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A NEW CONCEPT OF R&D IN NEO OPEN INNOVATION - TRANSFORMATION OF R&D TRIGGERED BY AMAZON

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ABSTRACT

Amazon was the world's top R&D firm in 2017. Its R&D investment was double that of 2015, quintuple that of 2012, and tenfold that of 2011. It deploys a unique R&D model as conducting "routine or periodic alterations" and "significant improvement" simultaneously. Since traditionally the former is classified as non-R&D, Amazon's rapid and notable increase has raised the question of a new R&D definition in the digital economy.

By means of an empirical analysis of the Amazon's R&D model, this paper attempted to provide a convincing answer to this question.

Amazon has invested considerable resources in extremely innovative business areas, which has developed its assimilation capacity. In parallel with such forefront innovation, Amazon is endeavoring to absorb soft innovation resources from external markets and assimilate them into its business model. This then transforms "routine or periodic alterations" into "significant improvement", leading to the company becoming the world's top R&D firm.

Such an endeavor has triggered a new concept of R&D in neo open innovation and revealed the significance of a transformation of the R&D concept in the digital economy.

KEYWORDS

R&D, neo open innovation, Amazon, transformation, technology and content

1. INTRODUCTION

While crucial dilemma between R&D expansion and productivity decline derived from the two-faced nature of information and communication technology (ICT) centered on the advancement of the Internet has become a serious problem for ICT firms [1], global ICT leaders exhibited a remarkable R&D growth.

Fig. 1 illustrates world top 25 R&D leaders by their R&D expenditure in 2017 which demonstrates notable R&D growth rate in software and Internet leaders in 2017 as 40.4% (Amazon), 12.7% (Google), 8.8% (Microsoft), 28.5% (Huawei) and 24.5% (Apple) while growth rate in computer & electronics has shown extremely lower as -3.2% (Samsung) and 5.0% (Intel). Noteworthy is Amazon's conspicuous jump. It invested 22.6 billion US\$ R&D in 2017 and jumped up to the world's top R&D firms exceeding rivals of global ICT leaders. It is only in the past few years that Amazon's spending has ranked among the potential global leaders in R&D.

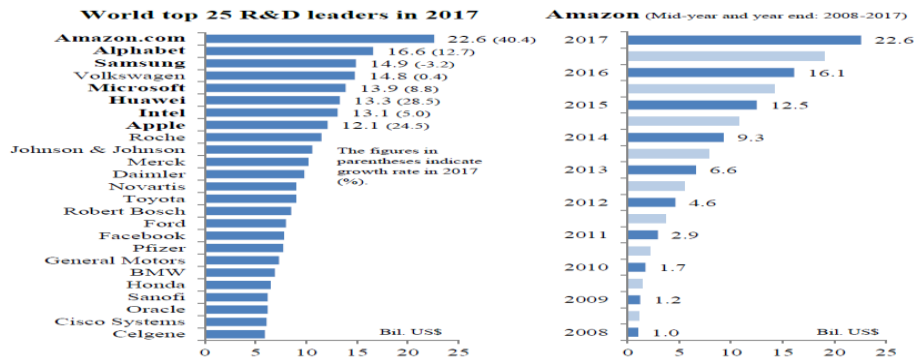


Figure 1. Amazon's conspicuous jump into the world's R&D leader in 2017.

Original sources: [2], [3].

The rapid increase in R&D showed no signs of slowing in 2018. The amount spent by Amazon on R&D in 2018 is poised to surpass the GDP of Iceland as demonstrated in **Fig. 2** [4].

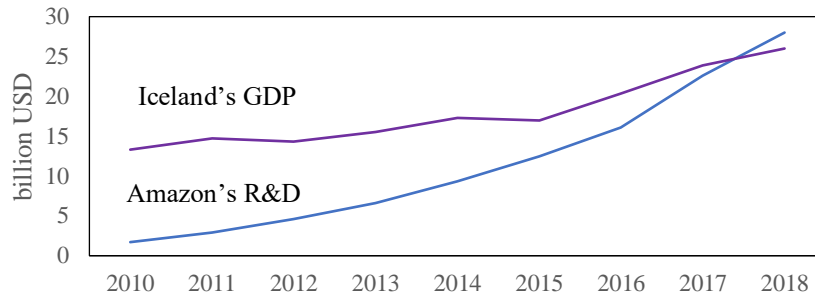


Figure 2. Trends in Amazon's R&D investment and Iceland's GDP (2010-2018).

Sources: [5] and Quartz projection.

Such a rapid and notable increase in R&D investment has raised the two questions.

First, the definition of R&D in the digital economy. Authors pointed out the structural change of the concept of output in the digital economy and revealed the limitation of GDP in measuring the output of the digital economy [6], [7] by demonstrating the increasing dependence on uncaptured GDP [8], [9]. Amazon's rapid and notable increase in its R&D investment amidst the digital economy prompts us a possibility of a structural change of the concept of R&D, similar to the output. Amazon insists on describing "technology and content," not "R&D" as its "R&D investment." This implies profound insights about the R&D model in the digital economy.

Second, a disruptive business model that provides a reasonable solution to the dilemma between

R&D expansion and productivity decline. Notwithstanding such a fear of dilemma, Amazon has been accomplishing notable performance [10] by making full utilization of such a rapidly increasing R&D. Amazon has invested considerable resources into extremely innovative business areas such as Amazon Web Services (AWS), Alexa (Amazon Echo) and Amazon Go which develops its assimilation capacity.

In parallel with such forefront innovation challenge, it endeavors to absorb soft innovation resources such as sleeping and untapped resources [11] from external markets and assimilate them into its business model. This transforms “routine or periodic alternations” (classified as non R&D in the traditional accounting standard) into “significant improvement” (similarly classified as R&D) leading to the company becoming the world’s top R&D firm.

Since this endeavor can be expected to trigger the new concept of R&D in neo open innovation, an empirical analysis of Amazon’s initiative may lead the way in revealing the significance of transformation of R&D concept in the digital economy.

In light of such an Amazon’s notable business performance based on its unique business model, to date, a significant number of studies attempted to analyze its notable performance and unique business model (e.g., [12], [13], [10]). In addition, given such a rapid and notable R&D increase as leading Amazon to world’s top R&D firm in 2017 over such a short period of time as reviewed above, number of questions were raised to its R&D model, really R&D or merely routine or periodic alternations (e.g., [3], [14]). However, none has analyzed its R&D model from the view point of providing a solution to the dilemma between R&D expansion and productivity decline that majorities of global ICT firms have been confronting in the digital economy [11]. Authors, in their preceding work, postulated a significance of neo open innovation in the digital economy as a promising solution to such a dilemma [1]. Examination of this postulate by analyzing Amazon’s R&D performance is expected to shed light on the transformative direction toward a new concept of R&D in the digital economy.

This paper attempted to elucidate this dynamism. An empirical analysis focusing on Amazon’s R&D performance by absorbing external R&D resources, particularly soft innovation resources and assimilating them in its business model was conducted.

Organization of this paper is as follows: Section 2 over reviews Amazon’s unique R&D model. Its R&D, scope, definition, and way of implementation is discussed in Section 3. Section 4 elucidates Amazon’s R&D inducement dynamism. Section 5 summarizes the noteworthy findings, policy suggestions, and future research.

2. AMAZON’S UNIQUE R&D MODEL

2.1. BASIC MODEL

Notwithstanding a rapid and notable increase in expenses for business activities generally described as “R&D,” based on its basic principle for customer service, Amazon insists on describing “technology and content” in its annual report [15].

Amazon has invested considerable resources in extremely innovative business areas such as AWS, Alexa and Amazon Go.

In parallel with such forefront innovation, Amazon is endeavoring to absorb soft innovation resources from external markets and assimilate them into its business model which transforms “routine or periodic alterations” business activities into “significant improvement” ones leading to

Amazon becoming the world's top R&D firm.

This transformation depends on its high level of assimilation capacity which can be attributed to the rapid and notable increase in its R&D investment, and also on the absorption of broad soft innovation resources based on Amazon empire chain and big data collection system.

2.2. R&D STRUCTURE

2.1.1 Scope

Amazon has been encompassing a broad area of activities such as research, design, development, and maintenance of both new and existing products and services in its “technology and content” business activities. It accomplishes these activities in such broad scope simultaneously with the principle that its business should not be managed by separating activities of the type as classified in the traditional accounting standard.

2.1.2 Costs

Costs for “technology and content” activities consists primarily of expenses for employees and infrastructure costs.

(i) Expenses for employees

Payroll and expenses for employees involved in the research and development of new and existing products and services, development, design, and maintenance of its websites, curation, and display of products and services made available on its websites.

(ii) Infrastructure costs

Servers, networking equipment, and data center related depreciation, rent, utilities, and other expenses necessary to support AWS, as well as these and other efforts.

2.1.3 Management policy

Its management has been conducted in a consistent and systematic way for improving customer experience based on the Amazon doctrine, as was explained by Amazon CEO Jeff Bezos in 2012 as “Above all else, align with customers. Win when they win. Win only they win.”

(i) Basic philosophy

Manage these costs for “technology and content” activities collectively, as investments being made on behalf of its customers to improve their experiences.

(ii) Operation policy

Manage the total investment in its employees and infrastructure across all its products and services, not separate activities of the type as classified in the traditional accounting standard.

(iii) Resource Allocation Strategy

Most of its profits come from its high-tech division, cloud computing operation, and AWS. These profits have been reinvesting in its business and employees not in dividends and buybacks. That strategy is reflected in spending on “technology and product” development activities which has led to Amazon becoming the world's top R&D firm in a short period.

2.3. R&D Inducement Dynamism

Amazon's business model and endeavors to frontier innovation challenge in AWS, Alexa and Amazon Go have developed its growing empire fusing physical and digital toward “selling

anything that can be sold online” and also subsequent big data collection system.

This empire chain and big data collection system has enabled Amazon to absorb external innovation resources extensively and assimilate them in its indigenous business model. This assimilation has been transforming “routine or periodic alterations” activities into “significant improvement” activities as illustrated in **Fig. 3**.

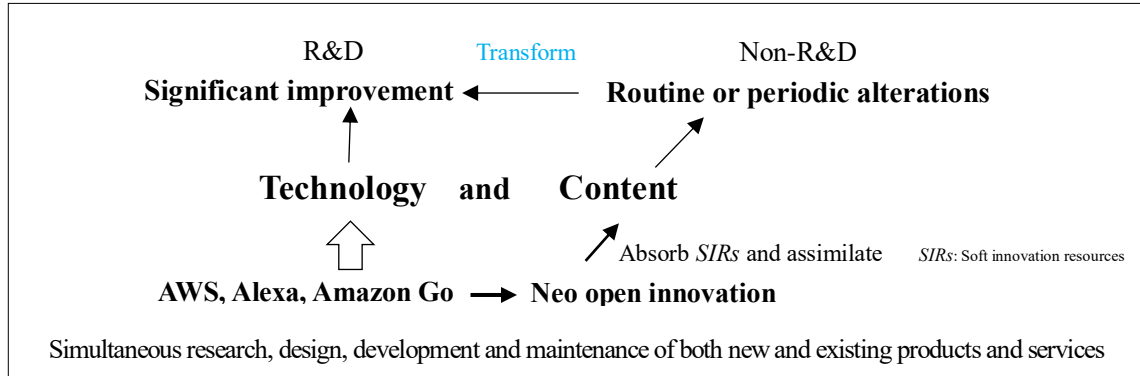


Figure 3. Scheme of Amazon’s unique R&D model.

Wholistic management policy, not separate activities of the type as classified in the traditional accounting standard, contributes broad dissemination of this transformation effects. Amazon endeavors to forefront innovation and assimilation of external innovation, particularly of soft innovation (neo open innovation) mixed well leading to self-propagating R&D initiatives. All can be attributed to its leadership principles as *customer obsession; ownership; invent and simplify; are right, a lot; learn and be curious; hire and develop the best; insist on the highest standards; think big; bias for action; frugality; earn trust; dive deep; have backbone, disagree and commit; and deliver results* [16].

As a consequence of such a unique R&D model as a system, Amazon has been depending on its identical R&D concept. It has been describing “technology and content” for business activities generally considered R&D investment since 1999. While this description brings suspicion on the content of Amazon’s huge amount of investment classified in “R&D” in cross firms comparison, this description incorporates profound implications that Amazon has been pursuing identical innovation endeavor.

Next Section unveils such profound implications.

3. AMAZON’S R&D

3.1. DESCRIPTION OF R&D INVESTMENT

Amazon has been pursuing identical innovation endeavor by insisting on describing its business activities generally considered R&D investment as “technology and content.” **Table 1** compares this concept with R&D conducted by Apple.

Table 1. Comparison of “R&D investment” description between Amazon and Apple (2017).

| | Category | Description |
|--------|-------------------------|---|
| Amazon | Technology and contents | Technology and content costs include payroll and related expenses for employees involved in the research and development of new and existing products and services, development, design, and maintenance of our websites, |

| | | |
|-------|--------------------------|---|
| | | curation, and display of products and services made available on our websites, and infrastructure costs. Infrastructure costs include servers, networking equipment, and data center related depreciation, rent, utilities, and other expenses necessary to support AWS, as well as these and other efforts. Collectively, these costs reflect the investments we make to offer a wide variety of products and services to our customers. |
| Apple | Research and development | Because the industries in which the Company competes are characterized by rapid technological advances, the Company's ability to compete successfully depends heavily upon its ability to ensure a continual and timely flow of competitive products, services and technologies to the marketplace. The Company continues to develop new technologies to enhance existing products and services, and to expand the range of its offerings through R&D, licensing of intellectual property and acquisition of third-party businesses and technology. |

Sources: [15], [17].

Similar to other ICT leaders, while Apple has been stressing the significance of continued R&D, licensing and M&A for ensuring a continual and timely flow of competitive products, services and technologies to the marketplace, Amazon has been insisting on collective securement and management of costs for broad areas of employees (involving in research and development of new and existing products and services, development, design, and maintenance of AMS, curation and display of products and services made available on AMS) and infrastructure (including servers, networking equipment, and data center related depreciation, rent, utilities, and other expenses necessary to support AWS) for offering a wide variety of products and services to its customers.

3.2. THE SIGNIFICANCE OF TECHNOLOGY AND PRODUCT CONCEPT – DEBATE WITH THE SECURITIES AND EXCHANGE COMMISSION

In light of the vast amounts of money coming and going from particular segments of ICT giants such as Google's You Tube and Amazon's AWS and Alexa, the US Securities, and Exchange Commission (SEC) paid special attention to Amazon's allocation of R&D spending.

In a series of letters that it sent to Amazon executives during the fall and winter in 2017-18 and released to the public in April 2018, SEC urged Amazon to disclose its R&D spending as other companies do. Points of the debate can be summarized as follows which unveils Amazon's profound implications on its unique R&D model [3]:

SEC (27 Sep. 2017)

Please tell us and disclose in future filings the total amount of research and development costs charged to expense for each year presented in the consolidated statements of operations as required by ASC (Accounting Standards Codification).

Amazon (26 Oct. 2017)

Our business model encourages simultaneous research, design, development, and maintenance of both new and existing products and services. For example, our teams are constantly working to build new Alexa skills and simultaneously maintain current skills, and these activities are within a continuum of those described in ASC 730-10-55-1 and 2 (see below) and are not easily distinguishable operationally.

SEC (24 Nov. 2017)

As previously requested, please disclose the total amount of research and development costs charged to expense for each year presented in the consolidated statements of operations as required by ASC 730-10-55-1.

Amazon (21 Dec. 2017)

Because of our relentless focus on innovation and customer obsession, we do not manage our business by separating activities of the type that under ASC 730-10-55-1 are “typically ... considered” research and development from our other activities that are directed at ongoing innovation and enhancements to our innovations. Instead, we manage the total investment in our employees and infrastructure across all our product and service offerings, rather than viewing it as related to a particular product or service; we view and manage these costs collectively as investments being made on behalf of our customers in order to improve the customer experience. We believe this approach to managing our business is different from the concept of planned and focused projects with specific objectives that were contemplated when the accounting standards for research and development were developed under FAS 2 (Financial Accounting Standards). Given the significant breadth of projects and improvements that we have underway, our employees routinely work concurrently on multiple projects, including projects that could be defined as research and development in nature and also more routine, ongoing activities to refine, enrich, or otherwise improve or adapt our existing products and services. Similarly, our activities may focus on developing new products and services, but these activities often result, in whole or in part, in enhancements to existing products and services.

SEC (22 Jan. 2018)

If you are unable to identify or estimate research and development costs, please explain in detail the reasons for your inability.

Amazon (16 Feb. 2018)

In reassessing this conclusion in response to your comment, we discussed with our investor relations department whether quantifying traditional research and development costs within the scope of ASC 730-10-55-1 would be meaningful or useful for investors, and we also reviewed our earnings call transcripts for the past three years to see whether investors ask questions about research and development costs within the scope of ASC 730-10-55-1. These discussions and review reaffirmed that such costs are not material for two reasons. First, as discussed above, because of the range of innovation activities we undertake to support the hundreds of millions of different products and services that we offer, aggregate research and development cost data would not indicate any particular area of activity and would not reveal trends with regard to development efforts that are material to an understanding of our business. Second, we believe that distinguishing between costs attributable to activities of the type described in ASC 730-10-55-1 and those attributable to activities described in ASC 730-10-55-2 would be confusing and misleading to investors, as the resulting disclosures would not fairly present the investments we make in order to offer a wide variety of products and services to our customers.

SEC (9 Mar. 2018)

We have completed our review of your filing. We remind you that the company and its management are responsible for the accuracy and adequacy of their disclosures, notwithstanding any review, comments, action or absence of action by the staff.

3.3. AMAZON'S CLAIMS TO TRADITIONAL R&D DEFINITION

Financial Accounting Standards Board (FASB) Accounting Standards Codification (ASC) provides the U.S. generally accepted accounting principles (GAAP) for businesses. GAAP defines R&D as follows [18]:

Research is planned search or critical investigation aimed at discovery of new knowledge with the hope that such knowledge will be useful in developing a new product or service (hereinafter "product") or a new process or technique (hereinafter "process") or in bringing about a significant improvement to an existing product or process.

Development is the translation of research findings or other knowledge into a plan or design for a new product or process or for a significant improvement to an existing product or process whether intended for sale or use. It includes the conceptual formulation, design, and testing of product alternatives, construction of prototypes, and operation of pilot plants.

It illustrates activities typically included and excluded from R&D as summarized in **Table 2**. The former activities correspond to those of contributing to significant improvement while the latter activities contribute only to routine or periodic alterations.

Table 2. Activities typically included and excluded from R&D.

| |
|---|
| <p>Activities typically included in R&D (730-10-55-1)</p> <ul style="list-style-type: none"> a. Laboratory research aimed at discovery of new knowledge b. Searching for applications of new research findings or other knowledge c. Conceptual formulation and design of the possible product or process alternatives d. Testing in search for or evaluation of product or process alternatives e. Modification of the formulation or design of a product or process f. Design, construction, and testing of preproduction prototypes and models g. Design of tools, jigs, molds, and dies involving new technology h. Design, construction, and operation of a pilot plant that is not of a scale economically feasible to the entity for commercial production i. Engineering activity required to advance the design of a product to the point that it meets specific functional and economic requirements and is ready for manufacture j. Design and development of tools used to facilitate research and development or components of a product or process that are undergoing research and development activities. |
| <p>Activities typically excluded from R&D (730-10-55-2)</p> <ul style="list-style-type: none"> a. Engineering follow-through in an early phase of commercial production b. Quality control during commercial production including routine testing of products c. Trouble-shooting in connection with break-downs during commercial production d. Routine, ongoing efforts to refine, enrich, or otherwise improve upon the qualities of an existing product e. Adaptation of an existing capability to a particular requirement or customer's need as part of a continuing commercial activity f. Seasonal or other periodic design changes to existing products g. Routine design of tools, jigs, molds, and dies h. Activity, including design and construction engineering, related to the construction, relocation, rearrangement, or start-up of facilities or equipment other than the following: <ul style="list-style-type: none"> 1. Pilot plants (see [h] in the preceding paragraph) 2. Facilities or equipment whose sole use is for a particular R&D project |

- | |
|---|
| i. Legal work in connection with patent applications or litigation, and the sale or licensing of patents. |
|---|

Source: [19].

Amazon claims that the boundary between two activities has been blurring in the digital economy, and also difficult to separate as its R&D activities are implemented in such a way as simultaneous research, design, development and maintenance of both new and existing products and services in a wholistic business operation. Also, Amazon's R&D has been conducted in transforming routine or periodic alterations into significant improvement during the R&D process as it absorb soft innovation resources from external environments and assimilate them into its routine or periodic alterations activities leading to transforming these activities into activities that lead to significant improvement.

Next Section elucidates this dynamism.

4. AMAZON'S R&D INDUCEMENT DYNAMISM

4.1. EXPONENTIAL INCREASE IN R&D TRIGGERED BY AWS-BASED SERVICES

Amazon's business model and endeavors to frontier innovation challenge in AWS, Alexa and Amazon Go develops its growing empire fusing physical and digital toward "selling anything that can be sold online" and also subsequent big data collection system as demonstrated in **Fig. 4**.

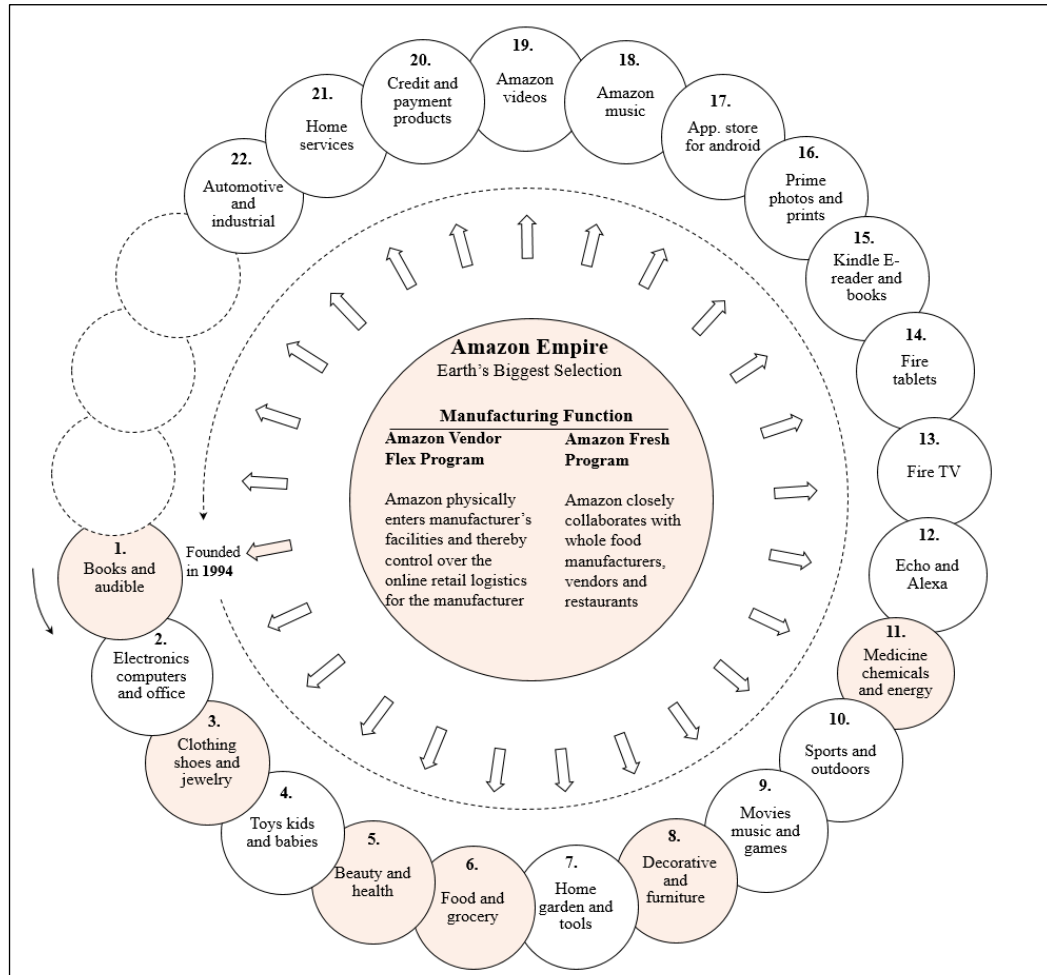


Figure 4. Amazon's growing empire by final product category.

Source: [20].

From November 2010 all of its retail web services have transformed into those of AWS-based services by migrating to AWS [21]. This transformation has leveraged dramatic increase in R&D (expenses on technology and contents) aiming at offering a wide variety of products and services to its customers. Its R&D exceeded that of Apple from 2011 and triggered its lead as demonstrated in **Fig. 5**. Since then Amazon has transformed into R&D-driven firm as demonstrated by its notable increase in its R&D intensity (ratio between R&D and sales) as demonstrated in **Fig. 6**. While R&D increase contributes to sales increase which increases profits, Amazon reinvests such profits to R&D based on its resource allocation strategy as reviewed earlier.

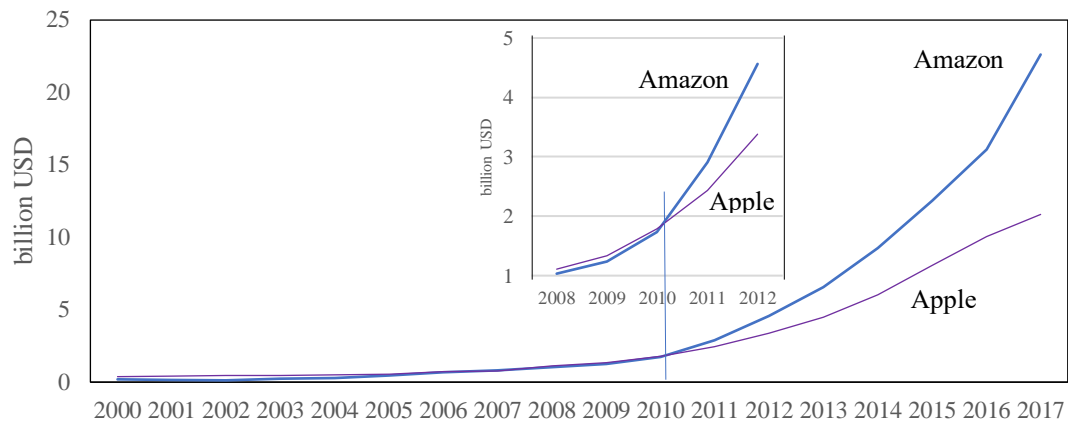


Figure 5. The trend in R&D investment in Amazon and Apple (2008-2017).

Sources: [15], [17].

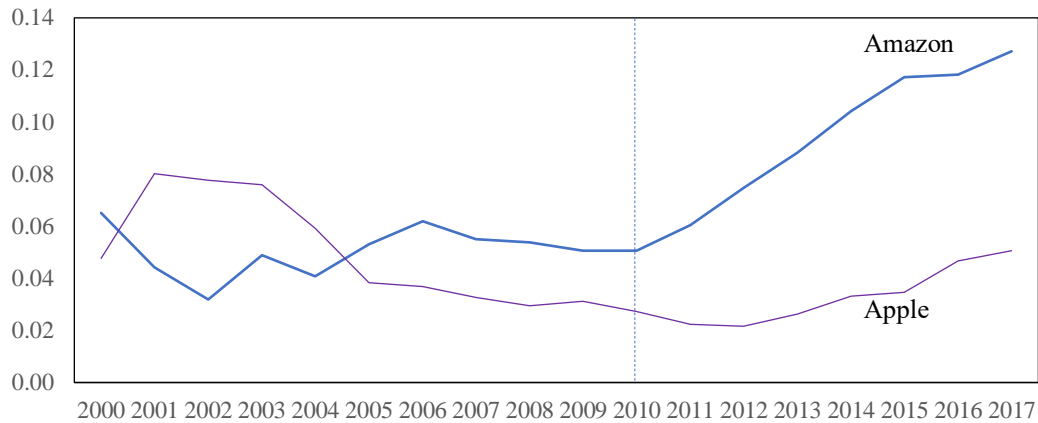


Figure 6. The trend in R&D intensity in Amazon and Apple (2001-2017).

Sources: [15], [17].

Consequently, its R&D intensity continued to increase since 2010 while this intensity was not time-dependent before 2009 as demonstrated in **Table 3**.

Table 3. Time dependency on Amazon's R&D intensity (2000-2017).

$$\ln R/S = -273.47 + 0.017 D_1 t + 0.135 D_2 t + 236.38 D_1 \quad adj. R^2 0.846 \quad DW 1.51$$

$$(-5.13) \quad (0.90)^* \quad (5.09) \quad (3.62)$$

where t : time trend, D : dummy variables (D_1 : 2000-2009 = 1, other years = 0); D_2 : 2010-2017 = 1, other years = 0).

The figures in parentheses indicate t-statistics: All are significant at the 1% level, except * is not significant.

Table 3 demonstrates that R/S increased exponentially since 2010 while this intensity was not time-dependent before 2009.

Consequently, above transformation into AWS-based services in 2010 has triggered extremely high level R&D intensity (higher than double of Apple's intensity level) as compared in **Table 4**.

Table 4. Comparison of trends in key managerial factors between Amazon and Apple (2000-2017).

| year | Amazon | | | | | | Apple | | | | | |
|------|--------|------|-------|-------|-------------|-------|--------|-------|-------|-------|------|-------|
| | Sales | OI | R | OI/S | R/S | OI/R | Sales | OI | R | OI/S | R/S | OI/R |
| 2000 | 2762 | -864 | 180 | -0.31 | 0.07 | -4.80 | 7983 | 522 | 380 | 0.07 | 0.05 | 1.37 |
| 2001 | 3122 | -412 | 138 | -0.13 | 0.04 | -2.98 | 5363 | -344 | 430 | -0.06 | 0.08 | -0.80 |
| 2002 | 3933 | 64 | 125 | 0.02 | 0.03 | 0.51 | 5742 | 17 | 446 | 0.00 | 0.08 | 0.04 |
| 2003 | 5264 | 270 | 257 | 0.05 | 0.05 | 1.05 | 6207 | -1 | 471 | 0.00 | 0.08 | 0.00 |
| 2004 | 6921 | 440 | 283 | 0.06 | 0.04 | 1.55 | 8279 | 326 | 491 | 0.04 | 0.06 | 0.66 |
| 2005 | 8490 | 432 | 451 | 0.05 | 0.05 | 0.96 | 13931 | 1643 | 535 | 0.12 | 0.04 | 3.07 |
| 2006 | 10711 | 389 | 662 | 0.04 | 0.06 | 0.59 | 19315 | 2453 | 712 | 0.13 | 0.04 | 3.45 |
| 2007 | 14835 | 655 | 818 | 0.04 | 0.06 | 0.80 | 24006 | 4409 | 782 | 0.18 | 0.03 | 5.64 |
| 2008 | 19166 | 842 | 1033 | 0.04 | 0.05 | 0.82 | 37491 | 8327 | 1109 | 0.22 | 0.03 | 7.51 |
| 2009 | 24509 | 1129 | 1240 | 0.05 | 0.05 | 0.91 | 42905 | 11740 | 1333 | 0.27 | 0.03 | 8.81 |
| 2010 | 34204 | 1406 | 1734 | 0.04 | 0.05 | 0.81 | 65225 | 18385 | 1782 | 0.28 | 0.03 | 10.32 |
| 2011 | 48077 | 862 | 2909 | 0.02 | 0.06 | 0.30 | 108249 | 33790 | 2429 | 0.31 | 0.02 | 13.91 |
| 2012 | 61093 | 676 | 4564 | 0.01 | 0.07 | 0.15 | 156508 | 55241 | 3381 | 0.35 | 0.02 | 16.34 |
| 2013 | 74452 | 745 | 6565 | 0.01 | 0.09 | 0.11 | 170910 | 48999 | 4475 | 0.29 | 0.03 | 10.95 |
| 2014 | 88988 | 178 | 9275 | 0.00 | 0.10 | 0.02 | 182795 | 52503 | 6041 | 0.29 | 0.03 | 8.69 |
| 2015 | 107006 | 2233 | 12540 | 0.02 | 0.12 | 0.18 | 233715 | 71230 | 8067 | 0.30 | 0.03 | 8.83 |
| 2016 | 135987 | 4186 | 16085 | 0.03 | 0.12 | 0.26 | 215639 | 60024 | 10045 | 0.28 | 0.05 | 5.98 |
| 2017 | 177866 | 4106 | 22620 | 0.02 | 0.13 | 0.18 | 229234 | 61344 | 11581 | 0.27 | 0.05 | 5.30 |

S: Sales, OI/R: Operating income, R: R&D expenditure.

Sources: [15], [17].

4.2. R&D-DRIVEN BUSINESS MODEL INDUCING USER-DRIVEN INNOVATION

Such a spiral increase in Amazon's R&D enabled Amazon offering a wide variety of products and services to its customers corresponding to its very first leadership principle: *Customer obsession*.

This accomplishment can be evidenced by its high level of stock prices as demonstrated in **Fig. 7** and **Table 5**.

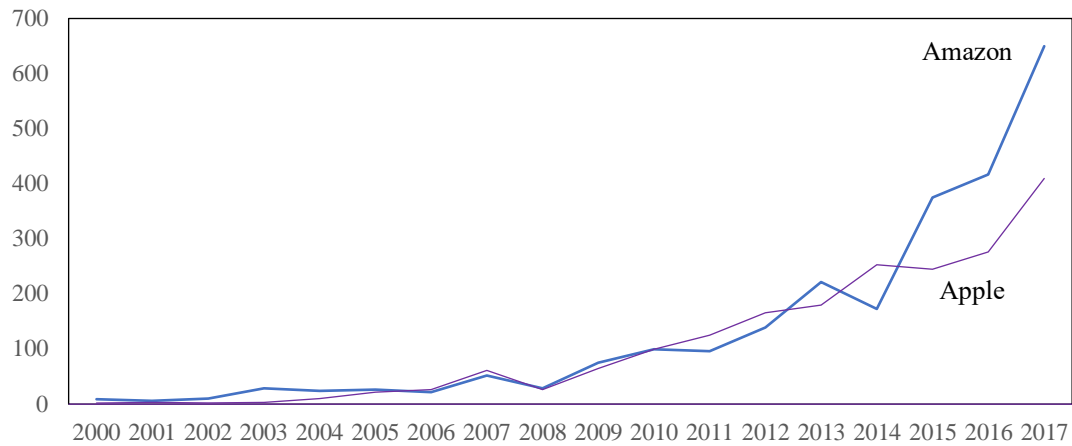


Figure 7. The trend in stock prices in Amazon and Apple (2000-2017) - Index: 2010 = 100.

* Stock prices indicate the closing price of each year.

Sources: [22], [23].

Table 5. Governing factors of stock prices in Amazon and Apple (2000-2017).

$$\ln ST = A + b \ln OI + c \ln R$$

| | <i>A</i> | <i>b</i> | <i>c</i> | <i>adj. R</i> ² | <i>DW</i> |
|--------|---------------------|--------------------|-------------------|----------------------------|-----------|
| Amazon | -1.035 (-2.22)** | 0.161 (1.63)*** | 0.657 (9.77)* | 0.942 | 2.13 |
| Apple | -4.503 (-5.10)* | 0.433 (4.37)* | 0.501 (2.49)** | 0.917 | 1.61 |

The figures in parentheses indicate t-statistics. *, ** and *** are significant at the 1 %, 5% and 10% level, respectively.

Note: $ST = F(S, OI, R, OCF)$

where ST : stock prices, S : sales, OI : operating income, R : R&D expenditure, OCF : operating cash flow.

Translog (transcendental logarithmic) expansion on the first term:

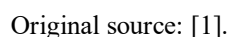
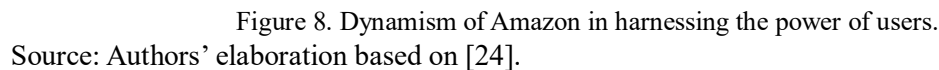
$$\ln ST = A + a \ln S + b \ln OI + c \ln R + d \ln OCF$$

Regression analysis by backward elimination method at 20% significance level identifies

$$\ln ST = A + b \ln OI + c \ln R \quad \text{in both firms examined.}$$

Table 5 demonstrates that Amazon largely depends on R&D, not significantly on OI in its stock prices formation while Apple depends both on OI and R&D. This analysis supports the postulate that Amazon has provided qualified products and services to its customers corresponding to its first leadership principle: *Customer obsession* by means of R&D-driven business model.

The offering of such products and services, in turn, has induced user-driven innovation. Such a business model has enabled Amazon absorbing external resources extensively and assimilating them in its business. Amazon has deployed “architecture of participation,” thus making the most of digital technology by harnessing the power of its users to create more value [24] as illustrated



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innovation and emergence of soft innovation resources can be expected.

4.3. ASSIMILATION OF SOFT INNOVATION RESOURCES

This dramatic advancement of the Internet has emerged soft innovation resources as also illustrated in Fig. 9. Emerged soft innovation resources activated self-propagating function which induced functionality development leading to supra-functionality beyond the economic value that corresponded to customers' preferences shift. Activation of the self-propagating function depends on assimilation capacity of soft innovation resources. Amazon has developed a high level of this capacity as demonstrated in Fig. 10.

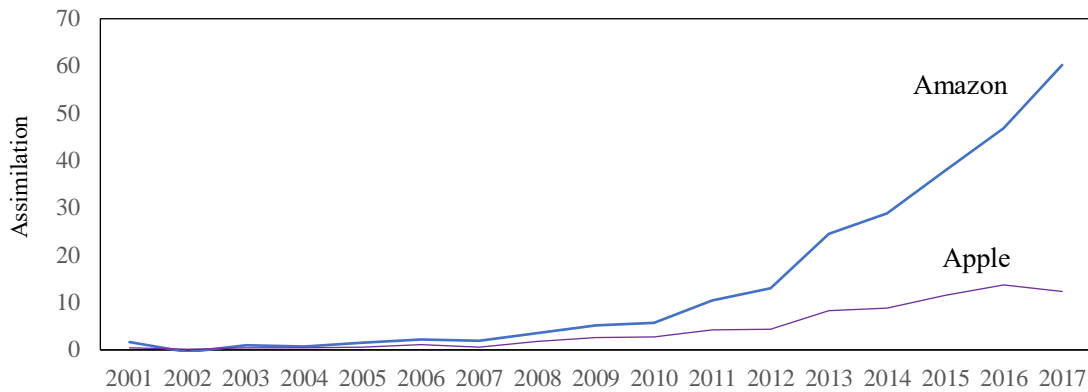


Figure 10. Trend in assimilation capacity in Amazon and Apple (2001-2017).

Note: Based on the measurement scheme illustrated as bellow where T_i and T_s are used by R and Internet dependence (ID) in the US as proxies, respectively. R and ID are index (2000 = 100).

Scheme of measuring dynamic assimilation capacity

Assimilation capacity

$$z = \frac{1}{1 + \frac{\Delta T_s}{T_s} \bigg/ \frac{\Delta T_i}{T_i}} \cdot \frac{T_i}{T_s}$$

$T_i \approx \frac{R_i}{\rho + g} \approx \frac{R_i}{H}$ [6]

$T_s = F(ID)$ [1]

R_i : R&D
 ρ : rate of obsolescence of technology
 g : R&D at initial stage
 H : constant

ID : Internet dependence

$$T_s = \sum_{j \neq i}^n T_j$$

T_i : indigenous technology stock
 T_s : Technology spillover pool

Source: [26].

Amazon's high level of assimilation capacity largely depends on its rapid and notable increase in R&D investment (high level of $\frac{\Delta T_i}{T_i}$ much higher than $\frac{\Delta T_s}{T_s}$ and subsequent high level of $\frac{T_i}{T_s}$).

Such a business model has enabled Amazon absorbing external resources extensively and assimilating them in its indigenous business.

This assimilation transforms "routine or periodic alterations" (non R&D) into "significant improvement" (classified as R&D). Image of this transformation can be illustrated as Fig. 11.



Figure 11. Illustration of Amazon's R&D.

Wholistic management policy, not separate activities of the type, contributes broad dissemination of this transformation effects. Such transformation exercises are similar to experiments which Jeff Bezos has been encouraging by stressing that, "Experiments are key to innovation because they rarely turn out as you expect and you learn so much." At Amazon, experimentation is always occurring initiated by employees in broad fields throughout the company and ideas are constantly being presented to Jeff Bezos leading to satisfying first leadership principle: *Customer obsession*. Motivated employees understand that these ideas are going to be altered in many ways [27].

5. CONCLUSION

In light of a rapid conspicuous increase in Amazon's R&D that jumped up to world top R&D firm in 2017 based on its unique R&D model, and subsequent debate on the new concept of R&D in the digital economy, the transformative direction of R&D was examined.

On the basis of an empirical analysis focusing on Amazon's R&D-driven disruptive business model, a new concept of R&D in neo open innovation that harnesses the vigor of soft innovation resources was investigated.

It was identified that Amazon, based on R&D as a culture of the company, has been endeavoring companywide experimentation to make customers to be obsessed for making purchase decision. Such endeavor enabled Amazon to deploy architecture of participation which has made the most of digital technologies by harnessing the power of its users. Such user-driven innovation accelerated dramatic advancement of the Internet which, in turn, accelerated co-emergence of soft innovation resources in the market place. This emergence activated self-propagating function which induced functionality development leading to supra-functionality beyond an economic value that satisfies customer's preferences shift which Amazon has been paying the highest priority. While this system depends on assimilation capacity of soft innovation resources, Amazon has developed high level of this capacity supported by a rapid and notable increase in R&D investment. All functioned a virtuous cycle leading to transforming "routine or periodic alterations" into "significant improvement."

These findings give rise to the following insightful suggestions for reconstructing R&D model in the digital economy which incorporates a two-faced nature and subsequent dilemma between R&D expansion and productivity decline:

- (i) The system of neo open innovation should be more specified on a priority basis.

- (ii) Role of assimilated soft innovation resources in transforming “routine or periodic alteration” into “significant improvement” should be further analyzed.
- (iii) Dynamism in increasing assimilation capacity via M&A and big data collection system should be elucidated.
- (iv) Development of assimilation capacity should be endeavored.
- (v) Accounting principle of R&D in the digital economy should be reviewed.

This analysis provides new insights for shedding light on exploring a practical solution to a dilemma between R&D expansion and productivity decline in the digital economy.

Future works should focus on further elucidation of micro dynamism of transformation of “routine or periodic alteration” into “significant improvement.” Further identification of systems effects of R&D between Amazon’s R&D model and models initiated by other network firms should also be focused.

Lessons from Amazon-initiated new concept of R&D should be accrued to establishment of new concept of R&D in neo open innovation as a priority of national innovation system in the digital economy.

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