Intermediation and Payment*

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Abstract

Many trading platforms offer both brokerage (matching buyers and sellers) and credit services (such as buy-now-pay-later options) simultaneously. We investigate the impact of the platform's dual role on allocation efficiency in a directed money search framework involving sellers with different matching capabilities. We show sellers with higher matching efficiency can attract more buyers and command higher prices. As a result, they have a greater incentive to use platform-provided credit to avoid the inflation costs associated with using cash. We further show that the equilibrium credit provision by the platform generally deviates from the socially optimal level. The platform may either provide *excessive credit*, aiming to extract trade surplus through raising the ad valorem fee, or *insufficient credit*, as the platform can only partially capture the benefits of engaging in credit trade. Our study underscores the complexity of regulatory oversight.

Keywords: Platform, Money, Credit, Payment, Directed Search

JEL Classification Number: D4, F1, G2, L1, L8, R1

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1 Introduction

The rise of trading platforms like Amazon, Alibaba, Rakuten, and JD.com has significantly changed the way retail operates. These platforms not only act as brokers for transactions but also offer credit to customers. One of the popular services they provide is called 'Buy-Now-Pay-Later' (BNPL), which allows customers to purchase items now and pay for them later. Despite the seamless experience this dual-service model presents, regulatory frameworks often treat these credit services as distinct from brokerage, proposing separate rules from regulating the platforms. An example of this is the UK Treasury's legislative proposal published in February 2023, which aimed to enhance the regulation of BNPL services by mandating that all BNPL agreements from third-party lenders comply with a new set of regulations, without acknowledging that major third-party lenders are, in fact, platform operators. This fragmented approach is also evident in the revised European Consumer Credit Directive, published in October 2023, which focuses on the obligations of credit service providers without considering their potential role as platform operators. In the US, the Consumer Financial Protection Bureau (CFPB) proposed in November 2023 that payment services from major tech firms should face the same regulatory scrutiny as traditional banking and credit union services.[1]

This dichotomy in the regulatory approach raises critical questions about the efficiency of platform operations when they provide both brokerage and credit services concurrently. This paper delves into the implications on the efficiency of this integrated/dual service model, aiming to shed light on the regulatory challenges that arise when credit is intertwined with brokerage within the platform economy.

In Section 2, we offer a micro-foundation to understand why sellers might opt for costly credit technology. We assume that sellers bear the expenses of this technology because buyers can usually avoid any costs by paying within a set period, usually 30 days, while sellers need to pay to the platform to be eligible to provide credit to buyers. Additionally, sellers must pay service fees to withdraw their earned revenue from their platform account.[2]

We consider a directed search framework where there are a large number of buyers and sellers. Each buyer has unit demand for a good. Each seller possesses one unit of inventory. Seller's

[1]For the UK proposal, refer to *https://www.gov.uk/government/consultations/regulation-of-buy-now-pay-later-consultation-on-draft-legislation*. For the CFPB's proposal, refer to *https://www.consumerfinance.gov/about-us/newsroom/cfpb-proposes-new-federal-oversight-of-big-tech-companies-and-other-providers-of-digital-wallets-and-payment-apps/*. For the European regulations, refer to *https://www.loyensloeff.com/insights/news–events/news/regulating-buy-now-pay-later-code-of-conduct-and-revision-of-consumer-credits-directive*. All links were accessed on Jan 31, 2024.

[2]Here, the cost of using credit technology is considered a constant, and in subsequent analysis, the cost will be the service fee charged by the platform.

matching efficiencies are different, reflected in their differing probabilities of being matched with a buyer at a given buyer-seller ratio. In regard to the payment method, sellers face a choice: to accept payment in cash, which incurs inflation costs for all parties involved in trade, or to adopt credit technology that eliminates the need to use cash but comes with a fixed (for now exogenous) cost.

In directed search equilibrium, buyers must be indifferent between visiting different sellers. This means that sellers with higher matching efficiency can attract a longer queue of buyers and can charge higher prices for their goods. Suppose a seller only accepts cash payment; then the total expected amount of cash required to finalize a trade equals the seller's price multiplied by the number of buyers waiting in queue. Consequently, sellers with higher efficiencies need more liquidity and face proportionally higher inflation costs. These sellers thus have higher incentives to adopt credit technologies so as to avoid inflation costs.

Using this microfoundation, we construct a platform economy in Section 3 where a monopolist platform operates the market. On the one hand, the platform provides brokerage services to match buyers and sellers and charges a proportional fee based on the sales revenue, known as the ad valorem fee. On the one hand, the platform offers direct credit services, e.g., buy-now-pay-later, to sellers at a fixed fee. We characterize the first best allocations, which depend on the level of the nominal interest rate.

Section 4 is the equilibrium analysis. With regard to payment methods, in a typical case, the equilibrium features that all sellers choose to accept cash only (pure monetary payment) for low interest rates, all sellers choose to accept credit (pure credit payment) for high interest rates, and for intermediate interest rates, a hybrid of payment methods where sellers with matching capability above a certain threshold opt for credit payment while the rest only accept pay by cash.

Section 5 compares the equilibrium to the planner's solution. We found that the platform's incentive to provide credit payment services is generally not aligned with that of the planner. Specifically, if the platform's profit-maximization fees induce credit use for all participating sellers, it ends up providing excessive credit relative to the social optimum (when the nominal interest rate is not too high). This occurs because the platform incentivizes sellers to use credit services by offering them for free and then extracting the surplus through ad valorem fees. If the platform's equilibrium fees lead to a mix of credit and cash-using sellers, the platform provides insufficient credit compared to the socially optimal level. This is because the platform captures only a partial benefit when sellers switch from cash to credit transactions. The discrepancies between equilibrium and the planner's solution underscore the need for regulatory oversight.

While the inefficiencies above are largely caused by a standard market power distortion, i.e., the platform aims to charge a higher fee and thus lower the quantity of brokerage and credit services, the regulation is not straightforward. As discussed in Section 6, there are several concerns that distinguish the platform credit regulation from a standard case. First, the platform tends to subsidize participants' use of credit services and even provides credit for free. Thus, direct regulation of credit usage fees (or the introduction of external third-party lenders) does not work. Secondly, placing a cap on the ad valorem fee has an ambiguous impact on credit provision. When the ad valorem fee is limited, there is a compensatory effect whereby the platform can marginally increase the credit usage fee, which may lead to lower credit provision. Third, whether and how much to regulate the ad valorem fee depends on the level of nominal interest rates; our model suggests procyclical regulations, i.e., stronger regulation when the nominal rate is high. Finally, there is often a conflict between the objectives of having more agents join the platform and having the platform provide sufficient credit.

Related Literature

Our paper is closely related to the burgeoning literature on the hybrid or dual-mode of platform economies, e.g. Tirole and Bisceglia (2023), Madsen and Vellodi (2023), Gautier, Hu and Watanabe (2023), Etro (2023b), Etro (2023a), Shopova (2023), Hagiu, Teh and Wright (2022), Anderson and Bedre-Defolie (2022), Kang and Muir (2022), Padilla, Perkins and Piccolo (2022), Zennyo (2022), Etro (2021a), and Etro (2021b). The focus of these papers is on platforms that act as intermediaries between consumers and third-party sellers, while also offering their own first-party products. However, our research delves into a different but equally prevalent dual mode where the platform combines standard platform services with direct credit provision to facilitate transactions. To our knowledge, this perspective has not been examined in previous research.

Our modeling approach of monetary and credit payment follows from the modern monetary theory. Among the New Monetarist models based on Lagos and Wright (2005), our paper is broadly related to the literature on the coexistence of money and credit, e.g., Wang, Wright and Liu (2020), Andolfatto, Berentsen and Martin (2019), Gu, Mattesini, Monnet and Wright (2013), Sanches and Williamson (2010), Telyukova and Wright (2008), and Berentsen, Camera and Waller (2007). These models typically assume an exogenous subset of agents are eligible to use credit.

Dong and Huangfu (2021) model costly credit and focus on the buyer's choice of credit. Our formalization of costly record-keeping is conceptually similar to the information acquisition decision in Nosal and Rocheteau (2011), Lester, Postlewaite and Wright (2012), and Lotz and Zhang (2016) where sellers must incur a fixed cost to authenticate and hence accept an asset for trade. What sets our research apart from these studies is that we examine a directed search environment and with heterogeneous matching efficiencies of sellers, both of which are realistic in the e-commerce marketplaces. These two elements generate an endogenous subset of sellers who adopt costly credit technologies. This microeconomics of payment is then integrated into the platform economy where the payment choices of sellers depend on platform fees and inflation rates.

2 The microfoundation of payment choice

Consider a modified Lagos and Wright (2005) model where a centralized market (CM) and decentralized market (DM) open sequentially within a period. Time is discrete and continues forever. Agents discount between periods with factor $\beta \in (0,1)$ and no discount within a period. The CM is Walrasian, in which agents produce and consume a divisible good. In the DM, agents trade bilaterally in directed search (more on this below). If the trade in the DM requires fiat money as the medium of exchange, then buyers need to prepare sufficient balance in the previous CM. Holding money incurs a cost of inflation represented by the nominal interest rate i.

2.1 DM Trade: Payment and Matching

There is a continuum of agents who are either sellers or buyers. To enter DM, the buyer must pay an entry cost of $k \in (0, u-c)$ (in terms of the CM good). In the DM, each buyer has unit demand for an indivisible good with utility $u > 0$. Sellers sell the indivisible good to buyers. They produce on the spot at a constant marginal cost of c, and each of them has a selling capacity of one unit.

Sellers have different matching technologies. Given the queue length of buyers x, i.e., buyer-seller ratio in a submarket, a seller has a matching probability of $\xi\alpha(x)$, where $\alpha(x)$ satisfies properties that can be derived from a standard matching function, e.g., $\alpha'(x) > 0, \alpha''(x) < 0$, and $\xi \in (0,1)$ is the *seller's matching efficiency.* A buyer who visits this seller has a matching probability of $\frac{\xi\alpha(x)}{x}$. We assume that ξ follows a distribution with a support of $(\underline{\xi}, \bar{\xi})$, with $\frac{k}{u-c} < \underline{\xi} < \bar{\xi} < 1$.

In the decentralized marketplace (DM), sellers have the option to buy a credit technology at a fixed cost of ϕ. This technology enables buyers to pay using credit in the next CM when they visit a seller who has purchased it. However, if a seller has not bought the credit technology, buyers visiting that seller will have to pay using fiat money in the previous CM. Using money, the pair needs to bear the inflation cost. Using credit, the pair needs to bear the adoption cost ϕ.

In the CM prior to the opening of the DM, sellers simultaneously announce prices and payment methods. Observing the prices and the types of sellers (payment methods and ξ), buyers simultaneously decide which seller to visit. We assume there are free entries of buyers, and the entry cost is denoted by $k \in (0, u-c)$.

2.2 Using Credit or Money

Use Credit Consider a seller with matching parameter ξ. If he chooses to use credit, he solves the problem of

$$\max_{x,p} \ \xi\alpha(x)(p-c),$$
$$s.t. \ \frac{\xi\alpha(x)}{x}(u-p) = k.$$

Inserting the constraint into the objective yields

$$\xi\alpha(x)(u-c) - xk.$$

The first order condition is $\xi\alpha'(x_c)(u-c) = k$. And the second order condition is satisfied. The maximized profit is denoted by

$$\pi_c(\xi) = \xi\alpha(x_c)(u-c) - x_c k. \tag{1}$$

Note that the equilibrium queue length $x_c(\xi)$ is increasing in ξ.

Use Money If a seller chooses to use money, he solves the problem of

$$\max_{x,p} \ \xi\alpha(x)(p-c),$$
$$s.t. \ \frac{\xi\alpha(x)}{x}(u-p) - ip = k.$$

The first order condition yields $v(x_m, i) = k$, where $v(\cdot)$ is continuously differentiable and strictly decreasing in i. Note that this is only a necessary condition. We show in the appendix that $x_m(i,k)$

is generically decreasing in i and k. We denote the maximized profit by

$$\pi_m(\xi, i) = \xi\alpha(x_m)\left(\frac{\xi\alpha(x_m)u - x_m k}{\xi\alpha(x_m) + x_m i} - c\right). \tag{2}$$

We rewrite (2) to make it clear that the sellers bear the inflation cost $ix_m p_m$:

$$\pi_m(\xi, i) = \xi\alpha(x_m)(u - c) - x_m k - ix_m p_m. \tag{3}$$

Of course, once we insert that $p_m = \frac{\xi\alpha(x_m)u - x_m k}{\xi\alpha(x_m) + x_m i}$, (2) and (3) are the same.

The marginal inflation cost for sellers is measured by profit loss as i increases:

$$-\frac{d\pi_m(\xi, i)}{di} = x_m p_m + ix_m \frac{\partial p_m}{\partial i} = \frac{\xi\alpha(x_m)}{\xi\alpha(x_m) + x_m i} x_m p_m > 0.$$

At $i = 0$, the marginal inflation cost reduces to

$$-\frac{\partial \pi_m(\xi, i)}{\partial i}|_{i=0} = x_c p_c,$$

where $x_c p_c$ is the expected liquidity an ξ-seller attracts when $i \to 0$. In equilibrium, a higher ξ-seller is able to attract more buyers and charge higher prices, namely, x_c and p_c both increase in ξ. Thus the marginal inflation cost (at $i = 0$) increases in ξ.

Credit or Money To use credit or not, sellers compare the cost of adopting credit, ϕ, and the benefit

$$\Delta\pi(\xi, i) = \pi_c(\xi) - \pi_m(\xi, i), \tag{4}$$

which is the profit increase (net of the cost ϕ) when using credit. $\Delta\pi(\xi, i)$ has the following properties. First, there is no gain of using credit when $i = 0$: $\Delta\pi(\xi, 0) = 0$; and the gain increases as i increases: $\frac{\partial \Delta\pi(\xi,i)}{\partial i} = -\frac{\partial \pi_m(\xi,i)}{\partial i} > 0$. Second, as stated in the following lemma, sellers of higher ξ gain more by adopting credit payment.

Lemma 1 *$\Delta\pi(\xi, i)$ increase in ξ.*

Proof. Using (1) and (3) gives

$$\Delta\pi(\xi, i) = \left\{[\xi\alpha(x_c) - \xi\alpha(x_m)](u - c) - (x_c - x_m)k\right\} + x_m i p_m.$$

Taking derivative with respect to ξ, and noticing that the effect through x_c and x_m can be ignored by the Envelop Theorem, we have

$$\frac{\partial \Delta\pi(\xi,i)}{\partial \xi} = \underbrace{(\alpha(x_c)-\alpha(x_m))\,(u-c)}_{\text{volume effect}} + \underbrace{x_m i[\partial p_m/\partial \xi]}_{\text{price effect}},$$

where

$$\frac{\partial p_m}{\partial \xi} = \frac{\partial\left[\frac{\xi\alpha(x_m)u - x_m k}{\xi\alpha(x_m)+x_m i}\right]}{\partial \xi} = \frac{\alpha(x_m)x_m(iu+k)}{(\xi\alpha(x_m)+x_m i)^2} > 0.$$

■

We have broken down the impact of ξ on $\Delta\pi(\xi,i)$ into two effects. The first is a *volume effect*. Using credit, a seller can attract a longer queue, $x_c > x_m$ and obtain a higher trade volume (probability): $\xi(\alpha(x_c)-\alpha(x_m))$. A higher ξ amplifies the volume increase. The second effect is due to a seller with a higher ξ being able to charge a higher price p_m, thus saves on the inflation cost.

For a given set of parameters, there exists a monetary equilibrium where all sellers are active if $i < \bar{i} \equiv (\underline{\xi}(u-c)-k)/c$. Then $\Delta\pi(\xi,i)$ is well defined, and has a range between $\Delta\pi(\underline{\xi},i)$ and $\Delta\pi(\bar{\xi},i)$. The choice of payment methods is characterized by a threshold denote by $\hat{\xi}$.

Proposition 1 *Suppose that $\Delta\pi(\xi,i)$ is well defined. There exists a unique $\hat{\xi} \in [\underline{\xi},\bar{\xi}]$ such that sellers with $\xi \geq \hat{\xi}$ adopt credit, and those with $\xi < \hat{\xi}$ only accept money payments.*

Next, we use this result to characterize the platform economy where ϕ is the choice variable of the platform.

3 The platform economy

Suppose that the D market is operated by a platform. The platform can charge an ad valorem fee $t \in [0,1]$ to each of the participating sellers and offers them the credit payment technologies at a fixed fee $\phi \in [0,\bar{\phi}]$ where $\bar{\phi}$ is a finite positive number. The strategy space of the platform is denoted by $\mathbb{T} \equiv [0,1]\times[0,\bar{\phi}]$. Sellers who trade on the platform can either accept money from buyers at no cost or accept credit payment by paying ϕ to the platform. If a seller opts for the platform-provided credit, a buyer who purchases from the seller will pay in the next CM, which is monitored and enforced by the platform at a cost $\phi_0 > 0$.

Sellers are ex-ante the same. Each of them draws a matching efficiency parameter, denoted as $\xi \in [\underline{\xi},\bar{\xi}]$ by the end of the CM. We assume ξ follows a continuous distribution with a cumulative distribution function (CDF) of $G(\xi)$ and a probability density function (PDF) of $g(\xi)$. The distribution is common knowledge.

There is a free entry of buyers, and to join the platform, buyers incur a utility cost of $k \in (0, u)$. On the other hand, sellers need to produce one unit of the DM goods in advance at cost π_0. π_0 can be regarded as the common outside option value of sellers.[3]

The timing is as follows. At the end of the CM, the platform announces a pair (t, ϕ) for the coming DM. Each seller draws a matching efficiency parameter ξ from $G(\cdot)$ and decides whether to join the DM or not. Those who join the DM announce whether or not to accept credit payments offered by the platform, and the price they will commit to on the platform. Observing the posted price, matching efficiency parameter, and whether to accept credit or not from all sellers, buyers simultaneously decide which sellers they want to visit in the coming DM. In particular, buyers who plan to visit sellers that only accept money also decide the amount of money to hold.

The solution concept is subgame perfection. An ξ-seller joins the platform if

$$\min\{(1-t)\pi_m(\xi, i), (1-t)\pi_c(\xi) - \phi\} \geq \pi_0. \tag{5}$$

Provided a seller has participated in the platform, he adopts platform-provided credit if

$$(1-t)\Delta\pi(\xi) \geq \phi. \tag{6}$$

Based on sellers' best responses, the platform chooses a (t, ϕ) to maximize its profits. To make the analysis relevant, we impose that the highest matching efficiency seller is willing to trade using credit payment: $\pi_c(\bar{\xi}) - \phi_0 > \pi_0$ since otherwise, the analysis is trivial with credit payment not used in equilibrium. Before addressing the platform's profit-maximization problem, we first examine the planner's solution.

3.1 Social optimum

We refer to the sellers that join the platform with the lowest matching efficiency as the *marginal entrants* and let their matching efficiency be ξ_l. Denote the threshold of matching efficiency that adopts platform credit by $\hat{\xi}$. Suppose the social planner can use lump-sum transfers. Then, the planner can mandate ξ_l and $\hat{\xi}$ directly. We denote the planner's solution by a superscript FB.

SUPPOSE SELLERS' OUTSIDE OPTION VALUE π_0 IS LOW: $\pi_0 \leq \pi_c(\underline{\xi}) - \phi_0$, then social optimum

[3]From now on, we impose the "cost" in the previous section $c = 0$ since goods need to be produced in advance rather than on the spot.

requires all sellers join the platform. We define two nominal interest rates, i_1 and i_2, as follows:

$$\pi_m(\bar{\xi}, i_1) = \pi_c(\bar{\xi}) - \phi_0,$$
$$\pi_m(\underline{\xi}, i_2) = \pi_c(\underline{\xi}) - \phi_0.$$

The three profit functions $\pi_m(\bar{\xi}, i_1), \pi_m(\bar{\xi}, i_2)$ and $\pi_c(\xi)$ are shown in Figure 1 and satisfy $0 < i_1 < i_2 < \bar{i}$. Monetary payment dominates credit payment for $i < i_1 : \pi_m(\xi, i) > \pi_c(\xi) - \phi_0$ for all ξ. Credit payment dominates for $i > i_2 : \pi_c(\xi) - \phi_0 > \pi_m(\xi, i)$.

Proposition 2 (Optimal Allocation - Low π_0) *Suppose $\pi_0 \leq \pi_c(\underline{\xi}) - \phi_0$, the social optimal allocation requires all sellers to join the platform ($\xi_l^{FB} = \underline{\xi}$), and for payment methods, we have*

- *all sellers use money if $i \leq i_1$, i.e., $\hat{\xi}^{FB} = \bar{\xi}$;*
- *all sellers use platform-provided credit if $i \geq i_2$, i.e., $\hat{\xi}^{FB} = \underline{\xi}$;*
- *hybrid payment if $i \in (i_1, i_2)$, where $\hat{\xi}^{FB}$ is determined by*

$$\pi_m(\hat{\xi}^{FB}, i) = \pi_c(\hat{\xi}^{FB}) - \phi_0. \tag{7}$$

Sellers with $\xi > \hat{\xi}^{FB}$ opt for platform credit, while those below opt for monetary payment.

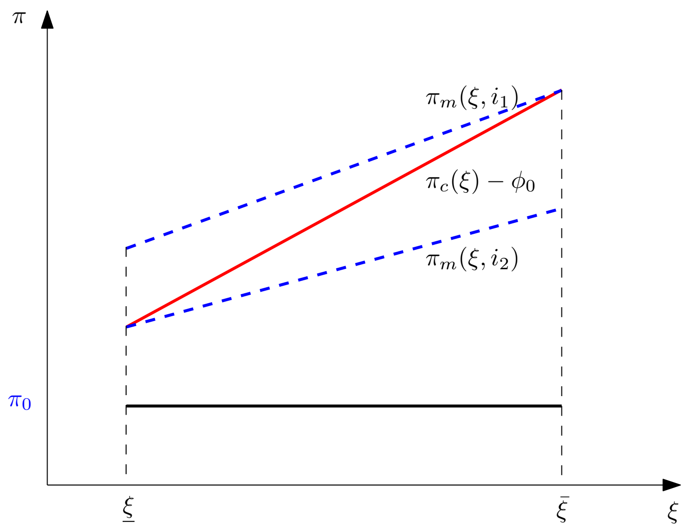

Figure 1: Social Optimal Allocation when $\pi_0 < \pi_c(\underline{\xi}) - \phi_0$.

SUPPOSE SELLERS' OUTSIDE VALUE IS HIGH: $\pi_c(\underline{\xi}) - \phi_0 < \pi_0$, as shown in Figure 2, then optimal allocation does not necessarily require all sellers to participate. Define two nominal interest rates i_{11} and i_{22} as follows:

$$\pi_m(\underline{\xi}, i_{11}) = \pi_0, \tag{8}$$
$$\pi_m(\xi_1, i_{22}) = \pi_0.$$

i_{11} is the maximum interest rate at which all sellers are obliged to join the platform in the first-best. i_{22} is the minimum interest rate at which credit payment prevails. Relevant profit functions are also shown in Figure 2 and it should be clear that $i_1 < i_{22} < i_2$. Moreover, i_{11} is lower than i_{22}, but it can be higher or lower than i_1.

Proposition 3 (Optimal Allocation - High π_0) *Suppose π_0 intersects $\pi_c(\xi) - \phi_0$ at some ξ_1 between $\underline{\xi}$ and $\bar{\xi}$. Then, in terms of participation, social optimum requires all sellers join the platform ($\xi_l^{FB} = \underline{\xi}$) if $i \leq i_{11}$; Otherwise, only sellers with $\max\{\pi_c(\xi) - \phi_0, \pi_m(\xi, i)\} \geq \pi_0$ participate. In terms of payment methods, we have*

- *pure monetary payment ($\hat{\xi}^{FB} = \bar{\xi}$) if $i \leq i_1$;*
- *pure credit payment ($\hat{\xi}^{FB} = \xi_l^{FB}$) if $i \geq i_{22}$;*
- *hybrid payment with threshold $\hat{\xi}^{FB}$ satisfying (7) if $i \in (i_1, i_{22})$. Namely, sellers that are above $\hat{\xi}^{FB}$ opt for platform credit while those below $\hat{\xi}^{FB}$ opt for monetary payment.*

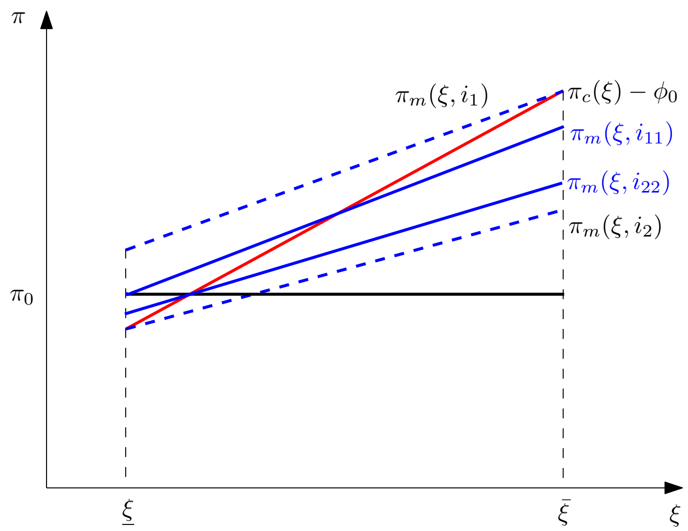

Figure 2: Social Optimal Allocation when $\pi_0 > \pi_c(\underline{\xi}) - \phi_0$.

It is worth mentioning that the socially optimal allocation described above can be implemented by a social planner who is restricted to choosing an ad valorem fee $t \in [0, 1]$ and a fixed credit usage fee $\phi \geq 0$. The social planner can simply set $t = 0$ and $\phi = \phi_0$, which would result in the optimal allocation and a zero profit to the platform, making this plan a feasible one. Of course, there is a set of feasible $(t, \phi) \in \mathbb{T}$ that implement the socially optimal allocation while generate a non-negative profit for the platform. We delegate a detailed analysis to the appendix.

In the following, we shall take the former case, referred to as LOW π_0 as the benchmark and then demonstrate how the analysis and conclusions are modified for high π_0.

4 Platform Profit Maximization

The strategy space of the platform, $\mathbb{T}$, can be separated into two sets. A pair (t, ϕ) either lets the marginal entrant sellers, i.e. with matching efficiency ξ_l, opt for credit payment or lets them accept monetary payment only. We shall refer to these two cases by MONEY ENTRY and CREDIT ENTRY, solve profit-maximizing solutions for two cases separately. We denote the solutions in two cases by superscripts m and c, respectively. Additionally, we assume sellers choose monetary payment when indifferent between credit and cash.

4.1 Credit Entry

To begin with, first consider the scenario with $\pi_c(\underline{\xi}) - \phi_0 \geq \pi_0$. This condition implies $\pi_c(\underline{\xi}) > \pi_0$. Under credit entry, $\xi_l = \hat{\xi}$. The profit-maximizing problem of the platform can be written as

$$\Pi_c = \max_{(t,\phi)\in\mathbb{T}} \int_{\xi_l}^{\bar{\xi}} \left(t\pi_c(\xi) + \phi - \phi_0\right) dG(\xi), \tag{9}$$

$$s.t.\ \ (1-t)\pi_c(\xi_l) - \phi = \pi_0, \tag{10}$$

$$(1-t)\pi_m(\xi_l, i) < \pi_0. \tag{11}$$

(10) is the participation constraint for sellers with $\xi > \xi_l$. Note that restricting the ξ_l-seller to obtain π_0 carries no loss because if $(1-t)\pi_c(\xi_l) - \phi > \pi_0$, the platform can increase t to gain higher profits. (11) indicates that sellers with $\xi \leq \xi_l$ are unwilling to join the platform by using monetary payment.

The following lemma states that profit maximization features that the platform offers credit payment service for free.

Lemma 2 *Suppose marginal entrant sellers opt for credit payment, then profit-maximization entails* $\phi = 0$ *and* $t = 1 - \pi_0/\pi_c(\xi_l)$.

Proof. Fix an ξ_l, as indicated by (10) there is a trade-off between increasing t or increasing ϕ:

$\phi + t\pi_c(\xi_l) = \pi_c(\xi_l) - \pi_0$. Inserting ϕ from (10) into (9) gives $\max_t \int_{\xi_l}^{\bar{\xi}} \left(t\left(\pi_c(\xi) - \pi_c(\xi_l)\right) - \pi_0 - \phi_0\right)$. The objective is monotonically increase in t, thus, optimization gives $\phi = 0$ and $t = 1 - \pi_0/\pi_c(\xi_l)$. Since $\pi_c(\xi_l) > \pi_c(\underline{\xi} > \pi_0$, such t is smaller than 1. ■

The intuition is as follows: for a given ξ_l, the platform has two options to get profits - it can either charge a lump-sum credit usage fee or an ad valorem fee t. Since t is proportional to the trade revenue of sellers with different levels of ξ, it is more effective in extracting surplus than a fixed amount ϕ.

Lemma 2 provides an inspiring insight as many platforms offer multiple services, just like in our model, where the platform provides both a trade avenue and a credit service. When assessing anti-trust concerns, it's crucial to consider not only the direct fees, such as the usage fee for the credit payment service, but also indirect fees, like the ad valorem fee, on trading revenue.

Using Lemma 2, we see that constraint (11) must be satisfied since $\pi_0 = (1-t)\pi_c(\xi_l) > (1-t)\pi_m(\xi_l)$ holds for any ξ_l. Then use (10), there is a one-to-one relationship between ξ_l and t for $t \in [1 - \frac{\pi_0}{\pi_c(\underline{\xi})}, 1 - \frac{\pi_0}{\pi_c(\bar{\xi})}]$. Also, note that any t outside this range can not be a solution. The platform's problem can be reformulated as one choosing ξ_l :

$$\Pi_c = \max_{\xi_l \in [\underline{\xi}, \bar{\xi}]} \Pi_c(\xi_l), \tag{12}$$

where

$$\Pi_c(\xi_l) \equiv \int_{\xi_l}^{\bar{\xi}} \left(\left(1 - \frac{\pi_0}{\pi_c(\xi_l)}\right) \pi_c(\xi) - \phi_0 \right) dG(\xi).$$

The analysis also applies to the other scenario of high π_0, i.e., $\pi_c(\underline{\xi}) - \phi_0 < \pi_0$, with a minor modification. Under credit entry, a platform will not choose $\xi_l < \xi_1$. This can be shown by a way of contradiction. Suppose such an ξ_l is chosen by the platform, then

$$\pi_c(\xi_l) - \phi_0 < \pi_0 = (1-t)\pi_c(\xi_l) - \phi,$$

In fact, for all $\xi \in (\xi_l, \xi_1)$, we have

$$\pi_c(\xi) - \phi_0 < \pi_0 < (1-t)\pi_c(\xi) - \phi,$$

which yields $t\pi_c(\xi) + \phi - \phi_0 < 0$, i.e., the platform obtains a negative profit from these sellers. A profitable deviation is to increase t so that the entrant sellers have matching efficiency ξ_1. Recall that ξ_1 is defined by $\pi_c(\xi_1) - \phi_0 = \pi_0$. This way, sellers that give the platform negative profits are driven out, and the platform extracts a higher proportion from participating sellers.[4]

[4]Note that $\Pi_c > 0$ provided $\pi_c(\bar{\xi}) - \phi_0 > \pi_0$. For example, the platform can set $\phi = 0$ and t to satisfy $(1-t)\pi_c(\bar{\xi}_1) =$

With these arguments, problem (12) can be revised as follows. Define $\underline{\xi}_c = \xi_1$ if $\pi_c(\underline{\xi}) - \phi_0 < \pi_0$; and $\underline{\xi}_c = \underline{\xi}$ otherwise. Then let the feasible set of ξ_l be $[\underline{\xi}_c, \bar{\xi}]$.

4.2 Money Entry

Define $\bar{i}$ by $\pi_m(\bar{\xi}, \bar{i}) = \pi_0$. If $i \geq \bar{i}$, $\pi_m(\xi, i) \leq \pi_0$ for all ξ, hence $\Pi_m(i) = 0$. Now we suppose $i \leq \bar{i}$, then the platform's profit-maximization problem is:

$$\Pi_m(i) \equiv \max_{(t,\phi)\in\mathbb{T}} \int_{\xi_l}^{\hat{\xi}} t\pi_m(\xi, i) dG(\xi) + \int_{\hat{\xi}}^{\bar{\xi}} \left(t\pi_c(\xi) + \phi - \phi_0\right) dG(\xi) \tag{13}$$

$$s.t.\ \ (1-t)\pi_m(\xi_l, i) = \pi_0, \tag{14}$$

$$(1-t)\pi_c(\hat{\xi}) - \phi = (1-t)\pi_m(\hat{\xi}, i). \tag{15}$$

(14) is the participation constraint of the marginal entrants. (15) defines a threshold that sellers with $\xi > \hat{\xi}$ choose credit payment, and those with $\xi \leq \hat{\xi}$ only take monetary payment. It is possible that all participating sellers use monetary payment if $\hat{\xi} = \bar{\xi}$.

There are three observations with regard to this problem. First, there is no loss by restricting (t, ϕ) such that (14) and (15) hold with equality. For any given ξ_l, if $(1-t)\pi_m(\xi_l, i) > \pi_0$, the platform can increase t to obtain higher profits. With regard to (15), on the one hand, if ϕ is high that $(1-t)\pi_c(\bar{\xi}) - \phi < (1-t)\pi_m(\bar{\xi}, i)$, then lower ϕ to restore the equality does not influence the platform profits. On the other hand, if ϕ is low that $(1-t)\pi_c(\xi_l) - \phi > (1-t)\pi_m(\xi_l, i) = \pi_0$, then all participating sellers (including the ξ_l sellers) use credit payment. However the platform can marginally increase ϕ, and all sellers with $\xi > \xi_l$ still participate and choose credit payment, but at a higher fee that generates more profit for the platform.

Second, a special case is $(1-t)\pi_m(\xi_l) = (1-t)\pi_c(\xi_l) - \phi = \pi_0$. Given our tie-breaking assumption, the ξ_l-sellers use monetary payment while the rest of the participating sellers use credit payment. While this can be profit-maximizing in the set of money-entry strategies, it is strictly dominated by Π_c because the platform can deviate to credit entry by decreasing ϕ to zero while increasing t to $1 - \pi_0/\pi_c(\xi_l)$.

Third, (14) implies that sellers with $\pi_m(\xi, i) < \pi_0$ can not be active on the platform. Following a similar argument as in the previous section, in equilibrium, sellers with $\xi < \xi_1$ can not be active by using credit payment. In both cases, allowing sellers to participate only implies subsidizing

π_0. The platform thus obtains positive profits from all sellers with $\xi \geq \bar{\xi}_1$:

$$t\pi_c(\xi) - \phi_0 > t\pi_c(\bar{\xi}_1) - \phi_0 = 0.$$

them, as they create a lower trade surplus than π_0.

The binding constraints determine t and ϕ as functions of the two thresholds, ξ_l and $\hat{\xi}$:

$$t = 1 - \pi_0 / \pi_m(\xi_l, i),$$
$$\phi = \Delta\pi(\hat{\xi}, i)/(1-t).$$

Inserting t and ϕ into the objective gives the platform profits as a function of ξ_l and $\hat{\xi}$, we denote it as $\Pi_m(\xi_l, \hat{\xi}, i)$:

$$\begin{aligned}\Pi_m(\xi_l, \hat{\xi}, i) = & \int_{\xi_l}^{\hat{\xi}} \left[1 - \frac{\pi_0}{\pi_m(\xi_l, i)}\right] \pi_m(\xi, i) dG(\xi) \\ & + \int_{\hat{\xi}}^{\bar{\xi}} \left[1 - \frac{\pi_0}{\pi_m(\xi_l, i)}\right] \pi_c(\xi) dG(\xi) \\ & + \left(1 - G(\hat{\xi})\right) \left(\frac{\pi_0}{\pi_m(\xi_l, i)} \Delta\pi(\hat{\xi}, i) - \phi_0\right)\end{aligned}$$

Then problem (13) can be reformulated as choosing

$$\Pi_m(i) = \max_{\xi_l, \hat{\xi} \in \mathbb{R}_+^2} \Pi_m(\xi_l, \hat{\xi}, i), \text{ s.t. } \underline{\xi}_m \leq \xi_l \leq \hat{\xi} \leq \bar{\xi}, \tag{16}$$

where $\underline{\xi}_m$ is defined by $\pi_m(\underline{\xi}_m, i) - \phi_0 = \pi_0$ if $i < i_{11}$, or equivalently, $\pi_m(\underline{\xi}, i) - \phi_0 < \pi_0$; and $\underline{\xi}_m = \underline{\xi}$ otherwise. Recall that i_{11} is defined in (8).

It is possible that even though ξ_l-sellers use monetary payment, in equilibrium, more efficient sellers may opt for credit payment. Hence, a hybrid payment system arises. The following lemma states that a hybrid payment system arises when $\pi_c(\bar{\xi}) - \phi_0 > \pi_m(\bar{\xi}, i)$ (equivalently, $i > i_1$). If this condition is not met, all sellers use monetary payment in equilibrium.

Lemma 3 *Under the strategies of money entry, a hybrid payment with $\hat{\xi}^m < \bar{\xi}$ emerges iff $i > i_1$.*

Proof. First, consider $i > i_1$, or equivalently, $\pi_c(\bar{\xi}) - \phi_0 > \pi_m(\bar{\xi}, i)$. Suppose we have $\hat{\xi}^m = \bar{\xi}$ which implies that $(1-t)\pi_c(\bar{\xi}) - \phi \leq (1-t)\pi_m(\bar{\xi})$. Take difference of the two inequalities, we get $t\pi_c(\bar{\xi}) + \phi - \phi_0 > t\pi_m(\bar{\xi})$. Thus, the platform can make a profitable deviation by lowering ϕ, which will persuade the $\bar{\xi}$-sellers to opt for credit.

Next, consider $i \leq i_1$, or equivalently, $\pi_c(\bar{\xi}) - \phi_0 \leq \pi_m(\bar{\xi}, i)$. Suppose that $\hat{\xi}^m < \bar{\xi}$, which implies that $(1-t)\pi_c(\hat{\xi}^m) - \phi = (1-t)\pi_m(\hat{\xi}^m)$. This together with $\pi_c(\hat{\xi}^m) - \phi_0 < \pi_m(\hat{\xi}^m, i)$ gives $t\pi_c(\hat{\xi}^m) + \phi - \phi_0 < t\pi_m(\hat{\xi}^m, i)$. Namely, the platform can gain a higher profit if it marginally increases ϕ so that the $\hat{\xi}^m$-sellers opt for money. ■

It is intuitive that as i increases, $\pi_m(\xi, i)$ decreases, and $\Pi_m(i)$ can only be lower.

Lemma 4 $\Pi_m(i)$ *is continuous and strictly decreasing in i, satisfying* $\lim_{i\to 0}\Pi_m(i) > \Pi_c$, $\Pi_m(\bar{i}) = 0$, *and* $\Pi_m(i) < \Pi_c$ *if* $i \geq i_2$.

Proof. Problem (13) is well-defined, and by BERGE'S MAXIMUM THEOREM, $\Pi_m(i)$ is continuous.

Next, we show that $\Pi_m(i)$ strictly decreases in i. Suppose the solution gives $\hat{\xi} = \bar{\xi}$, then all participating sellers only take payment by cash and t is determined by $(1-t)\pi_m(\xi_l, i) = \pi_0$. Fix ξ_l, an increase in i leads to a lower t. In addition, $\pi_m(\xi, i)$ decreases in i. Thus, $\int_{\xi_l}^{\bar{\xi}} t\pi_m(\xi, i)dG(\xi)$ decreases in i. Consequently, $\Pi_m(i) = \max_{\xi_l}\int_{\xi_l}^{\bar{\xi}} t\pi_m(\xi, i)dG(\xi)$ strictly decreases in i.

Suppose the solution yields $\hat{\xi} = \xi_l$, then virtually all participating sellers accept credit payment. Since t is determined by $(1-t)\pi_m(\xi_l, i) = \pi_0$. Following the same argument in the previous paragraph, $\Pi_m(i) = \max_{\xi_l}\int_{\xi_l}^{\bar{\xi}}\Big(t\pi_c(\xi) - \phi\Big)dG(\xi)$ strictly decreases in i.

Suppose at the optimality, $\hat{\xi} \in (\xi_l, \bar{\xi})$, then

$$\Pi_m(i) = \int_{\xi_l^m}^{\hat{\xi}^m} t\pi_m(\xi, i)dG(\xi) + \int_{\hat{\xi}^m}^{\bar{\xi}^m} \left(t\pi_c(\xi) + \phi - \phi_0\right)dG(\xi).$$

where $t = 1 - \pi_0/\pi_m(\xi_l^m)$ and $\xi_l^m, \hat{\xi}^m$ denote optimal values and thus they are functions of i. By the Envelop Theorem, we have

$$\begin{aligned}\Pi_m'(i) = &\int_{\xi_l}^{\hat{\xi}} t\frac{\partial\pi_m(\xi, i)}{\partial i}dG(\xi) - t\pi_m(\xi_l^m, i)g(\xi_l^m)\frac{\partial\xi_l^m(i)}{\partial i} \\ &- (\Delta\pi(\hat{\xi}^m, i) - \phi_0)g(\hat{\xi}^m)\frac{\partial\hat{\xi}^m(i)}{\partial i}.\end{aligned}$$

If $\Pi_m(i)$ is not strictly decreasing in i, $\Pi_m'(i) = 0$ holds for at least two nominal interest rates, which is a knife-edge case.

At $i = \bar{i}$, we have $t = 1$, and $\hat{\xi} = \xi_l = \bar{\xi}$. Thus, $\Pi_m(\bar{i}) = 0$.

As $i \to 0$, for any given ξ_l, the optimized profits under money entry, $\Pi_m(\xi_l, i)$ (that is fix ξ_l and maximize the profits by choosing $\hat{\xi}$) satisfies

$$\begin{aligned}\Pi_m(\xi_l, i) &\geq \int_{\xi_l}^{\bar{\xi}} \left(1 - \pi_0/\pi_m(\xi_l, i)\right)\pi_m(\xi, i)dG(\xi) \\ &\approx \int_{\xi_l}^{\bar{\xi}} \left(1 - \pi_0/\pi_c(\xi_l)\right)\pi_c(\xi, i)dG(\xi) \\ &> \int_{\xi_l}^{\bar{\xi}} \Big(\left(1 - \pi_0/\pi_c(\xi_l)\right)\pi_c(\xi, i) - \phi_0\Big)dG(\xi) = \Pi_c(\xi_l).\end{aligned}$$

Since the above inequality holds for all ξ_l, we have $\Pi_m(i) > \Pi_c$.

■

By using Lemma 4, it is straightforward to show there exists an i^* that credit entry is more profitable if $i > i^*$, and money entry is more profitable if $i \leq i^*$.

Proposition 4 $\exists! i^* \in (0, i_2)$ *such that* $\Pi_m(i^*) = \Pi_c$.

To adopt for $\pi_0 > \pi_c(\underline{\xi}) - \phi_0$, one only needs to replace i_2 with i_{22} in Proposition 4.

Finally, combining Lemma 3 and Proposition 4, we immediately have two corollaries.

Corollary 1 *If* $i < \min\{i^*, i_1\}$*, then in equilibrium all participating sellers on the platform accept cash only.*

Corollary 2 *Suppose* $i^* > i_1$*, then for* $i \in (i_1, i^*)$*, there is a hybrid of the two payment methods in equilibrium, namely, sellers with higher* ξ *accept credit while those with lower* ξ *accept cash only.*

5 Efficiency Analysis

The purpose of this section is to compare the optimal entry of sellers and the provision of credit with the equilibrium. The first subsection explains that the entry of sellers can be inefficient due to a standard monopoly distortion. In particular, Proposition 5 shows that if the equilibrium involves credit entry, then the entry of sellers is efficient only when the credit cost ϕ_0 is sufficiently low. The second subsection indicates that the credit provision can be insufficient when money-entry strategies are adopted (see Proposition 6 when the nominal rate is low), and it can be either insufficient or excessive when credit-entry strategies are adopted (see Proposition 7 and 8 when the nominal rate is moderate or high).

5.1 Efficiency of Seller Entry

When π_0 is low, socially optimal entry requires all sellers to join the platform: $\xi_l^{FB} = \underline{\xi}$. Suppose the second order condition holds, then for $i \leq i^*$, the platform employs money-entry, and all sellers participate on the platform iff

$$\partial \Pi_m(\xi_l, \hat{\xi}, i)/\partial \xi_l|_{\xi_l = \underline{\xi}} \leq 0. \tag{17}$$

For $i > i^*$, the platform employs credit-entry in equilibrium, and the entry of sellers is efficient iff

$$d\Pi_c(\xi_l)/d\xi_l|_{\xi_l = \underline{\xi}} \leq 0. \tag{18}$$

When the corner solutions, i.e., $\xi_l = \underline{\xi}$, are not profit-maximizing, the entry of sellers is inefficient. The inefficiency is caused by a standard monopoly quantity distortion, which might lead to the conclusion that the inefficiency can be addressed by standard anti-trust regulations. For example, under the credit-entry strategies, the platform charges a higher fee than the planner solution. Restricting the ad valorem fee can improve efficiency, that is, to lower ξ_l^c.[5]

The next proposition shows that under credit entry, an optimal corner solution condition (18) is satisfied when credit technology is sufficiently cheap.

Proposition 5 *If $i > i^*$, then the entry of sellers is efficient iff*

$$\phi_0 \leq \pi_c(\underline{\xi}) - \pi_0 \left(1 + \frac{\pi_c'(\underline{\xi})}{\pi_c(\underline{\xi})} \int_{\underline{\xi}}^{\bar{\xi}} \frac{\pi_c(\xi)g(\xi)}{\pi_c(\underline{\xi})g(\underline{\xi})} d\xi\right). \tag{19}$$

Proof. In equilibrium, all participating sellers opt for platform credit, by Lemma 2, $\phi = 0$ and $t = 1 - \pi_0/\pi_c(\xi_l)$. Then platform choose an ξ_l to maximize:

$$\int_{\xi_l}^{\bar{\xi}} \left\{ \left(1 - \frac{\pi_0}{\pi_c(\xi_l)}\right) \pi_c(\xi) - \phi_0 \right\} dG(\xi).$$

The first-order condition for corner solution $\xi_l = \underline{\xi}$ gives the condition in the statement. The second-order derivative with respect to ξ_l is

$$\begin{aligned} &\left(\frac{\pi_0 \pi_c''(\xi_l)}{\pi_c(\xi_l)^2} - \frac{\pi_0 \pi_c'(\xi_l)^2}{\pi_c(\xi_l)^3}\right) \int_{\xi_l}^{\bar{\xi}} \pi_c(\xi) dG(\xi) - \frac{\pi_0 \pi_c'(\xi_l)}{\pi_c(\xi_l)} \\ &- \pi_c'(\xi_l) g(\xi_l) - (\pi_c(\xi_l) - \phi_0 - \pi_0) g'(\xi_l). \end{aligned}$$

The optimality of π_c implies that $\pi_c''(\xi) \leq 0$. Thus, the profit function of the platform is concave if $g'(\xi_l)$ is not very negative. ■

The analysis above applies to the case of high π_0 by replacing $\underline{\xi}$ with $\xi_l^{FB} \geq \underline{\xi}$.

5.2 Efficiency of Credit Provision

For $i < \min\{i^*, i_1\}$, a planner opts not to use platform credit, and in equilibrium, the platform also opts not to provide credit. Therefore, there is no issue of credit provision inefficiency. Now, let's focus on $i > \min\{i^*, i_1\}$. Then in equilibrium, a positive measure of sellers use platform-provided credit.

THE CASE OF $i^* > i_1$.

[5] We show in section 6 that restricting the ad valorem fee not necessarily lower ξ_l. The reason is that when t is restricted, the platform resorts to increasing the credit usage fee by raising ξ_l.

Figure 3 compares the payment modes of the planner's solution and the platform's solution when $i^* > i_1$. If $i \in (i_1, i^*)$, the equilibrium features a mixture of credit payment and monetary payment, which is consistent with the planner's solution. However, the level of platform-provided credit can be inefficient. If $i > i^*$, there is a clear inconsistency between equilibrium and the planner's solution. The equilibrium features that all participating sellers on the platform opt for credit payment; the planner's solution indicates hybrid payment for $i < i_2$ and pure credit otherwise.

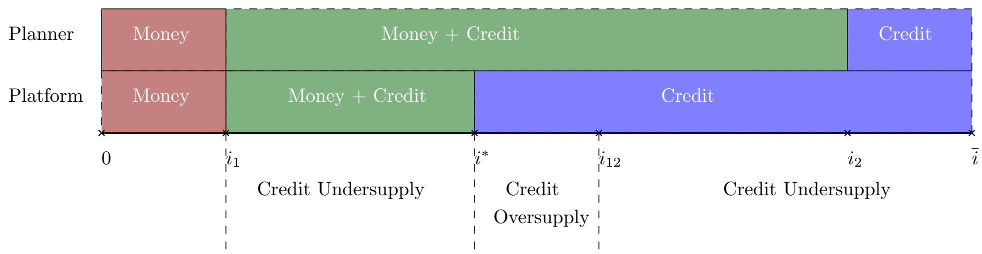

Figure 3: Compare Planner Solution and Equilibrium when $i_1 < i^*$.

Now, we examine whether credit provision is efficient or not. The next proposition states that the equilibrium credit supply is too low when inflation is low, $i < i^*$.

Proposition 6 *Suppose $i^* > i_1$. For $i \in (i_1, i^*)$, the credit supply is too low compared to the planner solution.*

Proof. Fix ξ_l, (and thus t is fixed) the platform's profits are

$$\int_{\xi_l}^{\hat{\xi}} t\pi_m(\xi, i)dG(\xi) + \int_{\hat{\xi}}^{\bar{\xi}} \Big(t\Delta\pi(\xi, i) + (1-t)\Delta\pi(\hat{\xi}, i) - \phi_0\Big)dG(\xi).$$

The first-order condition with respect to $\hat{\xi}$ yields

$$\Delta\pi(\hat{\xi}^c, i) - \phi_0 = (1-t)\frac{1-G(\hat{\xi}^c)}{g(\hat{\xi}^c)}\frac{\partial\Delta\pi(\hat{\xi}^c, i)}{\partial\hat{\xi}} > 0. \tag{20}$$

This implies that $\hat{\xi}^c > \hat{\xi}^{FB}$. ∎

Intuitively, when $t < 1$, the platform does not obtain the full surplus of sellers switching from monetary to credit payment; thus, the credit supply is necessarily too low. However, this explanation is not complete since in addition to the ad valorem fee, the platform also charges a fixed credit usage fee $\phi = (1-t)\Delta\pi(\hat{\xi}, i)$. When combined with the ad valorem fee, the platform obtains the full surplus of the marginal $\hat{\xi}$-seller switching from monetary payment to credit payment: $t\Delta\pi(\hat{\xi}, i) + \phi = \Delta\pi(\hat{\xi}, i)$. However, since ϕ is fixed for all sellers above $\hat{\xi}$, the platform has an incentive to increase ϕ further (equivalently, increasing $\hat{\xi}$) to extract more rents from those sellers. This explains why $\hat{\xi}^c > \hat{\xi}^{FB}$. In short, platform-provided credit is always too low whenever monetary payment is active.

The upper panel of Figure 4 plots $\Pi_m(i)$ and Π_c. Note that Π_c is independent of i. The lower panel plots the planner solution $\hat{\xi}^{FB}$, and the platform solutions $\hat{\xi}^m$ and $\hat{\xi}^c$, as a function of i. Note that $\hat{\xi}^c$ is independent of i. We can see that under money-entry, the credit provision is consistently lower than the first-best level, $\hat{\xi}^m > \hat{\xi}^{FB}$for all i.

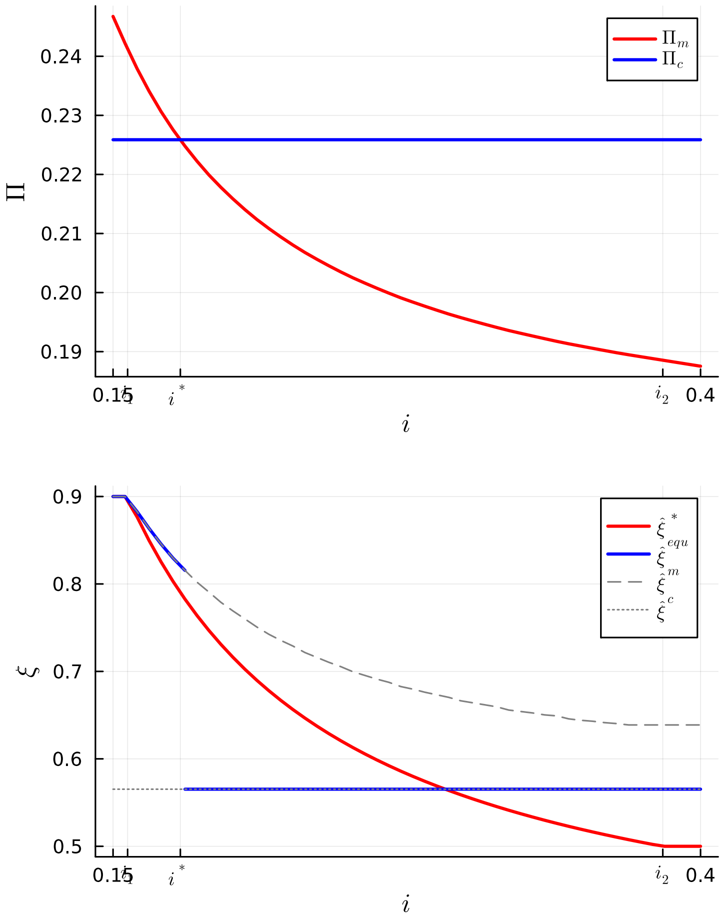

Figure 4: Compare Planner Solution and Equilibrium when $i_1 < i^*$.

Proposition 7 states that there is an oversupply of platform credit for intermediate levels of inflation, as well as an undersupply for high levels of inflation.

Proposition 7 *Suppose $i^* > i_1$. For $i \in (i^*, \bar{i})$, the platform uses credit-entry strategies in equilibrium. Let ξ_l^c be the entrant matching efficient chosen by the platform.*

- *If* $\xi_l^c = \underline{\xi}$ *(which indicates efficient entry of sellers), then credit provision is efficient for* $i \geq i_2$*, but too much for* $i \in (i^*, i_2)$.

- *If* $\xi_l^c \in (\underline{\xi}, \hat{\xi}^{FB}(i^*))$ *(which indicates inefficient entry), then* $\exists! i_{12} \in (i^*, i_2)$*. There is an oversupply of platform credit for for* $i \in (i^*, i_{12})$ *and an undersupply for* $i > i_{12}$.

- *If* $\xi_l^c > \hat{\xi}^{FB}(i^*))$*, then credit provision is too low for* $i > i^*$.

Under the credit-entry strategies, the threshold for adopting credit $\hat{\xi}^c$ (which is also the threshold of sellers' entry) is independent of i; however, the first best $\hat{\xi}^{FB}$ is monotonically decreasing in i (see Figure 4). For this reason, there exists a range of nominal interest rates where oversupplies happen, and another range of nominal interest rates where undersupplies of credit happen.

THE CASE OF $i^* < i_1$.

Figure 5 compares the payment modes in planner's solution and in equilibrium in the case of $i^* < i_1$. What differs this scenario from the case of $i^* > i_1$ is that in the range of $i \in (i^*, i_1)$, despite that monetary payment results in a higher trading surplus for all sellers, the platform chooses to use credit-entry by setting the credit usage fee to zero (induce them to use credit), and then extract surplus by increasing the ad valorem fee. In summary, the platform's market power results in an excess supply of credit, even when credit payments yield a lower trade surplus for all sellers.

The efficiency evaluation of this scenario is summarized in the following proposition and is illustrated in Figure 5. The key takeaway is that the oversupply of platform credit always exists for some range of interest rates, and if entry of sellers is inefficient $\xi_l^c > \underline{\xi}$, there also exists under supply of credit.

Proposition 8 *Suppose* $i^* < i_1$*. If* $\xi_l^c = \underline{\xi}$ *(efficient entry), then credit provision is efficient for* $i \geq i_2$*, and too much for* $i \in (i^*, i_2)$*. Otherwise, there exists* $\exists! i_{12} \in (i^*, i_2)$*. There is an oversupply of platform credit for* $i \in (i^*, i_{12})$ *and an undersupply for* $i > i_{12}$.

The above discussion on credit provision applies to the case when $\pi_0 > \pi_c(\underline{\xi}) - \phi_0$ by replacing i_2 with i_{22}.

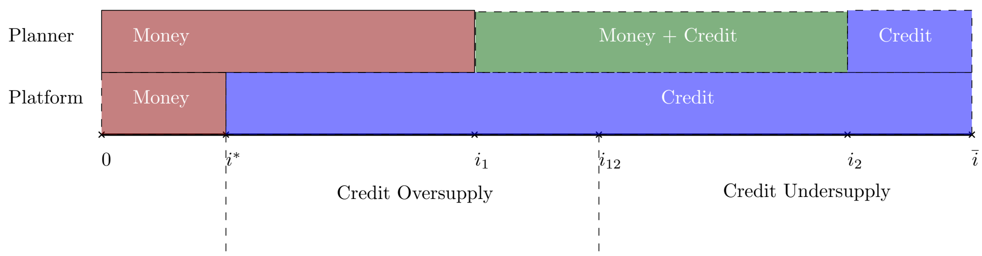

Figure 5: Compare Planner Solution and Equilibrium when $i_1 > i^*$.

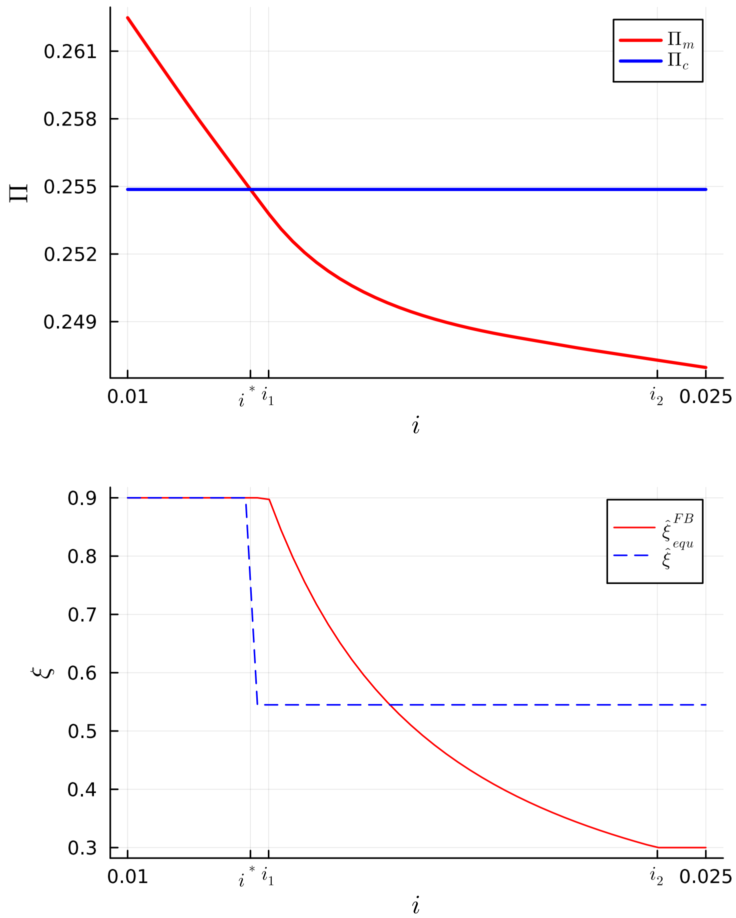

Figure 6: Compare Planner Solution and Equilibrium when $i_1 > i^*$.

6 Discussion on Policies

In this section, we discuss the challenges regulators face when attempting to address inefficiencies in seller entry and platform credit provision by limiting platform fees, as viewed through the model.

It is important to note that regulating the credit usage fee ϕ directly, which also includes, for instance, introducing financial intermediaries to compete with the platform in the credit market, cannot solve the inefficiency in credit provision. This is because, in equilibrium, the platform tends to charge a lower credit usage fee rather than a higher one. In fact, based on the model, we can see that the platform subsidizes sellers by charging $\phi < \phi_0$, and when $i > i^*$, the optimal usage fee for maximizing profits is $\phi = 0$. In the following, we analyze the effect of regulating the ad valorem fee.

6.1 Regulating the ad valorem fee t

Money-entry. Consider a regulation that imposes an upper bound t:

$$t \leq \bar{t}.$$

The impact on money-entry strategies is straightforward. Suppose the platform chooses $\xi_l^m > \underline{\xi}$ when the ad valorem fee is not restricted. The participation constraint must be binding:

$$(1 - t^m)\pi_m(\xi_l^m, i) = \pi_0,$$

where t^m is the platform's optimal choice. Imposing some $\bar{t} < t^m$ must make more sellers to enter: $\xi_l^{m\prime} < \xi_l^m$ where $\xi_l^{m\prime}$ satisfies

$$(1 - \bar{t})\pi_m(\xi_l^{m\prime}, i) = \pi_0.$$

In regard to the credit provision, suppose $\hat{\xi}^m$ takes an interior solution, then as is shown in (20), with a lower t, credit provision is even further away from the planner's solution since the platform obtains even lower incentives to provide credit.

Credit-entry. We turn to the platform's credit-entry problem under a restricted t. We focus on low π_0 (i.e., $\pi_c(\underline{\xi}) - \phi_0 > \pi_0$) so that the platform can choose ξ_l as low as $\underline{\xi}$. Our insights, however, do not depend on this assumption. Suppose the platform adopts the credit entry strategy, and given a $\bar{t} \in (0,1)$, it solves the following problem

$$\max_{t \in [0,\bar{t}], \phi \geq 0} \int_{\xi_l}^{\bar{\xi}} \Big(t\pi^c(\xi) + \phi - \phi_0 \Big) dG(\xi),$$

$$\text{s.t. } (1-t)\pi^c(\xi_l) - \phi \geq \pi_0, \tag{21}$$

$$(1-t)\pi^c(\xi_l) - \phi \geq (1-t)\pi^m(\xi_l, i). \tag{22}$$

(21) is the participation constraint, and (22) is the incentive constraint that ensures all sellers opt for credit payment. Let t^c be the platform's choice when t is not restricted. Impose $\bar{t} < t^c$. Clearly, $t \leq \bar{t}$ must be binding.

Unlike the problem with an unrestricted t, here, the participation constraint may be loose. To analyze when and which constraint would be binding, we rewrite the two constraints as

$$\phi \leq \phi_1(\xi) \equiv (1-\bar{t})\pi^c(\xi_l) - \pi_0, \tag{23}$$

$$\phi \leq \phi_2(\xi) \equiv (1-\bar{t})\pi^c(\xi_l) - (1-t)\pi^m(\xi_l, i). \tag{24}$$

One shall compare $\phi_1(\xi)$ and $\phi_2(\xi)$. There are two cases. If $\bar{t} \leq 1 - \frac{\pi_0}{\pi_m(\underline{\xi}, i)}$, then $\phi_1(\xi) \geq \phi_2(\xi)$ for all $\xi \in [\underline{\xi}, \bar{\xi}]$. In this case, (24) is binding while (23) is loose. Hence, under credit-entry strategies, $\xi_l = \underline{\xi}$. The profit-maximizing credit-entry strategy is to choose

$$\phi = \phi_2(\underline{\xi}) = (1-\bar{t})(\pi_c(\underline{\xi}) - \pi_m(\underline{\xi}, i).$$

If $\bar{t} > 1 - \frac{\pi_0}{\pi_m(\underline{\xi}, i)}$, then $\phi_1(\xi)$ intersects $\phi_2(\xi)$ at ξ_l^{ub}, which is defined by $(1-\bar{t})\pi_m(\xi_l^{ub}, i) = \pi_0$. The platform can choose a ϕ no more than $\bar{\phi} = (1-\bar{t})(\pi_c(\xi_l^{ub}) - \pi_m(\xi_l^{ub}, i))$ to implement credit-entry. That is, if the platform chooses $\phi > \bar{\phi}$, then the marginal entrant seller will not accept credit. The platform's problem (credit-entry) is to choose $\phi \in [0, \bar{\phi}]$ to maximize its profits. Equivalently, the problem can be reformulated as choosing an $\xi_l \in [\underline{\xi}, \xi_l^{ub}]$:

$$\max_{\xi_l \in [\underline{\xi}, \xi_l^{ub}]} \int_{\xi_l}^{\bar{\xi}} \left[\bar{t}\pi_c(\xi) + (1-\bar{t})\pi_c(\xi_l) - \pi_0 - \phi_0 \right]. \tag{25}$$

Let ξ_l^c and ξ_l^{cr} be the platform's optimal solution of entrant efficiency without and with $t \leq \bar{t}$, respectively.

Proposition 9 states that under credit-entry strategies, imposing $\bar{t}$ can increase credit provision when $\bar{t}$ is relatively high while it can decrease credit provision when $\bar{t}$ is low.

Proposition 9 *Consider some $i > i^*$ and $\bar{t} > 1 - \frac{\pi_0}{\pi_m(\underline{\xi}, i^*)}$. Suppose that under $t \leq \bar{t} < t^c$ credit-entry strategies maximize the platform's profits, and impose $\xi_l^{ub}(i^*) > \xi_l^c$. Let $\bar{t}_1 \equiv 1 - \frac{(\pi_c(\xi_l^c) - \pi_0 - \phi_0)g(\xi_l^c)}{(1-G(\xi_l^c))\pi_c'(\xi_l^c)}$. If*

$\bar{t} > \bar{t}_1$, $\xi_l^{cr} < \xi_l^c$; *if* $\bar{t} < \bar{t}_1$, $\xi_l^{cr} > \xi_l^c$.

Proof. First, the unrestricted ξ_l^c is solved by the first order condition of (12):

$$\int_{\xi_l^c}^{\bar{\xi}} \frac{\pi_0}{\pi_c(\xi_l^c)^2} \pi_c'(\xi_l^c)\pi_c(\xi)dG(\xi) \leq (\pi_c(\xi_l^c) - \pi_0 - \phi_0)g(\xi_l^c),$$

and $<$ holds only if $\xi_l^c = \underline{\xi}$. Second, note that $\bar{t} > 1 - \frac{\pi_0}{\pi_m(\underline{\xi},i)}$ for all $i \geq i^*$. The restricted ξ_l^{cr} is solved by the first order condition of (25):

$$\int_{\xi_l^{cr}}^{\bar{\xi}} (1-\bar{t})\pi_c'(\xi_l^{cr})dG(\xi) \leq (\pi_c(\xi_l^{cr}) - \pi_0 - \phi_0)g(\xi_l^{cr}).$$

and $<$ holds only if $\xi_l^{cr} = \underline{\xi}$. Therefore, $\xi_l^{cr} > \xi_l^c$ if

$$\int_{\xi_l^c}^{\bar{\xi}} (1-\bar{t})\pi_c'(\xi_l^c)dG(\xi) > (\pi_c(\xi_l^c) - \pi_0 - \phi_0)g(\xi_l^c).$$

This gives $\bar{t} < \bar{t}_1$. ■

It is a well-known economic principle that when prices are regulated, monopolists tend to produce more goods. In our model, this holds true as long as the regulated price (t) is not set too low, meaning that $\bar{t}$ must be greater than $\bar{t}_1$. However, it may come as a surprise that if the regulated price ($\bar{t}$) is set even lower, the platform will offer less credit. This happens because when t is restricted, the platform turns to increase ϕ. In the objective function (25), ϕ is represented by the term $(1-\bar{t})\pi_c(\xi_l)$. The platform has an incentive to increase ξ_l in order to extract surplus through ϕ.

We then present a numerical exercise in Figure 7 where we impose two upper bounds t: $\bar{t}_1 = 0.78$ and $\bar{t}_2 = 0.65$. They are higher than $1 - \frac{\pi_0}{\pi_m(\underline{\xi},i)} \approx 0.59$ for $i > 0.15$ and higher than the profit-maximizing $t^m(i)$ under monetary entry strategies. Therefore, both upper bounds only restricted ad valorem fees under credit entry.

We have several observations. First, imposing an upper bound for t apparently lowers Π_c. As a result, for $i \in (i^*, i_r^*)$, the platform switches from money-entry to credit-entry, as is shown in the upper panel. Second, the switching results in a change of credit supply from over-supply (under money entry) to even more over-supply when $\bar{t}_1$ is imposed, or to under-supply when $\bar{t}_2$ is imposed. This is consistent with 9. Third, for $i > i_r^*$, credit provision may move closer or farther away from the planner's solution depending on the nominal interest rates, which is illustrated in the middle panel. Finally, since ξ_l^{cr} can be lower or higher than ξ_l^c, the entry of sellers can be improved or worsened under credit entry.

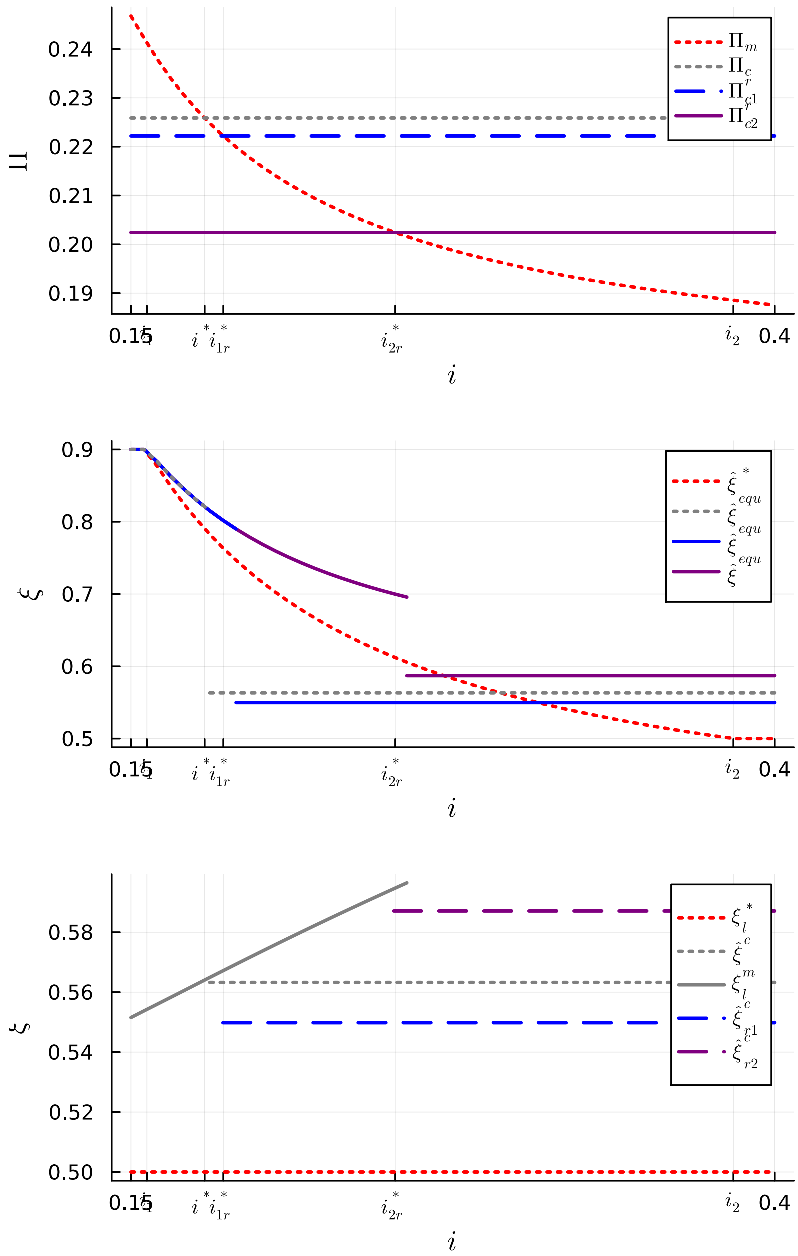

Figure 7: Regulating the ad valorem fee.

Procyclical regulations on t. Our model indicates that regulations on ad valorem fees exhibit a procyclical nature. When the inflation rate is low, denoted as $i \in (i_1, i^*)$, the regulations on the ad valorem fee should be lifted. This allows the platform to capture a larger portion of the sellers' surplus as they transition from monetary payments to credit payments, thereby increasing their incentive to provide credit. When the inflation rate is moderately high, denoted as $i > i^*$, the regulations on the ad valorem fee should be imposed with $\bar{t} < \bar{t}_1$. This ensures that the threshold ξ_l^{cr} is set even higher, effectively curbing the oversupply. In scenarios where the inflation rate is even higher, resulting in an undersupply of credit, the regulations on the ad valorem fee should be reimposed, but this time with $\bar{t} > \bar{t}_1$. This measure serves to lower the threshold ξ_l^{cr}, addressing the undersupply issue.

An important caveat must be considered: While adjusting the upper limit of t can effectively move ξ_l^c closer to the planner's optimal solution, such manipulation may deteriorate entry efficiency. For instance, in scenarios where credit is over-supply, implementing regulations aimed at increasing ξ_l^c certainly discourages sellers' entry, thereby exacerbating inefficiencies in the entry process.

7 Conclusion

This paper delves into the implications of the platform's dual mode of combining brokerage and credit services, aiming to shed light on the potential inefficiencies and regulatory challenges that arise when credit is intertwined with brokerage within the platform economy. The paper first presents a micro-model in which sellers adopt costly credit technologies. This microfoundation is then incorporated into a platform model where the platform sets an ad valorem fee and a credit service usage fee, the sellers choose a posted price and whether or not to use the platform's credit service, while the buyers decide which seller to visit and how much money to hold to prepare for trade. We characterize and compare the equilibrium with the socially optimal allocation. The results show that inefficiencies in credit provision and the entry of sellers exist at different levels of the nominal interest rate. We investigate the complex influence of regulating the ad valorem fee.

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