

## Asymmetric Information and Ranked Information Are Equivalent in Making Information Utilization Heterogeneous

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### Abstract:

In information economics, any piece of information is assumed to have the same value across people, even if the information is distributed asymmetrically. However, in actuality, information has different values across people, even if it is distributed equally, because people utilize the same information differently and reach different conclusions with it. In this paper, I construct a model of heterogeneous information utilization by introducing the concept of ranked information. I conclude that the effects of asymmetric information and ranked information on economic activities are essentially equivalent. However, there are still some differences between them, and ranked information will be more economically important than asymmetric information. Furthermore, ranked information can cause an extreme economic inequality.

**Keywords:** asymmetric information; economic inequality; government intervention; heterogeneity; information retrieval; ranking.

**JEL Classification:** D60; D63; D80; D82; D83.

### Introduction

In information economics, any piece of information is assumed to have the same value across people, and therefore the main question in information economics is whether some persons can exclusively access and benefit from some pieces of information, a concept known as asymmetric information (e.g., Grossman and Stiglitz, 1980; Greenwald and Stiglitz, 1986; Edlin and Stiglitz, 1995; Stiglitz, 2017). In other words, it is assumed that when a piece of information is given, anybody can equally utilize it fully and correctly. However, does any piece of information truly have the same value for any person? Suppose that all information is equally given to and can be accessed by anybody. In this case, do all people utilize the information in the same manner? In actuality, they unquestionably utilize it quite differently. Some people look upon some pieces of information as important whereas others do not. This means that the estimated values of pieces of information will be different across people even if they have equal access to the same information.

Take cooking as an example. Pieces of information can be interpreted as ingredients. Even if they are common to anybody (any cook), the results after utilizing (cooking) them (i.e., dishes) differ across people. Even though the same ingredients are given, the dishes created vary widely, from delicious to unpalatable. Similar to cooking, even if the same information is provided, different people will utilize it differently, and the outcomes will also differ. Conversely, the value of the same piece of information differs across people, depending on how they utilize it.

An important point in information utilization is that the number of pieces of information currently available is enormous, practically infinite. Therefore, people must first narrow down the number of pieces of information that should be used for a particular purpose by carefully selecting important pieces of information. To adequately select important pieces of information, people should place pieces of information in order according to their importance for the purpose; that is, they should rank them. If a person ranks and selects pieces of information less well than others for the same purpose, that person's efficiency will be lower than others. Therefore, ranking and selecting pieces of information are very important activities when trying to achieve high levels of efficiency both as an individual and for the entire economy. I refer to these selected and ranked pieces of information as "ranked information," and in this paper examine the nature of ranked information and its effects on an economy.

Although asymmetric information has been intensively studied, to the best of my knowledge, there has been no study of ranked information or similar concepts in economics. Stiglitz (2002, 2017) discussed the endogeneity

of information, which is narrowly similar or related to the concept of ranked information. It means that information is not exogenous or fixed. It is changeable, depending on the behaviors of market participants. In the sense that information is affected and differentiated by people's behaviors, the concepts of ranked information and endogeneity of information may be common, but at the core, the two concepts are clearly completely different.

In other fields (e.g., computer science), information retrieval is an important issue and has been intensively studied (Collins, 2002; Harrington, 2003; Chiriță et al., 2005). Ranking is the key element in information retrieval, and many methods or models for information retrieval have been proposed. However, these studies, do not consider macroeconomic aspects and mostly focus on technological aspects of information retrieval, such as on Web sites.

I first examine information retrieval from the point of view of economics. To adequately rank and select pieces of information for a purpose, it is necessary first to roughly collect relevant pieces of information from among the numerous available pieces of information for a given purpose. Then, the collected pieces of information need to be evaluated and ranked, and a small number of important pieces of information will be selected from these.

The selected pieces of information and their ranks will differ across people. There will, however, be objectively "correct" ranks in the sense that the ranking and selection are correct if the probability of achieving a given purpose when utilizing them is highest among all possible ranks and selections. This means that, by comparing the chosen ranks and selections with the "correct" ones, the various ranks and selections can be evaluated.

Taking these natures of ranked information into consideration, I construct a model of ranked information. The model shows that the effects of asymmetric information and ranked information on economic activities are essentially equivalent. In addition, it also shows that a few people can rank and select pieces of information much better than others. Therefore, the productivities of a few people can be exceptionally high, and furthermore, they can obtain persistent economic rents and enjoy very high success rates of investment. Persistent economic rents and heterogeneous success rates of investment are problematic because they can lead to an extreme economic inequality through the mechanism shown in Becker (1980) and Harashima (2010, 2012a, 2017, 2020a, 2020d, 2021a) In this sense, ranked information is significantly important economically, and government plays a crucial role in preventing such an extreme economic inequality by appropriately redistributing incomes among households.

## **1 Ranked Information**

### **1.1 Utilization of Information**

At the present time, people can access many pieces of information, but only some of that information is useful for each particular purpose. Because it would be harmful to take too many pieces of information into consideration, people must select a small number of important pieces of information from the enormous number of available pieces for any given purpose. Furthermore, we have to use pieces of information with different levels of importance or "weights". The necessity of selecting pieces of information with importance weights can be easily understood if you think about using the Internet without a search engine (e.g., Google). Even if a person has access to a huge amount of information, the information is useless unless it is somehow properly sorted and selected by level of importance. Only after it is properly selected can information be usefully and fully utilized. That is, possessing many pieces of information is not enough unless a smaller number of important pieces of information is properly retrieved from the much larger group.

The necessity of selecting pieces of information by weighted importance means that there are ranks among pieces of information by purpose. To properly retrieve important pieces of information, it is first necessary to rank them according to their importance.

### **1.2 Retrieving and ranking information**

Even if people select important pieces of information for a common purpose, their selections will be quite different, much like different Web search engines generate different search results for the same topic. This occurs because people's abilities to rank and select pieces of information are highly likely to be heterogeneous. Furthermore, in addition to having different abilities, people will also differ in their tendencies or preferences when ranking and selecting pieces of information.

The ability to rank and select pieces of important information certainly depends on intelligence. In psychology and psychometrics, the importance of fluid intelligence and crystallized intelligence has been particularly emphasized. According to Cattell (1963, 1971), fluid intelligence is the ability to solve novel problems by thinking logically without only depending on knowledge previously acquired. By contrast, crystallized intelligence is the capacity to acquire and use knowledge or experience. The ability to rank and select pieces of important information seems to require both types of intelligence.

Roughly speaking, the process of ranking and selection will be divided into two steps. The first step is to roughly filter out pieces of information that are not thought to be related to the purpose. In the first step, some keywords first need to be chosen, similar to the case of searches with Web-search engines. The choice of keywords will require crystallized intelligence because, if a person does not know and remember the words and knowledge concerned, the person cannot properly choose keywords. Crystallized intelligence therefore plays an important role in the first step.

Many people may collect similar pieces of information for a common purpose in the first step, but the ranks and selections of pieces of information in the second step will largely differ across people even if they collected the same pieces of information in the first step because people have to carefully analyze and evaluate the collected pieces of information. To analyze and evaluate something, fluid intelligence is indispensable. In this sense, fluid intelligence plays an essential role in the second step. People's abilities to analyze and evaluate them (i.e., fluid intelligence) are highly likely to differ across people as with most other kinds of abilities. A person whose fluid intelligence is higher should be able to rank and select pieces of information more correctly than those whose fluid intelligences are lower. Note that the meaning of "correct" rank and selection in this context will be discussed more in detail in Section 2.1

### 1.3 Heterogeneity and Fluid Intelligence

#### Item Response Theory

Fluid intelligence can be modeled on the basis of item response theory, which is widely used in psychometric studies (e.g., Lord and Novick, 1968; van der Linden and Hambleton, 1997). In particular, the item response function is used to describe the relationship between abilities and item responses (e.g., test scores or performances). A typical item response function (Harashima, 2018) is:

$$p(\eta) = c + \frac{1 - c}{1 + \exp[-a(\eta - b)]}, \quad (1)$$

where  $p$  is the probability of a correct response (e.g., answer) to an item (e.g., test or question),  $\eta$  ( $-\infty > \eta > -\infty$ ) is a parameter that indicates an individual's ability,  $a$  ( $> 0$ ) is a parameter that characterizes the slope of the function,  $b$  ( $-\infty \geq b \geq -\infty$ ) is a parameter that represents the difficulty of an item, and  $c$  ( $0 \leq c \leq 1$ ) is a parameter that indicates the probability that an item can be answered correctly by chance.

#### Fluid Intelligence and the Probability of Correctly Ranking and Selecting Pieces of Information

As shown in Section 1.2, fluid intelligence plays an essential role in ranking and selecting pieces of information in the second step. Therefore, the probability of correctly ranking them and selecting important pieces of information can be described by the item response function.

By reinterpreting the variables in equation (1), the probability of people's correctly ranking and selecting important pieces of information can be modeled such that  $p(\eta)$  is this probability,  $\eta$  ( $-\infty > \eta > -\infty$ ) is a person's fluid intelligence,  $a$  ( $> 0$ ) is a constant,  $b$  is the difficulty of correctly ranking and selecting important pieces of information, and  $c$  ( $0 \leq c \leq 1$ ) is the probability that important pieces of information are correctly ranked and selected by chance. As is evident from this function, the higher the person's fluid intelligence (i.e., the higher the value of  $\eta$ ), the higher the probability of correctly ranking and selecting important pieces of information.

Raven's Progressive Matrices test has been regarded as the best test to measure fluid intelligence (Raven, 1962; Snow et al., 1984; Raven et al., 1998). The results of the Raven test repeatedly have indicated that the outcomes are heterogeneous across people, which means that fluid intelligences are also heterogeneous across them. Fluid intelligences are most likely normally distributed among people as with most other kinds of abilities. In any case, if fluid intelligences of people are distributed roughly around  $b$  (i.e., if the average  $\eta$  is roughly equal to  $b$ ), the Maclaurin series of equation (1) indicates that the distribution of the probabilities of correctly ranking and selecting important pieces of information can be approximated by a linearly increasing function of fluid intelligence.

## 2. Asymmetry in Utilization of Information

### 2.1. Correctness

There are many possible sets of selected pieces of information for each purpose, and for a given purpose, some sets have higher probabilities to achieve the purpose than others. Suppose here for simplicity that no set has the same probability as that of any other set for a given purpose. Hence, all sets can be ranked according to their probabilities, and there is a set that has the highest probability to achieve each purpose among all possible sets. Furthermore, as will be shown in the following sections, all individual pieces of information can be also ranked for

each purpose.

In addition, heterogeneity in these probabilities allows us to define the meaning of “correct” based on the ranks of sets. I define “correct” with regard to ranked information such that a set is deemed to be correct if its probability to achieve a purpose is the same as that of the top ranked set for that purpose. Furthermore, the correct ranks of pieces of information for a purpose are those that are consistent with the ranks of sets for the purpose.

Nevertheless, it may not be clear what “achieve a purpose” means. Roughly speaking, it means that under given constraints, an objective is met at the least cost in the shortest amount of time. In the case of an objective such as managing returns that are obtained in every period, the discounted present values of returns are considered in the same manner as expected utilities and asset prices. If there are multiple purposes for a person at the same time (e.g., short- and long-term purposes, or purposes for an individual, family, community, nation, and the entire world), for each purpose, the purposes other than that purpose are considered to be constraints on achieving that purpose. For simplicity, however, constraint conditions, discount rates, etc. are assumed to be the same for any person if the purpose is the same.

In addition, the meaning of “correct” as defined above contains some uncertainties or ambiguities. What many people believe to be correct at present may not actually be correct. Theories that are believed to be correct by many people may change over time. Nevertheless, even though such uncertainties clearly do actually exist, it is assumed for simplicity in this paper that a set that is always correct for anybody exists for any purpose.

## 2.2 The model of Ranked Information

I refer to a piece of information as “Inf-piece.” A serial number  $q \in \mathbb{N}$  is assigned to each Inf-piece, and let  $IP_{i,q}$  be an Inf-piece with the serial number  $q$  for purpose  $i$ . Furthermore, I refer to a set of Inf-pieces as “Inf-set.” It is assumed for simplicity that all Inf-sets consist of  $n$  Inf-pieces. Let  $IS_i$  be the Inf-set that is selected for purpose  $i$  from among all existing Inf-pieces. Let  $IS_{i,q}$  indicate that Inf-piece  $q$  (i.e.,  $IP_{i,q}$ ) is included in  $IS_i$ .

In addition, let  $y(\cdot)$  be the Inf-set production function, where the production function represents the probability to achieve a purpose. A higher value of  $y$  for an Inf-set corresponds to a higher probability that the Inf-set will achieve the purpose; therefore, the Inf-set is more correct than Inf-sets with lower values of  $y$ . It is assumed that for purpose  $i$ , if the Inf-pieces in  $IS_{i,s}$  and  $IS_{i,r}$  are identical except for  $IP_s$  and  $IP_r$  and  $s < r$ , then:

$$y(IS_{i,s}) > y(IS_{i,r}) \tag{2}$$

for any  $s$  and  $r$ . Inequality (2) implies that an Inf-piece has a particular value that depends on its serial number such that the value of an Inf-piece is larger, if its serial number is smaller.

Suppose that each Inf-piece has a particular value, and the value of an Inf-set is equal to the sum of values of Inf-pieces of which the Inf-set consists. Note that the value of an Inf-piece is different from the serial number  $q$  assigned to it. On the basis of inequality (2), I define the relative value of  $IS_{i,q}$  such that, if  $y(IS_{i,s}) > y(IS_{i,r})$ , then,

$$IS_{i,s} > IS_{i,r} \tag{3}$$

for any  $s$  and  $r$ . By inequality (3), the relative value of  $IP_{i,q}$  is indicated such that, for purpose  $i$ , if  $y(IS_{i,s}) > y(IS_{i,r})$ , then,

$$IP_{i,s} > IP_{i,r} \tag{4}$$

because the value of an Inf-set is equal to the sum of values of Inf-pieces of which the Inf-set consists, and  $IS_{i,s}$  and  $IS_{i,r}$  are identical except for  $IP_s$  and  $IP_r$ . Inequality (3) means that  $IS_{i,s}$  is more correct for purpose  $i$  than  $IS_{i,r}$ , and inequality (4) means that  $IP_{i,s}$  is more important for purpose  $i$  than  $IP_{i,r}$ .

If inequalities (3) and (4) hold for any  $s$  and  $r$  for purpose  $i$ , the absolute value of  $IP_{i,q}$  is a decreasing function of  $q$  for purpose  $i$ . This means that  $IP_{i,q}$  can be ranked by  $q$  for purpose  $i$ . Therefore, if the serial numbers of Inf-pieces are appropriately assigned for each purpose such that the serial number of  $IP_{i,q}$  is equal to its rank for purpose  $i$ , the rank of  $IP_{i,q}$  for purpose  $i$  is  $q$ . In this case, the value of  $IP_{i,q}$  is an increasing function of  $N - q$  where  $N$  is the lowest rank; that is, it increases as the rank of Inf-piece  $q$  rises. In the following sections, it is assumed that the serial numbers are assigned as such.

### 2.3 Rank – Size Distribution

How the values of Inf-pieces are distributed over their ranks is an empirical question. However, it seems likely that the value of  $IP_{i,q}$  will be described by an exponentially increasing function of  $N - q$ .

#### Exponentially Increasing Value of Information Set

Suppose that there is a total of  $N$  Inf-pieces in an economy, and for any purpose, each Inf-set consists of  $n$  Inf-pieces selected from among the  $N$  Inf-pieces. There are many possible combinations of  $n$  Inf-pieces in an Inf-set. Suppose that the number of possible combinations in which Inf-piece with rank  $q$  is included in an Inf-set as one of  $n$  Inf-pieces is  $\Lambda$  for any purpose. A serial number is assigned to each of  $\Lambda$  possible combinations in order from 1 to  $\Lambda$ . Note that the number of possible combinations is commonly  $\Lambda$  for any  $q$ , Inf-set, and purpose. Let  $\tilde{IS}_{i,q}$  be the average value of Inf-sets in which Inf-piece with rank  $q$  is included, and let  $IS_{i,q,\lambda}$  be the value of Inf-set that corresponds to combination  $\lambda$  ( $\in \Lambda$ ). Hence,

$$\tilde{IS}_{i,q} = \Lambda^{-1} \sum_{\lambda=1}^{\Lambda} IS_{i,q,\lambda} .$$

Because the impact of a higher rank Inf-piece on  $\tilde{IS}_{i,q}$  will be larger than that of a lower rank Inf-piece, it seems likely that:

$$\tilde{IS}_{i,q} - \tilde{IS}_{i,q+1} > \tilde{IS}_{i,q+1} - \tilde{IS}_{i,q+2} . \quad (5)$$

That is, the increase in the average value of Inf-set when rank  $q + 1$  Inf-piece is replaced with rank  $q$  Inf-piece is larger than that when rank  $q + 2$  Inf-piece is replaced with rank  $q + 1$  Inf-piece. Of course, there will be many cases that do not actually satisfy inequality (5), but inequality (5) seems to be satisfied in general because the top rank Inf-piece seems to be by far the most important and useful in many cases.

Inequality (5) indicates that the value of Inf-set can be approximated by an exponentially increasing function of  $N - q$ ; that is,  $\tilde{IS}_{i,q}$  increases exponentially as the rank of Inf-piece  $q$  rises. Furthermore, if the production function  $y(\cdot)$  is a monotonously increasing function of the value of  $IS_{i,q}$ , the average value of  $y(IS_{i,q})$  can be also approximated by an exponentially increasing function of  $N - q$ ; that is, it increases exponentially as the rank of Inf-piece  $q$  rises.

#### Exponentially Increasing Value of Information Piece

If inequality (5) holds, the value of  $IP_{i,q}$  can also be approximated by an exponentially increasing function of  $N - q$ .  $\tilde{IS}_{i,q}$  can be divided into two parts: one is attributed to the Inf-sets in which Inf-piece with rank  $q + 1$  is included, and the other is attributed to the Inf-sets in which Inf-piece with rank  $q + 1$  is not. Let  $\tilde{IS}_{i,q,q+1}$  be the former and  $\tilde{IS}_{i,q,q}$  be the latter. Thereby,

$$\tilde{IS}_{i,q} = \tilde{IS}_{i,q,q+1} + \tilde{IS}_{i,q,q} . \quad (6)$$

$\tilde{IS}_{i,q+1}$  can similarly be divided into two parts: one attributed to the Inf-sets in which Inf-piece with rank  $q$  is included and the other in which Inf-piece with rank  $q$  is not. Let  $\tilde{IS}_{i,q+1,q}$  be the former and  $\tilde{IS}_{i,q+1,q+1}$  be the latter. Thereby,

$$\tilde{IS}_{i,q+1} = \tilde{IS}_{i,q+1,q} + \tilde{IS}_{i,q+1,q+1} . \quad (7)$$

Because the Inf-sets in which both Inf-pieces with ranks  $q$  and  $q + 1$  are included in Inf-set are common in  $\tilde{IS}_{i,q}$  and  $\tilde{IS}_{i,q+1}$ , then

$$\tilde{IS}_{i,q,q+1} = \tilde{IS}_{i,q+1,q} . \quad (8)$$

By equations (6), (7), and (8),

$$\tilde{IS}_{i,q} - \tilde{IS}_{i,q+1} = \tilde{IS}_{i,q,q} - \tilde{IS}_{i,q+1,q+1} \quad (9)$$

for any  $q$ . Therefore, by equation (9) and inequality (5),

$$\tilde{IS}_{i,q,q} - \tilde{IS}_{i,q+1,q+1} > \tilde{IS}_{i,q+1,q+1} - \tilde{IS}_{i,q+2,q+2} . \quad (10)$$

Inequality (10) means

$$IP_{i,q} - IP_{i,q+1} > IP_{i,q+1} - IP_{i,q+2} \quad (11)$$

Inequality (11) indicates that the value of Inf-piece can be approximated by an exponentially increasing function of  $N - q$ ; that is, the value of  $IP_{i,q}$  increases exponentially as the rank of Inf-piece  $q$  rises.

### 2.4 Heterogeneity in Information Sets

#### Distance of Information Set

Inf-sets other than the top rank Inf-set for a purpose are interpreted to be deviating from the correct Inf-set (i.e., the top rank Inf-set). The distance between each Inf-set and the correct Inf-set can be defined as follows.

As assumed above, each Inf-set consists of  $n$  Inf-pieces. A serial number is assigned to each Inf-set, and let  $\theta_{i,h}$  be Inf-set with the number  $h (\in \mathbb{N})$  for purpose  $i$ . Here, let  $IS_{i,q} |_{\theta_{i,h}} = \sum_{IP_{i,q} \in \theta_{i,h}} IP_{i,q}$  and  $IS_{i,q} |_{q=1,2,\dots,n} = \sum_{q=1}^n IP_{i,q}$ ; that is,  $IS_{i,q} |_{\theta_{i,h}}$  means the value of Inf-set  $h$  (i.e.,  $\theta_{i,h}$ ), and  $IS_{i,q} |_{q=1,2,\dots,n}$  means the value of Inf-set that consists of the top  $n$  Inf-pieces for purpose  $i$ . The "distance of Inf-set" (DIS) of Inf-set  $\theta_{i,h}$  is defined by:

$$D_{i,h} = 1 - \frac{y \left( IS_{i,q} |_{\theta_{i,h}} \right)}{y \left( IS_{i,q} |_{q=1,2,\dots,n} \right)} = 1 - \frac{y \left( \sum_{IP_{i,q} \in \theta_{i,h}} IP_{i,q} \right)}{y \left( \sum_{q=1}^n IP_{i,q} \right)} \quad (12)$$

Equation (12) indicates that the DIS of Inf-set  $\theta_{i,h}$  ( $D_{i,h}$ ) is the magnitude of deviation of  $\theta_{i,h}$  from the top rank Inf-set (i.e., the Inf-set whose value is largest for purpose  $i$ ). As Inf-pieces with lower ranks (larger  $q$ ) are included in Inf-set  $\theta_{i,h}$ , its DIS (i.e.,  $D_{i,h}$ ) increases. If the top  $n$  Inf-pieces are all included in Inf-set  $\theta_{i,h}$  (i.e.,  $\sum_{IP_{i,q} \in \theta_{i,h}} IP_{i,q} = \sum_{q=1}^n IP_{i,q}$ ),  $D_{i,h} = 0$ .

#### Average Distance

Let  $\theta_{i,m}$  be the set of all Inf-sets in which the highest rank Inf-piece is commonly  $IP_{i,m}$ . In addition, let  $D_{i,m}$  be the average DIS of  $\theta_{i,h} \in \theta_{i,m}$  such that

$$D_{i,m} = E \left( D_{i,h} |_{\theta_{i,m}} \right), \quad (13)$$

where:  $E$  is an operator and means that  $D_{i,m}$  is the average DIS of all Inf-sets that are included in  $\theta_{i,m}$ . Evidently, if  $m > l$ ,  $D_{i,m} < D_{i,l}$ . That is,  $D_{i,m}$  is a decreasing function of the value of  $IP_{i,m}$ , which means that it is an increasing function of  $D_{i,m}$  because  $D_{i,m}$  is a decreasing function of  $IP_{i,m}$ . Because  $D_{i,m}$  and  $IP_{i,m}$  similarly decrease as  $IP_{i,m}$  increases,  $D_{i,m}$  will basically be linearly proportional to  $D_{i,m}$ .

#### Correct Selection

The degree of correct selection (DCS) is defined as:

$$C_{i,m} = 1 - D_{i,m} \quad (14)$$

That is,  $C_{i,m}$  means how correct a selected Inf-set is when the highest rank inf-piece in the Inf-set is  $IP_{i,m}$ .

Here, as shown in Section 2.3, the value of  $IP_{i,q}$  can be approximated by an exponentially increasing function of  $N - q$ . Taking this property into consideration, the average value of Inf-sets that are included in  $\theta_{i,m}$  can be most simply modeled by:

$$E \left( IS_{i,q} |_{\theta_{i,m}} \right) = \frac{v}{e^{wm}} \quad (15)$$

and

$$\sum_{q=1}^n IP_{i,q} = \chi E \left( IS_{i,q} |_{\theta_{i,1}} \right) = \chi \frac{v}{e^w}, \quad (16)$$

where:  $v$ ,  $w$ , and  $\chi (> 1)$  are positive constants.  $\sum_{q=1}^n IP_{i,q}$  in equation (16) indicates the value of the top rank Inf-set for purpose  $i$  as shown in equation (12).

In addition, the production function is modeled most simply such that:

$$E \left[ y \left( IS_{i,q} | \theta_{i,m} \right) \right] = y \left[ E \left( IS_{i,q} | \theta_{i,m} \right) \right] = x \left[ E \left( IS_{i,q} | \theta_{i,m} \right) \right]^z, \quad (17)$$

where:  $x$  and  $z$  ( $0 < z < 1$ ) are positive constants. By equations (12), (13), (15), (16), and (17), therefore,

$$D_{i,m} = E \left( D_{i,h} | \theta_{i,m} \right) = 1 - \chi^{-z} e^{1-m}. \quad (18)$$

Hence, by equations (14) and (18),

$$C_{i,m} = 1 - D_{i,m} = \chi^{-z} e^{1-m}. \quad (19)$$

Equation (19) means that  $C_{i,m}$  is most likely approximately an exponentially increasing function of  $N - m$ ; that is, DCS exponentially increases as the rank of Inf-piece  $IP_{i,m}$  rises.

## 2.5. Asymmetry in the Utilization of Information

As shown in Section 1.3.2, a person's probability of correctly selecting pieces of information will be generally correlated positively and linearly with the person's fluid intelligence. On the other hand, as shown before, DCS will generally increase exponentially as the rank of the highest rank Inf-piece in Inf-set rises. Hence, it seems likely that the DCS of the Inf-set that a person selects is roughly correlated positively with the person's fluid intelligence and increases exponentially as it increases.

This correlation means that people are substantially heterogeneous with regard to information utilization, *i.e.*, a few people with very high fluid intelligences can enjoy exceptionally high probabilities of correctly ranking and selecting pieces of information because fluid intelligences most likely have a normal distribution over people as with most other kinds of abilities. An important point is that even if the same information is equally given to all people for an identical purpose, they are heterogeneous in utilizing the information. In other words, information is asymmetric in its utilization across people.

## 3. Asymmetric and Ranked Information

### 3.1. Equivalence

#### Imperfectly Utilizable Information

In the case of asymmetric information, even if two persons have the same ability to utilize information, one of them cannot access a part of the information but the other can. On the other hand, in the case of ranked information, although the same information is equally given to two persons, one of them cannot utilize it as adequately as the other. Even though this difference exists, however, asymmetric information and ranked information are essentially common in that they conceptually deal with heterogeneity in the utilization of information among people.

Because of this commonality, the problems caused by asymmetric information (e.g., moral hazard and adverse selection) are also basically generated by ranked information. Because moral hazard and adverse selection are problems caused by heterogeneity in information utilization itself, both asymmetric information and ranked information equivalently generate these problems even if their generation mechanisms of heterogeneity in information utilization are different. In this sense, asymmetric information and ranked information can be seen to be essentially equivalent.

An important point is that these problems will be more widespread than previously thought because they are generated by both asymmetric and ranked information. Heterogeneities in information utilization probably almost always exist in any business dealings.

#### Moral Hazard

Suppose that a principal has a relatively low ability to correctly rank and select Inf-pieces (hereafter, "ranking ability"). Because of this low-ranking ability, the principal may not sufficiently verify the efforts of agents. Hence, a problem of moral hazard may occur.

#### Adverse selection

Suppose that a principal has a relatively low-ranking ability, and the principal has to choose an agent from two candidates who are different only with regard to the disutility of effort. Because of the low-ranking ability, the principal may not distinguish the two candidates. Hence, a problem of adverse selection may occur.

### Signaling

As with the case of asymmetric information, signaling will be effective in the case of ranked information. If some particular kinds of signals from an agent are included in the information that the principal receives, the principal may more adequately understand what the provided information means.

### Screening

As with the case of asymmetric information, screening will be also effective for problems caused by ranked information. If a principal implements some kinds of screening, he or she may more adequately understand what the received information means.

### 3.2. Differences: Repetition and reputation

Nevertheless, asymmetric information and ranked information are not necessarily always equivalent. Some problems caused by asymmetric information can be mitigated if the same kind of contract is repeated and/or some agent reputation is formed because repetition and reputation can remove a part of the private information that agents possess. Can the problems caused by ranked information also be mitigated by repetition and reputation? Ranked information generates problems because people's ranking abilities differ and some have a low-ranking ability. Therefore, if repetition and reputation can raise a person's ranking ability, the problems caused by ranked information may also be mitigated by them. However, mitigating the problems caused by ranked information by these means will be more difficult than in the case of asymmetric information.

Regardless of a principal's ranking ability, the principal will learn some new knowledge if the same kind of contract is repeated and/or some agent reputation is formed, but the agents will also learn the same knowledge. That is, regardless of repetition and reputation, the information that the principal and agents have is the same. On the other hand, the principal's ranking ability itself does not change with repetition and reputation. Hence, the agents can still outwit the principal by exploiting opportunities that the principal's low-ranking ability provide, even after contracts are repeated and/or reputation is formed. The ways an agent may outwit may change over time depending on the information that the principal and agents have at that time, but the ability to outwit will continue because of the ranking ability of the principal does not change. As a result, unlike the case of asymmetric information, it will be more difficult to mitigate the problems through repetition and reputation in the case of ranked information.

### 3.3. Independence

Even if the effects of asymmetric information and ranked information are essentially equivalent, they are independent of each other. There is no correlation between them. Even if there is no asymmetric information, ranked information can exist and vice versa. If they both exist at the same time, their effects will be multiplied, not cancelled.

## 4. Inefficiency, Rent, and Economic Inequality

Important aspects of ranked information are not limited to its heterogeneity across people. Its negative effects on the economy (e.g., inefficiencies) are also important because DCS ( $C_{\theta,i,q}$ ) is not unity in many cases for most people. Furthermore, economic inequality also matters because, as shown in Section 2.5, a few people with very high fluid intelligences can enjoy exceptionally high probabilities of correctly ranking and selecting pieces of information.

### 4.1 Inefficiency

#### Effects on Productivity

Because asymmetric information and ranked information have common natures as shown in Section 3, ranked information can cause the same kinds of inefficiency as asymmetric information. From the macro-economic point of view, these inefficiencies are observed as a decline of productivity.

In the model of total factor productivity developed in Harashima (2009, 2012b, 2016, 2020b), the production function is described as:

$$Y = \bar{\sigma} \omega_A \omega_L A^\alpha K^{1-\alpha} L^\alpha,$$

where: Y is outputs, K is capital inputs, L is labor inputs,  $\alpha$  is a constant and indicates labor share, A indicates technologies (mostly scientific technologies),  $\omega_A$  and  $\omega_L$  indicate productivities of laborers with regard to technology and labor inputs respectively, and  $\bar{\sigma}$  indicates the accessibility to capital and represents the efficiency of various kinds of economic and social institutions and systems. Hence, productivities are divided

into three elements in this production function:  $A$ ,  $\omega_A$  and  $\omega_L$ , and  $\bar{\sigma}$ .

Among these three elements,  $A$  is basically irrelevant to ranked information because it represents the total amount of knowledge and technologies (largely scientific ones) in an economy. The total amount of knowledge and technologies itself is not changed by how each person personally ranks and selects pieces of information. On the other hand, the elements  $\omega_A$  and  $\omega_L$  and  $\bar{\sigma}$  will matter.

Effects on  $\omega_A$  and  $\omega_L$

Productivities of laborers ( $\omega_A$  and  $\omega_L$ ) are significantly influenced by fluid intelligence, as shown in Harashima (2009, 2012b, 2016, 2020b), because they reflect the abilities of laborers to solve unexpected problems in each production site. Hence, these productivities are heterogeneous across laborers. This means that fluid intelligence influences not only ranked information but also these productivities of laborers. Nevertheless, how are fluid intelligence, ranked information, and productivities of laborers related to each other? If the factor of fluid intelligence is already incorporated in  $\omega_A$  and  $\omega_L$ , ranked information may not additionally affect  $\omega_A$  and  $\omega_L$  through the channel of fluid intelligence.

If the information used when laborers solve unexpected problems by creating innovations is ranked, however, this means that  $\omega_A$  and  $\omega_L$  are affected through the channel of ranked information. If the value of ranked information used for solving unexpected is higher, better innovations will be created. That is, the influence of fluid intelligence on  $\omega_A$  and  $\omega_L$  can be divided into two phases; in the first phase, pieces of information are ranked and selected, and in the second, innovations are created based on the ranked information. In both phases, fluid intelligence is used and plays important roles. Furthermore, the direction of effects of fluid intelligence is the same in both phases. That is, if a person's fluid intelligence is higher, pieces of information are more correctly ranked and selected and better innovations are created. As a result, the person's productivity is higher.

Effects on  $\bar{\sigma}$

If the average DCS of Inf-sets selected by all people in an economy for all purposes is lower, the value of  $\bar{\sigma}$  of the economy will be lower because  $\bar{\sigma}$  is affected by fluid intelligence, and a lower average DCS conversely means a lower average fluid intelligence. In this sense, ranked information also affects  $\bar{\sigma}$ . However, the influence of fluid intelligence on  $\bar{\sigma}$  will also be divided into two phases in a similar manner to the case of  $\omega_A$  and  $\omega_L$ .

#### 4.2 Heterogeneous Success Rates of Investment

Fluid intelligence is also related to another kind of inefficiency. If it is lower, the success rate of investment will be lower, as indicated in Harashima (2021b). Taking ranking ability into consideration, the influence of fluid intelligence on the success rate of investment will be also divided into two phases as with the cases of  $\omega_A$ ,  $\omega_L$ , and  $\bar{\sigma}$ . If the ranking ability of a person who undertakes an investment is lower, DCS with regard to an investment is lower; therefore, information is less properly utilized. Because of both lower fluid intelligence and less proper information utilization, the person more often misjudges demand, makes costs overrun, and loses out in competition with rivals, and as a result, the probability of failure of the investment increases. Therefore, ranked information multiplies the magnitude of heterogeneity in the success rates of investment.

#### 4.3 Rents from Mistakes

Economic Rents from Mistakes in Business Dealings

Ranked information generates economic rents because it can increase the probability of making mistakes in business dealings. Harashima (2020c) showed that mistakes in business dealings generate economic rents such that a winner in a deal can receive a payment that exceeds the costs needed to receive it. The probabilities of making mistakes in business dealings are heterogeneous among people because fluid intelligences crucially influence the probabilities. In addition, these rents are generally not temporary but persistent because they are rooted in fluid intelligence.

If the ranking ability of a person is lower than that of other people, the person probably makes more mistakes in business dealings than others, and therefore provides the other parties with more economic rents than others. The economic rents due to ranked information will exist widely and in large amounts because ranking abilities are heterogeneous across people and therefore ranked information will play an important role for almost all business dealings and contracts. In this sense, ranked information will be very important economically.

The Model of Mistakes in Business Dealings

How mistakes in business dealings generate economic rents is modeled in Harashima (2020c). Suppose

that there are two economic agents, Agent 1 and Agent 2. The two agents are identical except for their fluid intelligences: the fluid intelligence of Agent 1 is higher than that of Agent 2. Suppose that the probability that a proposal is advantageous to Agent 1 is  $x$  ( $0 < x < 0.5$ ) and the probability that it is advantageous to Agent 2 is also  $x$  ( $0 < x < 0.5$ ). It is assumed that the probability that Agent  $i$  ( $= 1, 2$ ) judges that a proposal is advantageous even if it is actually disadvantageous is  $p_i$ , and the probability that Agent  $i$  wrongly judges that it is disadvantageous even if it is actually advantageous is also  $p_i$ . In addition, if a proposal is neither advantageous nor disadvantageous to both agents, the probability that Agent  $i$  wrongly judges that it is disadvantageous is  $0.5p_i$ , and the probability that Agent  $i$  wrongly judges that it is advantageous is also  $0.5p_i$ . Because the fluid intelligence of Agent 1 is higher than that of Agent 2,  $p_2 > p_1$ . In addition, suppose that Agent 1 is honest with the probability  $q_1$  ( $0 \leq q_1 \leq 1$ ) and dishonest with the probability  $1 - q_1$ , and Agent 2 is honest with the probability  $q_2$  ( $0 \leq q_2 \leq 1$ ) and dishonest with the probability  $1 - q_2$ .

If an agreement is objectively a win for Agent  $i$  (i.e., an advantageous deal), Agent  $i$  obtains the economic rents from that deal. Let  $z$  be the amount of these rents, and suppose that  $z$  is identical for any agreement. Conversely, if a deal is objectively a defeat for Agent  $i$ , Agent  $i$  suffers losses equivalent to  $-z$  for any agreement. Harashima (2020c) showed that the expected economic rents of Agent 1 in a business deal,  $E(Z_1)$ , are:

$$E(Z_1) = zx\{p_2 - p_1 + q_2p_1 - q_1p_2 + p_1p_2[q_2p_2 - q_1p_1 + 2(q_1 - q_2)]\}, \quad (20)$$

and those of Agent 2,  $E(Z_2)$ , are similarly,

$$E(Z_2) = zx\{p_1 - p_2 - q_2p_1 + q_1p_2 + p_1p_2[q_1p_1 - q_2p_2 - 2(q_1 - q_2)]\}. \quad (21)$$

Equations (20) and (21) indicate that if both Agents 1 and 2 are always dishonest (i.e.,  $q_1 = q_2 = 0$ ), Agent 1 persistently obtains the economic rents. However, even if both agents are always honest, Agent 1 persistently obtains economic rents and Agent 2 is persistently exploited because  $p_2 > p_1$ . As Agent 1 is more often honest (i.e., as  $q_1$  increases), the economic rents of Agent 1  $E(Z_1)$  decrease, and as Agent 2 is more often dishonest (i.e., as  $q_2$  decreases), the rents of Agent 1 also decrease.

#### Ranked Information and Mistakes

Ranked information will affect the probability of making a mistake ( $p_i$ ) because mistakes are influenced by fluid intelligence. A higher DCS clearly brings a lower probability of making a mistake  $p_i$ . Hence, equations (20) and (21) indicate that heterogeneous fluid intelligences across people result in disparity between the people who obtain economic rents because of lower values of  $p_i$  (i.e., higher fluid intelligences) and the others who are exploited because of higher values of  $p_i$  (i.e., lower fluid intelligences). As the fluid intelligence of a person is higher, the number of economic rents the person can obtain is greater and vice versa. That is, even if the same information is given, economic rents as well as inefficiency are generated due to ranked information. On the other hand, it seems unlikely that the degree of honesty  $q_i$  is affected by ranked information.

#### 4.4. Economic Inequality

##### Economic Inequality in Static Model

As shown in Section 2.4, it seems likely that the DCS of Inf-set selected by a person increases exponentially as the person's fluid intelligence increases. In addition, fluid intelligence quite likely has a normal distribution over people as with most other kinds of abilities. With these features, it seems highly likely that a very few people with very high fluid intelligences select exceptionally more correct Inf-sets for most purposes; therefore, this select group of people can enjoy exceptionally high productivities and large amounts of economic rents. That is, because of information ranking, the level of economic inequality will be increased. An important point is that even if the same information is equally given to all people, economic inequality will still be increased.

##### Economic Inequality in a Dynamic Model

However, a far more important and serious problem emerges if economic inequality is considered in the framework of a dynamic economic model. That is, heterogeneities caused by ranked information can result in an extreme economic inequality. As Becker (1980) and Harashima (2010, 2012a, 2017, 2020a, 2020d, 2021a) showed, in dynamic economic models, heterogeneous rates of time preference, degrees of risk aversion, persistent rents, and success rates of investment result in extreme economic inequalities if they are left as they are; that is, all capital will eventually be possessed by the most advantaged household. Among these four factors, heterogeneous persistent rents and success rates of investment are generated by ranked information, as shown in Sections 4.2 and 4.3. That is, ranking information can cause an extreme economic inequality.

To prevent such extreme economic inequality, therefore, appropriate government interventions are indispensable, as shown in Harashima (2012a, 2020a, 2020d, 2021a). That is, ranked information requires decisive government intervention for a society to stay stable persistently.

An important point is that the factors that can mitigate the problems caused by asymmetric information are not necessarily similarly useful for the problems caused by ranked information. As shown in Section 3.2.2, some problems caused by asymmetric information can be mitigated by repetition and reputation, but mitigating problems in the case of ranked information is not as easy. In this sense, it is crucially important for a government to intervene to solve the problems caused by ranked information.

Note that the heterogeneity in productivities  $\omega_A$  and  $\omega_L$  or  $\bar{\sigma}$  caused by ranked information does not result in an extreme economic inequality in dynamic economic models, although they do generate static economic inequalities to some extent.

### Concluding Remarks

In information economics, any piece of information is assumed to have the same value across people, but in actuality, it will not because even if the same information is given, people will utilize it differently. On the other hand, the number of available pieces of information is enormous, and therefore we must narrow down the number of pieces of information that is used for each purpose and rank pieces of information. If a person less adequately ranks and selects pieces of information than others when the purpose is the same, the person's efficiency will be lower than that of others. Therefore, how we rank pieces of information and what pieces of information are selected as important will be very important to achieve high efficiencies both for an individual and the entire economy.

To adequately rank and select important pieces of information, it is necessary first to roughly collect relevant pieces of information and then to evaluate and rank the collected pieces of information and select a small number of important pieces of information from among the collected pieces. Ranks can be more or less correct in the sense that, for a given purpose, ranks and selection are correct if the probability to achieve the purpose when using them is the highest. Hence, various ranks and selections can be evaluated by comparing them with the correct ranks and selections.

Taking these natures of ranked information into consideration, I construct a model of ranked information. The model shows that the effects of asymmetric information and ranked information on economic activities are essentially equivalent. In addition, it also shows that a few people can exceptionally correctly rank and select pieces of information. Therefore, a few people can exhibit very high economic performances, particularly obtain persistent economic rents, and enjoy very high success rates of investment, but this is problematic because an extreme economic inequality can be generated through the mechanism shown in Becker (1980) and Harashima (2010, 2012a, 2017, 2020a, 2020d, 2021a). In this sense, ranked information is significantly important economically, and the role of government to prevent such an extreme economic inequality by appropriately redistributing incomes among households is crucially important and indispensable.

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