From Cash to Buy-Now-Pay-Later: Impacts of platform-provided credit on market efficiency*

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Abstract

Many e-commerce platforms simultaneously provide two services: they match buyers and sellers (brokerage) and provide credit payment options like buy-now-pay-later (credit provision). We investigate how the platform's dual role affects allocation efficiency in a directed search framework. We consider a market operated by a monopolistic platform where a large number of sellers offer indivisible good to consumers. Sellers exhibit heterogeneous matching capacities. In equilibrium, sellers with higher matching efficiency attract longer queues of buyers and set higher prices; thus, their costs of using cash as the payment method (e.g., inflation costs) are higher. These sellers are more inclined to accept credit by consumers, a services provided by the platform and is costly. We show that the credit provided by the platform generally deviates from what would be socially optimal. The platform may offer *excessive credit*, aiming to increase profits through higher transaction fees, or *insufficient credit*, as it only partially benefits from sellers engaging in credit trade. Our study underscores the regulatory challenges associated with the dual role.

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

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

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1 Introduction

The emergence of e-commerce giants such as Amazon, Alibaba, Rakuten, and JD.com has dramatically transformed the retail landscape. These platforms have evolved beyond merely facilitating transactions; they now extend credit to consumers as well. A notable service they offer is "Buy Now, Pay Later" (BNPL), enabling customers to acquire products immediately and defer payment for several weeks. Despite the seamless experience this dual-service model presents, regulatory frameworks tend to consider the platform's roles in matchmaking and credit provision in isolation, which may overlook the intricate interplay between these functions, potentially missing critical nuances in how these platforms operate and impact the market.

An example of this is the UK Treasury's legislative proposal published in February 2023, which aimed to enhance the regulation of BNPL services, yet without acknowledging that some of the major BNPL providers are, in fact, platform operators. This separated regulation approach, treating the platform's matchmaking and credit provision in isolation, is also evident in the revised European Consumer Credit Directive (published in October 2023), and the proposal by the US Consumer Financial Protection Bureau (November 2023), both focusing on the obligations of credit service providers without considering their potential role as platform operators.[1]

This paper delves into the emergence and welfare implications of dual-mode platforms, aiming to shed light on the regulatory challenges that arise when credit services are intertwined with brokerage in the platform economy.

In Section 2, we provide a micro-foundation to understand why, in real life, some sellers adopt the costly credit technology while others do not. We consider a directed search framework where buyers and sellers trade a homogeneous indivisible good. Each buyer has unit demand, and each seller possesses one unit. Sellers have heterogeneous *matching efficiencies*, resulting in different probabilities of matching with buyers. The differences in matching efficiencies can be due to reasons such as inventory or advertising capacities, which we treat as exogenous.

Sellers can either accept cash payment, which incurs inflation costs since buyers need to prepare cash to trade, or they can adopt a credit technology that eliminates the need for cash but requires the seller to pay for the usage cost. Equipped with credit technology, sellers can accept IOUs issued by buyers. Thus, the credit technology is costly but comes with perfect enforcement. We will first treat the credit technology cost as exogenous, and then in Section 3, where the platform is introduced, the credit cost will be the service fee chosen by the platform.

Directed search means that in the market, buyers can observe the posted prices and accepted means of payment of all sellers, and choose which (submarket of) sellers to visit. In equilibrium,

[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.

buyers must be indifferent between visiting different sellers. As a result, 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 the queue. Consequently, sellers with higher matching efficiencies require more liquidity to finalize the trade and, thus, face higher inflation costs. These sellers, thus, have stronger incentives to adopt credit technologies to avoid inflation costs. It is worth noting that this result is unique to directed search. In a random search framework, for example, the seller's matching efficiency would not impact either the trade price or the queue length of buyers.

Built upon this microfoundation, we construct a platform economy in Section 3, where a monopolistic platform operates the market. On the one hand, the platform provides brokerage services to match buyers and sellers and charges a proportional *transaction fee* based on the sellers' revenue. On the other hand, the platform offers the credit technology to sellers at a lump-sum *usage fee* so the sellers' customers can pay by credit. Intuitively, the socially optimal payment method depends on a trade-off between the cost of using cash, i.e., nominal interest rates, and the cost of using credit.

We show that a dual-mode platform emerges in equilibrium whenever the nominal interest rate is not too low. In particular, when the nominal rate is high, the platform provides credit to all participating sellers *for free*. Thus, all trades on the platform use credit payment. When the nominal rate is moderate, a hybrid payment system arises. The platform provides credit service *at a positive usage fee*. Sellers with matching efficiency above a certain threshold adopt credit payment, while the remaining sellers only accept cash. Finally, when the nominal rate is low, the platform finds it too costly to introduce credit payment, and it functions solely as a matchmaker, letting all trades be paid by cash.

It's important to note that in a random search environment, sellers lack the incentive to adopt credit technology (even when it is provided for free). Consequently, in such contexts, the platform functions solely as a matchmaker.

We examine the market distortions in Section 4. We show that the platform's incentive to provide credit service deviates from the planner's in two ways. First, when equilibrium involves hybrid payment, that is, some sellers adopt credit while others only accept cash, the platform's credit provision is always too low compared to the planner's solution. This is because the platform's transaction fee is determined by the margin of offering brokerage services. Consequently, regarding credit provision, the platform captures only a partial benefit as sellers switch from monetary payment to credit trade.

Second, when equilibrium involves pure credit payment, the platform tends to provide more credit than the socially optimal level, provided the nominal interest rate is not too high. In this scenario, the platform offers credit services for free and imposes a high proportional transaction fee to select into the platform only sellers with high matching efficiencies. This strategy allows the platform to capture a larger share of revenue from these sellers. It proves to be so profitable that the platform may prefer pure credit payment even when monetary payment is favored from a social planner's perspective.

The discrepancies between the equilibrium and the planner's solution highlight the need for regulatory oversight. In Section 5, we consider scenarios where one of the platform modes is subject to regulation, while the other is not. When the credit service branch is regulated, we find that since the credit usage fee in the equilibrium often falls below the marginal cost of providing credit, direct regulation of the credit fee tends to be ineffective. This is also true if the regulator forces the credit service to operate independently of the platform, or introduces third-party lenders to the platform. In these cases, competition, at best, can lower the credit service fee to the marginal cost, which is still higher than the equilibrium credit fee charged by the platform.

When the brokerage branch is regulated, i.e., the regulator imposes a cap on the transaction fee while leaving the credit usage fee unregulated, we show there is an ambiguous effect on credit provision. Since the transaction fee is restricted, the platform optimally increases the credit usage fee to offset the loss, which modifies the platform's effective price elasticity. This shift can lead to either an increase or decrease in credit provision.

We conclude by arguing for a unified approach to regulating both the matching making and credit provision fees of the platform. When regulation on both fees is possible, we identify a simple relationship that results in socially optimal credit provision. To achieve this, the credit usage fee should equal the seller's share in total revenue times the marginal cost of providing credit. Simply put, the combined effect of these two fees should ensure that sellers shoulder the "correct" marginal cost.

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. Our paper 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 been largely ignored 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 and Wright (2016), 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 nominal interest rates.

Chiu and Wong (2022) examine the strategic choice of e-commerce platforms between operating with traditional cash or utilizing tokens. A cash-based platform earns through transaction fees, whereas a token-based platform can avoid cash-related costs and generate revenue through token sales or seigniorage. Our studies are related but different. Unlike their model, which employs random search, ours uses directed search, a critical element for the simultaneous presence of credit and cash payments. Their analysis centers on token issuance by platforms, whereas we delve into the adoption of credit technology, a more prevalent feature in today's platforms. In our model, both credit and cash payments coexist in equilibrium under certain conditions, contrasting with their scenario where platforms exclusively use either cash or tokens. Despite these differences, there are parallels in our findings: both studies suggest that the adoption of cash, tokens, and credit can be suboptimal, highlighting a common challenge in platform economics.

2 The microfoundation of payment choice

To understand the microfoundation of payment choice, we first assume away the platform. Consider a variant of 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 $\beta \in (0, 1)$ and do not discount within a period. The CM is Walrasian, in which agents produce and consume a divisible good. In the DM, agents trade an indivisible good bilaterally in directed search (more on this below). There are a larger number of sellers and free entry of buyers.

In the DM, sellers can choose to accept either cash only or both cash and consumer credit. If a seller accepts only cash, buyers intending to visit this seller must prepare money in advance during the CM. Holding money incurs an inflation cost for the buyers, represented by the nominal interest rate i. Due to free entry of buyers, these money holding costs are entirely transferred to the seller. If a seller opts to accept consumer credit, they must incur a lump-sum cost. We analyze the equilibrium choice of payment method in this setting.

2.1 DM Trade: Payment and matching

In the DM, each buyer has unit demand for an indivisible good with utility $u > 0$, and each seller has a selling capacity of one unit. To enter the DM, the buyers must pay an entry cost of $k \in (0, u)$ (in terms of the CM good), and the sellers must produce one unit in advance at cost $\kappa \in (0, u - k)$.

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 in each period, sellers draws a new matching efficiency parameter ξ at the end of the CM from a continuous distribution with CDF $G(\xi)$ and density $g(\xi)$. The support of this distribution is $(\underline{\xi}, \bar{\xi})$, where $\frac{k}{u-\kappa} < \underline{\xi} < \bar{\xi} < 1$.

In the DM, sellers can opt to adopt a credit technology at a lump-sum cost of $\phi \geq 0$. If a seller adopts the credit technology, buyers purchasing from this seller can choose to pay by credit, meaning the buyer will settle the payment in the subsequent CM. Conversely, if a seller has not adopted the credit technology, buyers must pay on the spot with fiat money, which needs to be prepared in the previous CM. Thus, monetary payments impose an inflation cost on the trading pair, whereas credit payments incur the adoption cost ϕ.

Each period, the sequence of events related to the DM trade is as follows: First, sellers simultaneously announce the prices they commit to for the upcoming DM and the payment methods they adopt in the CM. Sellers pay the adoption cost ϕ using the numeraire in the CM. Buyers observe the posted prices, accepted payment methods, and matching efficiency ξ of all sellers. They then simultaneously decide which seller to visit in the upcoming DM and prepare fiat money if needed. Finally, in the DM the matched pairs trade according to the posted prices.

2.2 Credit and monetary payment

Credit payment. Consider a seller with matching efficiency ξ. If he has adopted the credit technology, then it is optimal for the buyer to pay by credit rather than holding cash. The seller solves the following profit-maximization problem:

$$\begin{aligned} &\max_{p} \ \ \xi\alpha(x)p, \\ &\text{s.t.} \ \ \frac{\xi\alpha(x)}{x}(u - p) = k. \end{aligned}$$

Inserting the constraint into the objective gives $\xi\alpha(x)u - xk$. The first order condition is necessary and sufficient:

$$\xi\alpha'(x_c)u = k. \tag{1}$$

The second-order condition is satisfied. We see from (1) that the queue length $x_c(\xi)$ increases in ξ, meaning that a more efficient seller is able to attract a longer queue of buyers. We denote the maximized profit by

$$\pi_c(\xi) = \xi\alpha(x_c)u - x_c k. \tag{2}$$

Monetary payment. If a seller has not adopted the credit technology, then buyers who visit this seller must hold money. The seller's profit-maximizing problem is

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

The first-order necessary condition yields $v(x_m, i) = k$, where $v(\cdot)$ is continuously differentiable and strictly decreasing in i. In Appendix A.1, we show that the profit-maximizing queue length, denoted by $x_m(i, \xi)$, is generally decreasing in i and increasing in ξ. This indicates that a seller attracts a shorter queue of buyers when the nominal interest rate is higher and a longer queue when the seller's matching efficiency is higher.

We denote the maximized profit by

$$\pi_m(\xi, i) = \xi\alpha(x_m)\left(\frac{\xi\alpha(x_m)u - x_m k}{\xi\alpha(x_m) + x_m i} - c\right). \tag{3}$$

Rewriting (3) clarifies that since there is free entry of buyers, it is the seller who ultimately bears the inflation cost $ix_m p_m$:

$$\pi_m(\xi, i) = \xi\alpha(x_m)(u-c) - x_m k - ix_m p_m. \tag{4}$$

Note that once we insert $p_m = \frac{\xi\alpha(x_m)u - x_m k}{\xi\alpha(x_m) + x_m i}$, (3) and (4) are equivalent.

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 $i = 0$, this reduces to

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

The number of buyers in the queue for the ξ-seller is x_c, and each buyer has p_c in cash. Therefore, $x_c p_c$ represents the *expected liquidity* the ξ-seller needs to complete the trade as i approaches zero.

In equilibrium, a seller with a higher ξ is able to attract more buyers and charge higher prices. Consequently, both x_c and p_c increase with ξ. Therefore, the marginal inflation cost is higher for more efficient sellers.

Credit or money. To decide whether to adopt the credit technology, sellers compare the adoption cost, ϕ, with the adoption benefit, which can be expressed as:

$$\Delta\pi(\xi, i) = \pi_c(\xi) - \pi_m(\xi, i), \tag{5}$$

where $\Delta\pi(\xi, i)$ represents the increase in a seller's profits (net of the cost ϕ) when switching from monetary payment to credit payment. This benefit satisfies $\Delta\pi(\xi, 0) = 0$, indicating that there is no gain from using credit if $i = 0$. Additionally, $\frac{\partial\Delta\pi(\xi,i)}{\partial i} = -\frac{\partial\pi_m(\xi,i)}{\partial i} > 0$, meaning that the gain increases with i.

Furthermore, sellers with higher matching efficiency benefit more from adopting credit payment. To demonstrate this, we can insert π_c and π_m into (5) to obtain:

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

Taking the derivative with respect to ξ, and using the Envelope Theorem to ignore the effects through x_c and x_m, 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 thus broken down the impact of ξ on $\Delta\pi(\xi, i)$ into two effects. The first is a *volume effect*, meaning that by using credit, a seller can attract a longer queue ($x_c > x_m$) and achieve a higher trade volume (probability): $\xi(\alpha(x_c) - \alpha(x_m))$. A higher ξ amplifies this volume increase. The second effect is the *price effect*, which arises because a seller with higher ξ can charge a higher price p_m, thereby saving more on inflation costs. Both effects exist due to directed search, and importantly, whether a seller accepts credit is observable to buyers.

We summarize these observations in the following lemma.

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

Suppose $i < \bar{i} \equiv (\underline{\xi}(u - c) - k)/c$, 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 denoted by $\hat{\xi}$. 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. Then we can characterize the equilibrium allocation by the pair $(\xi_l, \hat{\xi})$. The equilibrium coincides with the planner's solution which we turn to next.

2.3 Social optimum

Suppose the social planner can use lump-sum transfers, meaning the planner can directly mandate ξ_l and $\hat{\xi}$. We denote the planner's solution by the superscript FB (First Best). We consider two scenarios: (i) when κ is low, resulting in a fully covered market where all sellers participate; and (ii) when κ is high, leading to a partially covered market where only sufficiently efficient sellers choose to participate.

SUPPOSE PRODUCTION COST κ IS LOW $\kappa \leq \pi_c(\underline{\xi}) - \phi$. Then social optimum requires all sellers join the platform. We define two nominal interest rates, i_1 and i_2, by

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

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 it holds that $0 < i_1 < i_2 < \bar{i}$. From the figure, it is intuitive that monetary payment dominates credit payment for $i < i_1 : \pi_m(\xi, i) > \pi_c(\xi) - \phi$ for all ξ. Credit payment dominates for $i > i_2$: $\pi_c(\xi) - \phi > \pi_m(\xi, i)$.

Proposition 1 (Planner's solution - Low κ) *Suppose $\kappa \leq \pi_c(\underline{\xi}) - \phi$, 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*

$$\pi_m(\hat{\xi}^{FB}, i) = \pi_c(\hat{\xi}^{FB}) - \phi. \tag{6}$$

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

SUPPOSE SELLERS' OUTSIDE VALUE IS HIGH: $\pi_c(\underline{\xi}) - \phi < \kappa$, then optimal allocation does not necessarily require all sellers to participate. Define two nominal interest rates i_{11} and i_{22} by

$$\pi_m(\underline{\xi}, i_{11}) = \kappa, \tag{7}$$
$$\pi_m(\xi_1, i_{22}) = \kappa.$$

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 plotted in Figure 2. It holds that 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.

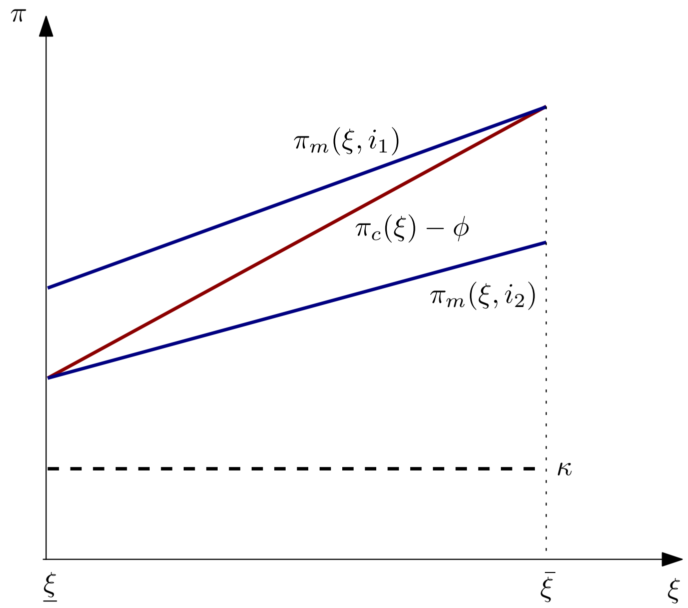

Figure 1: Social Optimal Allocation when $\kappa < \pi_c(\underline{\xi}) - \phi$.

Proposition 2 (Optimal Allocation - High κ) *Suppose κ intersects $\pi_c(\xi) - \phi$ 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 $\max\{\pi_c(\xi) - \phi, \pi_m(\xi, i)\} \geq \kappa$ 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 (6) if $i \in (i_1, i_{22})$. Namely, sellers that are above $\hat{\xi}^{FB}$ opt for credit payment while those below $\hat{\xi}^{FB}$ opt for monetary payment.*

3 The platform economy

So far, we have taken the cost of adopting credit payment in the DM as an exogenous parameter. Now we suppose the DM is operated by a monopolistic platform, and sellers and buyers can only trade DM good on this platform. We shall endogenize the sellers' credit adoption cost as a fee choice of the platform. Additionally, we allow the platform to charge a proportional transaction fee. We will use the LOW κ case as a benchmark, and then demonstrate how the conclusions are modified for the HIGH κ case.

The platform's fee structure is as follows: the platform charges a proportional *transaction fee* $t \in [0, 1]$ to each participating seller based on transaction revenue and offers a credit payment technology at a fixed *usage fee* $f \in [0, \bar{f}]$, where $\bar{f} < \infty$. The strategy space of the platform is

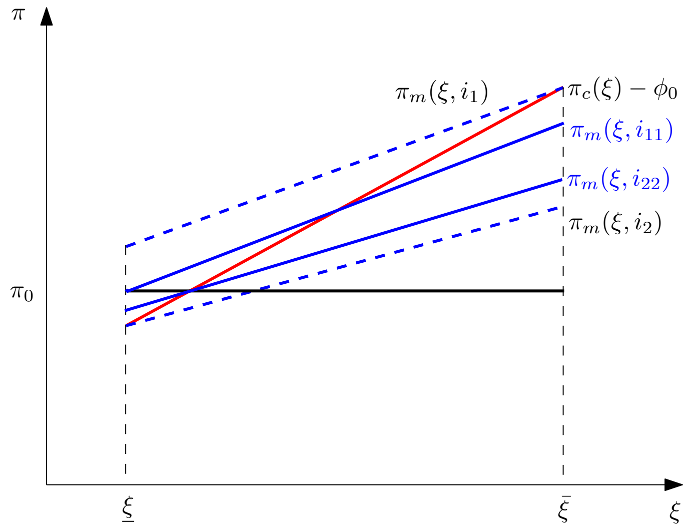

Figure 2: Social Optimal Allocation when $\kappa > \pi_c(\underline{\xi}) - \phi$.

denoted by $\mathbb{T} \equiv [0,1] \times [0, \bar{f}]$. Sellers who trade on the platform can either accept money from buyers at no cost or accept credit payments by paying f to the platform. If a seller opts for the platform-provided credit, a buyer who purchases from the seller can pay in the next CM, which is monitored and enforced by the platform at a cost $\phi > 0$. Note that the credit adoption cost for the platform is the same as the cost in the previous section. And for now we impose that there is no other credit service provider other than the platform.

This fee structure is reflective of real-world practices observed in major e-commerce platforms. For instance, Amazon charges sellers a referral fee, which is a percentage of the sales price, alongside optional fees for services such as fulfillment, advertising and credit provision, etc. Similarly, Walmart charges a referral fee and offers a range of additional services that come with their respective fees.

The timing is as follows. At the end of the CM, the platform announces a pair (t, f) 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 adopt the credit technology provided by the platform, and announce the price they will commit to on the platform. Observing the posted price, matching efficiency parameter, and whether to accept credit or not of 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. Following backward induction, an ξ-seller joins the platform if and only if

$$\min\{(1-t)\pi_m(\xi, i), (1-t)\pi_c(\xi) - f\} \geq \kappa. \tag{8}$$

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

$$(1-t)\Delta\pi(\xi) \geq f. \tag{9}$$

Based on sellers' best responses, the platform chooses a (t, f) to maximize its profits. To make the analysis relevant, we impose that the highest matching efficiency seller is willing to trade using credit payment: $\pi_c(\bar{\bar{\xi}}) - f > \kappa$ since otherwise, the analysis is trivial with credit payment not used in equilibrium.

Since this platform economy has the same environment as the one described in the previous section, thus, the socially optimal allocation remains the same as Propositions 1 and 2. Obviously, the planner's solution can be implemented by the platform choosing $t = 0$ and $f = \phi$, but this never shows up in equilibrium since the platform would then obtain a zero profit.[2]

To examine the profit-maximizing strategy, we divide the platform's strategy space, $\mathbb{T}$, into two subsets. A pair (t, f) either incentivizes the marginal entrant sellers, i.e., those with matching efficiency ξ_l, to opt for credit payment or to accept monetary payment only. We refer to these two scenarios as Money Entry and Credit Entry, respectively, and solve for the profit-maximizing solutions for each case separately. We denote the solutions in these two cases by the superscripts m and c, respectively. Throughout the analysis, we assume a tie-breaking rule where sellers choose cash payment when they are indifferent between credit and cash payment.

3.1 Credit entry

With $\pi_c(\underline{\xi}) - \phi \geq \kappa$, the platform's profit-maximizing problem under a credit-entry strategy can be written as

$$\Pi_c = \max_{(t,\phi)\in\mathbb{T}} \int_{\xi_l}^{\bar{\bar{\xi}}} \left(t\pi_c(\xi) + f - \phi\right) dG(\xi), \tag{10}$$

$$s.t.\ \ (1-t)\pi_c(\xi_l) - f = \kappa, \tag{11}$$

$$(1-t)\pi_m(\xi_l, i) < \kappa, \tag{12}$$

where (11) is the participation constraint for sellers with $\xi > \xi_l$, and (12) indicates that sellers with $\xi \leq \xi_l$ are unwilling to join the platform using monetary payment. Note that restricting the ξ_l-seller to obtain a value of κ, namely having (11) binding, carries no loss to solving the problem because if $(1-t)\pi_c(\xi_l) - f > \kappa$, the platform can increase t to gain higher profits.

The following lemma states that profit maximization features the platform offering credit payment service *for free*. The intuition is as follows: for a given ξ_l, the platform can either charge a lump-sum credit usage fee or a proportional transaction fee. The latter is better at extracting

[2] Of course, there is a set of feasible $(t, f) \in \mathbb{T}$ that implement the socially optimal allocation while generate a non-negative profit for the platform. We delegate a detailed analysis to the last section.

surplus than lump-sum fees simply because t is proportional to the trade revenue.

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

Proof. Fix an ξ_l. As indicated by (11), there is a trade-off between increasing t or increasing f: $f + t\pi_c(\xi_l) = \pi_c(\xi_l) - \kappa$. Inserting f from (11) into (10) gives $\max_t \int_{\xi_l}^{\bar{\xi}} \left(t\left(\pi_c(\xi) - \pi_c(\xi_l)\right) - \kappa - \phi\right)$. The objective is monotonically increasing in t, thus, optimization gives $f = 0$ and $t = 1 - \kappa/\pi_c(\xi_l)$. Since $\pi_c(\xi_l) > \pi_c(\underline{\xi}) > \kappa$, such t is smaller than 1. ■

Given that most e-commerce platforms today offer multiple services beyond mere matchmaking, such as providing both trade avenues and credit services, Lemma 2 presents a valuable observation. When evaluating the anti-trust implications of platforms offering multiple services, it is essential to consider not only the direct fees for specific services, like the usage fee for credit payment, but also the indirect fees, such as transaction fees on trading revenue. This is because cross-subsidization occurs across different services. In essence, one service may be subsidized, allowing the platform to profit from another service.

Using Lemma 2, we see that constraint (12) must be satisfied since $\kappa = (1-t)\pi_c(\xi_l) > (1-t)\pi_m(\xi_l)$ holds for any ξ_l. Then use (11), there is a one-to-one relationship between ξ_l and t for $t \in [1 - \frac{\kappa}{\pi_c(\underline{\xi})}, 1 - \frac{\kappa}{\pi_c(\bar{\xi})}]$. 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 :

$$\Pi_c = \max_{\xi_l \in [\underline{\xi}, \bar{\xi}]} \Pi_c(\xi_l), \tag{13}$$

where

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

Finally, when κ is high, i.e., $\pi_c(\underline{\xi}) - \phi < \kappa$, the analysis above also applies with a minor modification. Note that the 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

$$\pi_c(\xi_l) - \phi < \kappa = (1-t)\pi_c(\xi_l) - f,$$

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

$$\pi_c(\xi) - \phi < \kappa < (1-t)\pi_c(\xi) - f,$$

which yields $t\pi_c(\xi) + f - \phi < 0$, 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 $\pi_c(\xi_1) - \phi = \kappa$. This way, sellers that give the platform negative profits are driven out, and the platform extracts a higher proportion from participating sellers.[3] With these arguments, problem (13) can be revised as follows. Define $\underline{\xi}_c = \xi_1$ if $\pi_c(\underline{\xi}) - \phi < \kappa$; and $\underline{\xi}_c = \underline{\xi}$ otherwise. Then let the feasible set of ξ_l be $[\underline{\xi}_c, \bar{\xi}]$.

3.2 Money entry

Turn to the platform's profit-maximizing problem under money-entry strategies. Define $\bar{i}$ by $\pi_m(\bar{\xi}, \bar{i}) = \kappa$. If $i \geq \bar{i}$, $\pi_m(\xi, i) \leq \kappa$ for all ξ, hence $\Pi_m(i) = 0$. Suppose $i \leq \bar{i}$, then the platform's profit-maximization problem is:

$$\Pi_m(i) \equiv \max_{(t,f)\in\mathbb{T}} \int_{\xi_l}^{\hat{\xi}} t\pi_m(\xi, i) dG(\xi) + \int_{\hat{\xi}}^{\bar{\xi}} \left(t\pi_c(\xi) + f - \phi\right) dG(\xi) \tag{14}$$

$$s.t.\ \ (1-t)\pi_m(\xi_l, i) = \kappa, \tag{15}$$

$$(1-t)\pi_c(\hat{\xi}) - f = (1-t)\pi_m(\hat{\xi}, i). \tag{16}$$

(15) is the participation constraint of the marginal entrants. (16) defines the threshold that sellers with $\xi > \hat{\xi}$ choose credit payment, and those with $\xi \leq \hat{\xi}$ only accept monetary payment. Note that under money entry, it is possible that all participating sellers use monetary payment, i.e., $\hat{\xi} = \bar{\xi}$.

We have three observations regarding this problem. First, there is no loss by restricting (t, f) such that (15) and (16) hold with equality. For any given ξ_l, if $(1-t)\pi_m(\xi_l, i) > \kappa$, the platform can increase t to obtain higher profits. Regarding (16), on the one hand, if f is so high that $(1-t)\pi_c(\bar{\xi}) - f < (1-t)\pi_m(\bar{\xi}, i)$, then lowering f to restore the equality does not influence the platform's profits. On the other hand, if f is so low that $(1-t)\pi_c(\xi_l) - f > (1-t)\pi_m(\xi_l, i) = \kappa$, then all participating sellers (including the ξ_l sellers) use credit payment. However, the platform can marginally increase f, and all sellers with $\xi > \xi_l$ still participate and opt for credit payment but at a higher fee, which will generate higher profits for the platform.

Second, a special case is $(1-t)\pi_m(\xi_l) = (1-t)\pi_c(\xi_l) - f = \kappa$. 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 f to zero while increasing t to $1 - \kappa/\pi_c(\xi_l)$.

Third, (15) implies that sellers with $\pi_m(\xi, i) < \kappa$ cannot be active on the platform. Following a similar argument as in the previous section, in equilibrium, sellers with $\xi < \xi_1$ cannot be active by using credit payment. In both cases, allowing sellers to participate only implies subsidizing

[3] Note that $\Pi_c > 0$ provided $\pi_c(\bar{\xi}) - \phi > \kappa$. For example, the platform can set $f = 0$ and t to satisfy $(1-t)\pi_c(\bar{\xi}_1) = \kappa$. The platform thus obtains positive profits from all sellers with $\xi \geq \bar{\xi}_1$:

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

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

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

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

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

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

Then problem (14) can be reformulated as

$$\Pi_m(i) = \max_{\xi_l, \hat{\xi} \in \mathbb{R}_+^2} \Pi_m(\xi_l, \hat{\xi}, i), \text{ s.t. } \underline{\xi}_m \le \xi_l \le \hat{\xi} \le \bar{\xi}, \tag{17}$$

where $\underline{\xi}_m$ is defined by $\pi_m(\underline{\xi}_m, i) - \phi = \kappa$ if $i < i_{11}$; $\underline{\xi}_m = \underline{\xi}$ otherwise.[4]

It is possible that, in equilibrium, while ξ_l-sellers accept monetary payment only, the more efficient sellers opt for credit payment, in which case, a hybrid payment system arises. The following lemma states that a hybrid payment system arises when $\pi_c(\bar{\xi}) - \phi > \pi_m(\bar{\xi}, i)$ (equivalently, $i > i_1$). If this condition is not met, all participating sellers accept monetary payment only 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, $\pi_c(\bar{\xi}) - \phi > \pi_m(\bar{\xi}, i)$. Suppose we have $\hat{\xi}^m = \bar{\xi}$ which implies that $(1-t)\pi_c(\bar{\xi}) - \phi \le (1-t)\pi_m(\bar{\xi})$. Taking the difference of the two inequalities, we get $t\pi_c(\bar{\xi}) + \phi - \phi > t\pi_m(\bar{\xi})$. Thus, the platform can make a profitable deviation by lowering ϕ, which will persuade the $\bar{\xi}$-sellers to opt for credit.

Next, consider $i \le i_1$, or equivalently, $\pi_c(\bar{\xi}) - \phi \le \pi_m(\bar{\xi}, i)$. 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 $\pi_c(\hat{\xi}^m) - \phi < \pi_m(\hat{\xi}^m, i)$, gives $t\pi_c(\hat{\xi}^m) + \phi - \phi < t\pi_m(\hat{\xi}^m, i)$. 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 $i \ge i_2$.*

[4] $i < i_{11}$ is equivalent to $\pi_m(\underline{\xi}, i) - \phi < \kappa$; Recall that i_{11} is defined in (7).

Proof. Problem (14) 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 $\hat{\xi} = \bar{\bar{\xi}}$, then all participating sellers only take payment by cash and t is determined by $(1-t)\pi_m(\xi_l, i) = \kappa$. Fix ξ_l, an increase in i leads to a lower t. In addition, $\pi_m(\xi, i)$ decreases in i. Thus, $\int_{\xi_l}^{\bar{\bar{\xi}}} t\pi_m(\xi, i)dG(\xi)$ decreases in i. Consequently, $\Pi_m(i) = \max_{\xi_l} \int_{\xi_l}^{\bar{\bar{\xi}}} t\pi_m(\xi, i)dG(\xi)$ 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 $(1-t)\pi_m(\xi_l, i) = \kappa$. Following the same argument in the previous paragraph, $\Pi_m(i) = \max_{\xi_l} \int_{\xi_l}^{\bar{\bar{\xi}}} \Big(t\pi_c(\xi) - \phi\Big)dG(\xi)$ strictly decreases in i.

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

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

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

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

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 $\hat{\xi} = \xi_l = \bar{\bar{\xi}}$. 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

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

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

3.3 Profit maximization and platform mode

By using Lemma 4, it is straightforward to show there exists an i^* that credit entry strategies are more profitable if $i > i^*$, and money entry strategies are more profitable if $i \leq i^*$. For the low κ case that $\kappa \leq \pi_c(\underline{\xi}) - \phi$, we have:

Proposition 3 $\exists! i^* \in (0, i_2)$ *such that* $\Pi_m(i^*) = \Pi_c$.

To adopt for the high κ case, i.e., $\kappa > \pi_c(\underline{\xi}) - \phi$, one only needs to replace i_2 with i_{22} in Proposition 3.

Combining Lemma 3 and Proposition 3, we immediately have the following corollary, which states that the platform operates solely as a match-maker when the money holding cost is sufficiently low.

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

The next proposition characterizes the mode of the platform. It states that if the credit technology is not too cheap, then the hybrid payment system arises.

Proposition 4 *There exists $\tilde{\phi} > 0$ such that $i^* > i_1$ iff $\phi > \tilde{\phi}$. 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.*

The equilibrium platform mode is further characterized in Figure 4. If $i < i^*$, the platform uses the money-entry strategy, where there exists a range of sellers that adopt credit if i is not too low. If $i > i^*$, the platform finds it more profitable to use the credit-entry strategy, in which case all payments on the platform are made using credit.

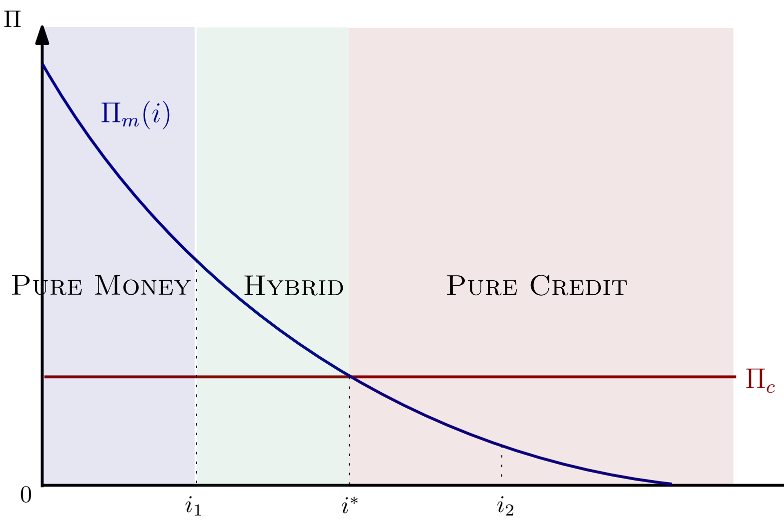

Figure 3: Equilibrium choice of the platform mode when $\phi > \tilde{\phi}$.

When the credit technology is sufficiently cheap, i.e., $\phi < \tilde{\phi}$, then the range of i where credit-entry strategies are more profitable becomes larger. In particular, $i_1 > i^*$. This indicates that, despite monetary payments creating higher surplus than credit trade, the platform still uses credit-entry strategies, aiming to extract a higher proportion of the surplus (i.e., a higher t). The platform mode in equilibrium is illustrated in Figure 4. The platform adopts either pure credit trade or pure monetary trade. There need not be a hybrid payment system.

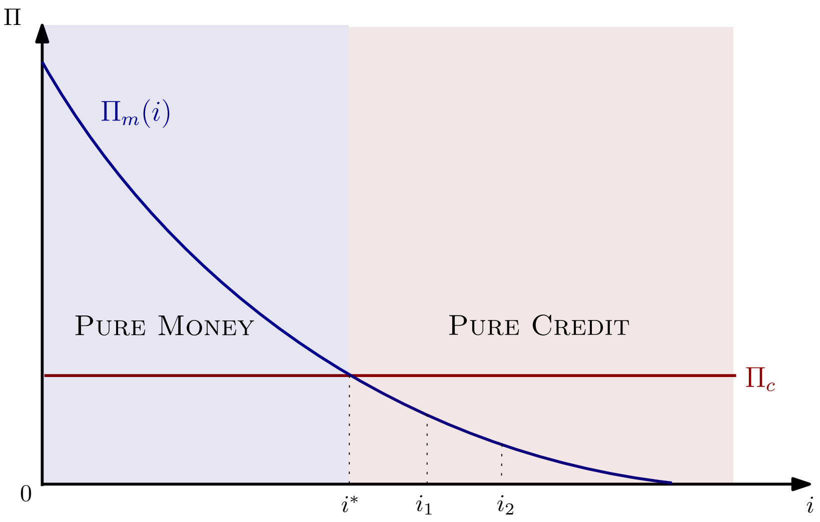

Figure 4: Equilibrium choice of the platform mode when $\phi < \tilde{\phi}$.

4 Distortions

In the platform economy outlined above, there are potential distortions on two margins: the sellers' entry margin onto the platform and the credit adoption margin. Depending on the platform mode, these two margins can either be merged or separated.

Under the pure money mode, credit provision is always efficient, meaning there is no credit trade. Therefore, we only need to discuss the efficiency of the entry margin. Under the hybrid mode, the two margins are separated. In contrast, under the pure credit mode, all sellers joining the platform adopt credit payment, thus the two margins are determined by a single trade-off.

We first demonstrate that the entry of sellers on the platform can be inefficient due to a standard monopoly distortion. We show that, at least in one case where the platform adopts a credit-entry strategy and the credit adoption cost is sufficiently low, traditional anti-trust regulations are not needed because, in this scenario, the entry of sellers is efficient.

We then show that credit provision is always too low when the platform uses money-entry strategies, while credit provision can be either too low or too high under credit-entry strategies. Specifically, we observe that as i increases, credit provision is initially undersupplied, then oversupplied, and eventually undersupplied again.

4.1 Distortions on the entry-margin

When κ is low, socially optimal entry requires all sellers to join the platform: $\xi_l^{FB} = \underline{\xi}$.[5] Suppose the second order condition holds, then for $i \leq i^*$, the platform employs money-entry, and all

[5]The analysis below applies to the case of high κ by replacing $\underline{\xi}$ with $\xi_l^{FB} \geq \underline{\xi}$.

sellers participate on the platform iff

$$\partial \Pi_m(\xi_l, \hat{\xi}, i)/\partial \xi_l|_{\xi_l=\underline{\xi}} \leq 0. \tag{18}$$

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

$$d\Pi_c(\xi_l)/d\xi_l|_{\xi_l=\underline{\xi}} \leq 0. \tag{19}$$

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 proportional transaction fee can improve efficiency, that is, to lower ξ_l^c.[6]

The next proposition shows that under credit entry, an optimal corner solution condition (19) is satisfied when credit technology is sufficiently cheap.

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

$$\phi \leq \pi_c(\underline{\xi}) - \kappa \left(1 + \frac{\pi_c'(\underline{\xi})}{\pi_c(\underline{\xi})} \int_{\underline{\xi}}^{\bar{\xi}} \frac{\pi_c(\xi)g(\xi)}{\pi_c(\underline{\xi})g(\underline{\xi})} d\xi \right). \tag{20}$$

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

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

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

$$\left(\frac{\kappa \pi_c''(\xi_l)}{\pi_c(\xi_l)^2} - \frac{\kappa \pi_c'(\xi_l)^2}{\pi_c(\xi_l)^3}\right) \int_{\xi_l}^{\bar{\xi}} \pi_c(\xi) dG(\xi) - \frac{\kappa \pi_c'(\xi_l)}{\pi_c(\xi_l)}$$
$$- \pi_c'(\xi_l) g(\xi_l) - (\pi_c(\xi_l) - \phi - \kappa) g'(\xi_l).$$

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. ■

4.2 Efficiency of Credit Provision

Credit provision can be inefficient when $i > \min\{i^*, i_1\}$.[7] First, consider the case of $i^* > i_1$. Figure 5 compares the payment modes of the planner's solution and the platform's solution when $i^* >$

[6] We show in section 5 that restricting the proportional transaction 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.

[7] If $i < \min\{i^*, i_1\}$, 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.

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.

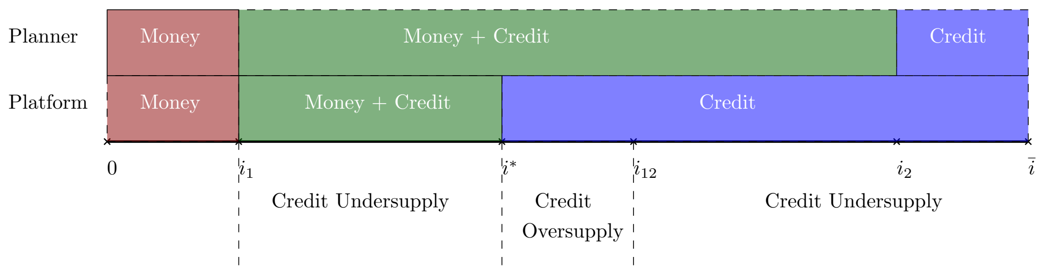

Figure 5: Compare Planner Solution and Equilibrium when $i_1 < i^*$.

The next proposition states that the equilibrium credit supply is too low when nominal interest rate 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

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

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

$$\Delta\pi(\hat{\xi}^c, i) - \phi = (1-t)\frac{1 - G(\hat{\xi}^c)}{g(\hat{\xi}^c)} \frac{\partial \Delta\pi(\hat{\xi}^c, i)}{\partial \hat{\xi}} > 0. \tag{21}$$

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 proportional transaction fee, the platform also charges a fixed credit usage fee $\phi = (1-t)\Delta\pi(\hat{\xi}, i)$. When combined with the proportional transaction 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 next proposition states that there is an oversupply of platform credit for intermediate levels of i, and an undersupply for high levels of i.

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 efficiency 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 $i \in (i^*, i_{12})$ and an undersupply for $i > i_{12}$.*
- *If $\xi_l^c > \hat{\xi}^{FB}(i^*)$, then credit provision is too low for $i > i^*$.*

The analyses so far are summarized in Figure 6 which 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. 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 6). 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. In summary, as i increases, credit provision is initially undersupplied, then oversupplied, and eventually undersupplied again.

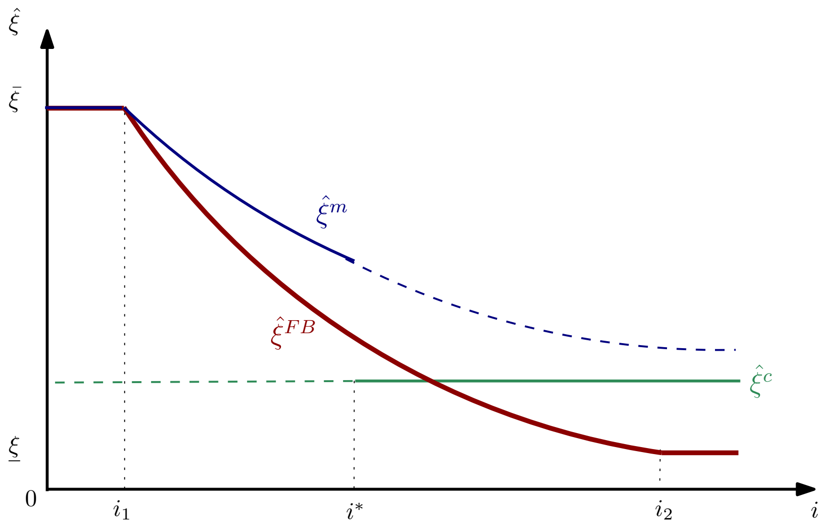

Figure 6: Compare Planner Solution and Equilibrium when $i_1 < i^*$.

Next, we turn to the case of $i^* < i_1$. Figure 7 compares the payment modes in the planner's solution and in equilibrium in the case of $i^* < i_1$. What differentiates this scenario from the case of $i^* > i_1$ is that in the range of $i \in (i^*, i_1)$, despite monetary payment resulting in a higher trading surplus for all sellers, the platform chooses to use credit-entry by setting the credit usage fee to zero (inducing them to use credit), and then extracts surplus by increasing the proportional transaction 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 Proposition 8. The key takeaway is that the oversupply of platform credit always exists for some range of interest rates, and if the entry of sellers is inefficient $\xi_l^c > \underline{\xi}$, there also exists an undersupply of credit.

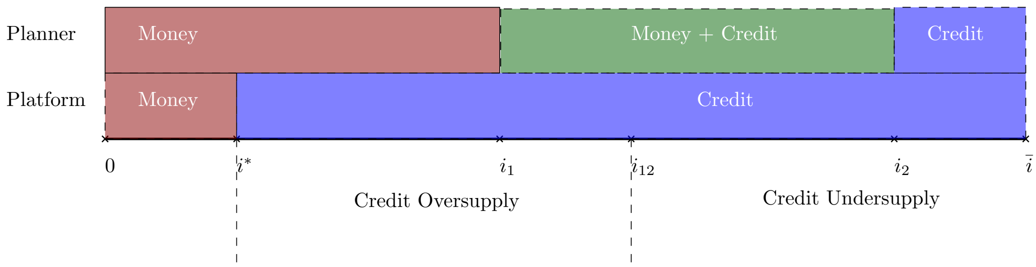

Figure 7: Comparison of Planner Solution and Equilibrium when $i_1 > i^*$.

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 a unique $i_{12} \in (i^*, i_2)$. There is an oversupply of platform credit for $i \in (i^*, i_{12})$ and an undersupply for $i > i_{12}$.*

So far we have assumed κ is relatively low. The discussion on credit provision applies to the case when $\kappa > \pi_c(\underline{\xi}) - \phi$ by replacing i_2 with i_{22}.

5 Regulations

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

It is important to note that regulating the credit usage fee f directly cannot solve the inefficiency in credit provision. This is because, in equilibrium, the platform tends to subsidize the credit usage rather than charge a mark-up. In particular, when $i > i^*$, the optimal usage fee for maximizing profits is $f = 0$. The same logic holds for regulations such as introducing third-party financial intermediaries to compete with the platform in credit provision on the platform. Therefore, in the following, we analyse the effect of regulating the proportional transaction fee.

5.1 Regulating the proportional transaction 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 proportional transaction fee is not restricted. The participation constraint must be binding:

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

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

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

While imposing a cap on t helps to improve the entry efficiency, it works to the opposite for the credit provision. Suppose $\hat{\xi}^m$ takes an interior solution, then as is shown in (21), 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 profit-maximization problem under credit-entry with a restricted t. We focus on low κ (i.e., $\pi_c(\underline{\xi}) - \phi > \kappa$) so that the platform can choose ξ_l as low as $\underline{\xi}$. Our conclusion, however, holds in general. Suppose the platform adopts the credit entry strategy, and given a $\bar{t} \in (0,1)$, it solves the following problem:

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

$$\text{s.t. } (1-t)\pi^c(\xi_l) - f \geq \kappa, \tag{22}$$

$$(1-t)\pi^c(\xi_l) - f \geq (1-t)\pi^m(\xi_l, i), \tag{23}$$

where (22) is the participation constraint, and (23) 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

$$f \leq f_1(\xi) \equiv (1-\bar{t})\pi^c(\xi_l) - \kappa, \tag{24}$$

$$f \leq f_2(\xi) \equiv (1-\bar{t})\pi^c(\xi_l) - (1-t)\pi^m(\xi_l, i). \tag{25}$$

One shall compare $f_1(\xi)$ and $f_2(\xi)$. There are two cases. If $\bar{t} \leq 1 - \frac{\kappa}{\pi_m(\underline{\xi}, i)}$, then $f_1(\xi) \geq f_2(\xi)$ for all $\xi \in [\underline{\xi}, \bar{\xi}]$. In this case, (25) is binding while (24) is loose. Hence, under credit-entry strategies, $\xi_l = \underline{\xi}$. The profit-maximizing credit-entry strategy is to choose

$$f = f_2(\underline{\xi}) = (1-\bar{t})(\pi_c(\underline{\xi}) - \pi_m(\underline{\xi}, i).$$

If $\bar{t} > 1 - \frac{\kappa}{\pi_m(\underline{\xi}, i)}$, then $f_1(\xi)$ intersects $f_2(\xi)$ at ξ_l^{ub}, which is defined by $(1-\bar{t})\pi_m(\xi_l^{ub}, i) = \kappa$. The platform can choose a f no more than $\bar{f} = (1-\bar{t})(\pi_c(\xi_l^{ub}) - \pi_m(\xi_l^{ub}, i))$ to implement credit-entry. That is, if the platform chooses $f > \bar{f}$, then the marginal entrant seller will not accept credit.

The platform's problem (credit-entry) is to choose $f \in [0, \bar{f}]$ to maximize its profits. Equivalently, the problem can be reformulated as choosing an $\xi_l \in [\underline{\xi}, \xi_l^{ub}]$:

$$\max_{\xi_l \in [\underline{\xi}, \xi_l^{ub}]} \int_{\xi_l}^{\bar{\xi}} \left[\bar{t}\pi_c(\xi) + (1-\bar{t})\pi_c(\xi_l) - \kappa - \phi \right]. \tag{26}$$

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 $\bar{t} > 1 - \frac{\kappa}{\pi_m(\underline{\xi}, i^*)}$. 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 $\bar{t}_1 \equiv 1 - \frac{(\pi_c(\xi_l^c) - \kappa - \phi)g(\xi_l^c)}{(1-G(\xi_l^c))\pi_c'(\xi_l^c)}$. 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 (13):

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

and $<$ holds only if $\xi_l^c = \underline{\xi}$. Second, note that $\bar{t} > 1 - \frac{\kappa}{\pi_m(\underline{\xi}, i)}$ for all $i \geq i^*$. The restricted ξ_l^{cr} is solved by the first order condition of (26):

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

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

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

This gives $\bar{t} < \bar{t}_1$. ■

It is well-known that when prices are capped, a monopolist tends to increase output to compensate for the loss caused by the price cap. In our model, this holds true only when the price cap on t is not too restrictive, i.e., $\bar{t} > \bar{t}_1$. However, it may come as a surprise that if the price cap is set even lower, the platform will offer even less credit. This occurs because when t is restricted, the platform turns to increasing f. In the objective function (26), f 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 f.

Procyclical regulations on t. Our model indicates that regulations on proportional transaction fees should exhibit a procyclical nature.

When the nominal interest rate is low, denoted as $i \in (i_1, i^*)$, the regulations on the proportional transaction 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 nominal interest rate is moderately high, denoted as $i > i^*$, the regulations on the proportional transaction 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 of credit.

In scenarios where the nominal interest rate is even higher, resulting in an undersupply of credit, the regulations on the proportional transaction 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 oversupplied, implementing regulations aimed at increasing ξ_l^c certainly discourages sellers' entry, thereby exacerbating inefficiencies in the entry process.

5.2 Jointly regulating t and f

Finally, we consider the scenario where the regulator is able to jointly set t and f. Then the regulator solves the following social planner problem:

$$\max_{(t,\phi)\in\mathbb{T}} \left\{ \int_{\xi_l}^{\hat{\xi}} \pi_m(\xi, i)dG + \int_{\hat{\xi}}^{\bar{\xi}} \left(\pi_c(\xi, i) - \phi\right) dG - (1 - G(\xi_l))\,\kappa \right\},$$
$$\text{s.t. } (1-t)\pi_m(\xi_l) \geq \kappa,\ \ \Delta\pi(\hat{\xi}, i) = \frac{f}{1-t},\ \ \Pi(t, f) \geq 0.$$

The first constraint is the participation constraint where the ξ_l seller finds it profitable to trade on the platform. The second constraint is the $\hat{\xi}$-seller's credit adoption rule. The last constraint ensures the platform gains a non-negative profits. The problem can be easily solved for $i \in (i_1, i_2)$, in which case (t, f) shall satisfy two rules:

(1) Setting an upper bound for t:

$$t \leq 1 - \frac{\kappa}{\pi_m(\underline{\xi}, i)};$$

(2) Connecting f to t and ϕ:

$$f = (1-t)\phi.$$

The second condition highlight that the combination of f and t shall let the seller shoulder the "correct" marginal cost of using credit.

For $i \leq i_1$ or $i \geq i_2$, more flexibility on f but the rules above still apply. In particular, Suppose $i \leq i_1$, to implement the first-best, (t, f) shall satisfy

$$\left\{ (t, f) \in \mathbb{T} \;\middle|\; t \leq 1 - \frac{\kappa}{\pi_m(\underline{\xi}, i)},\ \frac{f}{1-t} \geq \Delta\pi(\bar{\xi}, i) \right\}$$

Suppose $i \geq i_2$, to implement the first-best, (t, f) shall satisfy

$$\left\{(t, f) \in \mathbb{T} \;\middle|\; t + \frac{f}{\pi_c(\underline{\xi})} \leq 1 - \frac{\kappa}{\pi_c(\underline{\xi})},\ \frac{f}{1-t} \leq \Delta\pi(\bar{\xi}, i), \right.$$
$$\left. t\int_{\underline{\xi}}^{\bar{\xi}} \pi_c(\xi) dG - \phi + f \geq 0 \right\}$$

6 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 in the platform economy. We first present a microfoundation where in a directed search framework, sellers of heterogeneous matching efficiencies opt for costly credit technologies. This microfoundation is then incorporated into a platform economy where a monopolistic platform simultaneously provides brokerage and credit services and sets fees for both services. Active sellers on the platform choose posted prices and whether or not to use the platform's credit service, while the buyers decide which sellers to visit and how much money to hold to prepare for a trade. We characterize and compare the equilibrium with the socially optimal allocation. We show that distortions in credit provision and the entry of sellers exist at different levels of the nominal interest rate. Finally, we investigate the intricate influences of regulating a monopolistic dual-mode platform.

References

ANDERSON, S., AND BEDRE-DEFOLIE, Ö. "Online trade platforms: Hosting, selling, or both?" *International Journal of Industrial Organization*, Vol. 84 (2022), pp. 102–861.

ANDOLFATTO, D., BERENTSEN, A., AND MARTIN, F. M. "Money, Banking, and Financial Markets." *The Review of Economic Studies*, Vol. 87, 10 (2019), pp. 2049–2086.

BERENTSEN, A., CAMERA, G., AND WALLER, C. "Money, credit and banking." *Journal of Economic Theory*, Vol. 135 (2007), pp. 171–195.

CHIU, J., AND WONG, T.-N. "Payments on digital platforms: Resiliency, interoperability and welfare." *Journal of Economic Dynamics and Control*, Vol. 142 (2022), pp. 104–173, https://doi.org/10.1016/j.jedc.2021.104173, The Economics of Digital Currencies.

CORNELLI, G., GAMBACORTA, L., AND PANCOTTO, L. "Buy now, pay later: a cross-country analysis." *BIS Quarterly Review* (2023), pp. 61–75.

DONG, M., AND HUANGFU, S. "Money and Costly Credit." *Journal of Money, Credit and Banking*, Vol. 53 (2021), pp. 1449–1478.

ETRO, F. "Device-funded vs ad-funded platforms." *International Journal of Industrial Organization*, Vol. 75 (2021a), pp. 102–711.

——— "Product selection in online marketplaces." *Journal of Economics & Management Strategy*, Vol. 30 (2021b), pp. 614–637.

——— "The Economics of Amazon." *SSRN working paper 4307213* (2022).

——— "e-Commerce platforms and self-preferencing." *Journal of Economic Surveys* (2023a).

——— "Hybrid marketplaces with free entry of sellers." *Review of Industrial Organization*, Vol. 62 (2023b), pp. 119–148.

FERRARIS, L., AND WATANABE, M. "Liquidity constraints in a monetary economy." *International Economic Review*, Vol. 53 (2012), pp. 255–277.

GAUTIER, P., HU, B., AND WATANABE, M. "Marketmaking Middlemen." *The RAND Journal of Economics*, Vol. 54 (2023), pp. 83–103.

GU, C., MATTESINI, F., AND WRIGHT, R. "Money and Credit Redux." *Econometrica*, Vol. 84 (2016), pp. 1–32, https://doi.org/10.3982/ECTA12798.

HAGIU, A., TEH, T.-H., AND WRIGHT, J. "Should platforms be allowed to sell on their own marketplaces?" *The RAND Journal of Economics*, Vol. 53 (2022), pp. 297–327.

KANG, Z. Y., AND MUIR, E. V. "Contracting and vertical control by a dominant platform." *Unpublished manuscript, Stanford University* (2022).

LAGOS, R., AND WRIGHT, R. "A Unified Framework for Monetary Theory and Policy Analysis." *Journal of Political Economy*, Vol. 113 (2005), pp. 463–484.

LESTER, B., POSTLEWAITE, A., AND WRIGHT, R. "Information, liquidity, asset prices, and monetary policy." *The Review of Economic Studies*, Vol. 79 (2012), pp. 1209–1238.

LIU, Y. "Costly Enforcement in Credit Economies." *Working paper* (2021).

LOTZ, S., AND ZHANG, C. "Money and credit as means of payment: A new monetarist approach." *Journal of Economic Theory*, Vol. 164 (2016), pp. 68–100.

MADSEN, E., AND VELLODI, N. "Insider imitation." *SSRN working paper 3832712* (2023).

NOSAL, E., AND ROCHETEAU, G. , 2011 *Money, payments, and liquidity*: MIT press.

PADILLA, J., PERKINS, J., AND PICCOLO, S. "Self-Preferencing in Markets with Vertically Integrated Gatekeeper Platforms." *The Journal of Industrial Economics*, Vol. 70 (2022), pp. 371–395.

RUBINSTEIN, A., AND WOLINSKY, A. "Middlemen." *Quarterly Journal of Economics*, Vol. 102 (1987), pp. 581–593.

SANCHES, D., AND WILLIAMSON, S. "Money and credit with limited commitment and theft." *Journal of Economic theory*, Vol. 145 (2010), pp. 1525–1549.

SHOPOVA, R. "Private labels in marketplaces." *International Journal of Industrial Organization* (2023), pp. 102–949.

TELYUKOVA, I. A., AND WRIGHT, R. "A model of money and credit, with application to the credit card debt puzzle." *The Review of Economic Studies*, Vol. 75 (2008), pp. 629–647.

TIROLE, J., AND BISCEGLIA, M. "Fair gatekeeping in digital ecosystems." *TSE Working Paper* (2023).

WANG, L., WRIGHT, R., AND LIU, L. Q. "Sticky prices and costly credit." *International Economic Review*, Vol. 61 (2020), pp. 37–70.

ZENNYO, Y. "Platform encroachment and own-content bias." *The Journal of Industrial Economics*, Vol. 70 (2022), pp. 684–710.

A Appendix

A.1 The proofs for payment microfoundation

To be added.

A.2 Proportional credit usage fee

Suppose the cost of using credit is $\phi\pi_c(\xi)$. In this case, the marginal seller identified by $\hat{\xi}$ satisfies the equation $\Delta\pi(\hat{\xi}, i) = \phi\pi_c(\hat{\xi})$, or

$$\frac{\Delta\pi(\hat{\xi}, i)}{\pi_c(\hat{\xi})} = \phi.$$

To ensure that sellers with higher ξ are more inclined to adopt credit payment, we introduce the following assumption:

Assumption 1 *$\frac{\Delta\pi(\xi,i)}{\pi_c(\xi)}$ is strictly increasing in ξ.*

With this assumption, our conclusions align with the main text's analysis. When a planner selects (t, f), the condition for the marginal seller becomes

$$(1-t)\Delta\pi(\hat{\xi}, i) = f\pi_c(\hat{\xi}),$$

leading to the optimality condition

$$\frac{f}{1-t} = \phi.$$

In equilibrium analysis, there exists a unique $i^* \in (0, i_2]$ such that $\Pi_m(i^*) = \Pi_c$, and a positive threshold $\bar{\phi}$ that if $\phi < \bar{\phi}$, then $i^* < i_1$. Thus, the distortions identified in the main text persist: under a hybrid payment system, credit provision is consistently lower than the efficient level, while under pure credit payment, it can either exceed or fall short of the efficient level.