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# How do we keep proper level of content diversity?

: The influence of the gigantic platform on content diversity

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## Abstract

This paper aims to study the origin of the role of diversity in the new ICT ecosystem, and show how the gigantic platform influences on the level of diversity of content. Using genetic algorithm, it makes possible to reflect the new ICT ecosystem and experiment how the system is changing content diversity. The novelty of this method is introducing the new measurement of content diversity which is from the genotype diversity in artificial evolution area. The result of the experiments shows that the exposed diversity of content seems to be maintained, but the genuine diversity of content is decreased gradually and disappeared in the end. In addition, the average performance is also decreased in the long run. This clearly shows that decreasing diversity of content is not perceived as much of problem for the present; however, it will generate a big problem if the regulator does nothing to solve this problem. Therefore, this paper insists that diversity, which is reservoir of creativity and the power of sustainable growth in the new ICT ecosystem, must be kept properly and this is the very first step for settling the new standard. This might contribute for policy makers to give them wisdom by which criteria they can look at the reality in this rapidly changed technology and business environment and we hope more empirical studies are coming with it.

*Keywords:* content diversity, platform, ICT ecosystem, sustainability

## *1. Introduction*

Digitalization and the development of the internet and mobile technology have changed the human life (Castells, 2011). Nowadays, most of people consume various contents in digital form. In addition, as the mobile communication technology and the smart-devices are diffused by users rapidly, digital content are getting more approachable to the consumers. This process makes information and communication technology (henceforth, ICT) ecosystem, which consist of content, platform, network, device providers and users (henceforth, C-P-N-D-users), be connected closely each other and there are symbiotic relationships among the layers (Fransman, 2010).

However, all relationships among layers have not always been equal. It was the network layer which got the leadership of the initial phase of the ICT ecosystem. Since network business was a huge infrastructure business, it was the national level challenge and even consumers had no idea about the usefulness of digital content and web or mobile platform before experiencing the convenience of using network like broadband and mobile network (Fransman, 2010; p. 107). Therefore, it was possible for natural monopoly to be existed. Next leadership of the ICT ecosystem was taken by device layer as emerging the smart phone era. The innovation of smart phone, started by Apple. Inc., had aroused the consumers' enthusiasm and it made all users get their own smart devices. Recently, the leadership seems to belong to platform providers. They took a role of bridge mediating between content providers and consumers. They are invisible but the influence is getting large in the ICT ecosystem because of their unique and high necessary position (Hargittai, 2004).

As considering of previous U.S. regulation policy, government had prevented one firm's natural monopoly of network business from the new entries. The only firm supported by government was able to have incentive to innovate the new network technology because it was impossible that the initial cost for infrastructure was covered only by profit without being supported by government. After the monopolistic network provider was getting large, the government allowed new entries to enter, making the power of market be harmonized. In the case of the platform layer, however, there is no right to regulate the platform like network layer because the regulator cannot see the markup superficially and there seems to be no entry barrier, which is too high to see the height (Hargittai, 2007). Furthermore, it could be more serious problem since it is not about fashion or matter of durability, which is going to be back when time goes by, like device layer. Regardless of the monopoly issue, the most serious

problem is decreasing content diversity (Doyle, 2010; Napoli & Karppinen, 2013). As platform providers are huger, the role of selecting content is moving from consumers to the platform and this can drive the content diversity lower. NHN is a portal site with search engine and it has the most share of the market in South Korea<sup>1</sup>, however, it plays the role of content and media platform rather just providing a service of searching information. Most of people in Korea start their life with the first page of the portal and access the most of information through it. The role of selecting news, blogs, and web content and media is not played by consumers but by the platform. Few content selected by the platform would get more profit but most content not selected by the platform would be disappeared (Doyle, 2010; Hargittai, 2000). Consumers are likely to know that they could search the information or content exactly which they want to find, but the information or content on the platform is hardly enough to meet the consumers' hidden needs. As the platform is getting large, platform selects the content which could not only meet consumers' needs but also compensate platform's profit.

There are still arguing whether the government has the right of regulating a platform or not (Ballon & Van Heesvelde, 2011). Consumers has some onerousness with changing a platform in order to find the content they want (Xu, Venkatesh, Tam, & Hong, 2010) and they might be taken off searching burden if a huge platform recommends the similar content which consumers are likely to like. Furthermore, previous diversity measurements have been the exposed size of population like the number of content or genre, and these are always increasing trend (Champion, Doyle, & Schlesinger; Napoli, 2011a, 2011b). Therefore, it requires a study to put the problem, which cannot be seen outwardly, under microscope. The origin of content layer is art and culture. This kind of creative industry could not be raised by biased selection but by maintaining diversity and encouraging trial and error (Doyle, 2010, 2013). Therefore, the effect of disappearance of diversity on content layer would gradually make the whole ICT ecosystem sick. In this situation, this paper proposes such questions: Can the huge giant who has proximity with consumers play the game with small and medium size-content providers fairly? Could they be the good giant who would fairly regulate themselves and maintain appropriate diversity in the ecosystem? If not, how has the content diversity been changed with time and how will it be changed in the future?

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<sup>1</sup> 73.4% of market share in search engine area (2013. 12)

This paper aims to study the origin of the role of diversity in the new ICT ecosystem, and show how the platform influences on the level of diversity of content. Using genetic algorithm, it makes possible to reflect the new ICT ecosystem and experiment how the system is changing content diversity. To analyze the dynamics of the complex system, simulation is more powerful tool than empirical analysis using revealed data and the systemic approach can give us the wisdom of future which even big data cannot show<sup>2</sup>. This paper put the various content providers and a platform on the system and makes them evolve dynamically from entry of new content and selection by the platform; to imitating the best performer which meets the consumers' needs best by other content providers. The novelty of this method is introducing the new measurement of content diversity which is from the genotype diversity in artificial evolution area. It makes possible to distinguish the real difference between the content in the system and show a hint for the new measurement of content diversity in the real world.

The result of the experiments shows that the exposed diversity of content seems to be maintained, but the genuine diversity of content is decreased gradually and disappeared in the end. In addition, the average performance is also decreased in the long run. This clearly shows that decreasing diversity of content is not perceived as much of problem for the present; however, it will generate a big problem if the regulator does nothing to solve this problem. This might provide insights for policy makers by giving them a direction toward how to maintain appropriate level of genuine diversity of content and keep the entire ICT ecosystem healthy. Furthermore, it will give an answer for why diversity matters in this world which only efficiency is mattered, especially in the ICT ecosystem.

## *2. The framework of content diversity in the new ICT ecosystem*

The new ICT ecosystem consists of four layers; Content, Platform, Network, Device layer, which coevolve in the ecosystem interconnecting and influencing each other (Fransman, 2010; Iansiti & Levien, 2004). In this section, we provide the framework of the new ICT ecosystem and the importance of content layer, and then we summarize the role of diversity in the ecosystem and explain why content diversity is important in the new ICT ecosystem.

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<sup>2</sup> According to Bauer (2014), when it comes to the system competition and innovation between platform and content providers, since previous theories have no dynamics, policy implications through those theories would be applied only into short-term problem, but it might be side-effects in the long-run.

### *2.1. The nature of content layer and difficulty of fair trade with platform layer*

The origin of content layer in the ICT industry is from art and culture industry (Deuze, 2007), and this original content is digitalized rapidly with developing network and device technology. This allows content layer to enter the new ICT ecosystem naturally. Content layer is characterized by a great diversity of activities including music, books, games, films, television broadcasting, cultural spaces, software, and advertising (Abadie, Maghiros, & Pascu, 2008). Content is likely to be packed by anything like as a cup of water is shaped by the shape of the cup. The cup possibly is media, platform, or device. Water, which is content, flows via a platform and arrives at a device through a network.

Content business has high risk of returning initial cost back due to the difficulty of production and demand prediction (Doyle 2013). Therefore, distribution of content is more likely to be run by conglomerates. For example, a film of the blockbuster class, which is capital-intensive content, is able to be made by only conglomerates. However the conglomerates do not challenge themselves trying to make a film which has very low probability of gaining popularity. Only the medium or small-sized firms try to find hidden needs of consumers consistently, and this trial and error activity is an important process from which content innovation is coming. In addition, content is very easy to be copied. When a content is produced and starts to get popularity, similar content products or services spring up everywhere. The reason this is more issue for content layer than other layers is that content is not technology but idea itself; thereby it is more vulnerable to be imitated when the idea is exposed and hard to be protected by law like patent law.

According to Ballon and Van Heesvelde (2011), the types of platforms are classified into four kinds; (1) neutral platform such as google search, (2) broker platform such as facebook, (3) enabler platform such as intel, (4) integrator platform such as apple, and regulatory issues could vary from the kind of the platform. As far as the platform which controls over customers like broker and integrator platform concerned, regulator should concern the customer lock-in due to switching costs and price squeeze of content providers. As far as the platform which controls over assets like enabler and integrator platform concerned, regulator should concern the refusal to deal and lock-in of content providers. Therefore, that kinds of platform has to be regulated concerning about the issues of reducing diversity. When there are numerous content providers and customers and it is hard to contact each other directly,

platform make a contract with content providers on the one side and gather consumers on the other side, opening two-sided market. If content providers have various platforms to which provide their content, and if consumers have low switching cost to change to the other platform, the possibility of contracting fairly between a platform and a content provider would be high and a variety of content providers would have equal opportunity. However, if a platform achieves a huge popularity and consumers have no will to find a new content and do not want to endure annoyingness to find other sources and switching cost, it is impossible for content providers to make a fair contract with the platform.

### *2.2. Diversity as a role of producing vitality in the system*

Biological diversity is the most important index of checking the sustainability of the system in ecology. As ecosystem has evolved, living things inside the ecosystem might fail to adapt to the new environment when the system fails to keep proper level of biological diversity. When the environment is changing rapidly, living things adopt as combining their genes, so they must secure diverse genes even a gene looks useless right now. The extinct of one individual in ecosystem leads to destruction of overall ecosystem. Then, when does the important diversity decline to dangerous level? Selection mechanism is the most important factor to modulate the level of diversity in nature. In the earth, nature is the rule maker of the system and the platform on which diverse living things live. So far, the nature is successful manager of maintaining proper level of bio-diversity. If the nature has wrong selection mechanism like greedy search for the fittest organism, it looks grow efficiently in the short run but as diversity decrease rapidly, the system is not likely to adapt to the changing environment in the long run. On the other hand, when the nature has random selection mechanism, diversity is kept always high level but the system hardly has the direction of evolution and it makes also hard to adapt the new environment. Therefore, proper level of diversity is not only the best target but also the requisite to live and this wisdom of diversity management could apply to our society widely.

What is the role of diversity in the industrial ecosystem? In the beginning of the new ICT ecosystem, platform had to lower interdependency between the platform and content providers and devices based on their technology for high efficiency. In order to lower interdependency, the platform was able to manage various environment including content, platform, network, and device all together. Apple Inc. is the best example of the integrated

management. However, this kind of integrated platform business is hard to secure the diversity of content due to the biased selection mechanism (Lee, Lee, & Hwang, 2014). According to Kauffman (1996), The effective evolution toward one-way with high speed seems to rise rapidly toward the top of the fitness landscape, but in many cases it is a local peak. So if a living thing is stuck in the local peak it is going to die out. Therefore, the best strategy of the firm is to increase the probability of making a lot of combination, raising their diversity of technology, content, alliance, and so on under the rapid changing environment like digital convergence of the day, and from those diversity, the innovation is able to be popped up (Posen, Lee, & Yi, 2013). In addition, as the consumers' needs are changing quickly, managers and policy makers have to try not to lock in toward one technology keeping diversity in the ecosystem.

Diversity is also reservoir of creativity. Schumpeter (1934) defined the concept of innovation is the new combination, and when it comes to creativity, it is a mental process in which two or more idea come together in your mind to create a new combination and useful thought, which is the consensus among the most of creativity related researchers. However, nobody expect where the useful block come out. The idea block which looks useless with regard only to the efficiency would be the last hidden building block of the new combination which is able to lead innovation of industry. Therefore, creativity is based on diversity. Recently, in academic field, the number of collaboration between different areas is increasing trend, leading the new study trend and results in order to secure diversity of knowledge. The reason of collaboration is simple; the payoff is huge. According to Uzzi and Spiro (2005), the number of papers by solo researcher is decreasing while the number of papers by collaborating between hetero research groups, even between hetero academic fields, is increasing as years go by. This is because researchers are trying to find various combination of knowledge in order to publish A class journal, and they know it is getting hard to make a new knowledge as recombining between the similar fields. This clearly shows that the only combination between the new and different things gives vitality in the ecosystem.

### *2.3. Difficulty of measuring genuine diversity*

In the field of media and communication, there has been early recognition of the importance of diversity (Pluralism of media and journalism). Throughout the media including broadcast, diversity has been considered as a key principle and concept as evaluating the



performance of the media and industry and establishing a policy based on this evaluation (De Jong & Bates, 1991; Napoli, 2001). The fact of which the issue of diversity in media is coming to the force consistently, though there has been general consensus about the importance of diversity earlier on, shows how difficult to establish the precise indicators. It is not clear how far the regulator should limit the dimension of diversity and which respects should they see. In addition, even if the index is set, it is hard to describe the subtle difference from the same into a number and it is also great challenge to measure from the data because each dimension is not independent each other but correlated in the most case. Therefore, despite of consensus which the portion of diversity issue is important in establishing regulative policy of content and media, the definition of diversity or sub-components of the concept of diversity have not been easy to agree on.

The diversity in the media is defined as the extent or range of the selection of the different type program provided by the broadcast for the audience (Cass, 1981; Grant, 1994). Mainly it is measured how many different types (genre or content) are provided for audience within a specific time. As the definition of diversity is not clear, diversity seems to exist just various things. The concept of diversity is complex principle of crossing both social attention preventing monopoly and economic attention promoting expression of minorities (Napoli, 2001). Owen and Wildman (1992) considered diversity as three dimensions; (1) product diversity to extent of how many variation in different attributes of specific product or service exist, (2) idea diversity to extent of how many different idea, analysis, and critics exist, and (3) access diversity which means that media as gate keeper never exclude particular point of view for social issues. This paper follows Owen and Wildman (1992)'s philosophy of access diversity, and media as gate keeper is regarded as gigantic platform nowadays.

The authors divide the content diversity into external and internal diversity. External diversity is the number of population as being seen as it is. Internal diversity is not superficial but an index to extent of how different the content itself among all population's content. It seems like gene of living organism. Considering content as living organism, if DNA of content is similar each other, phenotypic characteristics are revealed similarly. Of course it is possible that phenotypic characteristics look similar or different even if genotypic characteristics are different or similar. However, it is genotype diversity not phenotype diversity more important in the ecosystem because phenotype characteristics are expressed by combination of genotype diversity in the gene level. Therefore, securing gene which has not

good phenotypic characteristics but unique and different from other genes influences not only on individual but also on whole ecosystem (Whitham et al., 2006). It clearly shows that the degree of how many traits of gene the ecosystem has is the most important index of probability of growing sustainably.

### *3. The mechanism of evolution in the relationship among platform, content, and users*

In chapter 3, this paper shows process how content providers and platform have evolved, making contracts step by step. The process of consuming content by consumer through platform consists of three steps; (1) content providers make their own content and enter to platform in order to make a contract with platform, (2) Platform makes a contract with content providers with regard to its preference, and (3) consumers select content only on the platform. Content selected by consumers get profit and reputation. On the other hand, content treated distantly by consumers or content refuted contract by platform benchmark the content selected by most of consumers, product the new content, and re-enter to the platform market (Back to the first step). While this process is being repeated, content providers, platform, and consumers are evolving together.

#### *3.1. The entry of content providers*

In the process when a content enters into the platform, first action of this process is just trying to enter. When it comes to durability, it is possible to predict to some extent the market demand, separated by a product specification, on the other hand, content is impossible to predict to extent of the market demand until releasing in the market. Consumers never know about their hidden needs of the content, the new information good, before consuming the content. Therefore this entry step is going through trial and error, the process of which content providers do a lot of trials. This step makes variety of content and platform should promote this step making content providers do more trials.

#### *3.2. Making a contract*

Even if a content provider has a great content, there is no chance to be selected by consumers if the content fails to make a contract with platform<sup>3</sup> Thus, this process is

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<sup>3</sup> Platform might be mobile OS providers like iOS or Android and social network service providers like facebook or twitter, and network providers or smart-phone suppliers. This paper focused on the platform which is mediate between content and

inevitable step for content providers to reach to consumers. It is first selection step of created variety and selection is forced to reduce diversity necessarily. If platform choose some content, other content which is not the fitter are out of system and then the preserving genes in the system have no choice to decrease. However, this selection step is important to challenge population having motivation of adopting and innovating themselves in order to be selected next time. Finally, how to manage the selective pressure is a key criterion of balancing between efficiency and diversity in the system.

### *3.3. Measurement of performance and diversity*

Through the above steps, content on the platform expose the part of the content to consumers and the content provider get profit by consumers' click activity consuming the content with advertisement. To be selected by consumers, content has to contain some points of consumers' needs. As mentioned above, consumers' needs are complex and categorized into various dimensions. Content retaining the unique but including universality get a lot of attention of consumers and this makes the content providers successful. In addition, once a content get popularity and profit, the content provider earn a reputation, thus making easy to make a contract with platform next period.

### *3.4. Benchmark or imitate the best performed content (recombination)*

All content on the platform are trying to meet consumers' needs by any means, but usually only few of them are success. Content providers, not taking a lot of attentions or not even making a contract with platform, get hints from the best performed content and have to benchmark it for survival. Content providers have no choice to imitate the successful content in order to reduce the risk due to the characteristic of the content industry, one big success covers the several failures. At this moment, they are divided into two kinds of content providers; one is fast learner group making content based on the best performed content like parody or generic version, the other is slow learner group making content based on their own content and try to combine the idea of the best performed content<sup>4</sup>.

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information or content like search engine and portal site providers.

<sup>4</sup> March (1991) introduced the concept of the fast or slow learners when he explained about the organizational learning mechanism in the seminal paper; Exploration and exploitation in organizational learning. *Organization science*, 2(1), 71-87.

#### 4. Model

##### 4.1. Genetic algorithm and the advantage of modeling the new ICT ecosystem

In traditional equilibrium finding method, one single rational individual, which is representative consumer who has full information about the market, directly finds out the optimal point. The optimum is not always a global peak, but once he reaches a peak, he stops searching. In contrast, Genetic algorithm (hence force GA) starts with multiple individuals, called population, and they do not have rationality. The population starts explore to achieve the global peak within the problematic space. At every period, all individuals take a fitness test. Those who have higher fitness value get higher chance to survive, which is called selection, and try to get higher fitness value through recombination. The survived population reproduces offspring and it becomes the next generation. Until population shares the same genetic code, the population keeps traveling. If some reach a local peak, they can escape from it by selection and reproduction mechanism. Once population reaches equilibrium, then there is no chance to evolve except mutation. Thereby, genetic diversity is a serious issue for GA. Through the process of selection and reproduction, individual codes get similar and finally they converge. If genetic diversity remains in the system for a long time, population can take journey far enough to find the global peak. In contrast, if diversity within the system disappears quickly, population will stick in the local peak, and lose the chance to improve further.

The evolutionary path of contents on the ICT ecosystem has high similarity with the general genetic algorithm. A variety of digital contents makes multiple individuals and they try to find the preference of the majority of consumer with various trial. However, they have no idea of which content is going to be success or not, such as the multiple individuals in GA do not have rationality. It is a huge philosophical difference between GA and traditional economic methods which has some hypothetical limitation of rationality. Next step is selection. This paper finds this step is the most different point compared with the general GA. In general there is God's eye to measure the all populations, while in the ICT ecosystem, a platform provider chooses some contents which are likely to meet the consumer's needs and makes a contract with the content providers. As far as the reproduction scheme concerned, it is similar with the convergence of the contents. When the best performer of the content which meets the hidden consumer's preference is popped, imitations are happened. Other content

providers start to recombine the best performers' idea into theirs. The last important similar point is the matter of diversity in the system. In this kind of evolutionary system, the potential of growth is measured by how much diversity is remained. If all contents are similar and the system has low diversity, all the population must be stuck in some local peak and there is no chance to improve. Table 1 shows the matching points between GA and dynamics in ICT ecosystem.

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Table 1. Dynamics in ICT ecosystem model based on genetic algorithm (here)  
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*4.2. The model of relationship between CP-PP-users (Dynamic rules)*

Selection is a primary aspect of evolutionary mechanism. According to Holland (1992), selection is defined as the members of a population survive to reproduce the next generation. In other words, it indicates the members of the current population affect the next generation. In this paper, the role of selection is only played by a gigantic platform. It decides the contracts with content providers with regard to previous fitness value and experience of the contract. In general GA, selection is simple mechanism: if an individual fails some test of fitness, he dies. If he passes the test of the fitness, he survives and reproduces his offspring and passes its gene down to the next generation. More fitted individuals are generally given a higher chance to participate in the reproduction process. Not every individual can join the intermediate population. As a result, information encoded in the current population is not entirely transferred into the next population. Likewise, if a content passes the contact with the platform and gets famous, the content passes its gene down to the next generation and also other content providers try to imitate the gene or converge the part of the gene.

Content is selected through two steps. First one is sampling. When the platform makes a contract with the new entries, there is an entry barrier like lobby activity. A new entry without any previous connection of the platform is hardly to overcome the entry barrier. However, if a new entry crosses the entry barrier once, the content would get a reputation which makes easy to make a contract with the platform next time. Second one is selection. It is carried out by consumers clicking the content on the platform. After the two selections the best consumed content is emerging, and other content providers want to know the strategy of the best performed content provider and imitate it. This process is called recombination in GA

term. When this process is going, there are two different types of content providers exist; fast imitator and slow imitator. Fast imitator is recombining the best performer's idea into their content rapidly while slow imitator is recombining the best performer's idea in their content slowly. Next step is measuring the score of how many dimensions the content meet the consumers' needs including their hidden needs. This is the end of the first period. Second period also starts from sampling but it is somewhat different with first period because there are not only new entries but also incumbents who have experience of contraction. Therefore, from the second period, sampling by the platform is considering the incumbents' reputation as well as their scores. Of course, new entries still need to overcome the entry barrier which gets higher while the platform is getting huge. Next to the sampling, consumers select the best performer and this dynamics circulate repeatedly. Figure 1 describes the dynamics of the platform and content providers.

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Figure 1. Dynamics of the platform and content providers (here)  
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In the process of selection scheme, loss of diversity is inevitable. Thus, balancing or overcoming the conflict of exploration and exploitation must be included in selection. As previously discussed, in evolutionary mechanism loss of diversity is fatal. In the system, once all individuals share the same bits, there is no more chance to evolve. If a system converges too fast and fails to take enough time to fix errors, the system is stuck in the low knowledge level; it is called premature convergence, which implies that the system stop evolving at the local peak. Selection methods, the tests whether an individual survive or not, deals with the level of diversity. In the ICT ecosystem, if the only gigantic platform exists and it could have only power of selecting contents, what happen on the level of diversity? This was the origin question of this paper. Is there any chance to remain the rare and useful gene in the system?

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Figure 2. Expansion of consumers' hidden needs (here)  
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In the above dynamics, consumers' needs consist of two characteristics. One part is matching point between consumers and platform's needs and the other part is consumers' hidden needs. The former part is usually the content which could give appropriate level of information that consumers are likely to like, including the advertisement. If the consumer

stays a lot of time on consuming the content, the consumer are satisfied to some degree and the platform also is satisfied, no one want to break away from this statement. However, the latter part of consumers' needs is never explored in this situation. In GA term, it is stuck in the local peak. Figure 2 describes the diagram of expansion of consumers' hidden needs. Consumers should know the truth that those content or information on the platform cannot satisfy their needs fully or even the aware of this is not all is needed. The more consumers are trying to keep balance to search information about some issues or content they want by any means as well as by the gigantic platform, the more content providers are trying to meet consumers' hidden needs by other routes. In other words, the active will of exploring consumers' hidden needs is making content diversity in the system and the new combination, creativity, of content is increasing, thus giving vitality in the ICT ecosystem.

#### *4.3. Variables*

Average performance is the average of fitness value of contracted contents in the period. Diversity varies into two variables: phenotype and genotype diversity. Phenotype diversity is the number of contracted contents in the period. In previous measurement of diversity in an industry is all about superficial things like a number of populations and a number of genres. However, the need to measure genuine diversity arises in a variety of contexts. In this paper, genotype diversity is applied into the new measurement of diversity in the ICT ecosystem. Genotype diversity is the genuine diversity of contracted contents. In evolutionary algorithm filed including GA, genotype diversity is often measured using pairwise Hamming distance, but it is not efficient to compare all distances among populations. Therefore, this paper introduces Morrison and De Jong (2002)'s method for calculating genotype diversity using the new moment of inertia method. Experimental variables are two folds; Pnew and Rs. Pnew means the height of entry barrier of the platform. Since this variable is probability of overcoming the entry barrier, this ranges from 0 to 1. Rs is the ratio of slow imitator, ranging from 0 to 1. Control variables are population size (popSize), the number of dimensions of the consumer preference (bits), probability of imitating the best performer for slow imitators (Pslow), probability of imitating the best performer for fast imitators (Pfast), and changing rate of consumer preference (Penv). Table 2 summarizes the list of variables and their detailed information.

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Table 2. The list of variables and their details (here)

Figure 3 shows an example of calculating variables. Population size is 7 and the number of dimensions of the consumer preference is 9. When contracted content are three; fast imitator of (1,1,0,0,0,1,1,1,0), fast imitator of (1,1,1,1,1,0,0,1,0), slow imitator of (1,1,1,0,0,0,0,0,1) and consumers' needs are (1,1,1,1,1,1,1,1,1), each performance is addition of matching consumer's preference; 5,6,4. Ratio of slow imitator is 1 by 3 because there is only one slow imitator among three contracted content. Table 3 shows an example of calculating phenotype diversity, genotype diversity, and average performance. When it considers average performance, it is calculated the sum of all contracted contents divided by the number of contracted content;  $(5+6+4)/3 = 5$ . Phenotype diversity is just the number of contracted content, so it is 3. Lastly, as far as the genotype diversity concerned, it means that the genuine diversity of contracted contents: degree of not overlapping between all bits. Therefore, firstly it is needed to calculate the coordinates of the centroid of each bit and secondly calculate the moment of inertia about the centroid. The details of equation are in table 3.

Figure 3. An example of calculating performance and ratio of slow imitator (here)

Table 3. An example of calculating phenotype diversity, genotype diversity, and average performance (here)

#### 4.4. Experiments

This paper designs the five experiments. Each experiment is carried out ten thousand times and average values are calculated in order to reduce the uncertainty and show the trend easily.

##### *Experiment 1*

First experiment aims to find how the gigantic platform influences on content diversity and average performance of the system. Parameters are set by neutral. In this paper, neutral setting



is as follows. Population size is one thousand, bits is five hundred,  $R_s$  is 0.5,  $P_{env}$  is 0.005,  $P_{new}$  is 0.1 and this value is decreasing as platform is getting huge as time goes by.

#### *Experiment 2*

Second experiment aims to find the role of content providers who are trying to keep their true characteristics. As changing  $R_s$  from 0.1 to 0.9 with other parameters are same with neutral setting, change of the three dependent variables is observed.

#### *Experiment 3*

Third experiment models the situation that consumers are trying to diversify the source of information and content, not satisfied only through the gigantic platform. This willingness would explore consumers' hidden needs and content providers are trying to meet their needs by making some roads to consumers. Other parameters are same with neutral setting (Experiment 1), while adding a setting that consumers' hidden needs are exploring as time goes by. change of trend of the three dependent variables is observed.

#### *Experiment 4*

Fourth experiment aims to observe the change of content diversity and average performance when the regulator prevents the phenomenon of getting higher entry barrier of the gigantic platform as it is getting larger. Suppose a non-profit platform, which is perfectly open to all consumers and content providers and no need to care about their advertisement profit, is introduced to market, it is possible to prevent to get higher of the entry barrier of the gigantic platform. Setting of parameters is same with experiment 3, but  $P_{new}$  is 0.1 and not decreasing.

#### *Experiment 5*

Last experiment aims to test the assumption of platform neutrality. Like network neutrality, platform neutrality means the statement that all content are able to access to the platform without any selection pressure. When the state exists, where do content diversity and average performance go? . Setting of parameters is same with experiment 3, but  $P_{new}$  is fixed 1. Table 4 summarizes above five experimental designs.

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Table 4. Experimental designs (here)

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### 5. Simulation result

#### *Experiment 1*

Figure 4 shows the result of experiment 1. Average performance is increasing as time goes by until at some point, and decreasing gradually. This trend is similar with that of phenotype diversity. Genotype diversity is increasing rapidly at initial phase but after peak it is declining and converging to zero. As Genotype diversity is starting to decline, phenotype diversity and Average performance lose the power of growth. Therefore, this paper insists that the power of sustain growth in the ecosystem is genotype diversity not phenotype diversity. The area under the trend of genotype diversity is the power of energy to grow system sustainably. After genotype diversity is declining, it does not recover. Firstly it is because the system is closed so providing of external diversity is not possible. Secondly, in the internal system, there exists double selection pressure; (1) sampling by platform (2) selection by consumers. Unless external diversity is not providing, recover of diversity in the system is hard. By all appearances, average performance and phenotype diversity is maintaining proper level, but it is already dead system with regard to genotype diversity.

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Figure 4. The result of experiment 1 (Trend of three dependent variables)

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### *Experiment 2*

Figure 5 shows the trend of average performance as changing the ratio of slow learner. Average performance has higher initial increasing but lower peak and converging point as the ratio of slow learner is low. It means that the higher the content provider try to keep their unique content and not to imitate the best performer by any means, the lower the speed of degrading ecosystem is, as the number of unique and useful bits in the ecosystem is reserved. This finding is also proved by the trend of content diversity (see figure 6). As mentioned before, regarding as the area under the trend of genotype diversity is the energy potential to grow system sustainably, the area under genotype diversity is increasing as elevating the ratio of slow learner. The last point of phenotype diversity is also increasing as elevating the ratio of slow learner, but it is not big change of exposed diversity.

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Figure 5. The result of experiment 2 (Trend of average performance)

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Figure 6. The result of experiment 2 (Trend of Geno/Pheno diversity)

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*Experiment 3, 4, 5*

Experiment 3 is supposing the situation that the consumers who used to use the gigantic platform previously are starting to search by various ways. Figure 7 shows that the level of genotype diversity is higher than experiment 1. In addition, figure 8 shows that phenotype diversity is also higher than experiment 1. However, the most prominent change is for the average performance. It is not only higher than experiment 1, but also keep the power of growth which is not existed in closed system. It means that the will of diverse search gives the system external diversity. Increase of diversity leads more trial and error activity of productizing content, and this increasing creativity explore the consumers' hidden needs consistently, thus making possible for the system to grow sustainably.

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Figure 7. Comparing the results of experiments (Trend of Genotype diversity)

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Figure 8. Comparing the results of experiments (Trend of Phenotype diversity and average performance)

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Experiment 4 suppose there is non-profit platform, thus not getting higher for entry barrier of the gigantic platform. The peak points of Genotype diversity and phenotype diversity moves up slightly. It is not dramatic change like experiment 1 to experiment 3, but the content diversity is increasing by introducing non-profit platform. Lastly, experiment 5 suppose the platform neutrality. Comparing with experiment 1, it is totally different but it is almost same with the result of experiment 4. This shows that existence of non-profit platform is almost same effect with the platform neutral situation.

*6. Discussion and conclusion*

How far the system can evolve is a matter of diversity. Diversity provides new and fresh knowledge to the organization. It is because that even if the expressive character of a gene is

not good but unique, it is able to influence on the whole ecosystem<sup>5</sup>. However, recent gigantic platforms in the ICT ecosystem do not give a chance to a new and distinctive content which is not giving the platform advertising revenue because it is not provocative or sensational. This paper verified the problem of declining content diversity through the results of simulation. As long as under the environment existing gigantic platform, it is inevitable that selection mechanism of content is distorted. Even though it looks like content are getting diversity (phenotype diversity seems not decreasing much), actual diversity of content's true characters decrease rapidly, having no chance to recover in the long run (genotype diversity decrease rapidly, converging zero). Of course, the simulation model is not able to reflect reality perfectly. However, we authors are sure that the direction of content diversity is down side if this gigantic platform system goes as is without any regulations.

The focus of this paper is how to relieve the speed of decreasing content diversity is and how to recover decreased content diversity, because in the system diversity is decreasing no matter which selection mechanism the system has. This paper found the implications for the view of content providers through the result of second experiment. The more the ratio of content provider which keeps their natural content and does selective imitation to best performed content (slow learner in the model) is, the more content diversity is raised to the high level. When we click to the portal sites representative of gigantic platform, we easily find the articles or content to attract people to click by entitling sensational title of content. Most of the journalism know about this fishing strategy works, so they used to use the same strategy altogether. When it comes to breaking news, we easily see the almost all of them from various sources are going to get similarity. Like lemon market, those phenomenons are going to cause adverse selection problem in the market of information good such as articles, content, music, and so on. Then, nobody will not value the information or trust the articles. However, what if the ratio of content providers who want to keep their truth and not to imitate thoughtlessly increase? The adverse selection problem will be solved gradually and content diversity is also secured.

Third experiment gives an important implication to the consumers. The result shows that reconstruction of decreased content diversity is able to be come from consumers' active will, trying to find their hidden needs. This is the way of expanding of ecosystem by making

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<sup>5</sup> <http://www.nature.com/nrg/journal/v7/n7/abs/nrg1877.html>

totally new combinations through a lot of new trials. For example, consumers become providers like one person-media, or try to make a variety for searching content and information, overcoming a little annoyingness. To sum up, consumers should cognize that the content on the gigantic platform is not reflecting their hidden needs but just reflecting the part of their needs which guarantee the platforms' advertising revenue.

Fourth and fifth experiments suppose that virtual non-profit portal is introduced and platform neutrality. To lower commercial dimensions of the gigantic platform and provide a high-quality information with public value consistently, it needs aiding methods for non-profit platform financially and supporting policy. Like as commercial broadcast and public broadcast are complementary in the media, it needs the public platform to raise the quality of life for member of society in the web.

Clearly the gigantic platform has contributed the big innovation in the internet ecosystem and made new markets. Moreover, there clearly exists the efficiency and usability of the platform. However, as considering the gigantic platform's social influence, we must need alternatives to avoid homogenization of information and reducing diversity and for creativity of content. Also, in this system, the ecosystem is vulnerable to be diffused of false or bad information<sup>6</sup>. Pursuit of profit is born nature of firms but if 'a' firm's social influence is getting large, a firm should care of their social responsibility like keeping diversity. In addition, users also should care of the firm's responsibility and just not easily enjoy the information they organize. Thus, not only platform provider, content provider, and government but also consumers should cognize the importance of keeping proper diversity and try to keep it together with all stake holders and this makes future ICT ecosystem healthy and grow sustainably.

According to March (1991), the balance between exploration and exploitation is important to maintain the healthy ecosystem. Furthermore, the essential method of this balance is lowering the decreasing speed of diversity. As all kinds of system evolve toward reducing diversity in order to select the innovative one among the diverse population, it is very serious problem when the diversity is low in the system and that is the reason why all kinds of system should keep appropriate level of the diversity desperately. Especially, the diversity of content providers is more important in the new ICT ecosystem than any other industrial ecosystem.

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<sup>6</sup> In the era of full connected network, viral and sensational message is diffusing and parodying by any means. In addition, since the issue could evolve badly, media user should aware and care of dealing that kind of issue (Vista, 2014).

The power of innovation in the new ICT ecosystem has moved from infrastructure layer like network, device to content layer. Content layer needs creativity and content diversity is reservoir of the creativity. Diversity is the source of providing the system with high flexibility and adaptability, and it is the most valuable factor to a firm's survival, especially under rapidly changing environmental conditions (Korhonen, 2001).

In the era of digital convergence, not only consumers are hard to adapt the rapid changing environment but regulators are also hard to regulate the market because they have to make the changed market definition about which products or services are in the competitive relations and prove how much the new business threat the social welfare. However, it is impossible for law and regulation to catch up the rapidly changing market because there are a lot of stakeholders who cause confusions of making a standard. Eventually we need obvious philosophy of this era above the regulation, law, and even economics. This paper insists that diversity, which is reservoir of creativity and the power of sustainable growth in the new ICT ecosystem, must be kept properly and this is the very first step for settling the new standard.

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**Tables**

Table 1. Dynamics in ICT ecosystem model based on genetic algorithm

<b>Genetic Algorithm</b>	<b>Dynamics in ICT ecosystem</b>
make a variety	Entry of the new comers Creation of a new content or a new combination of contents
selection	Measurement or scoring system of the contents - Scoring made by consumer's click (profit and score made by consumer's preference) - Content innovation which meet consumer's complex needs and expands niche market
	Contraction between platform and content providers (selection) - New comer has to pass the entry barrier ( $P_{new}=0.1$ )
	Exit of the non-contracted contents In the case of incumbent, score and the reputation of the content determine the probability of contract with platform
Mating (imitation)	Every content imitate the best performer among the content which won the contract or converge the bits of the best performer with their owns - $P_{slow}$ (Slow content): content provider which is likely to keep their original bits - $P_{fast}$ (Fast content): content provider which is likely to imitate the best performer's bits - $R_s$ (Ratio of Slow content): the ratio of the slow imitator content providers in the ecosystem
Environmental change (consumers' taste change)	The consumer preference is changed very gradually The probability of changing the consumer preference is low like changing fashion

Table 2. The list of variables and their details

<b>Dependent variables</b>	Phenotype diversity	The number of contracted contents in the period
	Genotype diversity	The genuine diversity of contracted contents: degree of not overlapping between each bits
	Average performance	The average of fitness value of contracted contents in the period
<b>Experimental variables</b>	Pnew	The height of entry barrier of the platform (range 0~1)
	Rs	The ratio of slow imitator (range 0~1)
<b>Control variable</b>	popSize	Population size (Initial setting = 1000)
	bits	The number of dimensions of the consumer preference (Initial setting = 300)
	Pslow	Probability of slow imitator (Initial setting = 0.1)
	Pfast	Probability of fast imitator (Initial setting = 0.9)
	Penv	Changing rate of consumer preference(taste) (Initial setting = 0.005)

Table 3. An example of calculating phenotype diversity, genotype diversity, and average performance

<b>phenotype diversity</b>	The number of contracted contents in the period = 3
<b>genotype diversity</b>	<p>The genuine diversity of contracted contents: degree of not overlapping between all bits</p> <p>1) The coordinates of the centroid of each bit is</p> $c_i = \frac{\sum_{j=1}^{j=P} x_{ij}}{P} = (3/3, 3/3, 2/3, 1/3, 1/3, 1/3, 1/3, 2/3, 1/3)$ <p>2) The moment of inertia about the centroid is</p>

	$I = \sum_{i=1}^{i=L} \sum_{j=1}^{j=P} (x_{ij} - c_i)^2$ $= 3[(1 - 3/3)^2 + (1 - 3/3)^2 + (0 - 1/3)^2 + (0 - 1/3)^2 \dots + (1 - 1/3)^2]$
<b>Average performance</b>	The average of fitness value of contracted contents in the period (5+6+4)/3 = 5

Table 4. Experimental designs

<b>Experiments</b>		<b>Parameter setting</b>
1	Trend of Pheno/Geno type diversity	Neutral
	Trend of Average performance	- popSize = 1000, bits = 500 - Rs = 0.5 (Pslow = 0.1, Pfast = 0.9) - Penv = 0.005 - Pnew = 0.1 (decreasing on)
2	Trend of Pheno/Geno type diversity under different ratio of slow learner	Rs changes (0.1,0.3,0.5,0.7,0.9)
	Trend of Average performance under different ratio of slow learner	Other parameters are same with neutral setting
3	Trend of Pheno/Geno diversity under different environment of consumers and content providers	Consumers' hidden needs are founding by any means (creative activity on).
	Trend of Average performance under different environment of consumers and content providers	Other parameters are same with neutral setting
4	Trend of Pheno/Geno diversity under existing non-	Consumers' hidden needs are

	profit platform	founding by any means (creative activity on). Pnew = 0.1 (decreasing off)
	Trend of Average performance under existing non-profit platform	
5	Trend of Pheno/Geno diversity under platform neutral statement	Consumers' hidden needs are founding by any means (creative activity on). Pnew = 1 (platform neutral)
	Trend of Average performance under platform neutral statement	

# Figures

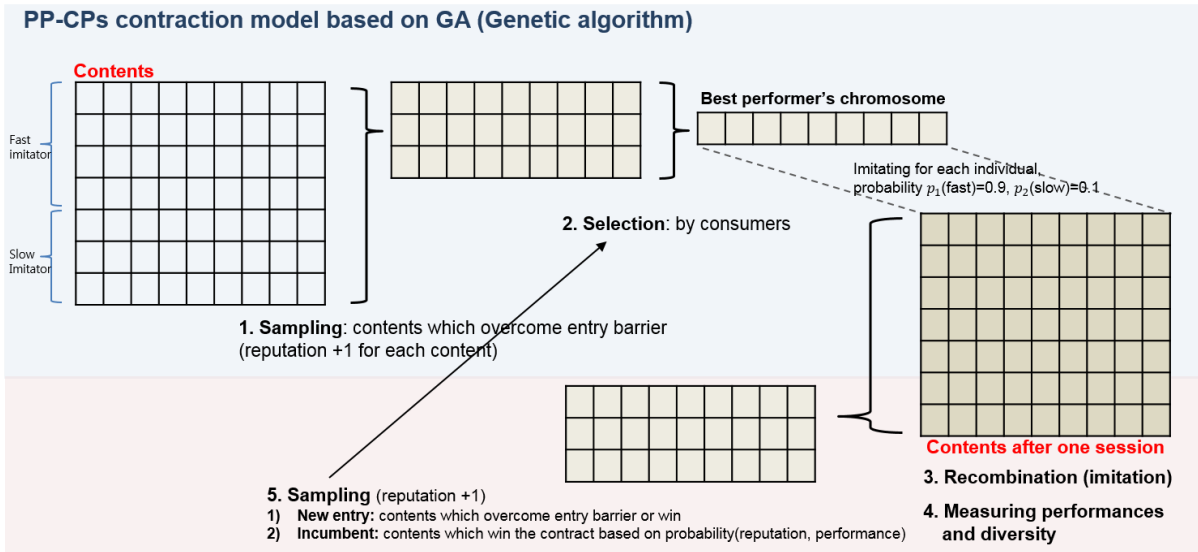


Figure 1. Dynamics of the platform and content providers

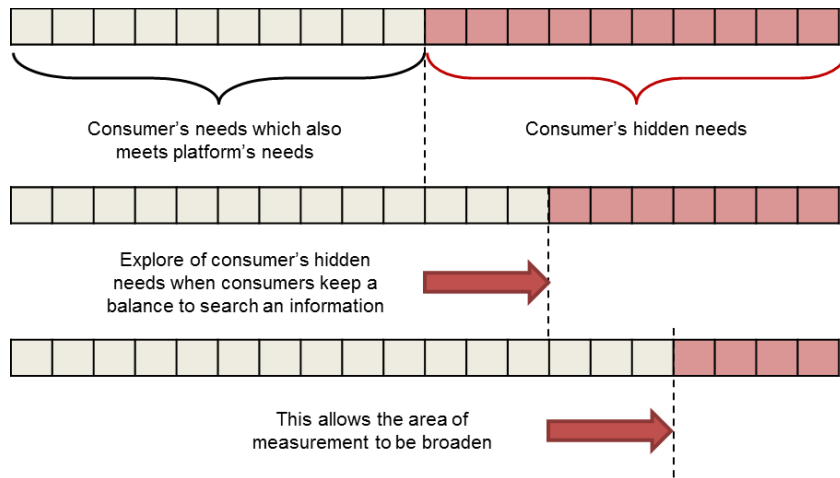


Figure 2. Expansion of consumers' hidden needs

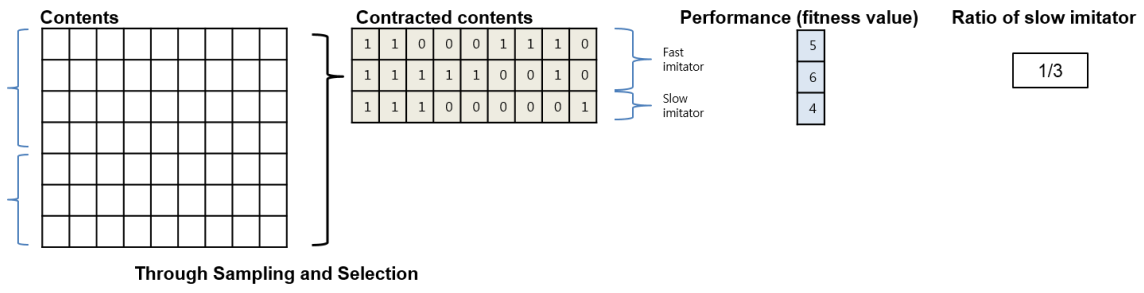


Figure 3. An example of calculating performance and ratio of slow imitator

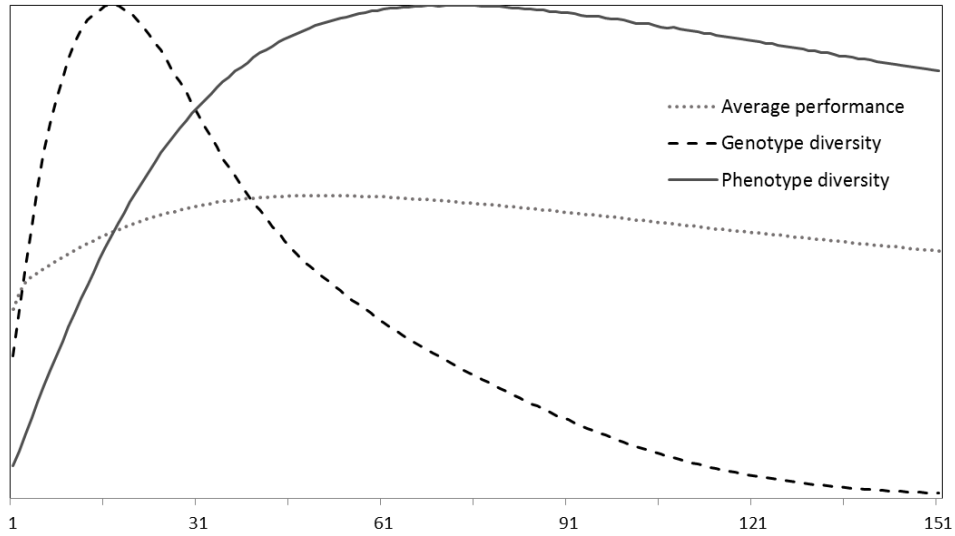


Figure 4. The result of experiment 1 (Trend of three dependent variables)

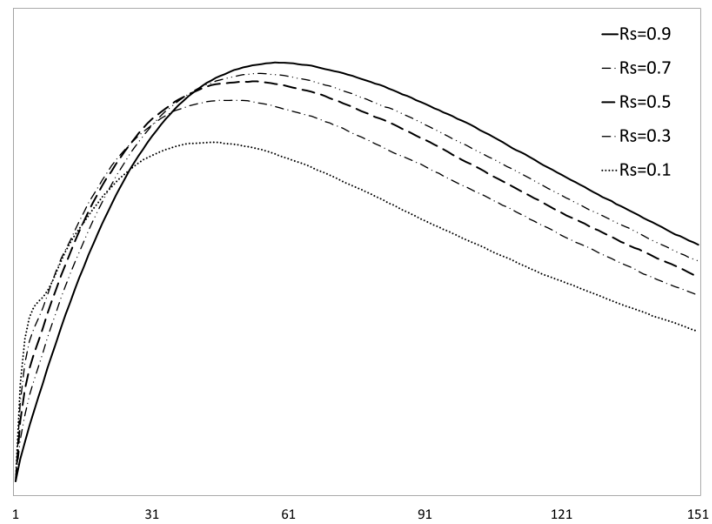
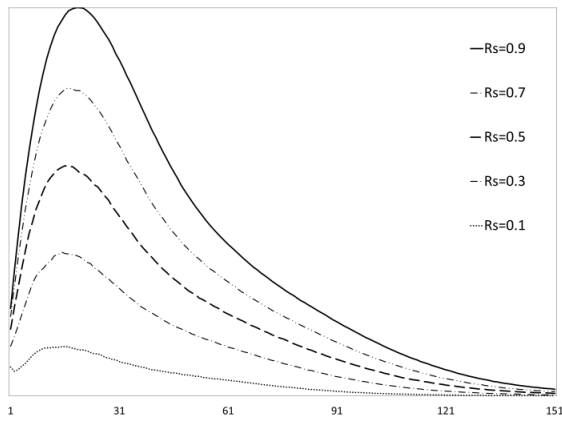
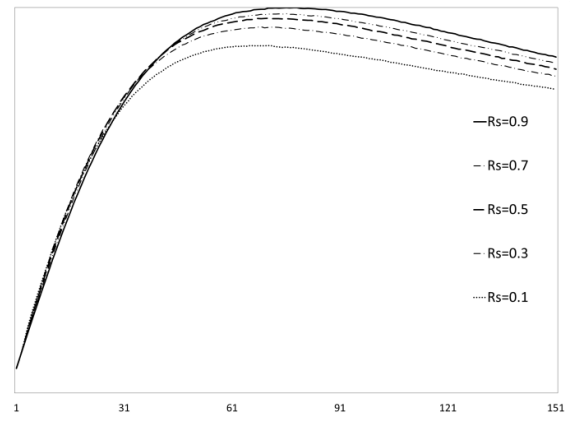


Figure 5. The result of experiment 2 (Trend of average performance)

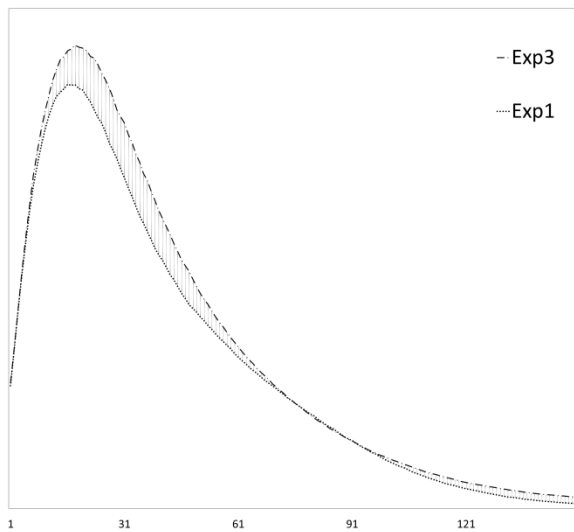


Genotype diversity

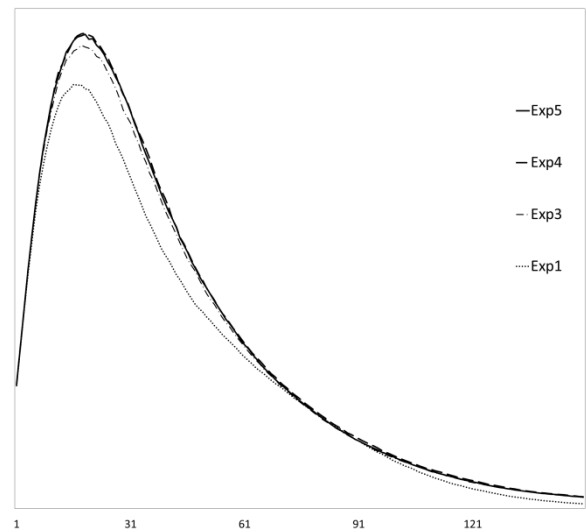


Phenotype diversity

Figure 6. The result of experiment 2 (Trend of Geno/Pheno diversity)



Genotype diversity (Experiment 1 and 3)



Genotype diversity (Experiment 1, 3, 4, and 5)

Figure 7. Comparing the results of experiments (Trend of Genotype diversity)



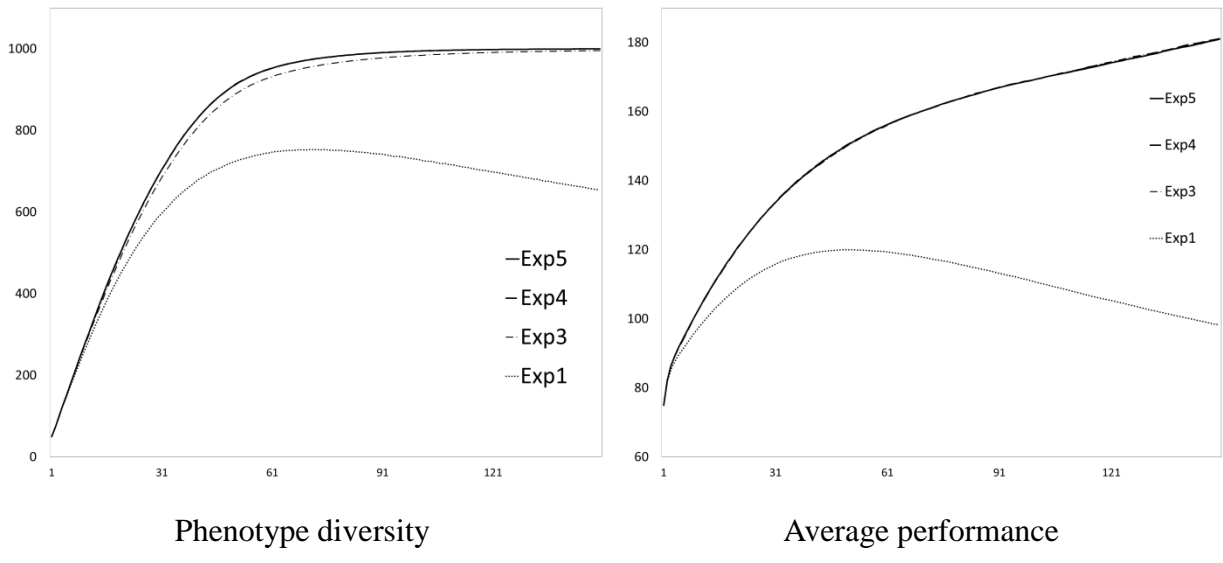


Figure 8. Comparing the results of experiments (Trend of Phenotype diversity and average performance)