An Analysis of the Influencing Factors of Rental Prices in the P2P Rental Market

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Keywords: P2P rental market, rental price, cost, influencing factors

Abstract: As technological progress and the development of the Internet have reduced search and transaction costs, the sharing economy has shown a vigorous development, and the P2P rental market is the main form of the sharing economy. In the rental process, the owner and the renter bear the different costs incurred by the product (durable goods). This paper analyzes the cost structure and further analyzes the impact of different costs on the rental price. The results of the study show that the rental price decreases with the increase of the ownership cost and the cost of inconvenience, and the rental price increases with the increase of the cost of moral hazard. When there is a BTM cost in the P2P rental market, the short-term equilibrium rental price increases, and whether it is a short-term equilibrium or a long-term equilibrium in the P2P rental market, the pass-through of BTM cost to the rental price is incomplete. Finally, this article makes conclusions and recommendations.

1. Introduction

Schor [1] classified the sharing economy into four categories according to the dimensions of "market orientation" and "market structure", namely: (P2P, non-profit), (P2P, profit), (B2P, non-profit) and (B2P, profit). Botsman &Rogers [2] divided the sharing economy into three types from the perspective of consumption, i.e., product service system, redistribution market and collaborative lifestyle. The model of product service system includes two profit types, P2P and B2P, proposed by Schor [3]. According to its participants, the sharing economy is divided into three forms: B2C, P2P and G2C [4]. The above literature review reveals that the real participants in the sharing economy are ordinary consumers, so P2P is the main form of the sharing economy [5].

The market where owners of durable goods sometimes use their assets for personal consumption and sometimes rent them is known as a peer-to-peer or P2P market [6]. P2P rental market is also called C2C market [7], in which consumers who rent out products (durable goods) are referred to as owners, consumers who rent goods (durable goods) are referred to as renters, and durable goods are referred to as products for short.

The economic justification for P2P rental market lies in that many durable goods are basically used for less than 100% of the time by their owners, which is less than the utilization rate (underutilization) and will lead to excess capacity, so it can be rented to non-owners who are willing to use but not yet sufficient to purchase the products [8]. The products (durable goods) will bring different costs to owners and renters when renting products in P2P market, thus this paper analyzes the impact of different costs on rental prices from the cost perspective.

2. Analysis of the Costs Borne by the Owners and Renters in P2P Rental Market

In the P2P rental market, the owner must first bear the fixed ownership cost, which includes not only the purchase cost, but also other ownership-related costs, such as storage-related costs and insurance. In all markets, it is a key issue to promote the trust between unfamiliar partners. This problem is particularly prominent in the P2P rental market, as owners will incur additional costs whenever the renter of the rented product causes additional wear and damage to the product (negligence on the part of the renter and improper use of the product) and the owner is exposed to moral hazard that incurs a cost of moral hazard [6]. Finally, the owner has to bear the BTM cost,

which refers to the cost incurred when the products (durable goods) enter the P2P rental market. Some of the costs are direct costs, including the labor cost required when the products or services enter the market, complementary consumables, and depreciation of assets during use. For example, using the Uber rental service requires labor, increased mileage, and a certain amount of gas. The other part of BTM cost is the coordination cost of rental, which in most cases includes the inherent transaction cost of finding a trading partner, reaching an agreement with the trading partner, completing payment and delivering goods. For example, in using Airbnb services, owners need to find and talk to customers, clean rooms, and distribute keys [8].

The renter will incur the cost of inconvenience of using other's products instead of his own, excluding the rent [6].

3. Analysis of the Influence of Ownership Cost, Cost of Moral Hazard and Cost of Inconvenience on Rental Price

According to Saif Benjaafa [6], if the owner's income is equal to the renter's and the product rent supply is equal to the rent demand, then,

$$\theta = \frac{c - \alpha\left((1-\gamma)p - d_o\right)}{p + d_r + \alpha\left(1 - p - d_r\right)\left((1-\gamma)p - d_o\right)\alpha} \quad (1)$$

$$a = \frac{\theta^2}{(1-\theta)^2 + \theta^2} \quad (2)$$

Where $c \in [0,1]$ represents the cost of product ownership, $d_o \in [0,1]$ represents the cost of moral hazard, $p \in [0,1]$ represents the rental price, and $\theta \in [0,1]$ represents the level of product use. The P2P rental platform takes a commission from a successful transaction, which is represented by $\gamma \in [0,1]$, and the owner rents out the products with a rental income per unit of $(1-\gamma)p$, so the owner needs to meet the condition $p(1-\gamma) \geq d_o$ when renting out the products without using them. If the product cost of inconvenience is expressed by $d_r \in [0,1]$, the renter needs to meet the condition $p < 1 - d_r$, assuming that $\frac{d_o}{1-\gamma} < 1 - d_r$ if he is willing to rent the product. $\alpha(0 \leq \alpha \leq 1)$ represents the probability that the owner will be able to find the renter in a balanced state whenever he rents the product. The product ownership cost c, the cost of moral hazard d_o, and the product cost of inconvenience d_r affect the rental price p.

By substituting formula (2) into (1) and expanding it, we can get $f(\theta, p) = \left[(1 + p + d_r) - ((1-\gamma)p - d_o)\right]\theta^3 - 2\left[(c + p + d_r) - ((1-\gamma)p - d_o)\right]\theta^2 + (2c + p + d_r)\theta - c = 0$. When $\theta = c, f(\theta, p) = c(1-c)\left[(1-\gamma c)p - ((1-d_r)(1-c) + d_o c)\right] = 0$. Then $p = \frac{(1-d_r)(1-c) + d_o c}{1 - \gamma c}$.

$$\frac{\partial p}{\partial c} = \frac{(1-\gamma c)(-1+d_r+d_o)-\gamma\left[(1-d_r)-(1-d_r)c+d_oc\right]}{(1-\gamma c)^2}$$

$$\frac{\partial p}{\partial c} = \frac{d_o-1+d_r+\gamma-d_r\gamma}{(1-\gamma c)^2}$$

$$\frac{\partial p}{\partial c} = \frac{d_o-(1-\gamma)(1-d_r)}{(1-\gamma c)^2}$$

$$\frac{\partial p}{\partial c} = \frac{\frac{d_o}{(1-\gamma)}-(1-d_r)}{\frac{(1-\gamma c)^2}{(1-\gamma)}} \tag{3}$$

$\frac{\partial p}{\partial c}<0$ because $\frac{d_o}{1-\gamma}<1-d_r$ is assumed $\frac{\partial p}{\partial c}<0$ indicates that the rental price decreases when the ownership cost is high, and increases when the ownership cost is low. In the absence of P2P rental market, the majority of the population are non-owners of the products when the ownership cost is high. With the introduction of P2P rental market, it is possible to own products because rental income subsidizes the high ownership cost. In this case, even if the rental price is low, people with high product utilization rate will become owners. Given the high percentage of renters in the population and the high probability of finding a renter, the conversion becomes more attractive for those with high product utilization, and vice versa. At low ownership cost, only individuals with low utilization rate are non-owners. In order to turn these non-owners into owners through the P2P rental market and result in higher ownership, the rental price must be high, which is also to compensate for the costs incurred in a low probability of finding renters.

$\frac{\partial p}{\partial d_o}=\frac{c}{1-\gamma c}>0$. With $\frac{\partial p}{\partial d_o}>0$, the rental price increases with the increase of cost of moral hazard. In P2P rental market, when the owner bears more moral hazard, the rental price will be higher to compensate the cost of the risk.

$\frac{\partial p}{\partial d_r}=\frac{c-1}{1-\gamma c}<0$. With $\frac{\partial p}{\partial d_r}<0$, the rental price decreases with the increase of cost of inconvenience. The income of the renter is reduced when the cost of inconvenience of the product to the renter is increased, so the rental price is lowered to compensate for the reduced cost.

4. Analysis of the Influence of BTM Cost on Rental Price in P2P Rental Market

4.1 The effect of BTM Cost on Short-Term Equilibrium Rental Price

4.1.1 Analysis of Short-Term Equilibrium of P2P Rental Market without BTM Cost

According to Apostolos Filippas [8], when there is no BTM cost in P2P rental market, the supply function is:

$$S\left(r;\sqrt{p}\right)=\int_{\sqrt{p}}^{1}\left(1-\alpha+\frac{r}{2}\right)dF(\alpha) \tag{4}$$

The demand function is

$$D(r; \sqrt{p}) = \begin{cases} 0 & r > 2\sqrt{p} \\ \int_{\frac{r}{2}}^{\sqrt{p}} \left(\alpha - \frac{r}{2}\right) dF(\alpha) & r \le 2\sqrt{p} \end{cases} \quad (5)$$

Where the price of the products purchased by the consumers is $p \in [0,1]$, and the consumers who estimate the value-in-use α of the products when the rent is r can rent out the production capacity of idle products of $1-\alpha$ at no cost. The market equilibrium is unique considering the monotonicity and continuity of supply curve and demand curve. However, the P2P rental market will clear up through two completely different ways in a short period of time.

(1) $S_0 \ge D_0$. If $S_0 = S(0; \sqrt{P})$ indicates the minimum available supply of alternative products, that is, the total amount of unused products before the products are rented, which is also the supply of the production capacity of idle products that can be provided in the P2P rental market, that is, the owners have no incentive to reduce the use of products $r = 0$. Similarly, $D_0 = D(0; \sqrt{P})$ indicates the maximum demand of P2P rental market, that is, the demand when $r = 0$. In the case of $S_0 \ge D_0$, the market supply of idle products exceeds the maximum demand for rent, and the P2P rental market is oversupplied. In turn, an oversupply occurs when the total rental supply of a product at the current level of ownership exceeds the demand of the total population renting the product. Because the idle production capacity of the products is sufficient to meet the demand of all potential renters, and there is no cost for the idle production capacity to enter the P2P rental market, the owners compete in the rental price, and the rental $r_s = 0$ when the market is clear.

(2) $S_0 < D_0$. In the P2P rental market, when the capacity of idle products is less than the maximum rental demand, the owners not only have the incentive to rent out the excess capacity of $1-\alpha$, but also reduce the use of products to provide more capacity for the rental market. As a result, the owner now basically chooses the "production" quantity. According to the demand function, $r \le 2\sqrt{p}$, the market is cleared at $r_s \in (0, 2\sqrt{p})$, and the rental demand is equal to the supply, that is, $S(r_s; \sqrt{p}) = D(r_s; \sqrt{p})$. The equilibrium point r_s is

$$S(r_s; \sqrt{p}, \gamma) = D(r_s; \sqrt{p}, \gamma) \quad (6)$$

$$\int_{\sqrt{p}}^{1} \left(1 - \alpha + \frac{r}{2}\right) dF(\alpha) = \int_{\frac{r}{2}}^{\sqrt{p}} \left(\alpha - \frac{r}{2}\right) dF(\alpha) \quad (7)$$

$$(1 - \sqrt{p}) - \frac{1-p}{2} + \frac{r}{2}(1 - \sqrt{p}) = \frac{p - \frac{r^2}{4}}{2} - \frac{r}{2}\left(\sqrt{p} - \frac{r}{2}\right)$$

$$\frac{1}{2} - \sqrt{p} + \frac{p}{2} + \frac{r}{2} - \frac{r}{2}\sqrt{p} = \frac{p}{2} + \frac{r^2}{8} - \frac{r}{2}\sqrt{p}$$

$$\frac{1}{2} - \sqrt{p} + \frac{p}{2} = \frac{r^2}{8}$$

$$r^2 - 4r = 4 - 8\sqrt{p}$$

$$r = 2 - 2\sqrt{2(1 - \sqrt{p})}$$

Then the equilibrium point is $r_s = 2 - 2\sqrt{2(1 - \sqrt{p})}$.

4.1.2 Analysis of Short-Term Equilibrium of P2P Rental Market with BTM Cost

Where the renter has the need to rent products, it shall meet $r \le 2\sqrt{p}$. When BTM cost γ exists, the owner has the motivation to rent out the product only when $r \ge \gamma$, and the necessary condition for P2P rental market is $\gamma \le 2\sqrt{p}$. With BTM cost γ, the supply function of P2P rental market at rent r is:

$$S\left(r;\sqrt{p},\gamma\right) = \begin{cases} \int_{\sqrt{p}}^{1}\left(1-\alpha+\dfrac{r-\gamma}{2}\right)dF\left(\alpha\right) & r > \gamma \\ 0 & r < \gamma \end{cases} \quad (8)$$

The decision of the renter is influenced by the rental price r, and the rental demand remains unchanged. The demand function is:

$$D\left(r;\sqrt{p},\gamma\right) = \begin{cases} \int_{\frac{r}{2}}^{\sqrt{p}}\left(\alpha-\dfrac{r}{2}\right)dF\left(\alpha\right) & r \le \sqrt{p} \\ 0 & r > \sqrt{p} \end{cases} \quad (9)$$

Due to the monotonicity of the supply curve and the demand curve, there is a unique equilibrium point in the P2P rental market with BTM cost.

(1) $S_0 \ge D_0$. Let $S_{0b} = S\left(r;\sqrt{p},\gamma\right)$, S$_{0b}$ is the lowest available supply, i.e. the sum of the unused production capacity of the owner's products before renting them out as an option, $D_{0b} = D\left(r;\sqrt{p},\gamma\right)$ represents the maximum demand in the P2P rental market and function D$_{0b}$ supports BTM cost γ. In case the capacity supply of unused products exceeds the demand of rented products, that is, $S_{0b} \ge D_{0b}$, the market is oversupplied, and the owners compete on the rental price. The market is cleared at $r_{sb} = \gamma$, and the rental price is pushed to the marginal "production" cost BTM cost γ.

(2) $S_{0b} < D_{0b}$. Owners will reduce the intensity of product utilization in order to rent more products in the P2P rental market. Because $S\left(r;\sqrt{p},\gamma\right)$ increases with the increase of r, $D\left(r;\sqrt{p},\gamma\right)$ decreases as r increases because $r \le 2\sqrt{p}$. And when $D\left(2\sqrt{p};\sqrt{p},\gamma\right) = 0$, the P2P rental market is cleared at the rent $r_{sb} \in \left(\gamma, 2\sqrt{p}\right)$, and the equilibrium point is $r_{sb} = 2 - 2\sqrt{\left(1-\sqrt{p}\right)\left(2-\gamma\right)}$, $S\left(r_s;\sqrt{p},\gamma\right) = D\left(r_s;\sqrt{p},\gamma\right)$. The equilibrium rental price is derived as follows:

$$S\left(r;\sqrt{p},\gamma\right) = D\left(r;\sqrt{p},\gamma\right) \quad (10)$$

$$\int_{\sqrt{p}}^{1}\left(1-\alpha+\frac{r-\gamma}{2}\right)dF(\alpha)=\int_{\frac{r}{2}}^{\sqrt{p}}\left(\alpha-\frac{r}{2}\right)dF(\alpha)$$

$$1-\sqrt{p}-\frac{1-p}{2}+\left(\frac{r-\gamma}{2}\right)\left(1-\sqrt{p}\right)=\frac{p-\frac{r^2}{4}}{2}-\frac{r}{2}\left(\sqrt{p}-\frac{r}{2}\right)$$

$$1-\sqrt{p}-\frac{1}{2}+\frac{p}{2}+\left(\frac{r-\gamma}{2}\right)-\left(\frac{r-\gamma}{2}\right)\sqrt{p}=\frac{p}{2}-\frac{r^2}{8}-\frac{r}{2}\sqrt{p}+\frac{r^2}{4}$$

$$\frac{1}{2}-\sqrt{p}+\frac{p}{2}+\frac{r}{2}-\frac{\gamma}{2}-\frac{r}{2}\sqrt{p}+\frac{\gamma}{2}\sqrt{p}=\frac{p}{2}+\frac{r^2}{8}-\frac{r}{2}\sqrt{p}$$

$$\frac{r^2}{8}-\frac{r}{2}=\frac{1}{2}-\sqrt{p}-\frac{\gamma}{2}+\frac{\gamma}{2}\sqrt{p}$$

$$r^2-4r=4-8\sqrt{p}-4\gamma+4\gamma\sqrt{p}$$

$$r^2-4r+4=8-8\sqrt{p}-4\gamma+4\gamma\sqrt{p}$$

$$\left(2-r\right)^2=4\left(2-2\sqrt{p}-\gamma+\gamma\sqrt{p}\right)$$

$$2-r=2\sqrt{2-2\sqrt{p}-\gamma+\gamma\sqrt{p}}$$

$$r=2-2\sqrt{2-2\sqrt{p}-\gamma+\gamma\sqrt{p}}$$

$$r=2-2\sqrt{\left(1-\sqrt{p}\right)\left(2-\gamma\right)} \tag{11}$$

In case of no BTM cost in P2P rental market, the market is cleared when $S_0\geq D_0$, at the rent $r_s=0$, and the market is cleared at $r_s\in\left(0,2\sqrt{p}\right)$ when $S_0<D_0$. When BTM cost exists in the P2P rental market and $S_{0b}\geq D_{0b}$, the market is cleared at $r_{sb}=\gamma$; When $S_{0b}<D_{0b}$, the P2P rental market is cleared at the rent $r_{sb}\in\left(\gamma,2\sqrt{p}\right)$, and the equilibrium point is $r_{sb}=2-2\sqrt{\left(1-\sqrt{p}\right)\left(2-\gamma\right)}=2-2\sqrt{2\left(1-\sqrt{p}\right)-\gamma\left(1-\sqrt{p}\right)}>r_s=2-2\sqrt{2\left(1-\sqrt{p}\right)}$.

When BTM cost exists in the P2P rental market, the short-term equilibrium rental price increases with the increase of BTM cost. Does the increase in rental price mean that the pass-through of BTM cost to the rental price by the owners is complete, and the renter will bear all BTM costs? Next, this paper analyzes the pass-through of BTM cost to the rental price from the short-term equilibrium and the long-term equilibrium of the P2P rental market.

4.2 The Impact of Pass-through of BTM Cost to Rental Price

4.2.1 Analysis of Short-Term Equilibrium of Pass-through of BTM Cost to Rental Price

$S\left(r;\sqrt{p},\gamma\right)=D\left(r;\sqrt{p},\gamma\right)$ can also be effectively rewritten as:

$$\int_{\sqrt{p}}^{1}\left(1-\alpha+\frac{r-\gamma}{2}\right)dF(\alpha)=\int_{\frac{r}{2}}^{\sqrt{p}}\left(\alpha-\frac{r}{2}\right)dF(\alpha) \tag{12}$$

$$\int_{\sqrt{p}}^{1}1dF(\alpha)-\left(\int_{\frac{r}{2}}^{\sqrt{p}}\alpha dF(\alpha)+\int_{\sqrt{p}}^{1}\alpha dF(\alpha)\right)+\int_{\frac{r}{2}}^{\sqrt{p}}\frac{r}{2}dF(\alpha)+\int_{\sqrt{p}}^{1}\frac{r}{2}dF(\alpha)-\int_{\sqrt{p}}^{1}\frac{\gamma}{2}dF(\alpha)=0$$

$$\int_{\sqrt{p}}^{1}1dF(\alpha)-\int_{\frac{r}{2}}^{1}\alpha dF(\alpha)+\int_{\frac{r}{2}}^{\sqrt{p}}\frac{r}{2}dF(\alpha)+\int_{\sqrt{p}}^{1}\frac{r}{2}dF(\alpha)-\int_{\sqrt{p}}^{1}\frac{\gamma}{2}dF(\alpha)=0$$

$$\int_{\sqrt{p}}^{1} 1 dF(\alpha) \underbrace{- \int_{\frac{r}{2}}^{1} \alpha dF(\alpha) + \int_{\frac{r}{2}}^{\sqrt{p}} \frac{r}{2} dF(\alpha)}_{I} + \underbrace{\int_{\sqrt{p}}^{1} \frac{r}{2} dF(\alpha)}_{II} - \underbrace{\int_{\sqrt{p}}^{1} \frac{\gamma}{2} dF(\alpha)}_{III} = 0$$

In a short-term equilibrium, the rent r_s increases with the increase of γ, and the owner reduces the utilization of products to provide additional supply to the market, while it becomes unprofitable for the owner when the demand remains unchanged. Generally, if an oversupply occurs, $r_s = \gamma$, so r_s increases as γ increases, and there is a complete pass-through cost. If the demand for the rent exceeds supply, item III increases with γ and items (I) and (II) increase with r Obviously, in order to achieve market equilibrium, the increase of γ is offset by the increase of r, and the pass-through of BTM cost to rent is incomplete. If the pass-through of BTM cost to rent is complete, the demand in item (I) will not increase with the increase of r, which will only happen when the elasticity of demand is infinite, because at this time either all consumers already own products or no consumers will rent goods, which obviously does not happen.

4.2.2 Analysis of the Long-Term Equilibrium of Pass-through of BTM Cost to Rental Price

In accordance with Apostolos Filippas [8)], there exist α_L and r_L make the P2P rental market a long-term equilibrium. Suppose the BTM cost increases by some amount $\varepsilon > 0$, which results in a decrease in the available supply in the market, but the demand remains constant, so the rental price will rise to clear the market. If the increase in r is greater than or equal to ε, all previous owners still decide to own the product, because the utility obtained by owning the products remains the same while that by renting the products decreases, and the number of products rented by these owners is the same as before, or even more. Besides, as the rent becomes more and more expensive, some former renters may now choose to own these items, so the supply does not decrease. In the meantime, demand has declined in both scale and intensity. The resulting contradictory conclusion proves that there is no complete pass-through of BTM cost, i.e. the new market equilibrium rent is lower than $r_L + \varepsilon$. Similarly, if the increase of r_L is 0, it will become unprofitable or even bear the loss for the owner to continue to rent products. As a result, these owners reduce the rental quantity of products and even chose to withdraw from the P2P rental market, resulting in a sharp decrease in supply and an increase in demand. The resulting contradictory conclusion proves that r_L must be increased, that is, the new market equilibrium rental price is higher than r_L, so there exists incomplete pass-through of BTM cost to rental price. In the long-term equilibrium of P2P rental market, the rental price r_L increases with the increase of BTM cost γ but without incomplete transfer.

5. Conclusions and Recommendations

To sum up, when $\frac{d_o}{1-\gamma} < 1 - d_r$, $\frac{\partial p}{\partial c} < 0$ indicates that the rental price decreases when the cost of ownership is high, but increases when the cost of ownership is low. $\frac{\partial p}{\partial d_o} > 0$ indicates that the rental price increases with the increase of cost of moral hazard. $\frac{\partial p}{\partial d} < 0$ indicates that the rental price decreases with the increase of cost of inconvenience.

The short-term equilibrium rental price rises when there is a BTM cost in P2P rental market. However, the pass-through of BTM cost to rental price is incomplete in both the short term and the long term, suggesting that the demand side will not fully bear the increased BTM cost. As a result of the incomplete pass-through of BTM cost, anyone who buys products simply for rent will incur

losses with the increase of BTM cost if there is no economy of scale in the rental service provided by the owner.

The renter may abuse or destroy the owner's assets, so that the owner has to bear the cost of moral hazard, which leads to an increase in the rental price. The "type" of the buyer is irrelevant to the seller in most markets, but that of the renter is crucial to the owner in the P2P rental market. A feasible solution is to establish a bilateral reputation system, which is essentially to spread word-of-mouth information about "sellers" and "buyers" to reduce moral hazard. A wealth of empirical literature has described the importance of reputation systems for online market operations. In fact, there are some problems in reputation system that prevent owners from getting real information. Many literatures have expounded how to solve common problems in reputation system, including: encouraging feedback; introducing a new quality signal; solving the inducement of censorship fraud; and the tendency to cope with reputation expansion. The rise of social networks such as Facebook also offers new opportunities for platforms to inject information that parties can use to decide whether to sign up.

Both the rented products and participants' preferences for the products are often highly differentiated, so the matching between the owner and the renter becomes more important. Search algorithms and recommendation systems improve matching efficiency, thus reducing coordination cost in BTM cost. Coordination costs also depend on how the product is used in a customary way, and one of the factors directly affecting coordination costs is the chunk of time the product has been used, i.e. the duration of a rent period. Products that take up a lot of time but are not used in the middle are easier to rent than those that are broken down into many small "chunks" of time and have lower coordination costs. Suppose that x represents the capacity of the owner's idle products, and $\bar{x}$ represents the scale of product use time chunk, the smaller $\bar{x}$ the greater the coordination cost for the owner to rent the product. In other words, the total cost of renting out the products is directly proportional to $x\sqrt{x}$. As a result, owners are required to pay higher coordination costs for "low-chunk" products for renting the same "quantity". Another factor that affects coordination costs is the predictability of product use, i.e., how early renters know if they need the product. In many real markets, it takes time for owners and renters to find each other and evaluate each other. In general, the longer a product or service is expected to be rented, the easier it will be for the owner and the renter to match, and thus the lower the coordination cost.

Acknowledgements

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