

Initial Coin Offerings as a Commitment to Competition*

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Abstract

We show that utility tokens, commonly issued in Initial Coin Offerings (ICOs), can limit rent-seeking activities of large firms with market power while preserving efficiency gains due to network effects. We model online platforms where buyers and sellers can meet to exchange services or goods. Utility tokens serve as the sole medium of exchange on a platform and can be traded in a secondary market. We demonstrate that financing the platform through an ICO allows an entrepreneur to give up monopolistic rents associated with the control of the platform and make a credible commitment to long-run competitive prices.

Keywords: ICO, Utility Tokens, Crowd-funding, Blockchain, Financing.

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1 Introduction

The market for Initial Coin Offerings (ICOs) started with a lot of promise but subsequently hit a roadblock. Between 2016 and 2018, the ICO market grew rapidly and to a considerable size.¹ ICOs were hailed as a novel way of financing with potential to reinvent the technology market.² However, at its peak the unregulated ICO market was plagued with stories of fraud and investors losing money.³ Starting from mid-2018, ICO activity slowed to a crawl reflecting concerns about the underlying value of ICOs and increased regulatory scrutiny. The rapid rise of ICOs followed by an equally swift decline has left open questions about whether there is any value to this new form of fundraising. Did ICOs attract such a large amount of funds because they were simply a means of regulatory arbitrage or do they offer new, attractive features that are not available from other established forms of financing? If yes, what are these features, what ventures are the most suitable for this mechanism of fundraising, and what is the appropriate regulatory approach towards ICOs?

In this paper, we shed light on some of these questions and show that ICOs can improve trade and increase welfare in markets that are prone to rent-seeking or that exhibit network effects. In particular, we focus on ICOs in which entrepreneurs obtain financing to develop a platform by selling digital assets, commonly referred to as “utility” tokens. These tokens can be later exchanged for services on the completed platform and are typically traded in a secondary market. We demonstrate that such a token-based mechanism allows entrepreneurs with market power to credibly commit to the long-run competitive pricing of services. Moreover, even in an environment with multiple competing platforms, an ICO can generate welfare improvements in the presence of positive network efforts.

Our analysis is motivated by the observation that marketplaces that match buyers and sellers are growing increasingly common and naturally lead to rent-seeking by developers due to associated network effects. Consider ride-sharing applications such as Uber or Lyft, apartment-rental services such as AirBnB, or general marketplaces like Amazon. These

¹In 2016, 52 ICOs collectively raised about \$283 million in this nascent market. Only two years later, in 2018, over 3,800 ICOs raised close to \$29.7 billion, which was almost 90% of the size of the IPO market that year. See [Davydiuk, Gupta and Rosen \(2018\)](#) and [Ritter \(2018\)](#).

²“What are initial coin offerings?,” *The Economist*, 22 August 2017.

³See, for example, “First Initial Coin Offering Fraud Case Ends in Guilty Plea,” *Bloomberg*, 15 November 2018.

platforms require a large networks of users looking for and providing rides, apartments and general goods, giving rise to natural monopolies and oligopolies. For example, a user looking for a taxi will be unlikely to download a multitude of ride-sharing applications and compare prices and wait times across them all. Furthermore, a platform can better optimize wait times as the number of potential riders and drivers on the platform increases. There are, therefore, obvious efficiency gains from all users being on a single platform. However, rent-seeking can erode many of the welfare gains from such marketplaces. An inefficiency is generated even when multiple platforms compete to limit rent-seeking (for example, Uber and Lyft) as this splits users across platforms reducing the gains from network effects. We show that the ICO mechanism can help improve welfare by allowing entrepreneurs to commit to competitive pricing even if all users use a single platform.

A sale of utility tokens via an ICO is typically used by entrepreneurs to develop a decentralized, online platform that facilitates trade by matching potential sellers and buyers of a good or service. The token sold is the sole currency that is used on the platform. Buyers pay sellers in tokens, which sellers can later monetize by selling these tokens in a secondary market on an exchange. For example, a prominent ICO called Filecoin, which raised \$257 million in 2017, is developing a platform in which users can buy and sell online data storage.⁴ The company is developing 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. A user in need of storage purchases Filecoin tokens on an exchange,⁵ and uses it to buy storage on the platform. A user with excess storage sells it on the platform for Filecoin tokens, which they can then sell on the exchange. Such a common market where customers can buy tokens, in order to spend them later on the platform, and service providers can sell tokens, which they received from customers on the platform is a crucial aspect of the ICO mechanism.

In the model, an entrepreneur develops a platform, on which competitive service providers are matched with consumers. Consumers are heterogeneous in their valuations of the service, with some consumers valuing it more than others. The entrepreneur issues tokens and each

⁴See <https://icobench.com/ico/filecoin>.

⁵Examples of cryptocurrency exchanges include Coinbase, Coinmama and CEX.io.

token can be exchanged for one unit of the service. The entrepreneur chooses whether to allow a common marketplace in which tokens can be traded by everyone or, alternatively, to retain sole rights to sell and redeem tokens.

If the entrepreneur does not allow the common marketplace for tokens, the situation is equivalent to operating as a monopolist. Without commitment to a common market for tokens, the entrepreneur, as the sole seller of tokens, has the power to charge any price for a token, which is the cost of a unit of service. As the sole redeemer of tokens, the entrepreneur also has full discretion over how much to pay a service provider. In equilibrium, the entrepreneur will operate exactly as a monopolist — charging customers more than the marginal cost of service provision for each token. The entrepreneur will reimburse service providers at a price per token that is equal to their marginal cost of service provision, just enough to compensate them for their costs. Thus, the entrepreneur can earn a spread from each service exchange and can fully control the quantity and pricing of the service. The entrepreneur will, therefore, optimally set an equilibrium price and quantity resembling that of a monopolistic service provider, even though service providers are perfectly competitive.

In contrast, when the entrepreneur allows a common marketplace for tokens, the model setting resembles the mechanism typical for many ICOs. We show that, in this case, when agents can trade tokens directly with each other, the entrepreneur is able to commit to give up pricing power. With a common marketplace, providers, who receive tokens in exchange for their services, can resell tokens directly to service consumers instead of redeeming them with the entrepreneur. Therefore, each time the entrepreneur releases additional tokens, she increases the number of tokens that are sold in the future in the common marketplace, thereby generating competition for herself. Intuitively, in this case, we can think of the entrepreneur as having a limited stock of market power. Every time she wishes to monetize the platform, she necessarily creates future competition for herself, and uses up some of her market power.

We show that, in the presence of a common marketplace, the entrepreneur optimally chooses to release tokens over time rather than all at once, gradually increasing the number of consumers who purchase the service. 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. Over time, the equilibrium price of the service falls and the quantity increases

reaching levels that would occur in a competitive equilibrium. The long-run surplus is, therefore, always higher under a tokenized platform.

Additionally, we show that in the presence of network effects, a tokenized platform can generate welfare improvements even if platforms compete with each other and there is no monopolistic rent-seeking. Conditional on pricing, when network effects are positive it is efficient for all users to be on the same platform. By using tokens, the entrepreneur can commit to give up rent-seeking in the absence of competitive pressures, resulting from users migrating to platforms with better pricing. Therefore, a single tokenized platform can improve welfare by maximizing efficiency gains due to network effects.

Focusing on the financing decision, we further show that if an incumbent entrepreneur is facing a threat of future entrants, she may prefer to run a tokenized platform to deter entry. Additionally, we model the entrepreneur's choice between having an ICO and operating as a monopolist even when future competition is absent. We show that if the entrepreneur is raising money from outside investors who do not derive any value from consuming the product and only benefit from the return on their investment, the entrepreneur indeed always prefers to operate as a monopolist. However, if the entrepreneur is raising money from investors who also get utility from consuming the service, she may prefer to have an ICO and be better off committing to long-run competition. Consumers of the platform get higher surplus when prices are lower. They will, therefore, take into account their future surplus from consuming the product as well as the return on their investment when they are funding the entrepreneur. Consumers of the platform effectively subsidize the entrepreneur during an ICO, allowing her to capture a larger share of the total surplus. If this subsidy is large enough, the entrepreneur may prefer to have an ICO over operating as a monopolist. The ICO mechanism, therefore, gives rise to *endogenous crowd-funding*, in which future consumers of the platform are the only investors who can successfully fund its creation.

An important feature of tokens in our framework which enables commitment to competitive pricing — a fixed token to service exchange rate — was not common in the ICO market historically but has been a recent subject of interest in cryptocurrency markets. In particular, there has been a push towards asset-backed cryptocurrencies in which the price of a token is fixed to the value of an underlying asset. For example, a token called RealT ties the value

of each token to a fixed ownership stake in a property.⁶ Asset-backed cryptocurrencies are gaining in popularity with investors hoping that tying token values to assets will reduce uncertainty about the economic value of each token, thereby reducing volatility and generating stability in the cryptocurrency market. Our analysis demonstrates an additional advantage of having this feature in utility tokens in two-sided marketplaces — facilitation of a commitment to competitive pricing.

While our main framework translates most naturally to marketplaces whose main activity is to match buyers and sellers of products or services, it also applies to companies that focus on social media and have ad-based revenue models. Advertisers on these platforms looking to purchase ad slots constitute one side of the market while users, whose profiles advertisements are posted on, form the other side of the market. Most social media platforms are essentially subsidizing users by providing them their services for free and are selling advertising slots on their profiles. In the absence of tokens, the platform will charge monopolistic prices for the matching of advertisers to the relevant users. However, we can imagine a situation where platforms share their maintenance costs with users and, crucially, advertisers buy ad slots directly from users. In this case, our results show that introduction of tokens can help a platform commit to competitive pricing of ad slots increasing total surplus.

Our results suggest that platforms operating with utility tokens can deliver higher welfare and, therefore, the issuance of such tokens through ICOs should be encouraged by regulators. Indeed, the ICO market can be revived by, for example, introducing a special regulatory regime for the issuance of utility tokens such as the “Token Safe Harbor” proposed last year by one of the SEC commissioners.⁷ Our paper has also policy implications on how to limit the market power of established technology companies. There has been an increased congressional focus on how best to regulate the monopolies of firms such as Facebook, Twitter and Amazon.⁸ Some policy proposals recommend breaking up these companies.⁹ However,

⁶See <https://realt.co/>.

⁷See Peirce (2020). According to the proposal, the 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 SEC’s securities evaluations.

⁸“Tech monopoly? Facebook, Google and Amazon face increased scrutiny,” The Guardian, 3 June 2019.

⁹“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.

in practice this may be inefficient or impractical due to network effects as users benefit from other users being on the same platform. Our paper demonstrates an alternative way to limit the market power of large companies while preserving efficiency gains due to network effects — by introducing utility tokens. In fact, some companies already use currency on their platform similar to utility tokens. Our model suggests that changes to some features of these currencies can lead to welfare gains. 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 gift to their favorite streamers. Streamers can redeem Bits for 1.00 cent per Bit.¹⁰ Thus, Twitch as a sole redeemer of Bits is similar to a tokenized platform in our model without a common marketplace. Our analysis suggests that establishing a common marketplace for Bits trading would reduce rent seeking by the platform.

Fundamentally, the commitment to competitive pricing through tokens is enabled and supported by blockchain technology. In particular, the key parameters of the platform such as the price of service in tokens and the permission to trade tokens in an open exchange market constitute the computer code that is developed by the entrepreneur initially. The decision to utilize blockchain implies that, when the platform is launched, this code is released to and adopted by all users. In order to use the platform, users run the common code on their devices. Once the platform is operational, if the entrepreneur decides to make any changes to the platform's code she will not be able to do so unilaterally. Instead, for any changes to take place, the majority of users needs to reach a consensus and switch to running the new code. The entrepreneur will, therefore, need to come to an agreement with the users on any changes.¹¹ Thus, blockchain technology effectively commits entrepreneur to adhere to the mechanism that is chosen at the development stage and to which users consent through the initial adoption of tokens during an ICO.

Related literature. Our paper contributes to the nascent but rapidly growing literature that studies various aspects of the ICO mechanism: [Catalini and Gans \(2018\)](#), [Chod and](#)

¹⁰See <https://www.twitch.tv/bits>.

¹¹For more on decentralized consensus on blockchains, see [Cong and He \(2019\)](#).

Lyandres (2018), Cong, Li and Wang (2019b), Bakos and Halaburda (2019).¹²

The closest papers to ours are Li and Mann (2018), Sockin and Xiong (2018), Lee and Parlour (2019) and Canidio (2018). Both Li and Mann (2018) and Sockin and Xiong (2018) show that the ICO mechanism allows entrepreneurs to resolve the coordination failure problem between consumers and providers who decide whether to participate in a new platform developed by entrepreneurs. We abstract from the coordination problem and study how token issuance affects pricing of a service exchanged between providers and consumers on a platform.

Lee and Parlour (2019) show how the crowdfunding mechanism allows consumers to finance socially efficient service provision that might be forgone by traditional profit-maximizing intermediaries in light of potential competition. In contrast, we show that entrepreneurs can commit to competitive platform pricing via the ICO mechanism.

Canidio (2018) considers how entrepreneurs dynamically sell tokens in the post-ICO period, which creates incentives and generates financial resources for further development of the platform. We, instead, focus on how the ICO mechanism allows an entrepreneur to commit to letting a platform run in a truly decentralized way and, thereby, supports commitment to competitive pricing.

Other papers study the economics of blockchains including benefits and limitations of adopting cryptocurrencies, such as Bitcoin, as a means of payment: Yermack (2013), Harvey (2014), Chiu and Koepl (2018), Abadi and Brunnermeier (2018), Budish (2018), Pagnotta (2018), Hinzen et al. (2019b), Biais, Bisière, Bouvard and Casamatta (2019), Chiu and Koepl (2019), Cong, Li and Wang (2019a), Saleh (2019), Easley et al. (2019), and Huberman, Leshno and Moallemi (2019).¹³ Our paper is related to the work by Cong and He (2019) who develop a model in which blockchain technology can increase competition by allowing entrants to commit to delivering goods. In their paper, blockchain technology helps to overcome barriers

¹²Empirical literature on ICOs is also rapidly expanding, e.g., see Davydiuk, Gupta and Rosen (2018); 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); Jong, Roosenboom and Kolk (2018); Howell, Niessner and Yermack (2019); Lyandres, Palazzo and Rabetti (2018); and Benedetti and Kostovetsky (2018).

¹³See Chen et al. (2019) for an overview of the recent research into blockchain economics. See also Hu et al. (2018), Liu and Tsyvinski (2018), Hinzen et al. (2019a), and Li et al. (2019) for empirical analysis of cryptocurrencies.

to entry arising from information asymmetry problems, which give rise to a lemons problem in traditional markets. In contrast, we focus on a case in which natural monopolies can commit to competitive pricing.

Our paper also relates to the literature on monopolists selling durable goods. Coase (1972) shows that when a monopolist sells durable goods, in the continuous time limit, the monopolist immediately saturates the market. Stokey (1981) shows that in a discrete time version, the speed of market saturation depends on the interval of time between periods. The monopolist reaps larger profit when the period of times between successive intervals lengthens. Bulow (1982) shows that durable-good monopolists have an incentive to produce less durable products. In our paper, the re-tradability of tokens generates durability even though the service provided is not durable. This durability allows the entrepreneur to commit to acting like a monopolist selling durable goods, rather than one selling a non-durable good.

Finally, our paper also contributes to the literature on how to improve efficiency in markets with natural monopolies.¹⁴ One strand of this literature relates to private-market solutions without the need for government intervention on prices. This literature argues that the implementation of policy regulating the prices charged by firms can be costly and inefficient in practice. Therefore, conditional on being implementable, private-market solutions to regulating monopolies are preferable even if they achieve second-best welfare rather than the first-best. Papers in this literature focus on competition *for* the market rather than competition *within* the market. Chamberlin (1989) shows that if there is intermodal competition (for example, a car industry competing with a natural monopoly in railroad), then the unregulated market outcome can be close to the second-best. Demsetz (1968) proposes a mechanism in which prospective entrants of an industry which is a natural monopoly have to place bids such that the company with the lowest bid would win the right to operate. Such a mechanism may be difficult to implement if market conditions change over time since the bidding has to be done *ex ante* and pricing has to be contractually specified at the time of bidding before operations begin. Our mechanism does not require that market be specified *ex ante*. Further, the entrepreneur can be incentivized to choose to have a tokenized platform even in the absence of other potential future competition.

¹⁴See Braeutigam (1989) for a detailed review.

A second strand of the literature focuses on government regulation of the prices that can be charged by a monopolist. The simplest method of maximizing total surplus is to allow a monopolist to price discriminate and charge consumers different prices. However, the distribution of surplus in such a case may not be optimal as the monopolist captures all the surplus. Moreover, if consumer types are private information, simple price discrimination is not possible to implement. Non-linear tariffs in which customers are charged different amounts for a good depending on how many units of the good they buy can often lead to the first-best and generate Pareto-improvements in welfare (see, for example, Willig (1978)). In the presence of asymmetric information about consumer preferences, non-linear tariffs have to be structured in such a way that each consumer is incentivized to pick the quantity/price bundle aimed at them. In our setting, each period, consumers only demand one unit of the good. As such, differences in the quantity of the good each consumer has access to cannot be used to incentivize consumers with different valuations of the service to pay different amounts. Therefore, non-linear tariffs cannot be used to improve efficiency.

The rest of this paper is organized in the following way. In the next section, we setup the model. Section 3 illustrates the main intuition behind our results in an example. Section 4 analyzes equilibrium in the general model. Section 5 extends the baseline model by introducing network effects and platform competition, a financing stage, and demand uncertainty into the model. Section 6 discusses how our framework can be used in practice to improve welfare and the commitment enabled by blockchain technology. The last section concludes.

2 Model Setup

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

Platform and tokens: The platform is initiated by the entrepreneur at the beginning of the first period, $t = 1$, and allows consumers to obtain services from service providers by matching them in all periods $t \geq 1$. We assume that the service can only be purchased through the

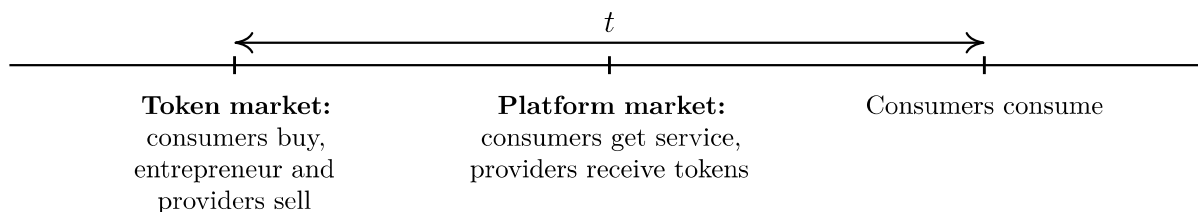


Figure 1: Sequence of events during a period t .

platform and there is no another way for service providers to match with consumers looking for the service.¹⁵ Tokens are the only means of payment on the platform. Thus, in order to acquire the service, consumers have to get tokens first — this requirement generates a non-zero value for tokens. We assume that each token can be exchanged for 1 unit of the service. In addition to the platform exchange, each period t , there is also a market for tokens, in which service providers and the entrepreneur can sell any tokens they have to consumers for a price p_t that is determined in equilibrium. The sequence of events during a period t is summarized in Figure 1.

Entrepreneur: Each period t , the entrepreneur sells $q_t \geq 0$ tokens to consumers in the token market. As described above, consumers value tokens because they can be exchanged for the service on the platform. The entrepreneur is the only agent who can create tokens. In the baseline model, we do not consider any financing that the entrepreneur might require in order to develop the platform.¹⁶

Service providers: A large mass of service providers can access the platform and sell their service in exchange for tokens. Their marginal cost of producing a unit of the service is c . Since service providers can participate in the market for tokens, they accept tokens at t as payment for the service knowing that they can sell tokens in the next period $t + 1$ in this market. We assume that service providers can redeem their tokens with the entrepreneur for a price c at the end of each period. This assumption is necessary for tokens to be a

¹⁵Matching, 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 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 the related information to meet outside the platform.

¹⁶In Section 5.2, we extend the model to incorporate a financing stage in which the entrepreneur can choose between raising funds with an ICO or raising funds with an profit-sharing contract.

credible medium of exchange on the platform in a finite horizon model. It also ensures that the entrepreneur has no incentives to release additional tokens that would push the token price below the marginal cost of service provision.¹⁷ We assume that service providers have a weak preference for selling tokens to consumers over redeeming them with the entrepreneur when their payoff from both actions is the same.

Consumers: There is a unit mass $[0, 1]$ of consumers who are long-lived. Every period, each consumer values only one unit of the service. There are $N \leq T$ types of consumers. Each period t , a consumer of type i values a unit of service at $v_i \in [\underline{v}, \bar{v}]$ where $\underline{v} \geq c$. Any subsequent units of the service in the same period are valued at 0. 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 α_i and, therefore, $\sum_{i=1}^N \alpha_i = 1$. As mentioned above, consumers purchase tokens in the token market in order to exchange them for the service on the platform. We assume that consumers are deep pocketed and, therefore, unconstrained in their ability to buy tokens.

Token prices: Finally, we define how the price of tokens is set in the token resale market. We assume that if the mass of buyers is larger than the mass of sellers in this market, then the token price is given by the value of the marginal buyer. In the opposite case, when the mass of sellers is larger than the mass of buyers, the token price is given by the value of the marginal seller.

Entrepreneur's problem: The entrepreneur decides how many tokens to sell each period t in the token market q_t . Importantly, the entrepreneur understands that the total number of tokens she creates and the amount she decides to release each period will affect the current as well as future token prices. Thus, the entrepreneur solves the following problem:

$$\max_{\{q_t\}_{t=1}^T} \sum_{t=1}^T \delta^{t-1} q_t \cdot p_t(q_1, \dots, q_T) - \delta^{T-1} \sum_{t=1}^T q_t \cdot c. \quad (1)$$

The first term in the entrepreneur's problem is the discounted sum of revenues from tokens sold each period while the second term is the amount she is committed to pay to service providers in the final period when they redeem their tokens with the entrepreneur.

¹⁷The assumption can be relaxed in an infinite horizon model. However, then, the entrepreneur must additionally issue tokens in a fixed supply at $t = 0$.

Definition (Equilibrium). *A subgame perfect equilibrium of this model is given by the number of tokens q_t (and the associated token prices p_t) that the entrepreneur sells in each period t to solve (1) subject to the optimal actions of: i) consumers, who buy tokens whenever the price p_t is weakly below their value of the service; and ii) service providers, who can participate in the common token market in all periods.*

In the baseline model, we abstract from any financing needs of the entrepreneur. We, therefore, start our equilibrium analysis assuming the platform is already financed and fully operational. We compare equilibrium quantities, prices, profits, and welfare derived in the model to those derived in an alternative scenario, in which the entrepreneur shuts down the token resale market and effectively operates as a monopolist.

To differentiate between the two main scenarios in the rest of the paper we call the monopolistic entrepreneur, who does not allow an active token resale market, the *monopolist* while we call the entrepreneur, who allows the token resale market, simply the *entrepreneur*.

3 Example with $T = 2$ and $N = 2$

To illustrate the intuition behind our results, we start the analysis with an example, in which we set $T = 2$ and $N = 2$. Thus, the platform operates 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 $v_H > v_L \geq c$. Additionally, in the most of our analysis, we assume that $\delta = 1$ and only briefly discuss how results change when $\delta < 1$.¹⁸

3.1 Monopolistic Entrepreneur

We first consider a scenario in which the token resale market is shut down. In this case, the entrepreneur acts as a monopolistic service provider.

When the exchange of the service on the platform is implemented with tokens but there is no resale market, the entrepreneur can sell tokens to consumers for one price and redeem them

¹⁸See Appendix B for a complete analysis of the example with $\delta < 1$.

from service providers for another price in every period. By setting an appropriate spread between the two prices, the entrepreneur can obtain the profits of a monopolist who produces the service herself at constant marginal cost c and charges a unit price p_t to consumers. Specifically, this is the case when the entrepreneur charges consumers the monopolistic price p_t for tokens and redeems them from service providers for c — the providers' marginal production cost.

Without an active token resale market, in each of the two periods, the monopolist holds all the tokens and chooses the number of tokens $q_t \in [0, 1]$ to sell to consumers. Therefore, the entrepreneur's multi-period problem (1) separates into two identical one-period problems, in which the monopolist trades off rents extracted from high-type consumers versus rents collected from serving a larger mass of consumers.

The monopolist will find it optimal to sell $q_1 = q_2 = \alpha_H$ fraction of tokens, serving only high-type consumers, for a price $p_1 = p_2 = v_H$ if

$$\alpha_H(v_H - c) \geq v_L - c. \quad (2)$$

In this case, extracting the maximum rents from high consumer types is more profitable than selling to both high- and low-type consumers. The monopolist's total profit over the two periods is

$$2\alpha_H(v_H - c). \quad (3)$$

If condition (2) does not hold, the monopolist will optimally sell $q_1 = q_2 = 1$ fraction of tokens, serving both types of consumers, for a price $p_1 = p_2 = v_L$. In this case, forgoing some rents from high-type consumers and instead serving all consumers is more profitable.

In the following, we focus on the more interesting case when (2) holds, as this is when the surplus with a monopolist is less than that in a competitive market.

3.2 Entrepreneur with Active Token Resale Market

In this subsection, we consider our main scenario in which the token resale market is active. In this scenario, tokens that service providers received from consumers in exchange for the

service at $t = 1$ are sold by providers in the token market at $t = 2$ to cover their costs. Therefore, if the entrepreneur sells q_1 tokens at $t = 1$ to consumers, the consumers exchange these tokens for the service at $t = 1$. In turn, service providers sell q_1 tokens directly to consumers in the token resale market at $t = 2$, as long as the token price is higher than their production cost, $p_2 \geq c$. This implies that consumers purchase tokens at $t = 2$ both from providers and from the entrepreneur.

Since the platform operates for two periods the entrepreneur 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. 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 the period as consumers will not want to 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 will be worthless at $t = 2$.

Depending on the entrepreneur's token release schedule, there are three candidate equilibrium price schedules:¹⁹

1. If $q_1 \leq \alpha_H$ and $q_2 \leq \alpha_H - q_1$, the equilibrium price in both periods is high, $p_1 = p_2 = v_H$.
2. If $q_1 > \alpha_H$, the equilibrium price in both periods is low, $p_1 = p_2 = v_L$.
3. If $q_1 \leq \alpha_H$ and $q_2 > \alpha_H - q_1$, the equilibrium price is high in the first period and it is low in the second period, $p_1 = v_H$ and $p_2 = v_L$.

Note that the third case never occurs in the scenario with the monopolist since her problem is the same in each period and, thus, the price will either always be high v_H or always low v_L . In contrast, with an active token resale market, the equilibrium price schedule is always according to the third case above, in which the token price is high v_H at $t = 1$ and then falls to v_L at $t = 2$.

To verify, consider the first candidate price schedule, in which there is a high price for tokens in both periods. It is optimal for the entrepreneur to issue the maximum amount of

¹⁹Note that the entrepreneur never wants to release tokens such that $q_1 + q_2 > 1$, since this would cause the market price to fall to c which is not profitable for the entrepreneur who is committed to redeeming tokens for c .

tokens possible that can be sold at this price, i.e., $q_1 + q_2 = \alpha_H$. Therefore, the entrepreneur's total profit over the two periods is

$$\alpha_H(v_H - c). \quad (4)$$

The entrepreneur can always do strictly better by selling α_H tokens at $t = 1$ and $(1 - \alpha_H)$ tokens at $t = 2$ since such a token release schedule would yield the total profit of:

$$\alpha_H v_H + (1 - \alpha_H)v_L - c > \alpha_H(v_H - c). \quad (5)$$

Next, consider the second candidate price schedule, in which there is a low price for tokens in both periods. Again, it is optimal for the entrepreneur to issue the maximum amount of tokens possible that can be sold at this price, i.e., $q_1 + q_2 = 1$. Therefore, the entrepreneur's total profit over the two periods is

$$v_L - c. \quad (6)$$

Similarly to the previous case, the entrepreneur can do strictly better by selling α_H tokens at $t = 1$ and $(1 - \alpha_H)$ tokens at $t = 2$. Such a token release schedule allows the entrepreneur to make v_H instead of v_L on the first α_H fraction of tokens sold. Therefore, the equilibrium features the third price schedule.

There are two key mechanisms at play in our main scenario. First, each time the entrepreneur wants to monetize the platform and sell additional tokens, she increases competition for herself with service providers in subsequent periods due to the open token resale market. Indeed, any tokens released by the entrepreneur will be subsequently resold by service providers. Over time, as the total quantity of tokens in circulation grows, competition in the resale market increases, reducing the price of tokens.

Second, the entrepreneur can only profit from each token once, since any released tokens will be subsequently resold each period by competitive service providers. The entrepreneur as a token issuer will, therefore, price discriminate to get the maximum surplus from each token. Intuitively, we can think of the entrepreneur 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,

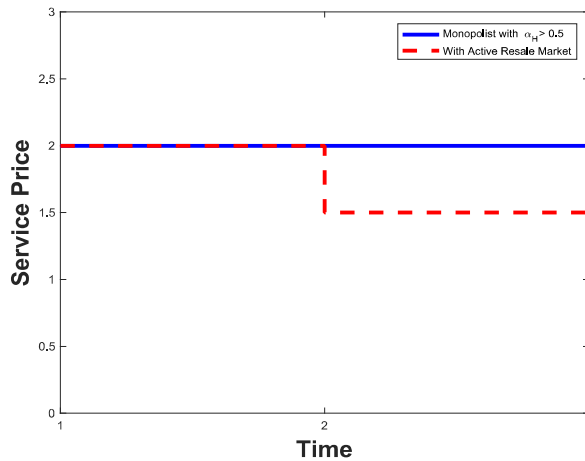


Figure 2: Equilibrium prices of the service. The equilibrium prices of the service under the monopolist and under the entrepreneur with an active token resale market. The parametrization is as follows: $v_H = 2$, $v_L = 1.5$, $c = 1$, $N = 2$, $T = 2$, $\delta = 1$.

everyone who values the service more than its marginal cost will be able to obtain the service. Absent time discounting, when $\delta = 1$, the entrepreneur will practice perfect price discrimination over time. Thus, only high value consumers obtain the service at $t = 1$ while low value consumers obtain it at $t = 2$. Consequently, in exactly 2 periods, competitive pricing of the service is reached, in which all consumers who value the service above its marginal cost are able to obtain it. As we show in the analysis of the general model with N types, this competitive pricing is reached in exactly N periods.

Figure 2 plots the equilibrium price of the service or, equivalently, the token price under the monopolist and under the entrepreneur with an active token resale market. The price under the entrepreneur is independent of the fraction of high value consumers α_H as she always finds it optimal to price-discriminate over time. In contrast, the monopolist prefers to serve only high-type consumers and excludes low-type consumers from the market for high values of α_H , when (2) holds. In this case, an active token resale market can help the entrepreneur commit to competitive pricing over time.

With an active token resale market, a competitive pricing is reached over time. Specifically, all consumers who value the service above its marginal cost to service providers obtain the service over time. Therefore, the long-run quantity of tokens released will always be weakly

higher than that under a monopolist and the long-run price will always be weakly lower than the monopolist's price. However, due to the perfect price discrimination by the entrepreneur, the short-run price and quantity supplied may be less than those under the monopolist. As we showed above, under some conditions, the monopolist releases all tokens in both periods charging v_L . In contrast, with an active resale market, the price gradually declines to the competitive level.

When the entrepreneur discounts revenues from future periods, $\delta < 1$, she might choose to sell tokens to multiple consumer types at once.²⁰ In our example, the entrepreneur prefers to release all tokens at $t = 1$ if $v_L > \alpha_H v_H + \delta(1 - \alpha_H)v_L$, or equivalently,

$$\delta < \frac{v_L - \alpha_H v_H}{(1 - \alpha_H)v_L}. \quad (7)$$

Time-discounting can, therefore, speed up the process of getting to the competitive price if the entrepreneur has a high discount factor for future payoffs. In the general model, the competitive price, at which all consumers are willing to buy the service, is reached in *at most* N periods.

It is clear from the analysis that an active resale market for tokens is the key factor that allows the commitment to long-run competition. Another key feature is that tokens allow transfer of the service between providers and consumers at a fixed exchange rate. This feature ensures that every time the entrepreneur “sells” a unit of the service (i.e., when the entrepreneur releases a token), a service provider will get to sell a unit of service in the future (i.e., when the service provider resells that token). This feature imparts durability to selling of the service — an inherently non-durable good. If, instead, service providers compete on how many tokens they require in exchange for a service provision, the market power is returned back to the entrepreneur. Appendix C extends the example to allow a floating token-to-service price and illustrates this point.

²⁰See Appendix B for a complete analysis of the example with $\delta < 1$.

4 Equilibrium Analysis

We now consider the general model setup, which lasts T periods and has N consumer types. As in the previous section, we compare the two scenarios: one with the entrepreneur who operates the platform with an active token resale market; and one with the monopolist who operates the platform without the token market, which is equivalent to the monopolistic service provider.

4.1 Entrepreneur with Active Token Resale Market

Define the total number of tokens released by the entrepreneur up to date t as $Q_t = \sum_{s=1}^t q_s$. The total supply of tokens sold in the market at t is always Q_t , i.e., service providers and consumers have no incentives to hoard tokens in order to sell or redeem them in the future instead of using or selling them at the earliest opportunity.²¹ Of this total supply, q_t are tokens that are newly sold by the entrepreneur and the remaining $Q_t - q_t = Q_{t-1}$ are tokens that are sold by service providers and have been in circulation before.

With the active token resale market, the entrepreneur faces a similar problem to the one in the example of the previous section. When future cash flows are not discounted, i.e., $\delta = 1$, the entrepreneur finds it optimal to release $q_t = \alpha_i$ tokens in period $t = i$, where α_i is the measure of consumers who have the highest value for the service among consumers who have not yet obtained the service before period t . Specifically, at $t = 1$, the entrepreneur releases α_1 measure of tokens, which is equal to the measure of consumers who have the highest value for the service, and the token price is $v_1 = \bar{v}$. At $t = 2$, providers sell these tokens, received as a payment for their service in the first period, and the entrepreneur releases additional α_2 tokens. The token price falls to the new level v_2 . This gradual release of tokens continues until the last period N , in which the entrepreneur sells tokens to the group of consumers who value the service the least and the token price falls to $v_N = \underline{v}$. By using such delayed token release schedule, the entrepreneur is able to price-discriminate perfectly and maximize her profit. In the general model, we establish the following proposition.

²¹In the equilibrium, token prices decrease over time. Service providers, therefore, want to sell tokens as soon as possible. Similarly, since the price of tokens falls over time, consumers have no incentive to hoard tokens as this means they would pay more than they have to in order to obtain the service in the future.

Proposition 1. *With the active token resale market, there is a unique equilibrium, in which the total quantity of tokens released increases over time while the token price decreases over time. With N different consumer types, the competitive outcome in the token market is achieved in exactly N periods if $\delta = 1$.*

When $\delta < 1$, the entrepreneur discounts future revenues and may choose to release new tokens to more than one type of consumers at once, starting from the first period. As in our example, lower δ speeds up the time it takes to get to competitive pricing which is achieved in at most N periods.

The key insight of our model is that the entrepreneur can profit from each token only once and is limited in how many tokens she can create for the platform to be feasible. Whenever the entrepreneur wants to monetize the platform by selling tokens, she is also necessarily creating competition in the future token resale markets as more tokens will be sold by service providers. We can think of the entrepreneur as having a limited stock of market power. The more new tokens the entrepreneur sells, the less market power she has in the token market going forward. As time passes, a competitive outcome is reached eventually in this market, in which all consumers who value the service above its marginal cost are able to obtain a token and, therefore, the service. Thus, the ICO structure allows commitment to long-run competitive price of the service to consumers.

As in the example of the previous section, we can compare the equilibrium in the scenario with the entrepreneur to the one that would exist if the entrepreneur operated as a monopolistic service provider. As argued above, the latter scenario is equivalent to the entrepreneur who operates the platform without token resale market and buys back tokens at c from service providers at the end of every period.

4.2 Monopolistic Entrepreneur

In the scenario of the platform without an active token resale market, the monopolistic entrepreneur holds all the tokens each period and chooses the number of tokens $q_t \in [0, 1]$ to sell for all t . Therefore, the entrepreneur's multi-period problem (1) separates into T identical one-period problems, in which the monopolist trades off rents extracted from serving higher

consumer types versus rents collected from serving a larger measure of consumer types at a lower price.

Irrespective of time discounting, the monopolist determines the marginal consumer type that is served each period:

$$i_m = \arg \max_i \sum_{j=1}^i \alpha_j (v_i - c). \quad (8)$$

Accordingly, the monopolist sells $q_t = \sum_{j=1}^{i_m} \alpha_j$ tokens for the price $p_t = v_{i_m}$ to consumers and redeems them from the service providers for c . Only the fraction $\sum_{j=1}^{i_m} \alpha_j$ of consumers obtains tokens, and, thus, are able to buy the service every period while the rest of consumers are not able to get it. With a monopolistic entrepreneur, there are, therefore, gains from trade between consumers and service providers that are not realized and some consumers who value the service above its marginal cost are not able to purchase it.

We now turn to comparing equilibrium profits and welfare under our two main scenarios: with the entrepreneur and with the monopolist. For the rest of the analysis, we assume $\delta = 1$, as it simplifies algebraic expressions. However, all our results are qualitatively similar if $\delta < 1$.

4.3 Profits

We now turn to calculating the monopolist's and the entrepreneur's profits. In particular, the monopolist is always more profitable than the entrepreneur.

Proposition 2. *The monopolistic entrepreneur earns a higher profit than the entrepreneur who allows the active token resale market.*

With the active token resale market, the entrepreneur can profit from each token only once. The monopolist, on the other hand, has the ability to earn continued profits as her market power gets reset every period. She therefore has full control over the quantity of tokens that are sold each period and the price that is charged for tokens. The monopolist can choose token quantities and prices to mimic those of the entrepreneur and replicate the entrepreneur's payoff. However, in the equilibrium, she finds an alternative strategy more profitable and sells to the same measure $\sum_{j=1}^{i_m} \alpha_j$ of consumers each period.

4.4 Welfare

With the active token resale market, competitive pricing, which maximizes the total per-period surplus, is always achieved in the equilibrium. However, due to price discrimination by the entrepreneur, this outcome is reached only after some time. If the monopolist makes enough profit by providing a large mass of consumers with the service, the total welfare under the monopolist may be higher. Specifically, the per-period surplus will be lower under the entrepreneur relative to that under the monopolist for the first i_m periods. Formally, we can establish the following proposition.

Proposition 3. *The total welfare under the entrepreneur is higher than the total welfare under the monopolist when the number of periods T is sufficiently high. The opposite is true if T is small and i_m is high, i.e., when the monopolist serves a sufficiently large mass of consumers.*

In the above analysis, we focus on the case of $\delta = 1$. If $\delta < 1$, the qualitative results are similar but there are two additional forces. On the one hand, the competitive outcome in the service market is reached sooner and, therefore, the total welfare is more likely to be higher under the entrepreneur who allows an active resale market. On the other hand, the discounted surplus from the future periods contributes less to the total surplus and early price discrimination reduces relative welfare under the entrepreneur to that under the monopolist.

5 Extensions

In this section, we consider a number of important extensions to the baseline model. First, we model competition between platforms when the platform exchange exhibits network effects. In this case, there can be benefits to moving to a token-based platform. We also show that an entrepreneur may want to run a tokenized platform to prevent entry by a competitor. Second, we show that even in the absence of the threat of entry, during financing, an entrepreneur can be incentivized to run a token-based platform rather than operate as a monopolist if consumers help finance the development of the platform. Finally, we incorporate demand uncertainty to our framework and show that our results remain qualitatively unchanged.

5.1 Platform Competition and Network Effects

In this subsection, we present an additional perspective on the total long-run welfare that is generated by a platform with an active token resale market. Recall that in the previous sections, comparing the two main scenarios, we showed that the long-run welfare is always higher with a token-based platform than with a monopolistic platform. Here, we explore how this welfare under a tokenized platform compares to the welfare generated by two competing platforms that operate without token resale markets. In this subsection, such platforms are called *standard* as opposed to a *tokenized* platform of the baseline setup.

We establish that if platform exchange exhibits network effects, a tokenized platform delivers higher total welfare than two competing standard platforms. Intuitively, if network effects are relatively high it is efficient to exchange the service only on one platform, even if competition between platforms is possible. Therefore, given our prior analysis, a single tokenized platform delivers the highest total welfare in the long run.

5.1.1 Platform Exchange under Network Effects

To demonstrate this idea, we model network effects in the following way. We assume that a higher mass of consumers on a platform leads to a lower marginal cost for service providers. For instance, a larger number of users on a ride-sharing platform means shorter idle time for drivers. Thus, the marginal cost is given by:

$$c = c(\alpha), \tag{9}$$

with $c'(\alpha) \leq 0$ and where $\alpha \in [0, 1]$ is a mass of consumers on a given platform. In this case, we can prove the following.

Proposition 4. *If the platform exchange exhibits network effects, it follows that: i) if the magnitude of network effects is high enough, the welfare under a monopolistic platform is higher than the welfare under two competing platforms; ii) the welfare under a tokenized platform in the long run (i.e., if $T \gg N$) is always higher than the welfare under two competing standard platforms.*

The first claim of the proposition asserts that if network effects are high enough, it is inefficient to split consumers between several platforms, i.e., the efficiency gains due to network effects are higher than the efficiency gains due to competition between standard platforms. This effect is amplified by the *long-run* competitive pricing of the token market in the second claim. Indeed, even if network effects are small, the welfare under a tokenized platform is higher than that under two competing platforms. In other words, under network effects, competition within a token market of a single platform is more efficient than competition between several standard platforms.

5.1.2 Example

As an illustration of the above result for platform exchange with network effects, we consider an example with a fully specified marginal cost function and service values for consumers. The example also allows us to demonstrate the short run effects of potential competition.

Specifically, the marginal cost for service providers as a mass of consumers α on a given platform is assumed to be:

$$c(\alpha) = \frac{1}{4} - c_n \alpha, \quad (10)$$

where $c_n > 0$ is a parameter gauging the size of network effects. Thus, a higher c_n means stronger network effects. Additionally, consumers' values have a linear form²², i.e., the consumer's inverse demand function is

$$v(\alpha) = \frac{1}{2} - \frac{1}{2} \alpha, \quad (11)$$

where with a slight abuse of notation α denotes the marginal consumer type of a higher-type consumer group with mass α . The total mass of consumers is 1, as in the baseline model, while $v(0) = \bar{v} = \frac{1}{2}$ and $v(1) = \underline{v} = 0$.

We next present the equilibrium outcomes in the three different scenarios: with a monopolistic standard platform, with a tokenized platform, and with two competing standard

²²This specification simplifies the exposition of the example and diverges from our inverse demand assumption in the baseline model where we use a step function. However, the difference between the two is small. In fact, a step inverse demand can be seen as an approximation of a smooth inverse demand for a discrete timeline.

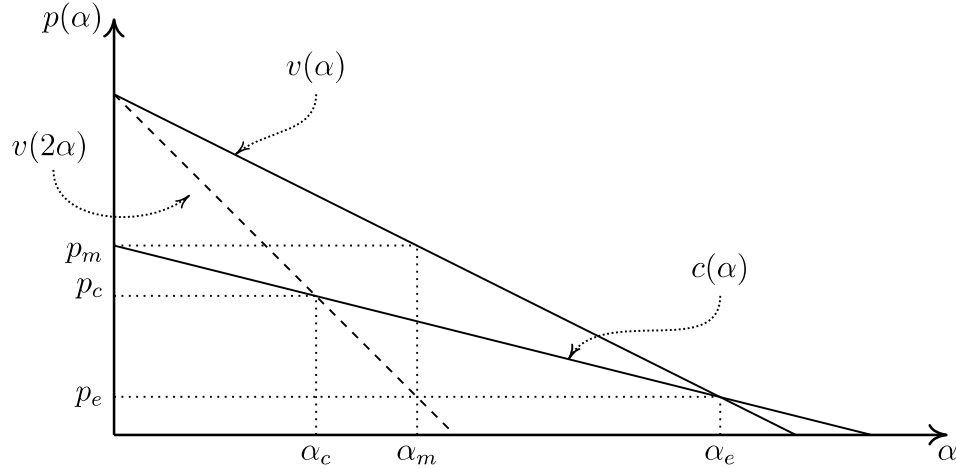


Figure 3: Equilibrium outcomes under network effects. The equilibrium outcomes (p, α) under network effects in the scenarios with: a monopolistic standard platform (m), a tokenized platform (e), and two competing standard platforms (c). The parameterizations for the cost function $c(\alpha)$ and consumer's inverse demand function $v(\alpha)$ are given in the example, $c_n = \frac{1}{4}$.

platforms. Figure 3 illustrates these outcomes.

Monopolistic standard platform. The monopolist optimally sets the price on the platform or, equivalently, chooses the mass of consumers to serve, to maximize her profit:

$$\max_{\alpha} (v(\alpha) - c(\alpha))\alpha. \quad (12)$$

Solving, the optimal mass of consumers on her platform is $\alpha_m = \frac{1}{4(1-2c_n)}$.²³ The monopolist serves more consumers when network effects are stronger, i.e., when c_n is higher.

Tokenized platform. As we noted in the analysis of the baseline model, *in the long run* a tokenized platform operates at full capacity and the price in the token market is set competitively so that the value of the marginal consumer on the platform is equal to the cost of the marginal service provider:

$$v(\alpha_e) = c(\alpha_e). \quad (13)$$

Thus, the *long-run* mass of consumers served by the platform is $\alpha_e = \frac{1}{2(1-2c_n)}$,²⁴ which is

²³The optimal price charged by the monopolist is $p_m = \frac{3-8c_n}{8(1-2c_n)}$, while the total per-period surplus in this scenario is given by: $TS_m = \frac{3-4c_n}{4} \left(\frac{1}{4(1-2c_n)} \right)^2$.

²⁴The *long-run* competitive token price in the token resale market is $p_e = \frac{1-4c_n}{4(1-2c_n)}$, while the total per-period surplus in the long run is given by: $TS_e = \left(\frac{1}{4(1-2c_n)} \right)^2$.

clearly higher than the mass of consumers served by the monopolist.

Two competing standard platforms. Finally, consider two standard platforms that compete à la Bertrand by setting the price of the service to consumers. In a symmetric equilibrium, prices on the platforms are the same and consumers are split equally between the two. Therefore, each platform faces a modified inverse demand function $v(2\alpha)$, which is twice steeper than that faced by a monopolistic platform or by a tokenized platform. Given perfect competition, the mass of consumers α_c served by each platform is such that the value of the marginal consumer on each of the two platforms is equal to the cost of the marginal service provider:

$$v(2\alpha_c) = c(\alpha_c), \quad (14)$$

which yields $\alpha_c = \frac{1}{4(1-c_n)}$.²⁵ Since $2\alpha_c < \alpha_e$, the total mass of consumers served in this scenario is smaller than that served by the entrepreneur, which provides the intuition for why the total welfare is smaller in the former case.

Comparing the total welfare under the three scenarios, we can make several observations. First, consistent with our baseline analysis, the *long-run* welfare under the tokenized platform is always higher than that under the monopolistic platform. Second, confirming the results in the Proposition 4, it can be shown that, when network effects are high enough ($c_n > 0.21$), the welfare under the monopolistic platform is higher than the welfare under the two competing platforms. In this case, the efficiency gains due to network effects are higher than the efficiency gains due to competition between standard platforms. Third, and by the similar reason, the *long-run* welfare under the tokenized platform is always higher than that under the two competing standard platforms.

Short-run competition. In addition, assuming specific values for the strength of network effects c_n allows us to make predictions about *short-run* competition. For example, suppose $c_n = \frac{1}{4}$ (see Figure 3). Then, the masses of consumers on a platform and the prices at which

²⁵The competitive price charged by each platform is $p_c = \frac{1-2c_n}{4(1-c_n)}$, while the total per-period surplus in the long run is given by: $TS_c = \left(\frac{1}{4(1-c_n)}\right)^2$.

they are served in the three scenarios are

$$p_m = \frac{1}{4} \text{ and } \alpha_m = \frac{1}{2}; \quad (15)$$

$$p_e = 0 \text{ and } \alpha_e = 1; \quad (16)$$

$$p_c = \frac{1}{6} \text{ and } \alpha_c = \frac{1}{3}. \quad (17)$$

It can be seen that, in this case, the price set by the two competing platforms p_c is lower than the monopolistic price p_m and, therefore, an entry of a second platform is a threat to the monopolistic platform when consumers can switch platforms with relatively low costs. If this threat is credible the monopolist cannot set the service price above p_c . Thus, the entry threat enhances welfare under the monopolist, since she will have to lower the price while all consumers remain on the single platform.

In contrast, the price set by two competing platforms p_c is higher than the *long-run* token price on a tokenized platform p_e and, therefore, the entry of a second platform is not a threat for a tokenized platform in the *long run*. However, if this threat is credible in the *short run*, to deter the entry, the tokenized platform might have to speed up the release of tokens in the earlier periods or during the financing stage so that the token price is no greater than p_c . Then, in the subsequent periods, the token price gradually declines to its *long-run* level p_e as in the baseline model.

5.2 Endogenous Crowd-Funding

In our baseline analysis, we focused on contrasting equilibrium outcomes for a platform in the two scenarios: with a monopolistic control and with a token-based exchange. Since profits are always higher in the former scenario, it might seem that the only way to achieve the welfare-superior outcome of a token-based platform is through a policy mandate. Indeed, this can be an attractive option for regulators as tokens can present a way to reduce the market power of large established technology companies without breaking them up, which would be inefficient as the previous subsection suggests.

In this subsection, we show that, alternatively, the incentives for an entrepreneur to

develop and operate a token-based platform might arise before the platform is developed — during an ICO fundraising. For this, we extend our baseline model to allow for a funding stage at the beginning of $t = 1$. At the stage, an entrepreneur, who is called a platform developer at this time, needs to raise an investment I to develop the platform and can choose between the two scenarios. In the first, she raises the required funds from outsiders with an equity contract²⁶ and operates as a monopolist. In the second scenario, she crowd-funds the required investment from consumers, i.e., holds an ICO, and operates as an entrepreneur allowing the token resale market. If the fundraising is successful, service providers and consumers can access the platform at $t = 1$ and the economy continues as in the baseline model. Additionally, we normalize the rate of return on outside investment options for all investors to 1 and assume that consumers are deep-pocketed at $t = 1$.

5.2.1 Fundraising in the Example

We introduce the intuition behind our results on the optimal fundraising by continuing our example with $T = 2$ and $N = 2$. Recall that the profit of the monopolist is always higher. However, if (2) holds, the total surplus under the entrepreneur is higher than that under the monopolist. In the following, we focus on this interesting case.

Fundraising from outsiders. It is straightforward to show that if a platform developer can raise funds only from outside investors who do not value the service available on the platform, i.e., if the sole way to attract investors is through profit-sharing contracts, the developer will always choose to operate as a monopolist rather than as an entrepreneur who allows a token resale market.

Indeed, to get funded by outside investors, a monopolist has to offer for sale a fraction of the platform s_m such that:

$$s_m = \frac{I}{2\alpha_H(v_H - c)}, \quad (18)$$

which is the ratio of the required investment to the monopolist's profit. This equity share makes investors break even. Analogously, the entrepreneur with an active token resale market

²⁶Since there is no uncertainty about future cash flows in the model, an equity contract is equivalent to any other profit-sharing contract. We focus on equity contracts for specificity.

has to offer a fraction of the platform s_e to outsiders such that:

$$s_e = \frac{I}{\alpha_H v_H + (1 - \alpha_H)v_L - c}, \quad (19)$$

which is the ratio of the required investment to the entrepreneur's profit.

Since the monopolist's profit is higher than the entrepreneur's, the monopolist can offer a smaller share of the firm to investors to generate the same return, i.e., $s_m < s_e$. It follows that the monopolist's total payoff is always higher than the entrepreneur's total payoff. Therefore, when trying to raise funds from investors who do not value service consumption, the platform developer prefers to operate as a monopolist.

Crowd-funding. In contrast to fundraising from outsiders, when the platform developer can crowd-fund the required investment from future consumers of the service, she may prefer to hold an ICO by selling tokens and subsequently operate as an entrepreneur with a token resale market rather than as a monopolist.

First, suppose that, as before, the entrepreneur raises funds with an equity contract. However, now, she can offer the profit sharing contract to consumers. Specifically, suppose that each high-type consumer invests an amount $\frac{I}{\alpha_H}$ to fund the platform's creation in return for a share $\frac{\tilde{s}_e}{\alpha_H}$ of the platform's profit. Then the total utility of a high-type consumer, who values the service at v_H , and whose investment is pivotal for the platform's success, is

$$\frac{\tilde{s}_e}{\alpha_H}(\alpha_H v_H + (1 - \alpha_H)v_L - c) - \frac{I}{\alpha_H} + (v_H - v_L), \quad (20)$$

where the first two terms are shares of profit and investment attributed to the consumer while the last term is the utility from service consumption. The consumption utility is equal to $(v_H - v_L)$ since the consumer is able to obtain a token in first period for the price v_H and she buys it in the second period for the price v_L , i.e., the utility is positive only in the second period.

Accordingly, the entrepreneur optimally chooses \tilde{s}_e such that a high-type consumer breaks even:

$$\tilde{s}_e = \frac{I - \alpha_H(v_H - v_L)}{\alpha_H v_H + (1 - \alpha_H)v_L - c}. \quad (21)$$

Thus, if the entrepreneur crowd-funds with an equity contract from consumers, the share of the firm she needs to sell is lower than the share she needs to offer if the investment is raised from outsiders, $\tilde{s}_e < s_e$. The high-type consumers know that, if there is an active resale market, token prices will decline at $t = 2$ and expect to obtain positive consumer surplus in the second period. Therefore, these consumers are willing to accept a lower share of the platform's profit in return for the investment.

Comparing this financing to the previous scenario, the platform developer will choose to operate as an entrepreneur and offer a profit-sharing contract to consumers rather than become a monopolist if

$$(1 - \tilde{s}_e)(\alpha_H v_H + (1 - \alpha_H)v_L - c) \geq (1 - s_m)2\alpha_H(v_H - c), \quad (22)$$

which is equivalent to

$$(v_L - c)(1 - 2\alpha_H) \geq 0. \quad (23)$$

Crowd-funding through an ICO. As an alternative to crowd-funding with a profit sharing contract, the entrepreneur can also crowd-fund by selling tokens directly to high-type consumers at $t = 1$, i.e., she can implement an ICO. We can show that these two options are, in fact, equivalent. Specifically, suppose the entrepreneur sells $q_1 = \alpha_H$ tokens in the first period to raise the required investment amount I . In this case, a high-type consumer, who believes that his participation is pivotal for the development of the platform, is willing to pay up to $v_H + (v_H - v_L)$ for a token. The first term v_H is the utility that the consumer gets from exchanging a token for the service in the first period while the second term $(v_H - v_L)$ is the future consumer surplus she expects to obtain in the second period. Therefore, the maximum proceeds from the ICO in the first period are $\alpha_H(2v_H - v_L) - I$.

Again comparing this crowd-funding option to the previous scenario of fundraising from outsiders, the developer will choose to operate as an entrepreneur and hold an ICO for consumers rather than become a monopolist if

$$\alpha_H(2v_H - v_L) - I + (1 - \alpha_H)v_L - c \geq (1 - s_m)2\alpha_H(v_H - c), \quad (24)$$

which simplifies to the same condition (23). Therefore, the two crowd-funding options from future consumers: with a profit-sharing contract and with an ICO are equivalent.

Our analysis has a few important implications. If investors are only accounting for the share of a platform's profit they have access to, a platform developer will always prefer to operate as a monopolist. However, if agents who obtain utility from service consumption in the future participate in fundraising, the developer might prefer to hold an ICO. Therefore, in our model, it is endogenously required that a token-based platform is financed through a crowd-funded ICO. Furthermore, the platform will be funded by the consumers who value the service relatively more as they get the highest surplus from the operational platform and are, therefore, willing to pay the highest price for tokens sold in an ICO. Since high-type consumers are willing to pay more than their one-period value of the service, the token price during an ICO can be much higher than the subsequent secondary market price of tokens.

5.2.2 Fundraising in the General Model

We now turn to the analysis of fundraising in the general model with T periods and N types and show that the results of the example carry through. First, we establish the following lemma.

Lemma 1. *If investors of the platform do not obtain any benefit from service consumption on the platform, the platform developer always prefers to operate as a monopolist and offers investors a profit-sharing contract.*

In contrast, if investors of the platform value the service, which becomes available once the platform is operational, they are willing to subsidize the developer. Indeed, if the developer operates as an entrepreneur with a token resale market, investors-consumers expect to benefit from lower prices of the service in future periods and can share this surplus with the developer at the financing stage. Consequently, the platform developer may find it optimal to hold an ICO. In particular, we can establish the following proposition.

Proposition 5. *If consumers are able to participate in financing, the platform developer prefers to raise funds with an ICO and have an active token resale market rather than operate as a monopolist for a non-empty set of parameter values.*

To summarize, a platform developer will optimally choose to issue tokens and operate as an entrepreneur rather than become a monopolist only if future consumers participate in financing of the platform. Our model, therefore, endogenously calls for crowd-funding as imperative for an ICO's success. Since consumers account for their future consumption surplus when purchasing tokens during an ICO, the entrepreneur can charge a much higher token price at this stage than any future prices. Thus, the model implies that token prices during ICOs can be higher than secondary market prices after ICOs have taken place.

5.2.3 First Best Through Multiple Financing Rounds

In our model, the first best level of welfare can be achieved by allowing the developer to have multiple financing rounds before the platform is operational. Additional financing rounds are always welfare-improving and make the entrepreneur more likely to profit from an ICO. Indeed, extra financing rounds, in which the developer can charge different prices for a token, allow her to price-discriminate and extract all consumer surplus from different consumer types during the financing stage. Such mechanism increases the entrepreneur's profit relative to her payoff from having a one-round ICO.

If there is no limit on the number of financing rounds that an entrepreneur can have, she will optimally choose to have N rounds and release all tokens over the different financing rounds. In the case, when a positive mass of consumers value the service at close to its marginal cost, such financing allows the entrepreneur to extract all consumer surplus that is generated under a competitive outcome in each period.²⁷ Since the monopolist's profit is always smaller than the total consumer surplus under competition, the platform developer would always prefer to have an ICO. Once the financing is over and the platform is operational,

²⁷As before, each consumer type commits their future surplus only if they believe that their ICO investment is pivotal for the platform development. To implement such financing, the entrepreneur can use staggered soft caps, i.e., set a minimum fundraising amount for each round. If one of the limits is not met, all investments are returned to investors. In practice, smart contracts allow the implementation of such procedure and soft caps are commonly used for ICOs.

the equilibrium token quantity and price on the platform immediately reach the competitive level, which maximizes the per-period welfare. Formally, we can establish the following proposition in case the financing stage can be broken into multiple rounds.

Proposition 6. *If \underline{v} is close to c , i.e., a non-zero measure of consumers value the service approximately at its marginal cost, the platform developer will always choose to have N financing rounds and have an active token resale market. In each financing round i , the entrepreneur sells α_i tokens at a price $v_i + (T - 1)(v_i - c)$.*

Multiple financing rounds can also potentially benefit the platform developer if she operates as a monopolist and raises money from consumers. Indeed, any consumer served by the monopolist will be willing to share his surplus with her while multiple financing rounds will help the monopolist to price-discriminate and extract this surplus. However, since the monopolist cannot commit to charging a price lower than v_{i_m} , she is not able to generate any extractable surplus for consumers who value the service less than the monopolistic price. Therefore, if the platform developer can have multiple financing rounds, she always prefers to commit to future competitive pricing by operating as an entrepreneur with a token resale market.

In practice, many ICOs have pre-sales in which some tokens are released before a scheduled main ICO round. However, pre-sales are often used as a promotion, to attract early investors and generate interest in the ICO, and, thus, token prices are typically lower in early rounds than later ones. Our analysis highlights a different use of the pre-sale mechanism. It makes an ICO more profitable and a platform developer, who otherwise might operate as a monopolist, is more likely to implement an ICO if staggered financing is available.

5.3 Demand Uncertainty

As discussed previously, our results for the token-based platform rely on a fixed rate at which tokens can be exchanged for services.²⁸ A natural concern is how restrictive this assumption is and whether it poses any limitations if there are changes to the demand for the service

²⁸In the baseline model, a single token can be exchanged for one service.

over time. In this subsection, we extend the model to incorporate demand uncertainty and show that the general intuition is preserved.

Specifically, we assume that the demand function, which is defined in the baseline by the masses of consumer types α_i with different valuations for the service v_i , can vary between periods. Formally, we denote by α_i^t the measure of consumers who value the service at v_i at period t , keeping the assumption that the total mass of consumers at any period is equal to 1, $\sum_{j=1}^N \alpha_j^t = 1$. We further assume that at any period, there is a positive measure of consumers of each type, i.e., $\alpha_i^t > 0 \forall i, t$.

In this extended model, the competitive pricing is reached over time as in the baseline. First, we show that the entrepreneur cannot get market power back in periods where demand is low relative to the number of tokens that have already been released. Formally, we show that if the number of tokens outstanding is larger than the mass of customers who value the service above its marginal cost in any given period, i.e., if $Q_t > 1$, the entrepreneur cannot make any profits by buying back tokens and selling them at a higher price in the future. In other words, market power is not returned to the entrepreneur if the demand is low.

Lemma 2. *Service providers will not redeem tokens with the entrepreneur at a price c , if the expected price in any future period s is greater than c , i.e., if $\mathbb{E}[p_s] > c$ for some $s \geq t$. This implies that if there is a period t in which $Q_t = 1$, then the price at any future period s will be c , i.e., $p_s = c$ for all $s \geq t$.*

The first part of the lemma is straightforward: if a service provider expects to obtain more than c for a token in the future, it is a dominant strategy to hold on to the token and sell it later when the price is higher rather than redeem the token with the entrepreneur in the current period. The second part of the lemma follows naturally from the first. For any future price in period $s \geq t$ to be higher than c , it has to be that $Q_s < 1$. Since $Q_t = 1$, this implies that, at some period between t and s , some tokens are sold back to the entrepreneur as the total supply of tokens outstanding decreases. However, this contradicts the first part of the lemma since no service provider redeems tokens with the entrepreneur between t and s if they expect the price of tokens at period s to be higher than c .

Given Lemma 2, we can show that if T is large enough, competitive pricing will eventually be reached. The key intuition here is similar to that in the baseline model — it is optimal for the entrepreneur to sell tokens gradually — only to one consumer type at a given period — moving from high value types to low ones. With demand uncertainty, the entrepreneur waits until she sells tokens to the maximum measure of consumers $\max_t \alpha_i^t$ of each type i before moving to the next. The time it takes for the economy to converge to competitive pricing will, therefore, vary depending on the nature of the demand uncertainty. Formally, we can establish the following proposition.

Proposition 7. *The total quantity of tokens released increases over time while the token price decreases over time. In the long run, i.e., if $T \rightarrow \infty$, the service is priced competitively.*

5.3.1 Growing Demand Over Time

The previous analysis assumes the variability in demand is stationary. However, it does not include the case of perpetually growing demand. When demand grows every period, it is possible for the equilibrium service pricing on a token-based platform to resemble that of a monopolist and never decrease to the competitive price. Intuitively, each period, the entrepreneur may prefer to sell tokens only to the newly added mass of consumers with relatively high value for the service rather than gradually release tokens to all customers as in the baseline model. Such a strategy will maintain a high price of tokens and, consequently, of the service.

To illustrate, consider the following extension to our example with two types. Assume that, between periods $t = 1$ and $t = 2$, the mass of high-type consumers scales by g_H and the mass of low-type consumers scales by g_L . Then, at period $t = 2$, the entrepreneur will prefer to sell only to the new high-type consumers if

$$\alpha_H g_H (v_H - c) > (\alpha_H g_H + \alpha_L (1 + g_L)) (v_L - c). \quad (25)$$

If the above condition holds, the pricing on the token-based platform resembles pricing under the monopolist. However, since some surplus is captured by service providers in the

former case, the entrepreneur makes a lower profit than the monopolist. Thus, if the demand of high-type consumers does not grow fast enough, the entrepreneur is more likely to lower prices than the monopolist. Indeed, the condition (25) is stricter for the entrepreneur than its counterpart for the monopolist (under which she prefers to serve only high-type consumers):

$$\alpha_H(1 + g_H)(v_H - c) > (\alpha_H(1 + g_H) + \alpha_L(1 + g_L))(v_L - c). \quad (26)$$

Therefore, even though it is possible for prices to remain high on a token-based platform, the perpetual demand growth needed for this to happen is higher.

6 Discussion

In this section, we discuss how the financing mechanism analyzed in our paper can be implemented and used in practice. The discussion consists of three parts. First, we draw parallels between the model's tokenized platform, including its financing, and the existing ICO market. We aim to highlight the key features necessary to implement the proposed mechanism that enables competitive pricing and discuss which of them are commonly seen in ICO markets and which are not. Second, we review several types of marketplaces in which the mechanism can be readily applied and can lead to welfare improvements. Finally, we discuss the commitment enabled by blockchain technology and what an equivalent commitment technology would require.

6.1 Parallels to the ICO Market

A tokenized platform in the model requires three key features to enable the commitment to competitive pricing — tokens have to be the sole currency on the platform that is exchanged for the service at a fixed rate, there has to be a token resale market, and service providers need to be able to redeem tokens with the entrepreneur at a price that covers the marginal cost of service provision.

In the model, the entrepreneur adheres to these features with the background assumption that their implementation through blockchain technology and smart contracting supports

this commitment. This is due to the fact that, in practice, the platform's features coded on the blockchain can not be changed unilaterally by entrepreneurs. Instead, for any changes to take place, the majority of the platform's users needs to reach a consensus and switch to running the new blockchain code. Thus, entrepreneurs are bound by the features chosen at the development stage and to which users consent through the initial adoption of tokens during an ICO.

Smart contracts can be leveraged to implement a fixed token to service rate. For example, asset-backed cryptocurrencies use smart contracting on the blockchain to maintain a fixed exchange rate between their tokens and another asset. Historically, the fixed token to service price has not been a common feature in the ICO market for utility tokens, with most utility tokens having a floating price between the token and service. However, there has been growing interest in asset-backed cryptocurrencies with investors being drawn to the stability provided by token values being tied to an underlying economic good. While asset-backed cryptocurrencies are more common in security tokens, our analysis suggests that they can be useful in providing economic value to utility tokens and may be a good feature for ICO markets to adopt going forward.

In practice, smart contracts are also used by platform developers to buy back tokens with the subsequent aim to reduce the total supply of tokens in circulation (which is called "burn"). In some cases, burning is done during every transaction, in others, there is much more discretion about timing and quantity of token reduction.²⁹ Our results suggest that this practice is beneficial for an entrepreneur who can force a buyback at a favorable price, as a monopolist does in our paper. On the other hand, buybacks are not beneficial for an entrepreneur who can only buy tokens back in an open token market. Indeed, in this case, service providers prefer not to redeem their tokens because they anticipate that a "burn" would lead to higher token prices in future, which makes them willing to hold on to their tokens.

When fundraising, a platform developer in our model will choose to run a tokenized platform rather than operate as a monopolist if future users of the platform participate in financing and share some of their future consumer surplus with the developer. For this

²⁹The examples of different implementations include BNB, MKR, Tron, EOS, Stellar, and XPR.

to be an equilibrium, future users need to believe that their investment is pivotal for the platform's success. One way to induce such belief is by having a minimum fundraising threshold specifying that a platform will be built if the threshold is met and if it is not met then any funds raised will be returned to users-investors. In practice, many ICOs have this feature and include such minimum fundraising limits referred to as *soft caps*.

Additionally, our analysis reveals that, to achieve the first best level of welfare, multiple fundraising rounds are required. The staggered financing is also commonly observed in practice — many ICOs have early fundraising rounds called *pre-sales*. A prevalent explanation for these is that they are used to attract early investors at promotional prices. Our mechanism outlines an alternative use for the pre-sales in which the goal is to sell tokens to different user types and, thereby, facilitate more efficient pricing once a platform is launched.

6.2 Application to Common Marketplaces

There are three types of common two-sided marketplaces in which the mechanism presented in this paper can lead to welfare improvements. We discuss these below.

Monopolist controlled two-sided marketplace. In such marketplace, there is a single monopolist intermediary-platform that matches agents from two sides of the market — buyers and sellers of a good or a service. One could argue that an example of a company which controls the majority of its marketplace is Amazon. Although there are other companies that offer similar services in e-commerce, they do not compete at a similar scale giving Amazon substantial market power.

Our analysis implies that introducing tokens on such platform would lead to competitive pricing in the long-run. In this case, the welfare improvement of a tokenized platform comes from the reduction of intermediary rents, which are available due to some form of market power. The platform exchange does not necessarily have to exhibit network effects. However, network effects may be the underlying source of the market power.

Competitive two-sided marketplace with network effects. In such marketplace, there are several competing intermediaries-platforms that match two sides of the market. Additionally, sellers' or buyers' value of the platform exchange increases with the number of other

users on the same platform, i.e., the marketplace exhibits network effects. An example of two actively competing companies in a single market with clear network effects is ride-sharing platforms Uber and Lyft.

Unlike in the previous case, here, intermediaries are restricted by competition and are not able to generate high rents. However, consumers are split between several platforms and this generates inefficiency. Introducing tokens to such marketplace would enable a single platform to commit to charging competitive prices and, in turn, attract all consumers, which would reduce the inefficiency by maximizing network effects. In this case, network effects are essential for tokens to be welfare improving as prices are competitive even without tokens.

Platform with ad-based revenue and market power. Our framework can also be applied to companies with market power that have ad-based revenue models. Often, such platforms are free to use and provide utility to their users through a service they specialize in. Examples of this type of platforms are Facebook and Twitter, which offer social networking services to their users.

To map these platforms to our model, advertising slots can be interpreted as a good being sold, advertisers as buyers of the slots, and platform's users as sellers of the slots. Tokenization of a platform means that advertisers would pay directly to users in tokens to buy advertising slots on their profiles. Then, according to our model, the competitive long-run price for an advertising slot should be close to a marginal cost of providing such slot. This cost, faced by users, can be thought of as a cost of maintaining an online profile plus any disutility that users experience from having advertisement slots on their profiles minus any benefit they obtain from socializing on the platform.

In the absence of tokens, a platform will use its market power, often generated by network effects, and charge monopolistic prices for matching advertisers to the relevant users and the advertising slots on their profiles. In contrast, tokens can help a platform to commit to competitive pricing and give users the ability to monetize their data.³⁰

³⁰Note that while tokenization can break pricing monopolies, our analysis does not apply to informational monopolies that may be facilitated by social networking websites.

6.3 Equivalent Commitment Technology

In our model, tokens underpinned by blockchain technology provide a way for an entrepreneur controlling a platform to commit to competitive pricing even when future demand is uncertain. In this subsection, we discuss the characteristics that are necessary for an alternative commitment technology to achieve the same outcome.

Recall that in the baseline model, each period, the consumer demand and the cost of service provision are deterministic. However, in Section 5.3, we extend the model to incorporate demand uncertainty. We show that under general modeling assumptions, tokens allow for commitment to competitive pricing even if future service demand is uncertain.

If tokenization is not available, an alternative commitment technology trying to achieve the same outcome would, therefore, need to enable the entrepreneur to commit at $t = 0$ to charging competitive prices in a *state-contingent* manner. This means, for example, that a ride-sharing company would have to commit to the prices it will charge for matching riders and drivers for all possible combinations of demand and supply curves in the ride-sharing market. We believe that such commitment seems a priori unlikely in practice, since the sheer size of all possible contingencies is hard to grasp and even harder to put in a legally binding document. Even if it was possible, demand and supply curves are not easily observable and as such proving in a court that the entrepreneur did not adhere to her commitment would be difficult. In that case, the fear of legal repercussions is unlikely to provide the necessary level of commitment.

7 Conclusion

This paper shows that tokenization through the ICO mechanism allows an entrepreneur to give up control of a service exchange platform and can help her to commit to competitive pricing of the exchanged service. Due to network effects, many online exchange platforms, which require a critical number of users to be operational, are natural monopolies and give rise to inefficient rent-seeking by their developers. Our theory can help rationalize the emergence of ICOs, many of which seek funding for such platforms. Our model demonstrates that many features of ICOs such as an active secondary market for tokens and fundraising

with pre-sales help platform developers to commit to competition and can greatly improve efficiency. Moreover, in the presence of network effects, tokenization of a single platform can improve welfare even relative to competing platforms.

Importantly, we show that traditional forms of financing, such as a venture capital funding, in which investors benefit only from profit-sharing, cannot support token-based platforms as, in this case, investors would prefer that developers retain the full control of a platform and its price setting. In contrast, financing through ICO mechanism is only feasible when platform consumers themselves contribute to the financing. Crowd-funding is, therefore, an integral part of the ICO market.

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Appendix A: Proofs

Proof of Proposition 1. We formally prove the proposition by backward induction. In Section 3, we have already shown that the statement of the proposition holds when there are 2 consumer types. Therefore, we need to show that if the entrepreneur optimally releases tokens to $N - 1$ different consumer types in $N - 1$ periods, then she finds it optimal to release tokens to N consumer types in N periods.

Without loss of generality, suppose the additional N -th consumer type is the one that has the highest value for the service. Define also the entrepreneur's optimal payoff that she obtains when she releases tokens to $N - 1$ lower consumer types in $N - 1$ periods as $V_{N-1}^*(\alpha_2, \dots, \alpha_N)$. Given this definition, if the entrepreneur serves all consumers of the highest type in the first period, we reach the induction step and the entrepreneur optimally releases her remaining tokens in the remaining $N - 1$ periods for the payoff $V_{N-1}^*(\alpha_2, \dots, \alpha_N)$. Consequently, we need to show that the entrepreneur does not have incentives to speed up the release of tokens by serving two or more consumer types in the first period or delay the release until the next periods.

Specifically, consider the two possibilities. If the entrepreneur releases $q_1 = \alpha_1$ tokens in the first period then the token price is $p_1 = v_1 = \bar{v}$ and her continuation payoff is $V_{N-1}^*(\alpha_2, \dots, \alpha_N)$. Clearly, there is no incentive to release $0 < q_1 < \alpha_1$ tokens since the token price is the same when $q_1 = \alpha_1$. If, however, the entrepreneur releases slightly more tokens $q_1 = \alpha_1 + \epsilon$ then their price falls below the value of the highest consumer type, $p_1 = v_2 < v_1$, and the entrepreneur's continuation payoff also decreases, $V_{N-1}^*(\alpha_2 - \epsilon, \dots, \alpha_N) < V_{N-1}^*(\alpha_2, \dots, \alpha_N)$, because her remaining stock of tokens gets smaller. Finally, since

$$\alpha_1 v_1 + V_{N-1}^*(\alpha_2, \dots, \alpha_N) > (\alpha_1 + \epsilon) v_2 + V_{N-1}^*(\alpha_2 - \epsilon, \dots, \alpha_N) \quad (\text{A.1})$$

the former release schedule yields a higher total payoff. Thus, it is suboptimal for entrepreneur to speed up the release of tokens in the first period.

Finally, it is also suboptimal for the entrepreneur to delay the release of tokens, by setting $q_1 = 0$, since this means that she will have to speed up their release in the remaining $N - 1$ periods. Therefore, she finds it optimal to release tokens to N consumer types in N

periods. □

Proof of Proposition 2. The total profit in the monopolistic scenario is the lifetime sum of one-period profits:

$$T \sum_{j=1}^{i_m} \alpha_j (v_{i_m} - c). \quad (\text{A.2})$$

The total profit of the entrepreneur who gradually releases all the tokens and allows the active resale market is

$$\sum_{j=1}^N \alpha_j (v_j - c) = \sum_{j=1}^N \alpha_j v_j - c. \quad (\text{A.3})$$

The monopolist always earns a higher profit than the entrepreneur. First, note that, if $T > N$ the monopolist earns a positive profit after period $t = N$ while the entrepreneur sells all her tokens by that time and earns zero in subsequent periods. Second, even if the number of periods T is small the monopolist has a greater market power and she can always choose to replicate the cash flow that is optimal for the entrepreneur with the active token resale market. In particular, the monopolist achieves this by selling α_t tokens for v_t at every period $1 \leq t \leq N$ while still redeeming them from providers at c in each period. Therefore, any alternative equilibrium strategy chosen by the monopolist must be more profitable. □

Proof of Proposition 3. The total welfare in the scenario with the monopolist is the lifetime sum of her per-period profits and per-period surpluses of consumers who are able to obtain the service:

$$T \sum_{j=1}^{i_m} \alpha_j (v_{i_m} - c) + T \sum_{j=1}^{i_m} \alpha_j (v_j - v_{i_m}) = T \sum_{j=1}^{i_m} \alpha_j (v_j - c). \quad (\text{A.4})$$

Since the monopolist 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 .

When $T \geq N$, the total welfare in the scenario with the entrepreneur, who releases all the tokens eventually but with an initial delay, is the sum of entrepreneur's, consumers', and providers' surpluses:

$$\begin{aligned}
\sum_{j=1}^N \alpha_j (v_j - c) + \sum_{j=1}^N \sum_{i=1}^{j-1} \alpha_i (v_i - v_j) + \sum_{j=1}^N \sum_{i=1}^{j-1} \alpha_i (v_j - c) + (T - N) \sum_{i=1}^N \alpha_i (v_i - c) \\
= \sum_{j=1}^N \sum_{i=1}^j \alpha_i (v_i - c) + (T - N) \sum_{i=1}^N \alpha_i (v_i - c). \quad (\text{A.5})
\end{aligned}$$

The sum of the first three terms represents the total surplus in the first N periods when the entrepreneur gradually releases tokens to consumers. Specifically, in period j , the entrepreneur releases α_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 entrepreneur.

Finally, the last term in the sum (A.5) 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 entrepreneur is higher than that under the monopolist since (A.4) is smaller than the last term in (A.5). Alternatively, if T is small and i_m is sufficiently close to N , the total surplus under the monopolist can be higher since (A.4) can be larger than (A.5). \square

Proof of Proposition 4. To prove the proposition, we first derive the equilibrium outcomes under network effects in different scenarios: with a monopolistic platform, with a tokenized platform, and with two competing standard platforms. Next, we compare the welfare across these scenarios.

Monopolistic standard platform. The monopolist who controls a standard platform solves the following problem:

$$\max_{\alpha} (v(\alpha) - c(\alpha))\alpha. \quad (\text{A.6})$$

Compared to the baseline model where the marginal cost c is constant, the monopolist has incentives to serve more consumers since $c(\alpha)$ is decreasing with higher α . The price is

$p_m = v(\alpha_m)$ and the total welfare in this scenario is

$$TS_m = \int_0^{\alpha_m} (v(\alpha) - p_m)d\alpha + (p_m - c(\alpha_m))\alpha_m = \int_0^{\alpha_m} (v(\alpha) - c(\alpha_m))d\alpha. \quad (\text{A.7})$$

Tokenized platform. As we noted in the analysis of the baseline model, *in the long run* a tokenized platform operates at full capacity and the price in the token market is set competitively such that

$$v(\alpha_e) = c(\alpha_e). \quad (\text{A.8})$$

This price is $p_e = v(\alpha_e)$ and the total welfare in this scenario is

$$TS_e = \int_0^{\alpha_e} (v(\alpha) - c(\alpha_e))d\alpha. \quad (\text{A.9})$$

Two standard competing platforms. Finally, consider two standard platforms that compete à la Bertrand by setting price of the service to consumers. In a symmetric equilibrium, prices on the platforms are the same and consumers are split equally between the two. Therefore, each platform faces a modified inverse demand function $v(2\alpha)$, which is twice steeper than that faced by a monopolistic platform or by a tokenized platform. Given perfect competition, the mass of consumers α_c served by each platform is such that

$$v(2\alpha_c) = c(\alpha_c). \quad (\text{A.10})$$

The price on each platform is $p_c = v(\alpha_c)$ and the total welfare in this scenario is

$$TS_c = 2 \int_0^{\alpha_c} (v(2\alpha) - c(\alpha_c))d\alpha. \quad (\text{A.11})$$

Given the equilibrium outcomes in the three scenarios, we can prove the proposition. It is convenient to start with its second claim.

Proof of ii). Since the demand faced by two competing platforms is steeper than that faced by a single platform, it is clear that $\alpha_e > \alpha_c$. Therefore, since $c(\alpha_e) \leq c(\alpha_c)$ it follows from (A.8) and (A.10) that $\alpha_e \geq 2\alpha_c$. Finally, the welfare under competing platforms can be modified

to:

$$TS_c = \int_0^{\alpha_c} (v(2\alpha) - c(\alpha_c))d(2\alpha) = \int_0^{2\alpha_c} (v(u) - c(\alpha_c))du. \quad (\text{A.12})$$

Thus,

$$TS_e = \int_0^{\alpha_e} (v(u) - c(\alpha_e))du \geq \int_0^{2\alpha_c} (v(u) - c(\alpha_e))du \geq \int_0^{2\alpha_c} (v(u) - c(\alpha_c))du = TS_c, \quad (\text{A.13})$$

where the first inequality is due to $\alpha_e \geq 2\alpha_c$ and the second is due to $c(\alpha_e) \leq c(\alpha_c)$.

Proof of i). Since the demand faced by two competing platforms is steeper than that faced by a single platform, it follows that $\alpha_m > \alpha_c$. If $\alpha_m \geq 2\alpha_c$ then the proof is the same as in *ii).* Alternatively, if $\alpha_m < 2\alpha_c$ then

$$TS_m - TS_c = \int_0^{\alpha_m} (c(\alpha_c) - c(\alpha_m))d\alpha - \int_{\alpha_m}^{2\alpha_c} (v(u) - c(\alpha_c))du, \quad (\text{A.14})$$

which is positive if $c(\alpha_c) - c(\alpha_m)$ is sufficiently high, i.e., if the cost function $c(\cdot)$ decreases fast enough with the mass of consumers on a platform. Thus, $TS_m > TS_c$ if $|c'(\alpha)| > C$ for some $C > 0$. \square

Proof of Lemma 1. If investors obtain no utility from service consumption, the platform developer can only offer them profit-sharing contracts in order to provide return on their investment. Let V_m represent the profit that the developer obtains as a monopolist and V_e represent the profit that she makes as entrepreneur with an active token resale market. We know from Proposition 2 that $V_m > V_e$.

Next, if the developer operates as a monopolist she has to offer investors the share of the profit s_m such that:

$$s_m = \frac{I}{V_m}, \quad (\text{A.15})$$

while if the developer operates as an entrepreneur she has to offer investors the share of the profit s_e such that:

$$s_e = \frac{I}{V_e}. \quad (\text{A.16})$$

Since $V_m > V_e$ it follows that $s_e > s_m$.

Finally, the platform developer's payoff when operating as a monopolist is

$$(1 - s_m)V_m = V_m - I, \quad (\text{A.17})$$

while the developer's payoff when she allows for an active token resale market is

$$(1 - s_e)V_e = V_e - I. \quad (\text{A.18})$$

Therefore, the entrepreneur is always better off by operating as a monopolist. \square

Proof of Proposition 5. The non-empty set of the parameters from the statement of the proposition is given by the equation (A.23). To derive it, as in the example, we first need to calculate the fraction of tokens that an entrepreneur would sell in an ICO. Since consumers of higher type derive more surplus from an operational platform and, thus, are willing to pay higher prices for a token during the ICO, we need to determine the marginal consumer type that participates in fundraising, call it i_e . If a consumer of this type i_e believes that he is pivotal, he will pay up to

$$v_{i_e} + \sum_{j=1}^{N-i_e} (v_{i_e} - v_{i_e+j}) + (T - (N - i_e + 1))(v_{i_e} - \underline{v}) \quad (\text{A.19})$$

for a token. In the expression, the first term is utility derived in the first period, the second term is utility derived in subsequent periods when tokens are gradually released, and the third term is utility derived in remaining periods when tokens are completely released and the market reaches competitive outcome.

Thus, if the entrepreneur sets the price at (A.19), everyone with type $i \leq i_e$ is willing to buy a token and the maximum mass of consumers participating in the ICO is $\sum_{j=1}^{i_e} \alpha_j$. The entrepreneur then optimally chooses i_e to maximize the surplus extracted from these consumers, i.e.,

$$i_e = \arg \max_i \sum_{j=1}^i \alpha_j \left(v_i + \sum_{j=1}^{N-i} (v_i - v_{i+j}) + (T - (N - i + 1))(v_i - \underline{v}) \right) \quad (\text{A.20})$$

Note that each type $i \leq i_e$ needs to believe that their participation is pivotal for the financing of the platform. This can be implemented by setting a minimum fundraising amount of:

$$\sum_{i=1}^{i_e} \alpha_i \left(v_{i_e} + \sum_{j=1}^{N-i_e} (v_{i_e} - v_{i_e+j}) + (T - (N - i_e + 1))(v_{i_e} - \underline{v}) \right) \quad (\text{A.21})$$

If this amount is not met, the investment collected from consumers is returned. Under this condition, all types $i \leq i_e$ purchase a token during the ICO at a price given by (A.19) with the type i_e being just indifferent between financing and not-financing the platform.

Finally, we can write down the condition when the platform developer chooses to hold the ICO rather than operate as a monopolist. This happens if her profit in the former scenario is higher:

$$\begin{aligned} \sum_{i=1}^{i_e} \alpha_i \left(v_{i_e} + \sum_{j=1}^{N-i_e} (v_{i_e} - v_{i_e+j}) + (T - (N - i_e + 1))(v_{i_e} - \underline{v}) \right) + \sum_{j=1}^{N-i_e} \alpha_{i_e+j} (v_{i_e+j}) - c - I \\ \geq T \sum_{j=1}^{i_m} \alpha_j (v_{i_m} - c) - I. \end{aligned} \quad (\text{A.22})$$

The above can be simplified to

$$\begin{aligned} T \left(\sum_{i=1}^{i_e} \alpha_i v_{i_e} - \sum_{j=1}^{i_m} \alpha_j v_{i_m} \right) + \sum_{j=1}^{N-i_e} v_{i_e+j} \left(\alpha_{i_e+j} - \sum_{i=1}^{i_e} \alpha_i \right) \\ - (T - (N - i_e + 1)) \underline{v} \sum_{i=1}^{i_e} \alpha_i - c \left(1 - T \sum_{j=1}^{i_m} \alpha_j \right) \geq 0. \end{aligned} \quad (\text{A.23})$$

If $i_m = i_e$, as in our example, the condition is further simplified to:

$$\sum_{j=1}^{N-i_m} (v_{i_m+j} - c) \left(\alpha_{i_m+j} - \sum_{i=1}^{i_m} \alpha_i \right) - (T - (N - i_m + 1)) (\underline{v} - c) \sum_{j=1}^{i_m} \alpha_j \geq 0. \quad (\text{A.24})$$

□

Proof of Proposition 6. If the entrepreneur has an ICO with N financing rounds and, in each

round i , she sells α_i tokens at a price of $v_i + (T - 1)(v_i - c)$ then she obtains a total profit of

$$(T - 1) \sum_{j=1}^N \alpha_j (v_j - c) + \sum_{j=1}^N \alpha_j v_j - c = T \sum_{j=1}^N \alpha_j (v_j - c). \quad (\text{A.25})$$

This is always greater than the monopolist's profit $T \sum_{j=1}^{i_m} \alpha_j (v_{i_m} - c)$.

Moreover, the profit (A.25) from fundraising with N financing rounds is also greater than having less than N financing rounds and releasing some tokens later when the platform is operational. Specifically, assume the entrepreneur decides to have $K < N$ financing rounds. In this case, the entrepreneur's profit is

$$T \sum_{j=1}^K \alpha_j (v_j - c) + \sum_{j=K+1}^N \alpha_j (v_j - c). \quad (\text{A.26})$$

It straightforward to see that the above is maximized when $K = N$. Therefore, it is optimal for the entrepreneur to have an ICO with N financing rounds. This mechanism can be implemented by setting a minimum fundraising amount equal to (A.25). In this case, the investment of every consumer is pivotal and all consumers will be just indifferent between purchasing and not purchasing tokens during the ICO. \square

Proof of Lemma 2. We can prove the first part of the lemma by contradiction. Assume a service provider redeems his token with the entrepreneur for c and $\mathbb{E}[p_s] > c$ for some $s \geq t$. Then the service provider has a profitable deviation. They can keep the token and sell it at a future period s when $\mathbb{E}[p_s] > c$, thereby in expectation making more than c .

The second part of the lemma follows from the first. Once $Q_t = 1$ tokens are released, for any future price in period s to be higher than c , it has to be that $Q_s < 1$. This implies that between period t and period s , at least some service providers need to redeem tokens with the entrepreneur. However, since $\mathbb{E}[p_s] > c$, according to the first part of the lemma, this will never happen. \square

Proof of Proposition 7. To prove the proposition, we show that there is a period t such that $Q_t = 1$ when T is large enough. For this, denote by $d_i^t = \sum_{j=1}^i \alpha_j^t$ the measure of consumers

who value the service at or above v_i in period t , and define the maximum of such measure as $\bar{d}_i = \max_t d_i^t$.

We first show that in any equilibrium, prices have to be weakly decreasing over time in periods in which a positive amount of tokens are sold. We can prove this by contradiction. Consider an equilibrium with a period $t < s$ such that $p_t < p_s$ and a positive measure of tokens are sold in both periods. Then any service provider who sells a token in period t has a profitable deviation. The provider can keep the token and sell it in period s instead. Therefore, in any equilibrium, prices are weakly decreasing over time in periods in which token sales happen.

We can further prove that there are no “dry” periods in which no tokens are sold. We prove this by contradiction. Consider an equilibrium with a period $t < s$ such that zero tokens are sold in period t but a positive measure of tokens are sold in period s . From consumers’ preferences and service providers’ cost of production, $c \leq p_s \leq v_1$. Since there is a positive measure of consumers of each type in every period, at time t there is a strictly positive measure of consumers who value the service at or above p_s . Since service providers would prefer to sell to these consumers at a price at or above p_s , trade will take place and no token trade cannot be an equilibrium.

Therefore, in any equilibrium, tokens will be sold every period and the token price will weakly decrease over time.³¹ Next, we show that if the entrepreneur is selling tokens at time t to customers of type i who value the service at v_i and $Q_t = \bar{d}_{i-1}$, it is always weakly optimal for the entrepreneur to sell tokens to all customers who value the service at v_i in that period, i.e., $q_t \geq \alpha_i^t$. In other words, if enough tokens have already been released equal to the maximum measure of consumers who value the service above v_{i-1} , the entrepreneur will sell tokens to at least everyone who values the service at i .

We can prove this by contradiction. Assume the entrepreneur chooses to sell tokens in period t to type i consumers such that $q_t < \alpha_i^t$. Then, if, at some time $s > t$, demand from the group who values the service at v_i is higher than α_i^t , the maximum profits the entrepreneur

³¹This implies, as in the benchmark model, that consumers have no incentive to hoard tokens.

can make from this group is

$$(\alpha_i^s - q_t)(v_i - c) + q_t(v_i - c) \quad (\text{A.27})$$

The entrepreneur can do as well by selling α_i^t tokens. On the other hand, if, at some time $s > t$, demand from the group who values the service at v_i is lower than α_i^t , the entrepreneur can do strictly better by selling α_i^t tokens at t .

Therefore, conditional on the entrepreneur selling tokens to a customer of type i in period t , it is weakly optimal to sell to all customers with the same valuations. From here, it is straightforward to see that the entrepreneur will release all tokens. With a large enough N and with $\delta = 1$, the entrepreneur will serve the maximum measure of customers of the highest type, and once that market is saturated, i.e., once $Q_t = \bar{d}_1$, serve the maximum measure of customers of the next type and so on. Eventually, since T is large, customers who value the service the least will be served and from then on the price will stay at the competitive level. \square

Appendix B: Baseline Example ($T = 2$ and $N = 2$) with

$\delta < 1$

In this Appendix, we solve the model of the baseline example with discounting, i.e., $\delta < 1$.

We explicitly show that the results derived for $\delta = 1$ carry over.

Monopolist's profit. If $\alpha_H(v_H - c) \geq v_L - c$, the monopolist's profit is

$$(1 + \delta)\alpha_H(v_H - c). \quad (\text{B.1})$$

Alternatively, if $\alpha_H(v_H - c) < v_L - c$, the monopolist's profit is

$$(1 + \delta)(v_L - c). \quad (\text{B.2})$$

Entrepreneur's profit. The entrepreneur promises to buy back tokens from service providers

in the end of the last period for c . With discounting, the cost of this buyback is δc . Since providers offer the service upfront and get paid only in the next period when they sell tokens, it is necessary that

$$\delta v_L \geq c \quad (\text{B.3})$$

for the platform to be operational. This condition guarantees that, in the second period, when they participate in the token market, service providers recoup their costs incurred in the first period, i.e., the discounted token price from the second period v_L is higher than the cost c .

If $\alpha_H v_H + \delta(1 - \alpha_H)v_L \geq v_L$, the entrepreneur releases tokens gradually, in 2 periods, and her profit is

$$\alpha_H v_H + \delta(1 - \alpha_H)v_L - \delta c. \quad (\text{B.4})$$

Alternatively, if $\alpha_H v_H + \delta(1 - \alpha_H)v_L < v_L$, the entrepreneur releases all tokens at once, in the first period, and her profit is

$$v_L - \delta c. \quad (\text{B.5})$$

It can be verified that the monopolist's profit is higher than the entrepreneur's profit under all possible scenarios as long as condition (B.3) is satisfied.

Welfare under monopolist. If $\alpha_H(v_H - c) \geq v_L - c$, the welfare under the monopolist is

$$(1 + \delta)\alpha_H(v_H - c). \quad (\text{B.6})$$

Alternatively, if $\alpha_H(v_H - c) < v_L - c$, the welfare under the monopolist is

$$(1 + \delta)\alpha_H(v_H - c) + (1 + \delta)(1 - \alpha_H)(v_L - c). \quad (\text{B.7})$$

Welfare under entrepreneur. If $\alpha_H v_H + \delta(1 - \alpha_H)v_L \geq v_L$, the welfare under the entrepreneur is

$$(1 + \delta)\alpha_H(v_H - c) + \delta(1 - \alpha_H)(v_L - c). \quad (\text{B.8})$$

Alternatively, if $\alpha_H v_H + \delta(1 - \alpha_H)v_L < v_L$, the welfare under the entrepreneur is

$$(1 + \delta)\alpha_H(v_H - c) + (1 + \delta)(1 - \alpha_H)(v_L - c). \quad (\text{B.9})$$

It can be seen that the welfare under the monopolist is lower than the welfare under the entrepreneur if $\alpha_H(v_H - c) \geq v_L - c$, i.e., when the monopolist excludes some consumers from the platform.

Appendix C: Competitive Pricing of Service

In this appendix, we relax the assumption that each token can be exchanged for one unit of the service and, instead, let market forces determine the price of the service in tokens each period. We show that, in this case, the monopoly power stays with the entrepreneur. The entrepreneur can release tokens in such a way that the competition between service providers creates an increasing token to service price over time. This allows the entrepreneur to release additional tokens each period to only service high-type consumers. This release schedule of tokens allows the entrepreneur to extract surplus from the same consumers more than once preserving her monopoly power.

We illustrate the argument in our example with $T = 2$ and $N = 2$. Define the price of a service unit in tokens at period t as r_t . In contrast to the baseline model that fixes $r_1 = r_2 = 1$, in this appendix, the two prices are determined in the equilibrium. As before, we can analyze the model through backward induction.

Staggered release of tokens. First, we show what happens if the entrepreneur follows the equilibrium token release schedule of the baseline model, under which all high-type consumers are served at $t = 1$ and the remaining consumers are served at $t = 2$. Since, at the end of the second period, service providers can redeem each token with the entrepreneur for c , the competition between them will result into the service price of $r_2 = 1$. To serve all consumers, the entrepreneur will release $q_2 = \max\{\frac{\alpha_L + \alpha_H}{r_2} - q_1, 0\}$ tokens in the market for tokens at $t = 2$ in addition to q_1 issued at $t = 1$. Thus, the total supply of tokens will be equal to $\frac{\alpha_L + \alpha_H}{r_2}$ and each consumer will purchase r_2 tokens for the price $p_2 = \frac{v_L}{r_2}$. Substituting in

$r_2 = 1$, at $t = 2$, the token and service markets are identical to the baseline with the fixed exchange rate of 1 token per one unit of the service.

Next, at $t = 1$, the competition between service providers will result into the price of r_1 tokens per unit of the service such that $r_1 p_2 = c$, i.e., with this price providers break even when they resell their tokens at $t = 2$. Substituting in $p_2 = v_L$, the service price is $r_1 = \frac{c}{v_L}$. Then, to serve all high-type consumers the entrepreneur sells $\alpha_H r_1$ tokens at $t = 1$ for a price of $p_1 = \frac{v_H}{r_1}$ with each high-type consumer purchasing r_1 tokens. Substituting in r_1 , the token price is $p_1 = \frac{v_H v_L}{c}$.

Computing the entrepreneur's profit under this release schedule and flexible r_t , it is higher than her profit under the fixed exchange rate of the baseline. Specifically, the entrepreneur's profit is

$$\begin{aligned} \alpha_H r_1 p_1 + (\alpha_L + \alpha_H - \alpha_H r_1) r_2 p_2 - 1 \cdot c = \\ \alpha_H v_H + \alpha_L v_L - c + \alpha_H (1 - r_1) v_L = \\ \alpha_H v_H + \alpha_L v_L - c + \alpha_H (v_L - c), \end{aligned} \tag{C.1}$$

where the last term is the additional profit the entrepreneur is able to obtain with the flexible r_t . This gain is the transfer from the profit of service providers who now earn

$$\alpha_H (r_1 p_2 - c) + 1 \cdot (r_2 c - c) = 0, \tag{C.2}$$

compared to their profit of $\alpha_H (v_L - c)$ in the baseline. The competition between providers erodes their profits and allows the entrepreneur to extract the same surplus at $t = 1$ by selling fewer tokens since $r_1 < 1$. This, in turn, implies that the entrepreneur sells more tokens at $t = 2$ receiving additional profit.

Finally, consumers profit is identical to the one in the baseline, with the fixed service price:

$$\alpha_H (v_H - r_1 p_1) + \alpha_H v_H + \alpha_L v_L - 1 \cdot r_2 p_2 = \alpha_H (v_H - v_L). \tag{C.3}$$

Equilibrium release of tokens. Next, using the same arguments, we can show that the entrepreneur might achieve even higher profit by choosing the token release schedule that

differs from the one in the equilibrium of the baseline model. First, we show that serving all consumers at $t = 1$ is suboptimal, as in the baseline. In this case, the competition between providers will cause $r_2 = 1$ with $p_2 = v_L$, and $r_1 = \frac{c}{v_L}$. Thus, if the entrepreneur serves both types of customers at $t = 1$, she will sell $q_1 = 1 \cdot r_1$ tokens for the token price of $p_1 = \frac{v_L}{r_1}$. Since, the entrepreneur's profit is $v_L - c$, which is less than her profit under the staggered release, serving all consumers at once is suboptimal.

However, in contrast to the baseline, the entrepreneur might prefer to serve only high-type consumers in both periods when the service price in tokens is flexible. Indeed, under this release schedule, the entrepreneur will sell $q_2 = \max(\alpha_H - q_1, 0)$ at $t = 2$ with the service price of $r_2 = 1$ and the token price of $p_2 = v_H$. At $t = 1$, the competition between providers will result into the service price of $r_1 = \frac{c}{v_H}$. Thus, the entrepreneur will sell $r_1 \alpha_H$ tokens at $t = 1$ for the price $p_1 = \frac{v_H}{r_1}$. In this case, the entrepreneur's profit is

$$\alpha_H r_1 p_1 + (\alpha_H - \alpha_H r_1) r_2 p_2 - \alpha_H c = \alpha_H (v_H - c) + \alpha_H (v_H - c) = 2\alpha_H (v_H - c). \quad (\text{C.4})$$

Similarly to the staggered release, the competition between providers allows the entrepreneur to extract the same surplus at $t = 1$ by selling fewer tokens since $r_1 < 1$. Thus, when the price of the service increases at $t = 2$, $r_2 > r_1$, the entrepreneur can continue extracting surplus only from the high-type consumers. In contrast, in the baseline model, the condition $r_1 = r_2$ implies that the entrepreneur has to switch and serve the lower type at $t = 2$ if all high-type consumers are served at $t = 1$.

Comparing the entrepreneur's profits in (C.1) and (C.4), the entrepreneur will prefer to serve only high-type consumers when $\alpha_H (v_H - c) > v_L - c$, which is the same as (2), i.e., precisely when the monopoly outcome is inefficient.³²

³²This intuition carries to a model with $T > 2$. In this case, in period t , the equilibrium token to service price will equal $r_t = \left(\frac{c}{v_H}\right)^{T-t}$. Each period t , the equilibrium price in the token market equals $p_t = \frac{v_H}{r_t}$ and the total supply of tokens is $Q_t = \alpha_H r_t$. As in the two period example, the equilibrium token to service price increases over time allowing the entrepreneur to sell additional tokens each period to only high-type consumers and preserve monopoly profits.