming tokens, the firm also does not sell more than  $L_N$  tokens because, otherwise, the token price drops to zero. Thus, the solutions of the firm's problem in the two cases are the same.

Similarly, if  $\delta < 1$ , there exists an equilibrium comparable to that of our main model in which the firm releases tokens gradually over time and the competitive outcome is obtained in  $S \leq N$  periods. This equilibrium can be supported by beliefs of service providers and consumers that  $p_t = v_N$  for all  $t > S$ .

#### D.4 Example ( $T = 2$ and $N = 2$ ) with $\delta < 1$

In this section, we solve the example of Appendix B with  $\delta < 1$ .

The firm's problem at  $t = 2$  is not affected by discounting because it is the last period of the model and the firm has no future profit. Therefore, the firm's problem at  $t = 2$  is identical to its problem when  $\delta = 1$  in Appendix B. The firm's optimal choice of  $q_2(Q_1)$  as a function of  $Q_1$  is given by (B.4) and its optimal profit  $\pi_2(Q_1)$  as a function of  $Q_1$  is given by (B.5).

At  $t = 1$ , when choosing the number of tokens to trade  $q_1$ , the firm anticipates how this choice will affect its future trading profit  $\pi_2(Q_1)$ . Indeed, providers' participation constraint is satisfied even if  $\delta < 1$  because  $\delta v_L \geq c$ . Thus, the firm knows that  $Q_1 = q_1$  because all tokens purchased by consumers at  $t = 1$  are exchanged for the service, and then subsequently



resold in the token market by providers at  $t = 2$ . The firm's problem is

$$\pi_1 = \max_{q_1 \geq 0} [p(q_1) - \delta c]q_1 + \delta \pi_2(q_1), \quad (\text{D.15})$$

where the equilibrium price  $p(Q)$  is given by (B.2). As with  $\delta = 1$ , the firm does not benefit from selling fewer than  $\alpha_H$  tokens in the first period when  $\delta < 1$ . However, the firm might speed up the release of tokens and sell to more than one consumer type in the first period.

Specifically,  $\pi_1$  is not necessarily maximized if the firm chooses  $q_1 = \alpha_H$ , which is optimal when  $\delta = 1$ . If  $q_1 = \alpha_H$ , the firm's total profit over the two periods is equal to

$$(v_H - \delta c)\alpha_H + \delta(v_L - c)\alpha_L. \quad (\text{D.16})$$

In this case,  $p_1 = v_H$  and, in the second period,  $q_2 = \alpha_L$  and  $p_2 = v_L$ . As with  $\delta = 1$ , choosing  $q_1 = \alpha_H$  dominates choosing  $q_1 < \alpha_H$ . Specifically, if  $q_1 < \alpha_H$ , the firm's profit  $\pi_1 < (v_H - \delta c)\alpha_H + \delta(v_L - c)\alpha_L$ . Intuitively, when  $q_1 = \alpha_H$ , the firm captures the maximum possible price of  $v_H$  for the first  $\alpha_H$  tokens and the maximum possible price of  $v_L$  for the next  $\alpha_L$  tokens.

However, the firm might obtain a higher profit if it sells more tokens in the first period by choosing  $q_1 \in (\alpha_H, \alpha_H + \alpha_L]$ . In this case, the firm's total profit is  $(v_L - \delta c)q_1 + \delta(v_L - c)(\alpha_H + \alpha_L - q_1)$ , which is maximized when  $q_1 = \alpha_H + \alpha_L = 1$ . Therefore, if

$$v_L - \delta c > (v_H - \delta c)\alpha_H + \delta(v_L - c)\alpha_L = v_H\alpha_H + \delta v_L\alpha_L - \delta c, \quad (\text{D.17})$$

or, simplifying, if

$$\delta < \frac{1}{\alpha_L} - \frac{v_H\alpha_H}{v_L\alpha_L}, \quad (\text{D.18})$$

the firm chooses  $q_1 = 1$  and  $q_2(q_1) = 0$  rather than  $q_1 = \alpha_H$  and  $q_2(q_1) = \alpha_L$ .

Intuitively, because the firm discounts future profit, it might prefer to sell more tokens at a lower price today than to delay the token release over time. Thus, if  $\delta$  is low enough, the firm may speed up its token release schedule.