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A Study onthe Dynamic Nature of Co-evolution Between Technology and Society: Hype Cycle Management Issues

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Abstract

Technology and society have been evolved with interaction. In the meantime, the hype cycle has been emerged due to time delay. As the peak of expectation is getting higher, the trough is getting deeper and it lowers the level of deployment of technology in society. This research, therefore, aims to find the way to maximize the level of technology deployment. More specifically, we tried to answer the following questions: Why does a hype cycle emerge?What does hype cycle imply for the sustainable growth of new technology? How can we properly manage the hype cycle? When does policy leverage have to be intervened to maximize the level of technology penetration into society? The result of this research could provide useful implications for not only scientific researchers but also policy makers.

Keywords: Co-evolution, Hype Cycle, System Archetypes, System Simulation

1. Introduction

Technology and society have been evolved in interaction[11]. Innovations of technology can dominantly affectthe societal changes and social factors can lead a technology innovation in the co-evolution process over time[13]. Especially noteworthy is that the hype cycle typically occurs in co-evolution process over time[4]. Gartner's Hype cycle is to characterize the typical progression of an emerging technology from over-enthusiasm through a period of disillusionment to an eventual understanding of the technology's relevance and role in a market or domain. It is socalled,a 'boom and bust'. Like as co-evolution between technology and society implies in the past, as the peak of expectation is getting higher, the trough is getting deeper and it lowers level of deployment of technology in society. During the period of industrialization, technology and society had been changed slowly. However, as technology has been changed much faster and society has been more complex and diverse in digital era, the hype cycle has shown sharp fluctuation.

Recently, Gartner analyzed technology maturity, commercial influence and future trend for approximately 1,900 technologies and proposed types of co-evolution as 76 types of hype cycle[5]. Especially, IoT (the Internet of things), Natural Language Question Answering are expected to reach at the peak in 2014. And Smart Robot, Virtual Personal Assistant and Human Augmentation are regarded as technologies that expectation of which is in rapid rise in society. However, regardless of types of technology or characteristic, the common phenomenon is to be shown as the hype cycle reaching a certain level of plateau through the pattern of over-enthusiasm and disillusionment inevitably in co-evolution process between new technologies and society.

It is considered as timely and important matters to study how to manage the hype cycle to maximize level of plateau as possible. There are advanced researches dealing with the hype cycle according to time delay between variables.However, they still have limitations to propose political implications to guide more successful change of society. The purpose of this research is to find the way to maximize the level of plateau. More specifically, we tried to answer to following questions.

- Why does hype cycle emerge and what does hypecycle imply for sustainable growth of new technology?

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- How can we properly manage the hype cycle?
- When should we leverage policy to maximize the level of technology penetration into society?

To answer those questions above, we developed conceptual model for managing the hype cycle based on CLD (Causal Loop Design) which was illustrated by analyzing underneath structure of the hype cycle in co-evolution process between technology and society. And we propose implications for effective political leverage and timing of political intervention through developing system simulation model on the hype cycle.

2. Backgrounds

2.1 Hype Cycle

Several technology life cycle models attempt to gauge the evolution of a technology. The most popular model is S-curve, which shows the increase in a technology's performance over time. However, Gartner suggests limitation of S-curve by explaining many corporations have wrong timing for market entrance and exit, and then fail to succeed[3]. This means that the corporations make mistakes by concerning market's interests rather than market breadth. The corporations start to rush into market when the market's interests of technology reach at the peak. On the contrary, when market's interests are going down, their position is replaced by competitors when the market is full-swing because they judge that they are already at maturity stage.

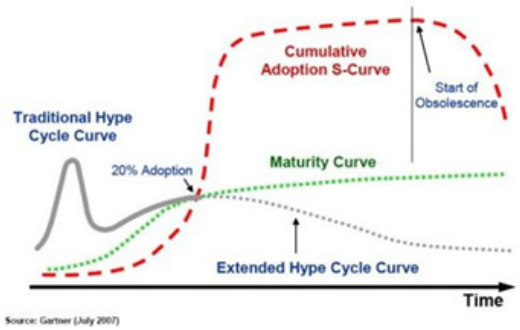


Figure 1. Technology Life Cycle Models.

Thus, Gartner conceptualize the phenomenon occurred when new technology is adopted into society as the Hype cycle. It shows market's visibility for new technology over time and also there is a bubble which the market's interest is growing rapidly though the market is not mature. When the adoption rate is over approximately 20%, the market's interest is being decreased. Gartner pays attention to the cycle before the adoption rate approaches 20%. The hype cycle does not cover the entire technology life cycle (from inception to decline). It addresses the early stages, when hype and mismatched expectations are at their highest levels. These stages are classified into 5 stages(Figure1, 2 and Table 1).

Figure 2. Phases of the Hype Cycle.

Table 1. Phases of the Hype Cycle

SL No.	Hype Cycle Phases	Description
1	Technology Trigger	A potential technology breakthrough kicks things off. Early proof-of-concept stories and media interest trigger significant publicity. Often no usable products exist and commercial viability is unproven.
2	Peak of Inflated Expectations	Early publicity produces a number of success stories—often accompanied by scores of failures. Some companies take action; many do not.
3	Trough of Disillusionment	Interest wanes as experiments and implementations fail to deliver. Producers of the technology shake out or fail. Investments continue only if the surviving providers improve their products to the satisfaction of early adopters.
4	Slope of Enlightenment	More instances of how the technology can benefit the enterprise start to crystallize and become more widely understood. Second- and third-generation products appear from technology providers. More enterprises fund pilots; conservative companies remain cautious.
5	Plateau of Productivity	Mainstream adoption starts to take off. Criteria for assessing provider viability are more clearly defined. The technology's broad market applicability and relevance are clearly paying off.

2.2 Hype Cycle and Co-evolution

There is a co-evolutionary process between technology and society. As this assertion implies, technology affects the societal changes in a specific context and vice versa in another context[11]. If that is the case, eithertechnological determinism or social constructivism is misleading as they are based on the linear perspective(x → y) that one determines and affect the other one-sidedly like as 'y = f(x)'. However, the idea of co-evolution is based on the reciprocal feedback(x → y) between technology and society. In a feedback, the changesreveal a dynamic behavior due to time delay, especially when a considerable time delay occurs between expectation, disillusionment and adoption[10]. The Internet companies (COM) which experienced the rapid growth followed by collapse clearly prove this. The social visibility of an information technology evolvesin ahype cycle through overshoot, collapse caused by societal immaturity, level of plateau which is regarded as realistic recognition. According to Gartner, dynamic behavior has common phenomenon emerged by co-evolution between technology and society in the past, that is the hype cycle[2].

3. Underlying Structure of the Hype cycle

To draw strategic implications for managing the hype cycle in the perspective of sustainability, we need to find a policy leverage to maximize the level of plateau on the hype cycle rather than the hype cycle itself. In this context, the system thinking is perhaps an important means to achieve this purpose because it is based on the perspective that the behavior is emerged by its underlying structure.

3.1 Reference Models for Hype Cycle

Among the archetypes of system thinking, 'limits to growth' is suitable for explaining the structure of a hype cycle and 'goal drifting' is useful for its management.

3.1.1 Limits to Growth

Basically, the archetype of 'the limits to growth' consists of two feedback loops (Figure 3). One of them is self-reinforcing loop (R) between performance and efforts to increase it, the other one is goal seeking loop (B) between the performance and the limits. In 'limits to growth' archetype, a dominant loop becomes clear over time. Figure 4. illustrates BOT (Behavior Over Time) of limits to growth. It displays the causes of the hype cycle and the implications for managing it in two aspects[8].

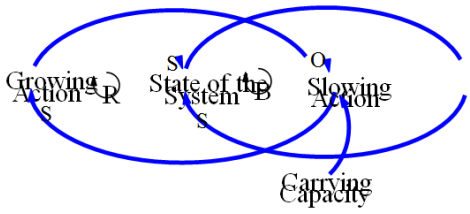


Figure 3. Limits to Growth' Archetype.

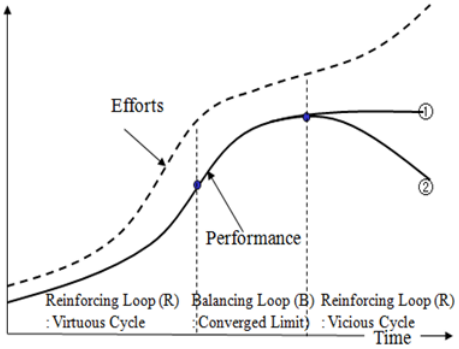


Figure 4. BOT of 'Limits to Growth' and the relationship between loops.

First, transition of the loop dominanceoccurs at the inflection points. Before reaching the first inflection point, growth loop (R) is dominant and the system grows exponentially. However, limiting loop (B) is becoming dominant as the limit begins. The system still grows but the net growth rate is getting close to zero like a logistic function (S-curve) until it reaches the second inflection point. Beyond the second inflection point, the limiting loop (B) starts affecting the growth loop (R) negatively. As a result, the growth loop (R) is turned into a vicious cycle, which causes the state of the system to change from continued growth (1) to decline (2) (Figure 4).

Second, constant monitoring is therefore required to prevent the growth loop from being a negative (from virtuous to vicious) circle caused by limits. Because growth is continued even after inflection point, it is easy to misunderstand that the growth loop is dominant. To prevent this misunderstanding, the pattern of limits to growth should be seen in the differential point of view[9].

3.1.2 Goal Drifting

In terms of managing the system's growth, the limiting condition (constraints) in Figure 3. needs to be eliminated. Most of the social systems relaxthe limiting constraints primarilythrough investment for improvement. Thus, Figure 3. can be extended as in Figure 5. by adding a negative feedback loop (B2) which controlsthe limits by investment. The newly added negative feedback loop is called as an improvement loop. In result, three feedback loops comprise the extended 'limits to growth' archetype; a growth loop, a limiting loop, and an improvement loop. This archetype states that a gap between the goal and the actual state can be managed in two ways: by taking corrective actions to achieve the goal, or by lowering the goal through compromise with reality.Figure 5. does not consider compromise with reality. Over time, lowering the goal will deteriorate performance. Figure 5.thus can be extended to Figure 6. by considering compromise with reality. Here, negative feedback loops B2 and B3 repeat the overcome and the compromise. This is 'goal drifting'[8].

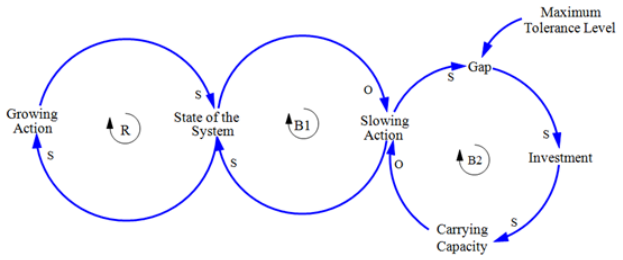


Figure 5. Extended Limits to growth 1.

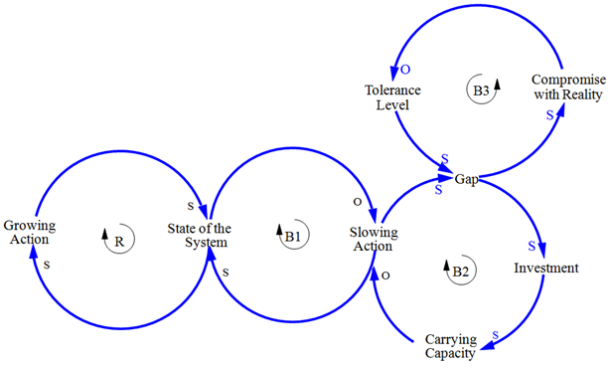


Figure 6. Extended Limits to growth 2.

3.2 CLD (Causal Loop Diagram) for Hype Cycle

The hype cycle in the process of co-evolution between technology and society can be classified into five phases as shown in Table 1. The following variables are extracted from each phases of the hype cycle as a precondition to develop a model for theunderneath structure of hype cycle.

- Technological Maturity
- Exposure to Media
- Visibility
- Expectation
- Technology Investment
- Disillusionment
- Societal Maturity
- Social Enlightenment

Figures 7 and 8 show CLD swhich reflect the extended limits to growth archetype as seen in Figure 6 with the extracted variables included. Basically, this model is developed to manage a hype system which has a gap caused by time delay between TM (Technological Maturity) and SM (Societal Maturity).

3.2.1 CLD with a Growth Lloop for Ttechnology-Push

Atechnology-driven force for the growth of new technology can be drawn as a positive (self-reinforcing) loop (R1) (Figure 7); Technology Maturity → Exposure to Media → Visibility → Expectations → Technology Investment → Technology Maturity. Initially, a new technology is exposed to the society by media and then the social visibility of technology is getting higher in short term; in turn it leads to high expectations and technology is getting more matured by investment. As a result, the social visibility of new technology overshoots.

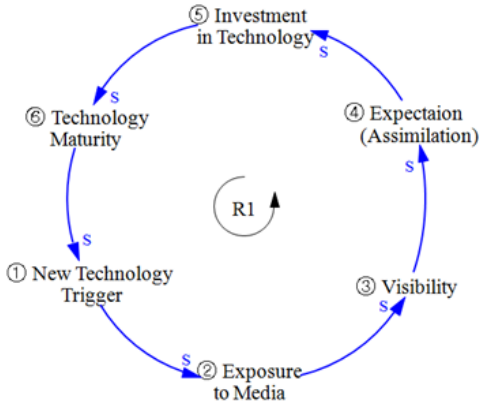


Figure 7. Technology-push growth loop.

3.2.2 CLD with Limiting Loops for Societal-Pull

The limiting force that interrupts growth of new

technology can be depictedin two negative (balancing) feedback loops (B1, B2) (Figure 8). This is similar to the goal drifting archetype: B1 corresponds to 'overcome' and B2 to 'compromise with reality'variable to the degree and characteristics of the gap between the expectation of new technology and the societal maturity which adopt it. Limiting loops as such usually work to reduce the gap through societal investment. However, the hype cycle is caused by the limiting loopswith considerable time delay in loop B1 (gap between expectation and societal condition → societal investment → social enlightenment → adoption → societal maturity →gap).Once the growth of new technology is stagnated or declined, loop B1 cannot help turning the system from negative (vicious) to positive (virtuous) cycle. A psychological factor involved in loop B2 makes it worse. As the gap between expectation and reality is not narrowed in short term and goes beyond atolerable level, compromisingloop B2 (gap → disillusionment → expectation → gap) is triggered, and reinforcing loop R1 in Figure 7 is turned into negative from the positive cycle.

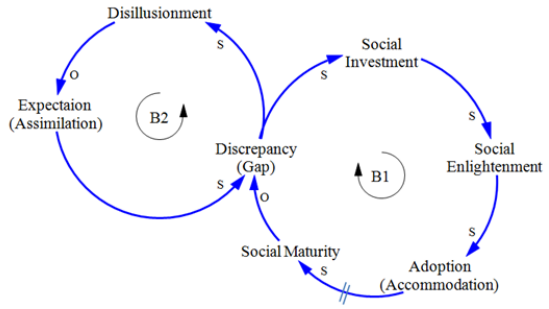


Figure 8. Societal-pull limits loop.

3.2.3 Underlying Structure of the Hype Cycle

Combining Figures 7 and 8 together, Figure 9 reveals a holistic view of the system's structure underlying the hype cycle and Figure 10 shows its behavior over time. In section [①-②] of Figure 10, loop R1 works dominantly and the visibility are growing rapidly. In section [②-③], both loop B1 trying to improve societal condition and loop B2 lowering the goal due to disillusionment work together. However, loop B1 is ineffective due to time delay while loop B2 is being dominant thus leads to lower the growth of visibility. Nevertheless, the accumulated visibility is still growing. In section [③-④], the visibility reaches at the peak and afterwards goes down rapidly because the reinforcing loop R1 turns from positive to negative cycle. In section [④-⑤], on the other hand, the overcoming loop B1 is getting effective and slows down the decrease of visibility but the accumulated visibility remains in decline and reaches at trough. In section [⑤-⑥], loop R1 turns to positive cycle by the help from reinforcing loop R2 (Visibility → Expectation → Gap → Societal Investment → Social Enlightenment → Societal Maturity → Visibility) where loop B1 is included. Finally, the visibility is tapering-off at certain level due to balance between the reinforcing loops and the balancing loops. In this phase, an attempt is made to narrow the gap between expectation and reality, learning through trial and errors. Meanwhile a new perspective comes up and adjusts the level of goal, eventually leading to plateau.

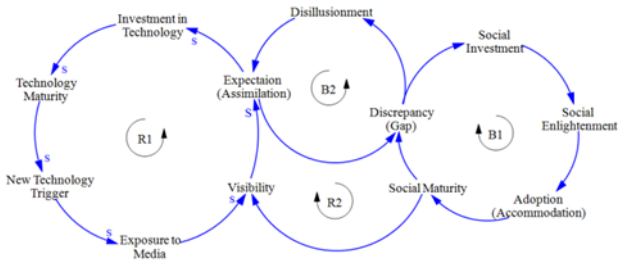


Figure 9. Integrated CLD.

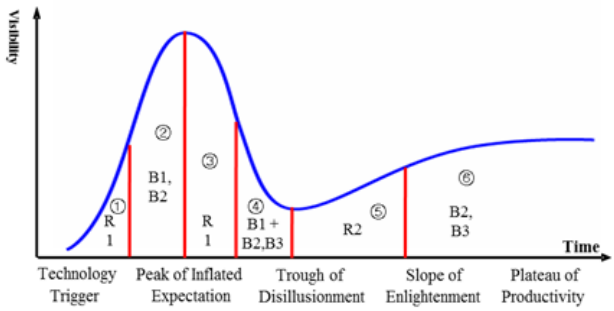


Figure 10. Phases of the Hype Cycle.

It is inevitable that visibility shows a shape of hype without any political intervention. The question is how to increase the level of plateau and reduce the amplitude of the hype cycle. Crowder suggeststwo waysto manage the hype cycle, which can be referred to develop scenarios for simulation: The first is to lower the inflated expectations to realistic level[1]. Social disillusionment usually occurred by the inflated expectation makes harder to increase adoption rate in plateau phase. The second is to enforcebusiness triggers to increase the rate of adoption by the society. In short, they focus on lowering level of the peak (expectation to new technology) and increasing level of the plateau (societal condition for adoption).

4. Simulation

4.1 Base Simulation

We developed simulation model based on the CLD as in Figure 9. The purpose of this experiment is to analyze and compare the sensitivity of BOT (Behavior Over Time) as the variables change, which cannot be shown in CLD. A simulation tool,Vensim was used and Time Step is set to 0.065 for analysis.

Simulation equations are based on NUMBER (Normalized Unit Modeling by Elementary Relationships) which enables a CLD to be converted into a SFD (Stock-Flow Diagram)[7]. It sets relationship between level variables and stock variables as an elementary relationship and equalizes measurement unit of variables to Time Step or value from 0 to 1.

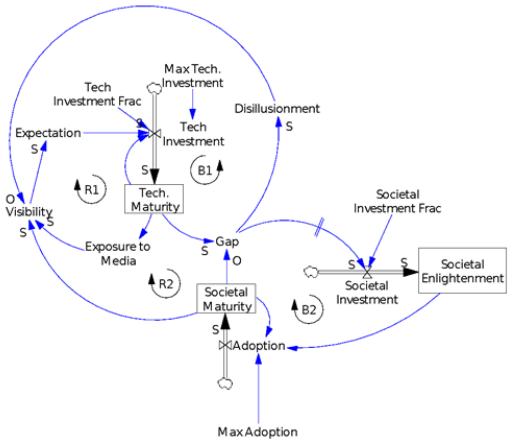


Figure 11. Hype Cycle Model described as SFD.

A SFD (Figure 11) was developed based on the relatively and intuitively indexed data rather than real data because it was difficult to gather empirical data. It is possible to capture behavior on the relative results of system's behavior and analyze effectiveness of leveraging policies even if indexed data is used for simulation.[6,12].

Figure 12. shows the behavioral patterns of the system of co-evolution where a considerable time delay exists between technology maturity and social maturity. The time delay is the main reason the hype cycle occurs. To test the sensitivity of the system's behavior influenced by the time delay, we simulated the hype cycle with changesin expectations, social maturity, and visibility. The results reveals that the more time delay involved in the societal domain, the greater amplitude of the hype cycle we have as shown in Figure 13, which will incurs a lot of social costs at the tapering stage (i.e., when reaching the plateau). Generic formulas and their BOTs for the limits to growth and the goal drifting archetypes are also provided for reference.

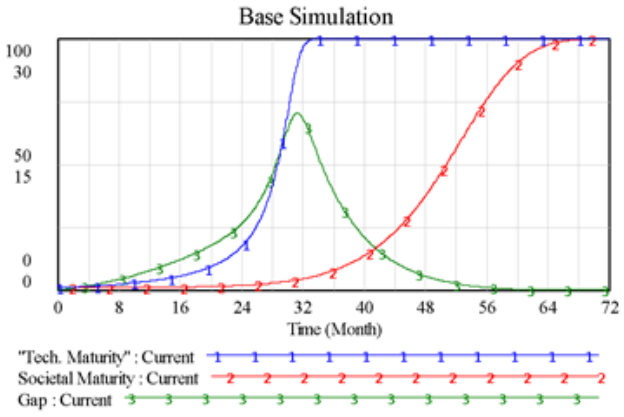
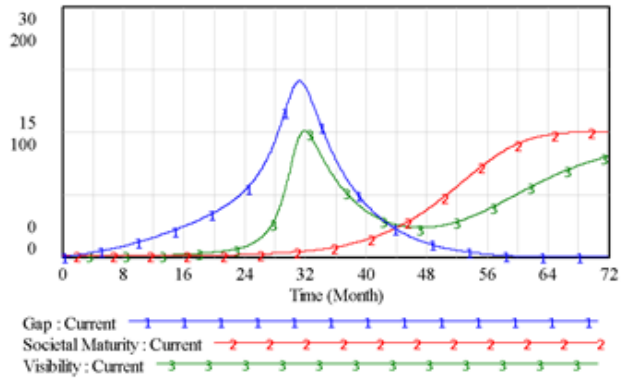


Figure 12. Time delay between technology and social maturity.



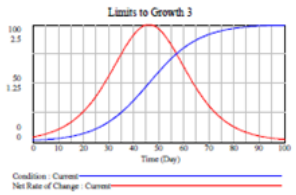
$$x'(t) = ax(t)\left(\frac{L - x(t)}{L}\right)$$

reordering

$$x'(t) = a\left(1 - \frac{x(t)}{L}\right)x(t)$$

$$x(0) = x_0$$

Where L is the limit of growth and a is the maximum fractional growth. For this example, $L = 100$, $a = 0.1$, and $x_0 = 1$.



$$x_1'(t) = -\frac{1}{T_1}x_1(t) + \frac{1}{T_1}x_2(t)$$

$$x_2'(t) = \frac{1}{T_2}x_1(t) - \frac{1}{T_2}x_2(t)$$

$$x_1(0) = x_{10} \text{ and } x_2(0) = x_{20}$$

For this example, $T_1 = 5$ and $T_2 = 10$ are the corresponding time constants of the balanced loops. $T_2 > T_1$ to represent the delay included as definition in B_2 by the original archetype in (Senge, 1990, 383.) $x_{10} = 100$ and $x_{20} = 40$.

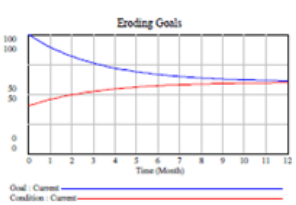


Figure 13. Hype Cycle. Limits to growth referential formula. Goal drifting referential formula

4.2 Simulation for Developing Strategies

4.2.1 Lowering Inflated Expectations to Realistic Level

Asseen in Figure 14, when the exposure of a new technology to media increases, the visibility and amplitude of hype cycle is increased and in result, the level of plateau is lowered. On the other hand, when we lower inflated expectations to the realistic level, the angle of recovery increases and does the level of plateau. But in case expectations are excessively lowered, the plateau is not leveled up as in the curve by the exposure to media 3. This implies that it is important to maintain moderate level of expectations14.

4.2.2 Enforcing the Social Adoptability

As seen in Figure 15, when societal investment is given more weight to increase social adoptability at the early stage for adoption of new technology, the plateau of visibility is leveled up. On the contrary, if technology investment is given more weight than societal investment, the plateau of visibility will be relatively lowered. This result is evident in that technical maturity is more easily achieved than the social maturity in which time delay is involved. Unless societal investment is given more at the earlier stage of growth, therefore, an imbalance in maturity between technology and society will make the 'boom-bust' scenario come into being.

4.2.3 Timing for Policy Intervention

New technology eventually meets with the plateau at a certain point in time of the co-evolution process with society. The level of plateau determines to fail or success of the co-evolution. Figure 16 shows when the policy leverage required for the successful adoption of new technology should be intervened.The upper part of Figure 16 shows the hype cycle– the accumulated visibility over time and the lower part shows how it changes per time unit–a net change. Quite often, policy makers are likely to decide a point in time(point B, C or D) for policy intervention only by looking at the hype cycle, which will lead them to miss the timing by the time they recognize the needs for intervention, and the angle of recovery which determines the level of plateau cannot be increased. However, with an attention to net changes in visibility as shown in the lower part of Figure 16 we easily come to know that the policy leverage should be intervened at point A.

Figure 17 shows the result of simulation when the policy leverage is intervened according to each point (A~D). The earlierintervention, the higher plateau we reach at the final stage of co-evolution. Specifically, practical policy establishment and modification should be done before point A, considering time delay between technology and social change. And the co-evolution would be successful when the policy leverage is intervened at least between A and B.

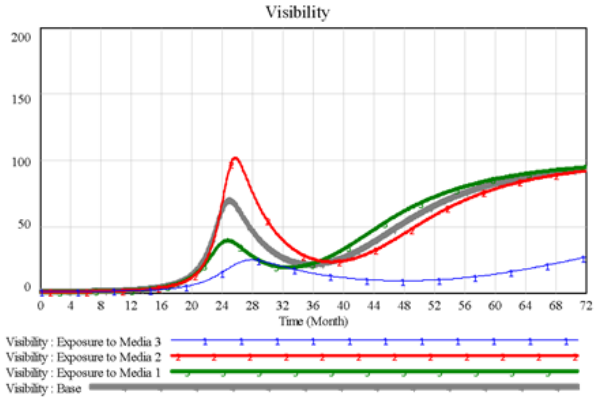


Figure 14. Exposure to Media Variable adjustment.
Base: 0.05
Exposure to Media 1: 0.02
Exposure to Media 2: 0.08
Exposure to Media 3: 0.007

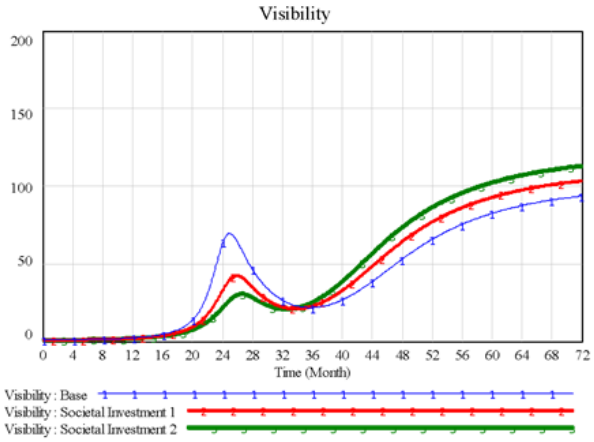


Figure 15. Exposure to Media Variable adjustment.
Base: 0.05
Societal Investment 1: 0.08
Societal Investment 2: 0.11

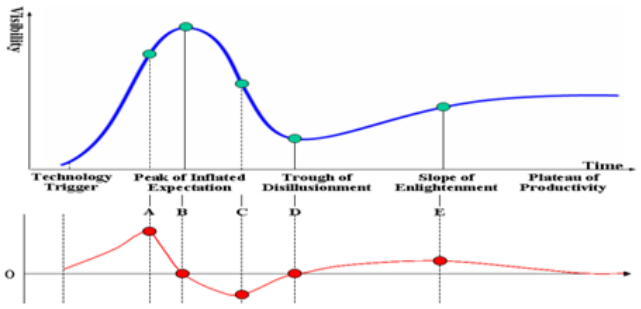


Figure 16. Policy Intervention.

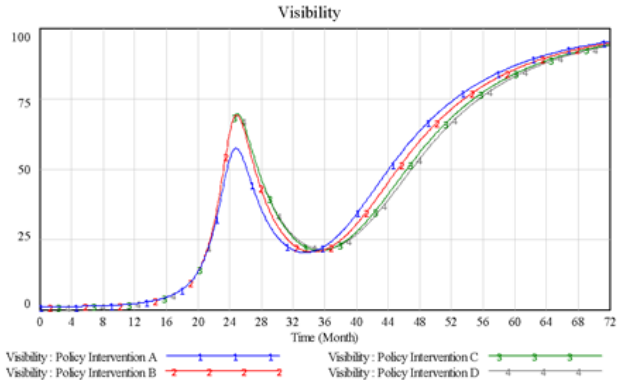


Figure 17. Policy Intervention Simulation.
Policy Intervention A: Time 20
Policy Intervention B: Time 24
Policy Intervention C: Time 28
Policy Intervention D: Time 32

5. Conclusion

Social adoption of new technology always entails a hype cycle, along the path of which 'inflated expectations' at the initial stage of adoption, as per the diagram below, quickly fall into 'disenchantment' at a subsequent stage. This 'boom-bust' scenario is primarily caused by an imbalance in maturity between society and technology. Such a situation can be compared to a horse-drawn carriage with two wheels. What if one wheel is bigger than the other? However hard a horse draws the carriage it won't move forward. In the same fashion, considering that technical maturity is more easily achieved than the societal is a key to the successful development of society through ICT applications.

This research focused on how to maximize the plateau of visibility in the last phase of co-evolution and the causes of the hype cycle which appears in the process of co-evolution between technology and society. The simulation reveals the hype cycle is caused by time delay between technology maturity and social maturity for adoption of the technology. And it suggests that the effort to lower the inflated expectations for a new technology down to the realistic level, and the policy that can increase social adoptability should be appliedto manage the hype cycle successfully. And the policy leverage should be applied in the early stage when the visibility starts increasing.

The strategic implications are as followings. First, the sustainability of new technology is increased as the gap of time delay between technology maturity and social maturity is narrowed. Thus social constraints which limit the growth of maturity should be detected in the earlier phase and the policy leverage should be established to eliminate those constraints.

Second, the exposure of new technology to media is not always desirable. The inflated expectation on the new technology may lead to disillusionment caused by constraints in the real world. Therefore, it is critical to maintain a moderate level of the expectation corresponding to the level of social maturity.

Third, for the sustainability of new technology, the policy to increase social adoptability should be developed and applied in the early phase when visibility starts increasing.

Despite the theoretical and practical contribution of this research, there are limitations. Although the method, NUMBER (Normalized Unit Modeling by Elementary Relationships) we adopted for simulation is useful to compare and assess the effectiveness of selected policies by analyzing the relative behaviors between variables, a more sophisticated model has to be developed, and the empirical data are required to reflect more realistic situations.

6. References

1. Crowder J. Leveraging Technology to Accelerate Adoption. Emerging Technology Component Subcommittee Quarterly Meeting; Noblestar. 2004.
2. Gartner Inc.Gartner's Hype Cycle Special Report for 2003.
3. Gartner Inc. Gartner's Hype Cycle Special Report for 2007.
4. Gartner Inc. Gartner's Hype Cycle Special Report for 2009.
5. Gartner Inc. Gartner's Hype Cycle Special Report for 2014.
6. Jeon JH. A Dynamic Analysis on the Relative Effectiveness of Promoting Policies for Information Security Industry. Korean System Dynamics Review. 2003; 4(2):5–44.
7. Kim DH. A Simulation Method of Casual Maps: NUMBER.

Korean System Dynamics Review. 2011; 1(2):91–111.
8. Kim D, Anderson V. Systems Archetype Basics. Waltham: Pegasus Communications, Inc; 1998.
9. Kim SW. System Thinking and System Scenario. Chungbuk National University Press. 2010.
10. Kim SW, Kim SH. A Thought on the Dynamic Mechanism of Coevolution between IT and Society and Its Policy Implications. Korean System Dynamics Review. 2006; 7(2):5–20.
11. Moore JF. The Death of Competition. Fortune. 1996; 133(7):142.
12. Sterman JD. Business Dynamics: Systems Thinking and Modeling for a Complex World. Irwin McGraw-Hill. 2000.
13. Warschauer M. Technology and Social Inclusion: Rethinking the Digital Divide; MIT. 2003.
14. Yeon, et al. Technological Forecasting and Social Change. 2006; 73(6):648–65.