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Data Ownership, Data Sharing and Data Transactions

A Two-sided Market Model Based on Commercial Platforms

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Motivation

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Data's unique characteristics: Nonrivalry $\rightarrow$ how to allocate data effectively

This paper focuses on personal consumption data.

- used in circulation phase
- leveraged by commercial digital platforms (CDPs): Amazon, eBay,$\cdots$

By data transactions to acquire more data

- A precondition: confirming data ownership
- Data ownership will affect profit rates of CDPs

Research Question

Key Question:

- examine the mechanisms of data sharing and data transaction between CDPs under different data ownership

Methods: a two-sided market model based on Marxian economics

Innovation:

- Analyze data ownership, data sharing, and data transactions within a unified framework
- The two-sided market model consider the relationship between commercial sectors and production sectors
- View data ownership as part of a new type of production relationship

Theoretical Foundation

The nature of data

Does data possess value?

Three main viewpoints:

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- Affective theory of value: value creation depends on platform's ability to initiate and maintain emotional relationships with users (Borch, 2007 ;Arvidsson & Colleoni, 2012)
- Audience theory of value: consumer activities online create value (Fuchs, 2010)
- LTV: raw data does not possess value, but once platforms process and refine raw data, it acquires value. During its application in production, data itself does not create new value but can transfers its embodied value (Mika, 2019).

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Another viewpoint: data income as virtual commodity income

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- Provide favorable conditions for reproduction, earning rental income based on ownership
- Sadowski (2020) expands the concept of land rent to data, platforms earn rental income by monopolizing data and digital technologies

Our point of view

Data value:

- does not directly arise from human labor within production
- no employment relationship between CDPs and consumers
- the raw data does not possess value
- requires labor from workers for enhancing circulation efficiency

Data income:

- enhance circulation efficiency and gain excess profits
- the income derived from data in the distribution process is akin to rent obtained through property rights

Profit sources of CDPs

CDPs play a critical role in the process of reproduction:

- Production sectors sell through CDPs, consumers log into CDPs to purchase
- CDPs provide a marketplace and control goods pricing
- A markup over production price

The profit of CDPs can be divided into average profit and rent:

- CDPs participate in the equalization of profit and get average profit
- The excess profit obtained by production enterprises is converted into differential rent collected by the CDPs
- CDPs can also leverage their monopoly over personal consumption data to collect monopoly rent

Data ownership, data sharing and data transaction

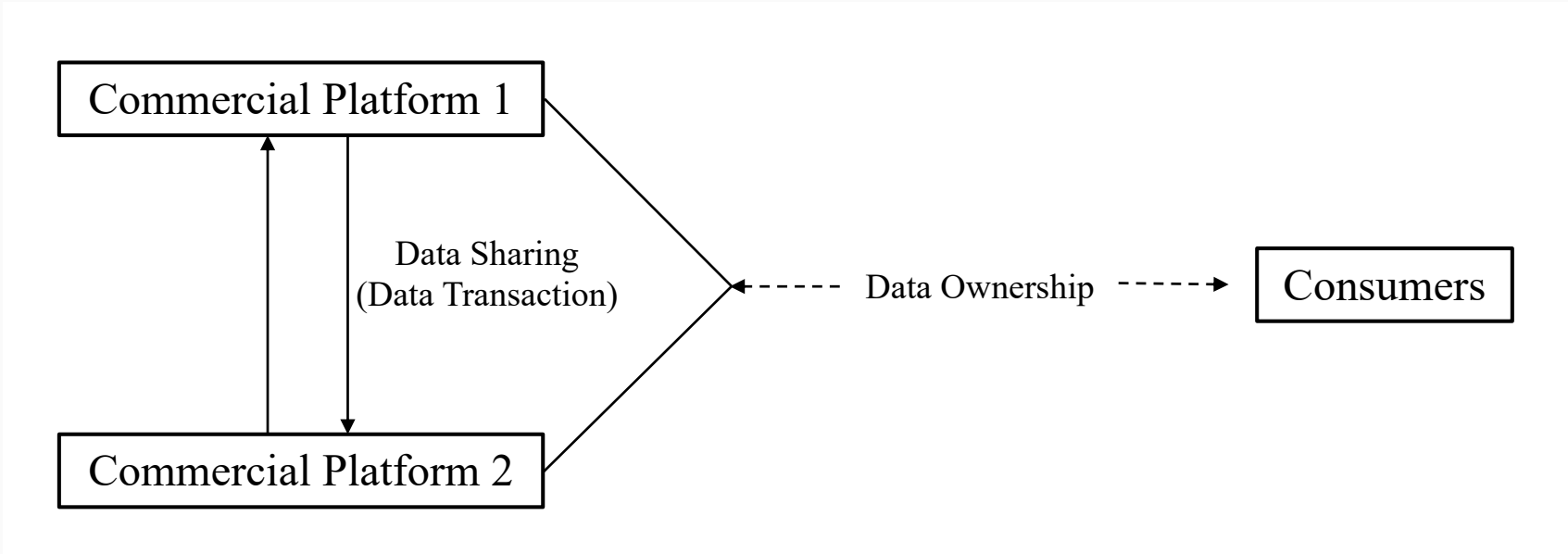

Figure 1: The relationships between data ownership, data sharing and data transaction

Model Set-up

Basic sssumptions for CDPs

CDPs can be classified into two levels: low-efficiency platform (LEP) and high-efficiency platform (HEP)

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- a_e^k: commodities input; l_e^k: direct labor input; q_e^k: the data platform holds; x_e^k: market size in a single circulation

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- a_e^k: commodities input; l_e^k: direct labor input; q_e^k: the data platform holds; x_e^k: market size in a single circulation
- $a_e^2 < a_e^1, l_e^2 < l_e^1, n_e^2 > n_e^1, x_e^2 > x_e^1$

Two-sided market mechanism of CDPs

The distinction between CDPs and general commercial capital:

- provide a digital virtual space to facilitate transaction
- charging a fee for the transaction process

Neoclassical two-sided market model: both buyers and sellers are considered to be in the circulation phase (Rochet and Tirole, 2006; Weyl, 2010)

Our model: emphasize how the profit and rent affect production enterprises, laborers, and the reproduction process

Two-sided Market Mechanism of Commercial Digital Platforms

Parameter settings:

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- production price: $p_c^k, (k = 1, 2)$; market price: p_w
- CDPs pay the cost of goods to production sectors after the goods are sold
- differential rent: LEP $z_1 = 0$, HEP $z_2 > 0$

The set of different scenarios

Table 1: Data ownership belongs to CDPs

		The direction of data transferred			
		HEP to LEP		LEP to HEP	
		Data transfer Method		Data transfer Method	
		Sharing	Transaction	Sharing	Transaction
Whether Data Usage	No	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Rights Transfer Affect Market Share	Yes	Scenario 5	Scenario 6	Scenario 7	Scenario 8

Table 2: Data ownership belongs to consumers

		The direction of data transferred			
		HEP to LEP		LEP to HEP	
		Data transfer Method		Data transfer Method	
		Sharing	Transaction	Sharing	Transaction
Whether Data Usage	No	Scenario 9	Scenario 10	Scenario 11	Scenario 12
Rights Transfer Affect Market Share	Yes	Scenario 13	Scenario 14	Scenario 15	Scenario 16

Confer Data Ownership on CDPs

Baseline model

$$(1+\frac{r_e}{n_e^1})(a_c p_c^1 + l_c b p_w) = p_c^1 \tag{1a}$$

$$(1+\frac{r_e}{n_e^2})(a_c p_c^2 + l_c b p_w) = p_c^2 \tag{1b}$$

$$((1+\frac{r_e}{n_e^1})(a_e^1 p_c^1 + l_e^1 b p_w) + p_c^1)x_e^1 + z_1 = p_w x_e^1 \tag{1c}$$

$$((1+\frac{r_e}{n_e^2})(a_e^2 p_c^2 + l_e^2 b p_w) + p_c^2)x_e^2 + z_2 = p_w x_e^2 \tag{1d}$$

Solving Procedure:

- $z_1 = 0$, given real wage b, (1a) divided by p_c^1
- (1c) divided by $p_c^1 x_e^1$

Baseling Model

Then we get:

$$\begin{cases} (1+r_e/n_e^1)(a_c + l_c b\frac{p_w}{p_c^1}) = 1 \\ (1+r_e/n_e^1)(a_e^1 + l_e^1 b\frac{p_w}{p_c^1}) + 1 = \frac{p_w}{p_c^1} \end{cases} \tag{2}$$

Let $\phi_c = a_c, \phi_e = a_e^1, \eta_c = l_c b, \eta_e = l_e^1 b, p_1 = \frac{p_w}{p_c^1}$:

$$\begin{cases} (1+r_e/n_e^1)(\phi_c + \eta_c p^1) = 1 \\ (1+r_e/n_e^1)(\phi_e + \eta_e p^1) + 1 = p^1 \end{cases} \tag{3}$$

$\phi_c, \phi_e, \eta_c, \eta_e$ are exogenously given

Baseline Model

We can solve relative production price p^{1*} and average profit rate r_e^* (negative solutions are disregarded):

$$\begin{aligned} p^{1*} &= \frac{(\eta_e+\eta_c-\phi_c)+\sqrt{(\eta_e+\eta_c-\phi_c)^2+4\eta_c(\phi_e+\phi_c)}}{2\eta_c} \\ r_e^* &= \left(\frac{\eta_e+\eta_c+\phi_c-\sqrt{(\eta_e+\eta_c-\phi_c)^2+4\eta_c(\phi_e+\phi_c)}}{2\phi_c\eta_e-2\eta_c\phi_e}-1\right)n_e^1 \end{aligned} \tag{4}$$

Proposition 1

The average profit rate r_e^* is determined by the circulation efficiency of LEP. Given that other conditions remain constant, the average profit rate increases as the turnover times of LEP increases, denoted as $\frac{\partial r_e^*}{\partial n_e^1} > 0$.

Baseline Model

Combined with Equation (1b) and (1d), let $\left(\frac{z^2}{p_c^2 x_e^2}\right)^* = \tau^{2*}$ we can get

$$\begin{aligned} \left(\frac{p_w}{p_c^2}\right)^* &= \frac{1}{(1+r_e^*/n_e^2)\eta_c} - \frac{\phi_c}{\eta_c} = p^{2*} \\ \left(\frac{z^2}{p_c^2 x_e^2}\right)^* &= p^{2*} - (1 + r_e^*/n_e^2)(a_e^2 + l_e^2 b p^{2*}) - 1 = \tau^{2*} \end{aligned} \tag{5}$$

The total profit rate $r_e^{2\#}$ and excess profit rate r_e^{2*} of HEP:

$$r_e^{2\#} = r_e^* + r_e^{2*} = r_e^* + \frac{\tau^{2*} n_e^2}{a_e^2 + l_e^2 b p^{2*}} \tag{6}$$

Proposition 2

The differential rent collected by commercial digital platforms is determined by the efficiency gap between HEP and LEP. Given that other conditions remain constant, the differential rent and excess profit rate of HEP increase with its turnover times, denoted as $\frac{\partial \tau_e^{2*}}{\partial n_e^2} > 0$ and $\frac{\partial r_e^{2*}}{\partial n_e^2} > 0$.

Scenario 1: HEP share data to LEP

Data sharing $\rightarrow$ increase in LEP's Δn_e^1

$$(1 + \frac{r_e}{n_e^1 + \Delta n_e^1})(a_c p_c^1 + l_c b p_w) = p_c^1 \tag{7a}$$

$$(1 + \frac{r_e}{n_e^2})(a_c p_c^2 + l_c b p_w) = p_c^2 \tag{7b}$$

$$((1 + \frac{r_e}{n_e^1 + \Delta n_e^1})(a_e^1 p_c^1 + l_e^1 b p_w) + p_c^1)x_e^1 + z_1 = p_w x_e^1 \tag{7c}$$

$$((1 + \frac{r_e}{n_e^2})(a_e^2 p_c^2 + l_e^2 b p_w) + p_c^2)x_e^2 + z_2 = p_w x_e^2 \tag{7d}$$

Scenario 1: HEP share data to LEP

The change of average profit rate:

$$\Delta r_e^* = \left(\frac{\eta_e + \eta_c + \phi_c - \sqrt{(\eta_e + \eta_c - \phi_c)^2 + 4\eta_c(\phi_e + \phi_c)}}{2\phi_c\eta_e - 2\eta_c\phi_c} - 1 \right) \Delta n_e^1 \tag{8}$$

The change in production price and differntial rent:

$$\begin{aligned} p^{2*} + \Delta p^{2*} &= \frac{1}{(1+(r_e^* + \Delta r_e^*)/n_e^2)\eta_c} - \frac{\phi_c}{\eta_c} = p^{2*\prime} \\ \tau^{2*} + \Delta\tau^{2*} &= p^{2*\prime} - (1 + \frac{r_e^* + \Delta r_e^*}{n_e^2})(a_e^2 + l_e^2 b p^{2*\prime}) - 1 \end{aligned} \tag{9}$$

The change in excess and total profit rate:

$$\begin{aligned} r_e^{2*} + \Delta r_e^{2*} &= \frac{(\tau^{2*} + \Delta\tau^{2*})n_e^2}{a_e^2 + l_e^2 b p^{2*\prime}} \\ r_e^{2\#} + \Delta r_e^{2\#} &= r_e^* + \Delta r_e^* + r_e^{2*} + \Delta r_e^{2*} \end{aligned} \tag{10}$$

Scenario 1: HEP share data to LEP

Lemma 1

In scenario 1, let data sharing can be achieved:
(i) If LEP gains more benefits from data sharing;
(ii) If the increase in average profit brought to the HEP by data sharing in period T offsets the reduction in differential rent, i.e.,

$$\Delta r_e^*(a_e^2 + l_e^2 bp^{2*\prime})x_e^2 + \Delta\tau^{2*} n_e^2 x_e^2 > 0$$

LEP can increase its average profit rate by acquiring more data usage rights for free through data sharing, condition (i) does not actually constrain

Scenario 2: HEP trade data to LEP

LEP pay data usage fee m_e^1 to HEP:

- total revenue of LEP: $p_w(n_e^1 + \Delta n_e^1)x_e^1 - m_e^1$
- total revenue of HEP: $p_w n_e^2 x_e^2 + m_e^1$

LEP total profit rate:

$$r_e^{1\#} = r_e^* + \Delta r_e^* - \frac{m_e^1/x_e^1}{\phi_e + \eta_e p^{1*}} \tag{11}$$

The change in HEP's excess and total profit rate:

$$\begin{aligned} r_e^{2*} + \Delta r_e^{2*} &= \frac{(\tau^{2*} + \Delta\tau^{2*})n_e^2 + m_e^1/x_e^2}{a_e^2 + l_e^2 b p^{2*\prime}} \\ r_e^{2\#} + \Delta r_e^{2\#} &= r_e^* + \Delta r_e^* + r_e^{2*} + \Delta r_e^{2*} \end{aligned} \tag{12}$$

Scenario 2: HEP trade data to LEP

Lemma 2

In scenario 2, let data transactions can be achieved:

(i) If the increase in average profit brought to the LEP by data transactions in period T offsets the data usage fee, i.e.,

$$\Delta r_e^*(\phi_e + \eta_e p^{1*})x_e^1 > m_e^1$$

(ii) If the increase in average profit and data usage fee brought to the HEP by data transactions in period T offsets the reduction in differential rent, i.e.,

$$m_e^1 + \Delta r_e^*(a_e^2 + l_e^2 b p^{2*\prime})x_e^2 + \Delta \tau^{2*} n_e^2 x_e^2 > 0$$

Scenario 3: LEP share data to HEP

Lemma 3

In scenario 3, let data sharing can be achieved:
(i) If LEP gains more benefits from data sharing;
(ii) If HEP gains more benefits from data sharing.

After data sharing, LEP's average profit rate does not increase.
Therefore, data sharing cannot be achieved.

Scenario 4: LEP trade data to HEP

An increase in HEP's turnover times Δn_e^2

$$(1+\frac{r_e}{n_e^1})(a_c p_c^1 + l_c b p_w) = p_c^1 \tag{13a}$$

$$(1+\frac{r_e}{n_e^2+\Delta n_e^2})(a_c p_c^2 + l_c b p_w) = p_c^2 \tag{13b}$$

$$((1+\frac{r_e}{n_e^1})(a_e^1 p_c^1 + l_e^1 b p_w) + p_c^1)x_e^1 + z_1 = p_w x_e^1 \tag{13c}$$

$$((1+\frac{r_e}{n_e^2+\Delta n_e^2})(a_e^2 p_c^2 + l_e^2 b p_w) + p_c^2)x_e^2 + z_2 = p_w x_e^2 \tag{13d}$$

Scenario 4: LEP trade data to HEP

Lemma 4

In scenario 4, let data transactions can be achieved:

(i) If LEP gains more benefits from data sharing;

(ii) If the increase in differential rent brought to the HEP by data transaction in period T offsets the data usage fee, i.e.,

$$\Delta\tau^{2*}(n_e^2 + \Delta n_e^2)x_e^2 > m_e^2$$

Scenario 5: HEP share data to LEP

Total service volume: $n_e^1 x_e^1 + n_e^2 x_e^2$, HEP transfer data usage rights to LEP:

- LEP total service volume: $(n_e^1 + \Delta n_e^1)(x_e^1 + \Delta x_e^1)$
- HEP total service volume: $n_e^1 x_e^1 + n_e^2 x_e^2 - (n_e^1 + \Delta n_e^1)(x_e^1 + \Delta x_e^1)$

Scenario 5: HEP share data to LEP

$$(1+\frac{r_e}{n_e^1+\Delta n_e^1})(a_c p_c^1 + l_c b p_w) = p_c^1 \tag{14a}$$

$$(1+\frac{r_e}{n_e^2})(a_c p_c^2 + l_c b p_w) = p_c^2 \tag{14b}$$

$$((1+\frac{r_e}{n_e^1+\Delta n_e^1})(a_e^1 p_c^1 + l_e^1 b p_w) + p_c^1)(x_e^1+\Delta x_e^1) + z_1 = p_w(x_e^1+\Delta x_e^1) \tag{14c}$$

$$((1+\frac{r_e}{n_e^2})(a_e^2 p_c^2 + l_e^2 b p_w) + p_c^2)x_e^{2\prime} + z_2 = p_w x_e^{2\prime} \tag{14d}$$

$$x_e^{2\prime} = x_e^2 - \frac{n_e^1\Delta x_e^1 + \Delta n_e^1 x_e^1 + \Delta n_e^1 \Delta x_e^1}{n_e^2} \tag{14e}$$

Scenario 5: HEP share data to LEP

Lemma 5

In scenario 5, let data sharing can be achieved:

(i) If LEP gains more benefits from data sharing;

(ii) If the increase in differential rent brought to the HEP by data sharing in period T offsets the decrease in differential rent and the loss of market share reduction, i.e.,

$$\Delta r_e^*(a_e^2 + l_e^2 b p^{2*\prime}) x_e^{2\prime} + \Delta \tau^{2*} n_e^2 x_e^{2\prime} > 0$$

Corollary 1

Compared to scenario 1, introducing the impact of data sharing on market share in scenario 5 makes the condition for data sharing more stringent.

Scenario 6: HEP trade data to LEP

LEP pay data usage fee m_e^1 to HEP:

- total revenue of LEP: $p_w(n_e^1 + \Delta n_e^1)(x_e^1 + \Delta x_e^1) - m_e^1$
- total revenue of HEP:
  $p_w(n_e^1 x_e^1 + n_e^2 x_e^2 - (n_e^1 + \Delta n_e^1)(x_e^1 + \Delta x_e^1)) + m_e^1$

Scenario 6: HEP trade data to LEP

Lemma 6

In scenario 6, let data transactions can be achieved:

(i) If the increase in average profit brought to the LEP by data transactions in period T offsets the data usage fee, i.e.,

$$\Delta r_e^*(\phi_e + \eta_e p^{1*})x_e^1 > m_e^1$$

(ii) If the increase in average profit and data usage fee brought to the HEP by data transactions in period T offsets the decrease in differential rent and the loss of market share reduction, i.e.,

$$m_e^1 + \Delta r_e^*(a_e^2 + l_e^2 b p^{2*\prime})x_e^{2\prime} + \Delta \tau^{2*} n_e^2 x_e^{2\prime} > 0$$

Scenario 6: HEP trade data to LEP

- LEP can improve their average profit rate and market share by buying data
- if the increase in average profit rate cannot offset the decrease in differential rent, HEP's motivation to engage in data transactions will diminish

Corollary 2

Compared to scenario 2, the introducing of the impact of data transactions on market share in scenario 6 leads to uncertainty regarding the ease of data transactions.

Scenario 7: LEP share data to HEP

The service volume of HEP increases Δx_e^2

- HEP total service volume: $(n_e^2 + \Delta n_e^2)(x_e^2 + \Delta x_e^2)$
- LEP total service volume: $n_e^1 x_e^1 + n_e^2 x_e^2 - (n_e^2 + \Delta n_e^2)(x_e^2 + \Delta x_e^2)$

Lemma 7

In scenario 7, let data sharing can be achieved:
(i) If LEP gains more benefits from data sharing;
(ii) If HEP gains more benefits from data sharing.

Compared to scenario 3, LEP's loss is more, data sharing cannot be achieved

Scenario 8: LEP trade data to HEP

$$(1+\frac{r_e}{n_e^1})(a_c p_c^1 + l_c b p_w) = p_c^1 \tag{15a}$$

$$(1+\frac{r_e}{n_e^2+\Delta n_e^2})(a_c p_c^2 + l_c b p_w) = p_c^2 \tag{15b}$$

$$((1+\frac{r_e}{n_e^1})(a_e^1 p_c^1 + l_e^1 b p_w) + p_c^1)x_e^{1\prime} + z_1 = p_w x_e^{1\prime} \tag{15c}$$

$$((1+\frac{r_e}{n_e^2+\Delta n_e^2})(a_e^2 p_c^2 + l_e^2 b p_w) + p_c^2)(x_e^2+\Delta x_e^2) + z_2 = p_w(x_e^2+\Delta x_e^2) \tag{15d}$$

$$x_e^{1\prime} = x_e^1 - \frac{n_e^2\Delta x_e^2 + \Delta n_e^2 x_e^2 + \Delta n_e^2 \Delta x_e^2}{n_e^1}$$

Scenario 8: LEP trade data to HEP

Lemma 8

In scenario 8, let data transactions can be achieved:

(i) If the data usage fee brought to the LEP by data transactions in period T offsets the loss of market share reduction, i.e.,

$$m_e^2 > p^{1*}(n_e^2 \Delta x_e^2 + \Delta n_e^2 x_e^2 + \Delta n_e^2 \Delta x_e^2)$$

(ii) If the increase in differential rent brought to the HEP by data transaction in period T offsets the data usage fee, i.e.,

$$(\tau^{2*} + \Delta\tau^{2*})(n_e^2 + \Delta n_e^2)(x_e^2 + \Delta x_e^2) - \tau^{2*} n_e^2 x_e^2 > m_e^2$$

Scenario 8: LEP trade data to HEP

Corollary 3

Compared to Scenario 4, the introducing of the impact of data transactions on market share in Scenario 8 leads to uncertainty regarding the ease of data transactions.

Summary

Summarizing Lemma 1-2 and Lemma 5-6:

Proposition 3

In the scenario where HEPs transfer data usage rights to LEPs:
(i) The increase in average profit brought to the HEP in period T offsets the decrease in differential rent (and the loss of market share reduction);
(ii) The increase in average profit and data usage fee brought to the HEP in period T offsets the decrease in differential rent (and the loss of market share reduction);
(iii) The increase in average profit brought to the LEP offsets the data usage fee.
If condition (i) is met, data sharing will occur; if condition (ii) and (iii) are met, data transactions will occur.

Summary

Summarizing Lemma 3-4 and Lemma 7-8:

Proposition 4

In the scenario where LEPs transfer data usage rights to HEPs:
(i) The data usage fee brought to the LEP in period T offsets the loss of market share reduction (if the market share does not decrease, this condition does not need to be met);
(ii) The increase in differential rent brought to the HEP in period T offsets the data usage fee.
If condition (i) and (ii) are met, data transactions will occur.

Confer Data Ownership on Consumers

Baseline model

$$(1+\frac{r_e}{n_e^1})(a_c p_c^1 + l_c b p_w) = p_c^1 \tag{16a}$$

$$(1+\frac{r_e}{n_e^2})(a_c p_c^2 + l_c b p_w) = p_c^2 \tag{16b}$$

$$((1+\frac{r_e}{n_e^1})(a_e^1 p_c^1 + l_e^1 b p_w + b^+(l_e^1+l_c)p_w) + p_c^1 + x_e^1 + z_1 = p_w x_e^1 \tag{16c}$$

$$((1+\frac{r_e}{n_e^2})(a_e^2 p_c^2 + l_e^2 b p_w + b^+(l_e^2+l_c)p_w) + p_c^2)x_e^2 + z_2 = p_w x_e^2 \tag{16d}$$

b^+ is the data payment to consumers, and the solving procedure is the same as before, let $\varphi = b^+(l_e^1 + l_c)$

Baseline model

Proposition 5

The average profit rate r_e^* is determined by the circulation efficiency of LEP. Given that other conditions remain constant, the average profit rate decreases as the data payment b^+ increases, denoted as $\frac{\partial r_e^*}{\partial b^+} < 0$.

Proposition 6

The differential rent collected by CDPs is determined by the efficiency gap between HEP and LEP. Given that other conditions remain constant, the differential rent HEP decreases as the data payment b^+ increases, denoted as $\frac{\partial \tau^{2*}}{\partial b^+} < 0$.

Scenario 9: HEP share data to LEP

$$(1+\frac{r_e}{n_e^1+\Delta n_e^1})(a_c p_c^1 + l_c b p_w) = p_c^1 \tag{17a}$$

$$(1+\frac{r_e}{n_e^2})(a_c p_c^2 + l_c b p_w) = p_c^2 \tag{17b}$$

$$((1+\frac{r_e}{n_e^1+\Delta n_e^1})(a_e^1 p_c^1 + l_e^1 b p_w + b^+(l_e^1+l_c)p_w) + p_c^1 + x_e^1 + z_1 = p_w x_e^1 \tag{17c}$$

$$((1+\frac{r_e}{n_e^2})(a_e^2 p_c^2 + l_e^2 b p_w + b^+(l_e^2+l_c)p_w) + p_c^2)x_e^2 + z_2 = p_w x_e^2 \tag{17d}$$

Scenario 9: HEP share data to LEP

Lemma 9

In scenario 9, let data sharing can be achieved:

(i) If LEP gains more benefits from data sharing;

(ii) If the increase in average profit brought to the HEP by data sharing in period T offsets the reduction in differential rent, i.e.,

$$\Delta r_e^*(a_e^2 + (l_e^2 b + b^+(l_e^2 + l_c))p^{2*\prime}) + \Delta\tau^{2*} n_e^2 > 0$$

Corollary 4

In scenario 9, conferring data ownership on consumer will affect data transfer between CDPs.

Scenario 10: HEP trade data to LEP

Lemma 10

In scenario 10, let data transactions can be achieved:
(i) If the increase in average profit brought to the LEP by data transactions in period offsets the data usage fee, i.e.,

$$\Delta r_e^*(\phi_e + (\eta_e + \varphi)p^{1*})x_e^1 > m_e^1$$

(ii) If the increase in average profit and data usage fee brought to the HEP by data transactions in period T offsets the reduction in differential rent, i.e.,

$$m_e^1 + \Delta r_e^*(a_e^2 + (l_e^2 b + b^+(l_e^2 + l_c))p^{2*\prime})x_e^2 + \Delta\tau^{2*} n_e^2 x_e^2 > 0$$

Scenario 10: HEP trade data to LEP

Corollary 5

Compared to scenario 2, introducing the impact of data ownership in scenario 10 makes the condition for data transactions more stringent.

Scenario 11: LEP share data to HEP

Lemma 11

In scenario 11, let data sharing can be achieved:
(i) If LEP gains more benefits from data sharing;
(ii) If HEP gains more benefits from data sharing.

After data sharing, LEP's data holdings will not change, leaving it no incentive to engage in data sharing

Scenario 12: LEP trade data to HEP

Lemma 12

In scenario 12, let data transactions can be achieved:
(i) If LEP gains more benefits from data sharing;
(ii) If the increase in differential rent brought to the HEP by data transaction in period T offsets the data usage fee, i.e.,

$$\Delta\tau^{2*}(n_e^2 + \Delta n_e^2)x_e^2 > m_e^2$$

Corollary 6

Compared to scenario 4, introducing the impact of data ownership in scenario 12 makes the condition for data transactions more stringent.

Scenario 13: HEP share data to LEP

$$(1+\frac{r_e}{n_e^1+\Delta n_e^1})(a_c p_c^1 + l_c b p_w) = p_c^1 \tag{18a}$$

$$(1+\frac{r_e}{n_e^2})(a_c p_c^2 + l_c b p_w) = p_c^2 \tag{18b}$$

$$((1+\frac{r_e}{n_e^1+\Delta n_e^1})(a_e^1 p_c^1 + l_e^1 b p_w + b^+(l_c+l_e^1)p_w) + p_c^1) + \frac{z_1}{x_e^1+\Delta x_e^1} = p_w \tag{18c}$$

$$((1+\frac{r_e}{n_e^2})(a_e^2 p_c^2 + l_e^2 b p_w + b^+(l_c+l_e^2)p_w) + p_c^2)x_e^{2\prime} + z_2 = p_w x_e^{2\prime} \tag{18d}$$

$$x_e^{2\prime} = x_e^2 - \frac{n_e^1 \Delta x_e^1 + \Delta n_e^1 x_e^1 + \Delta n_e^1 \Delta x_e^1}{n_e^2} \tag{18e}$$

Scenario 13: HEP share data to LEP

Lemma 13

In scenario 13, let data sharing can be achieved:
(i) If LEP gains more benefits from data sharing;
(ii) If the increase in differential rent brought to the HEP by data sharing in period T offsets the decrease in differential rent and the loss of market share reduction, i.e.,

$$\Delta r_e^*(a_e^2 + (l_e^2 b + b^+(l_c + l_e^2))p^{2*\prime})x_e^{2\prime} + \Delta\tau^{2*} n_e^2 x_e^{2\prime} > 0$$

Corollary 7

Compared to scenario 9, introducing the impact of data sharing on market share in scenario 13 makes the condition for data sharing more stringent.

Scenario 14: HEP trade data to LEP

Lemma 14

In scenario 14, let data transactions can be achieved:

(i) If the increase in average profit brought to the LEP by data transactions in period T offsets the data usage fee, i.e.,

$$\Delta r_e^*(\phi_e + (\eta_e + \varphi)p^{1*})x_e^1 > m_e^1$$

(ii) If the increase in average profit and data usage fee brought to the HEP by data transactions in period T offsets the decrease in differential rent and the loss of market share reduction, i.e.,

$$m_e^1 + \Delta r_e^*(a_e^2 + (l_e^2 b + b^+(l_c + l_e^2))p^{2*\prime})x_e^{2\prime} + \Delta\tau^{2*} n_e^2 x_e^{2\prime} > 0$$

Scenario 14: HEP trade data to LEP

Corollary 8

Compared to scenario 10, introducing the impact of data transactions on market share in scenario 13 leads to uncertainty regarding the ease of data transactions.

Scenario 15: LEP share data to HEP

Lemma 15

In scenario 15, let data sharing can be achieved:

(i) If LEP gains more benefits from data sharing;

(ii) If HEP gains more benefits from data sharing.

Scenario 16: LEP trade data to HEP

Lemma 16

In scenario 16, let data transactions can be achieved:

(i) If the data usage fee brought to the LEP by data transactions in period T offsets the loss of market share reduction, i.e.,

$$m_e^2 > p^{1*}(n_e^2 \Delta x_e^2 + \Delta n_e^2 x_e^2 + \Delta n_e^2 \Delta x_e^2)$$

(ii) If the increase in differential rent brought to the HEP by data transaction in period T offsets the data usage fee, i.e.,

$$(\tau^{2*} + \Delta\tau^{2*})(n_e^2 + \Delta n_e^2)(x_e^2 + \Delta x_e^2) - \tau^{2*} n_e^2 x_e^2 > m_e^2$$

Scenario 16: LEP trade data to HEP

Corollary 9

Compared to scenario 12, introducing the impact of data transactions on market share in scenario 16 leads to uncertainty regarding the ease of data transactions.

Summary

Proposition 7

In the scenario where HEPs transfer data usage rights to LEPs:
(i) The increase in average profit brought to the HEP in period T offsets the decrease in differential rent (and the loss of market share reduction);
(ii) The increase in average profit and data usage fee brought to the HEP in period T offsets the decrease in differential rent (and the loss of market share reduction);
(iii) The increase in average profit brought to the LEP offsets the data usage fee.
If condition (i) is met, data sharing will occur; if condition (ii) and (iii) are met, data transactions will occur.

Summary

Proposition 8

In the scenario where LEPs transfer data usage rights to HEPs:
(i) The data usage fee brought to the LEP in period T offsets the loss of market share reduction (if the market share does not decrease, this condition does not need to be met);
(ii) The increase in differential rent brought to the HEP in period T offsets the data usage fee.
If condition (i) and (ii) are met, data transactions will occur.

Summary

The form of Proposition 7 and 8 is the same as Proposition 3 and 4.

The key distinction is if data usage fee is paid to consumers, the conditions for data transactions will become more stringent.

Conclusion

Conclusion

Research findings:

- HEPs will decide the data transfer method by weighing the changes in average profit and differential rent
- LEPs only need to consider the change in average profit when determining the data transfer method
- If competition related to market share is introduced, the conditions for data sharing become more stringent, but the difficulty of data transactions remain uncertain
- If data ownership is conferred to consumers, data sharing and transaction conditions will be more stringent

Conclusion

Policy implications:

- conferring data ownership in a way that ensures the stable operation of social reproduction, enhances circulation efficiency, and protects individual privacy.

Further discussion:

- cross-border competition between platforms
- international transfer of personal consumption data

References i

Arvidsson, A. and E. Colleoni (2012). Value in informational capitalism and in the internet. *The Information Society 28*(3), 135–150.

Borch, C. (2007). Crowds and economic life: bringing and old figure back in. *Economy and Society 36*(4), 549–573.

Fuchs, C. (2010). Labor in informational capitalism and on the internet. *The Information Society 26*(3), 179–196.

Mika, B. (2019). Transgressing between consumption and production: Materialistic outlook on the digital labour of prosumers. *Capital & Class 43*(2), 339–356.

Rochet, J. C. and J. Tirole (2006). Two-sided markets: a progress report. *Rand Journal of Economics 37*(3), 645–667.

Sadowski, J. (2020). The internet of landlords: digital platforms and new mechanisms of rentier capitalism. *Antipode 52*(2), 562–580.

Weyl, E. G. (2010). A price theory of multi-sided platform. *American Economic Review 100*(4), 1642–1672.