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Institutional systems inducing R&D in Amazon- the role of an investor surplus toward stakeholder capitalization

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ABSTRACT

Amazon demonstrated a conspicuous increase in R&D and became the world's top R&D firm in 2017 with a skyrocketing increase in market capitalization, making it close to being the world's biggest company.

Such a remarkable accomplishment can be attributed to Amazon's institutional systems, which orchestrate techno-financing systems that fuse a unique R&D transformation system and a sophisticated financing system centered on the cash conversion cycle (CCC). These institutional systems support and endorse aggressive investment in R&D that incorporates the characteristics of uncertainty, a long lead time, and successive inflows of very large amounts of funding without interruption.

While some of this investment can be endorsed by Amazon's positive business results in terms of a sustained increase in sales and free cash flow, such a large amount of aggressive investment is beyond endorsement. In addition to actual economic performance, investors have been betting on a high level of risky investment with the expectation of Amazon's future success by trusting its R&D-inducing institutional systems.

While the former can be considered to be a general reaction to a producer surplus, the latter can be postulated as an investor surplus in which investors bet on overly optimistic future prospects instead of actual accomplishments. This is similar to a consumer surplus in which consumers pay more than the actual market price for attractive goods and services.

By introducing a concept of gross market value consisting of a producer surplus and an investor surplus, this paper attempts to elucidate the institutional systems that enable Amazon to invest a very large amount of financing resources in aggressive R&D.

An intensive empirical analysis focusing on the development trajectory of Amazon's techno-financing system over the last two decades was conducted, together with comparative analyses of the performance of the big four online service companies, Google, Apple, Facebook, and Amazon (GAFA).

It was identified that among GAFA, Amazon demonstrated the highest dependence on an investor surplus, which suggests that investors are betting on the continuation of Amazon's solid growth by means of its aggressive investment in R&D, supported and endorsed by its institutional systems. This idea is supported by the high elasticity of its investor surplus to R&D investment.

Noteworthy is that investors incorporate not only shareholders but also broad stakeholders centered on users, and that they expect not only economic value but also supra-functionality beyond such value.

A broadly applicable practical approach for measuring an investor surplus and an insightful suggestion highlighting the significance of an investor surplus toward stakeholder capitalism are thus provided.

1. Introduction

Contrary to the decisive role of research and development (R&D) in the digital economy, the dilemma of its expansion and productivity decline has become a worldwide concerns, which most digital economies are now confronting [1,2].

Notwithstanding such a dilemma, Amazon demonstrated a conspicuous increase in its R&D and became the world's top R&D firm in 2017

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with a skyrocketing increase in its market capitalization, making it close to being the world's biggest company, as demonstrated in Figs. 1 and 2. This rapid increase in R&D showed no sign of slowing down the pace in 2019 amounting to 35.9 US$ billion [4].

The authors, in their preceding analysis, elucidated a dynamism that led Amazon to such a rapid R&D jump within a short period of time [5–8].

They identified that Amazon, based on R&D as a culture, has been promoting company-wide experimentation, enabling it to deploy an architecture for participation that harnesses the power of users. Such user-driven innovation accelerated a dramatic advancement of the Internet that, in turn, accelerated the co-emergence of soft innovation resources in the marketplace. This emergence activated a self-propagating function that induced supra-functionality beyond economic value, which satisfied a shift in customers' preferences. The strong customer-centric visionary leadership of Jeff Bezos, founder and CEO of Amazon, together with motivated, brilliant, and consistently innovative employees, functions as a virtuous cycle, leading to the transformation of routine or periodic alterations to significant improvements during the R&D process [6,8].

Such a miraculous model has shed light on the financing system supporting and endorsing an aggressive challenge to risky investment in R&D, which incorporates characteristics such as uncertainty, long lead times, and successive huge amounts of funds without interruption.

This can be attributed to the orchestration in fusing a unique R&D transformation system and a sophisticated financing system centered on cash conversion cycle (CCC)-driven cash flow management.

The abovementioned orchestration can be enabled by its sophisticated institutional systems [5,6,8] based on.

(i) R&D as a culture promoting company-wide experimentation,
(ii) Architecture for participation inducing user-driven innovation,
(iii) Overwhelming power of customers and vendors in its marketplace in terms of the CCC initiative,
(iv) The co-emergence of soft innovation resources harnessing the vigor of users,
(v) A self-propagating system inducing supra-functionality beyond economic value, and
(vi) A sophisticated management system leading to the transformation of R&D.

This transformation corresponds to the paradigm change in the digital economy. [9]; by analyzing the economic effect of the

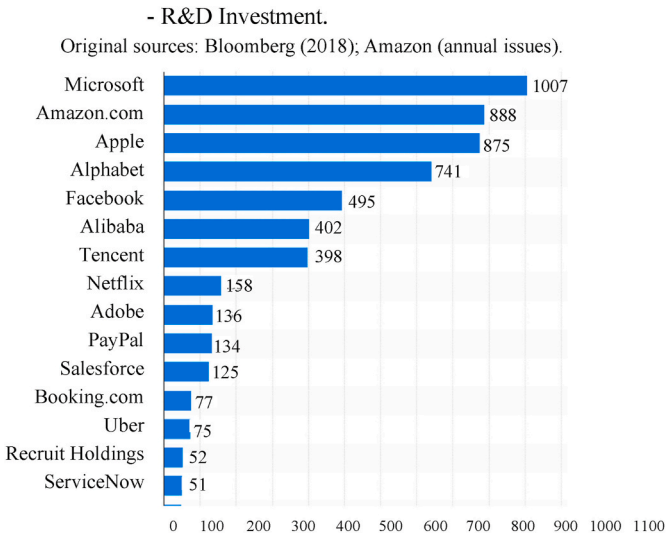


Fig. 2. Market capitalization of the top 15 internet companies (june 2019). Source: [3].

Internet-driven technology advancement in the digital economy, discussed the two-faced nature of information and communication technology (ICT) and its subsequent increasing dependence on uncaptured GDP. They pointed out that, although the advancement of ICT contributes to enhancing the prices of technology through new functionality development, the dramatic advancement of the Internet contributes to decreasing the prices of technology because of the unique inherent characteristics of freebies, easy replication, and mass standardization [10–12]. With this understanding, they supported Lowrey's [13] supposition that the Internet promotes a free culture, the consumption of which provides utility and happiness to people, but that it cannot be captured through the GDP statistics. They defined this added value that provides people with utility and happiness beyond economic value under a free culture as an uncaptured GDP.

The authors then analyzed the composition of uncaptured GDP and identified the significance of consumer surplus in that consumers pay a higher price than the actual market price for attractive goods and services [14,15]. By analyzing online booksellers, [16]; 2017) found that significant consumer surplus gains were created by the increased product variety and that efficiency gains resulted from increased

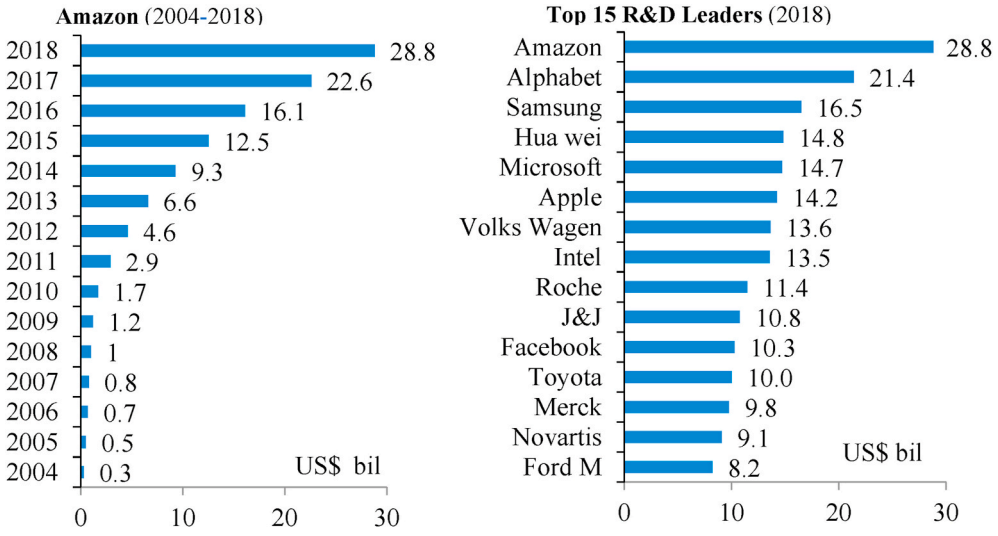


Fig. 1. Amazon's conspicuous jump to become the World's top R&D leader. Source: Bloomberg [54].

competition led to lower average prices. Their analysis demonstrates that the increased product variety of online bookstores enhanced consumer surplus significantly.

They expected the possibility of large welfare gains in other stock-keeping-unit (SKU)-intensive consumer goods, such as music, movies, consumer electronics, and computers. Similar results were demonstrated by the white paper of Japan's ICT, analyzing consumer surplus in music and audio-visual services [17].

By analyzing the big economic opportunities and challenges in capturing the maximum value of the Internet of things (IoT), McKinsey [18] estimated that consumer surplus derived from the IoT could be more than 10% of the global economy by 2025.

Amazon's conspicuous increase in its aggressive investment in R&D induced by its sophisticated institutional systems, as reviewed earlier, seems to be attributed to similar mechanism, such as consumer surplus initiated by investors bidding on Amazon's user-driven innovation.

To date, while a significant number of studies have analyzed Amazon's R&D system from the viewpoints of technology operation strategy and also financial management systems (e.g. Ref. [6–8,19–21], no one has analyzed its R&D-inducing dynamism from the view point of an investor surplus derived from its sophisticated institutional systems. In micro economics, while many studies have proposed approaches for estimating consumer surplus given the eqiuilibrium between the demand and supply curves in the traditional competitive market mechanism (e.g. Ref. [22–24], they are hardly applicable to firms' R&D investment strategies in the digital economy with increasing dependence on uncaptured GDP in which, due to the two-faced nature of ICT, ICT prices decrease as R&D advances on the supply side, and also customer's preferences shift to supra-functionality beyond economic value on the demand side [10].

Given the increasing concern about the inside of the black box of institutional systems, enabled Amazon large amount of risky investment in R&D, and also consumer surplus in the digital economy, this paper attempts to demonstrate the above hypothetical view.

In line with a new stream of research regarding the purpose of a corporation moving away from shareholder primacy to commitment to all stakeholders, including customers, employees, suppliers, communities, and shareholders [25], a study of the future of capitalism toward stakeholder capitalism [26] introducing a concept of gross market value consisting of a producer surplus and an investor surplus, and an intensive empirical analysis focusing on the development trajectory of Amazon's techno-financing system over the last two decades were conducted, together with comparative analyses of the performance of the big four online service companies, Google, Apple, Facebook, and Amazon (GAFA).

While a similar concept was preached by Porter [27]; the virtues of creating shared value (CSV), unlike financial performance, social and environmental outcomes cannot be readily monetized or aggregated into simple indicators [28]. In light of the absense of standard metrics for reporting firms' performance, the shift to stakeholder capitalism has been impeded, and a new practical approach for measuring an investor surplus was attempted.

It was identified that among GAFA, Amazon demonstrated the highest dependence on an investor surplus, which suggests that investors are betting on the continuation of Amazon's solid growth by means of its aggressive investment in R&D, supported and endorsed by its institutional systems. This idea is supported by the high elasticity of its investor surplus to R&D investment.

Noteworthy is that investors incorporate not only shareholders but also broad stakeholders centered on users, and that they expect not only economic value but also supra-functionality beyond such value.

A broadly applicable practical approach for measuring an investor surplus and an insightful suggestion highlighting the significance of an investor surplus toward stakeholder capitalism are thus provided.

These findings give rise to insightful suggestions that are supportive of the measurement of a consumer surplus in the digital economy.

Section 2 reviews the dynamism of Amazon's market value creation. Section 3 analyzes dynamism in inducing R&D through institutional systems. Section 4 postulates gross market value, encompassing both that which reflects the actual market performance and also that of the expectation of future success. The implications of an investor surplus are investigated in Section 5. Section 6 summarizes the noteworthy findings, policy suggestions, and future research recommendations.

2. Institutional systems orchestrating techno-financing systems

Amazon's miraculous orchestration can be enabled by its sophisticated institutional systems, consisting of the following chain systems [5,6,8]:

1) R&D as a Culture Promoting Company-Wide Experimentation

Amazon has endeavored to be an R&D-driven company and has promoted company-wide experimentation since its inception in 1994. This has provided a base for its institutional systems that support and endorse huge risky investments in R&D as follows:

(i) Stakeholders' commitment has been gained by appealing and demonstrating that establishing market leader status and raising shareholder value are essential for success.
(ii) The resources allocation policy has been established to re-invest profits into R&D for further development and, not into returns for shareholders (such as buybacks and dividends).

2) Architecture for Participation Inducing User-Driven Innovation

Amazon's business model and its endeavors have developed its empire chain, big data collection system, and the architecture for participation, harnessing the power of users and leading to user-driven innovation [6].

3) Overwhelming Power of Customers and Vendors in Terms of the CCC Initiative

Amazon has constructed overwhelming power of both customers and vendors in its marketplace, through constructing an extremely advanced CCC [29,30], leading to virtuous cycles between free cash creation, R&D advancement, sales increase, and the activation of interactions with users.

4) Co-Emergence of Soft Innovation Resources

Such user-driven innovation has accelerated a dramatic advancement of the Internet that, in turn, has accelerated the co-emergence of soft innovation resources (*SIRs*) in the marketplace. Here, *SIRs* are considered to be condensates and crystals of the advancement of the Internet and consist of the Internet-based resources that have either been sleeping or untapped or are the results of multi-sided interactions in the markets where the consumer is looking for functionality beyond economic value. A common feature of *SIRs* is that they are not accountable in the traditional GDP terms [1,2,31].

5) Activation of a Self-Propagating System

This emergence activated a latent self-propagating function indigenous to ICT [32] and induced supra-functionality beyond economic value that satisfies a shift in customers' preferences, which Amazon has been treating as the highest priority [33]. This shift, in turn, accelerates user-driven innovation and the subsequent further advancement of the Internet, leading to a virtuous cycle among SIRs emergence, supra-functionality beyond economic value, user-driven innovation, and Internet advancement.

While this system depends on the assimilation capacity of SIRs,

Amazon has developed a high level of capacity, supported by a rapid and notable increase in R&D investment [6].

Thus, leveraged by this activated latent digitalization function, the development trajectory transforms by spinning off from a captured GDP-based co-evolution cycle to an uncaptured GDP-driven co-evolution cycle.[1] This transformation can be attributed to the inertia of the shift in people's preferences and the Internet's function of creating new functionality corresponding to such a shift.

6) Sophisticated Management System Leading to the Transformation

Such a sophisticated management system has operated well because of the strong inertia induced by the strong customer-centric visionary leadership of Jeff Bezos, together with motivated, brilliant, and consistently innovative employees equipped with self-assessment and disruption analysis systems. These efforts function as a virtuous cycle - leading to the transformation of routine or periodic alterations into significant improvements during the R&D process [6].

Such a transformation led to Amazon becoming the world's top R&D leader in 2017 with corresponding sustainable increase in sales and a skyrocketing rise in its market capitalization. This conspicuous increase and the subsequent rise in sales and market capitalization continued in 2018, as illustrated in Figs. 1 and 2 and Fig. 3.

The abovementioned chain systems that constitute Amazon's sophisticated institutional systems prompt a hypothetical view that the value of these systems reflects its market capitalization, to which risk-heavy investment in R&D has close relevance [35]. Furthermore, following careful observation of the enablers of such aggressive behavior in terms of large amounts of investment into R&D, which incorporate characteristics such as uncertainty, a long lead times, and successive huge amounts of funds without interruption, it is postulated that certain functions beyond the accomplishment of economic value may be embeded in its institutional systems, and that this function tempts investors betting on the future remarkable advancement expected to be realized by its aggressive R&D investment.

3. Gross market value created by the price free cash ratio

3.1. Gross market value

Amazon has been endeavoring to be an R&D-driven company since its inception in 1994 [36]. Consequently, it aimed to increase its R&D investment, leading to it becoming the world's top R&D firm, as demonstrated in Fig. 1.

As reviewed in the preceding section, such a large amount of R&D investment can be attributed to gross R&D encompassing assimilated *SIRs* from the market and enabled by its sophisticated institutional systems [7].

While some of this investment can be endorsed by Amazon's positive business results in terms of a sustained increase in sales and free cash flow, such a large amount of aggressive investment is beyond endorsement. In addition to actual economic performance, investors have been betting on a high level of risky investment with the expectation of Amazon's future success by trusting its R&D-inducing institutional systems.

The value of such institutional systems, encompassing both captured and uncaptured GDP, reflects market capitalization measured by multiplying the number of outstanding shares by the current price of a single share (stock prices). While the former value reflects the actual objective economic performance, typically in terms of sales (which primarily reflects captured GDP), as demonstrated in Table 1, the stock prices themselves are highly subjective. In addition, they reflect largely uncaptured GDP in the digital economy where customers' preferences have been shifting toward supra-functionality beyond economic value.

Table 1 shows an extremely strong correlation between sales and the number of shares for Amazon, which demonstrates that this number reflects Amazon's economic growth as represented by increased sales, which enables higher R&D and income. The ratio of this income to the number of shares, earnings per share (*EPS*), indicates a company's profitability. A higher *EPS* represents a higher market value of the company because it can gain more investors who expect higher profits.

With such an understanding, market capitalization, which reflects the value of the institutional systems, is decomposed to the following equation, consisting of objectively reflecting the economic performance and the subjective "dream": expectation relating to the company's future success.

$$MC = N \times \frac{E}{N} \times \frac{S_p}{E/N} \tag{1}$$

wehre *MC*: market capitalization; *N*: number of shares; *E*: earning (net income); S_p: stock prices.

While *E/N* represents *EPS* and, together with *N*, it represents the actual economic performance, $\frac{S_p}{E/N}$ represents price earnings ratio (*PER*), which is highly subjective.

Equation (1) depicts gross market value, encompassing the actual economic value (in terms of *N* and *EPS*) and the value of the "dream" of future success (*PER*).[2]

While equation (1) reflects the value of the institutional systems that induce R&D, the treatment of *PER* for an objective analysis reflecting identical performance would be a key point.

3.2. Free cash flow for fueling risk-heavy challenges

Since R&D is such a high-risk investment that incorporates uncertainty, lengthy successive work with huge amounts of money without interruption, and a long lead time before commercialization, a lack of cash turns the return of all previous efforts to blisters. Therefore, intensive R&D investment can only be enabled by fueling ample and sustainable funding that is rich in mobility, which can be expected to come from net cash flow, rather than from net income (net profit).

While net income indicates leftover revenues after all expenses have been paid, by adjusting for due income and expenses from the operating income in conducting actual risky challenges, a timely ample amount of fuel that endorses companies facing such challenges is indispensable. Net cash flow is the fuel that helps companies expand, develop new products, buy back stock, pay dividends, or reduce debt. It is what allows companies to conduct their day-to-day business, particularly for risk-heavy businesses, as it includes all transactions that transfer cash [37].

Amazon as a world-leading R&D-driven company, highly depends on this flow [38], as demonstrated in Table 2 and Fig. 4.[3] Table 2 demonstrates extremely high levels of the marginal productivity of net income to free cash flow in Amazon as it manages with the priority of creating affluent free cash flow for R&D investment.

3.3. Free cash per share – Amazon's financial focus

As reviewed above, Amazon has highly prioritized creating free cash flow for vigorous R&D investment. In its 2004 letter to stakeholders,

[1] Fig. 12 in Section 5 illustrates this spin-off dynamism. In the upper dual cycles, the inner circle (pink color) indicates a captured GDP-based co-evolution cycle, while the outer circle (light blue color) indicates an uncaptured GDP-driven co-evolution cycle [10].

[2] Stock prices tend to contain information about future economic growth [47].

[3] In this paper, all data for GAFA are based on quarterly statistics. Aiming at maintaining consistency with other analyses in the paper, Facebook was analyzed between 2012 and 2018 as its IPO was in May 2012.

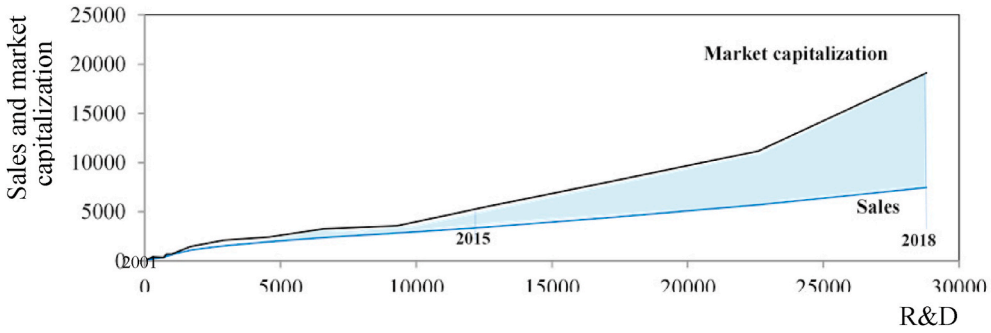


Fig. 3. The correlation between R&D investment and sales and market capitalization for Amazon (2001–2018) – index: 2001 = 100.
Source: [34].

Table 1
Correlation between the Number of Shares and Sales for Amazon (2000–2018).

$$\ln N = 5.53 + 0.16\, D_1 \ln S + 0.05\, D_2 \ln S - 0.89\, D_1 \qquad adj.\ R^2\ 0.990 \qquad DW\ 1.59$$
$$(209.20)\ (12.50) \qquad (21.61) \qquad (-8.35)$$

N: Number of shares outstanding; *S*: Sales; *D*: Dummy variables (D_1: 2000–2004 = 1, others = 0; D_2: 2005–2018 = 0; others = 1).
The figures in parentheses indicate t-statistics: all are significant at the 1% level.

Table 2
Correlation between Net Income and Free Cash Flow for GAFA (2005–2018)[a]. $FCF = a + b\,E + c_i D_i$.

	a	b	c_1	c_2	c_3	*adj.* R^2	DW
Google (Mar. 2005–Dec. 2018)	708.43 (2.07)	0.75 (7.56)	−7048.92 (−5.83)			0.559	1.23
Apple (Mar. 2005–Dec. 2018)	2283.00 (3.09)	1.17 (23.94)	−3629.99 (−4.73)	−3151.36 (−4.02)	−2830.90 (−3.66)	0.933	1.77
Facebook (Sept. 2012–Dec. 2018)	858.44 (3.33)	0.67 (7.52)				0.681	1.35
Amazon (Mar. 2005–Dec. 2018)	644.76 (3.03)	1.98 (5.92)	−5921.29 (−8.89)	−3311.07 (−5.06)	−2826.23 (−4.30)	0.713	2.29

FCF: Free cash flow; *E*: Net income; *a*, *b* and *c*: Coefficients. *b* indicates marginal productivity of *E* to *FCF*; *Di*: Dummy variables: Google: *D*1: 2012.6, 2018.3 = 1, others = 0; Apple and Amazon: *Di*: *i* quarter = 1, others = 0 (*i* = 1–3).
The figures in parentheses indicate t-statistics: all are significant at the 1% level.
[a] Facebook is 2012–2018.

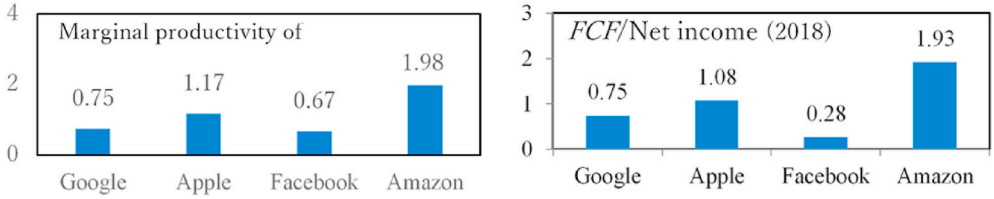


Fig. 4. Comparison of Free Cash Flow (*FCF*) vs Income for GAFA.

Bezos reminded them that Amazon's financial focus is on long-term growth in free cash per share, by stressing, *"Our ultimate financial measure, and the one we most want to drive over the long-term, is free cash flow* per *share."* To accomplish this focus, he elaborated, *"Amazon's free cash flow is driven primarily by increasing operating profit and efficiently managing both working capital and capital expenditures. We work to increase operating profit by focusing on improving all aspects of the customer experience to grow sales and by maintaining a lean cost structure"* [39].

As stressed by Bezos, Amazon's financial focus is on long-term growth in free cash per share to address its leading target of being an R&D-driven company. Fig. 5 illustrates the trend in Amazon's financial focus of free cash per share over the period 1996–2018, and it demonstrates long-term sustained growth, which is also demonstrated by Table 3.

Table 3 demonstrates that Amazon's free cash flow per share grew steadiliy with an average growth rate of 29% *p.a.* by 2011. This growth rate increased dramatically to 56% *p.a.* after 2012. This steady growth with a dramatic increase from 2012 led to Amazon becoming a world-leading R&D-driven company and to it demonstrating the significant role of free cash per share as a core indicator for managing such a company.

3.4. The price free cash ratio as an inducer of an investor surplus

On the basis of the foregoing analysis, with the aim of replicating the financial focus of a world-leading R&D-driven company, free cash flow per share (*FCPS*) is used for *EPS* in equation (1) as follows:

$$MC = N \times \frac{FCF}{N} \times \frac{S_p}{FCF/_N} \tag{2}$$

Here, $\frac{S_p}{FCF/_N}$ can be defined as the price free cash ratio (*PFCR*).

While right first and second items (*N* and *FCF/N*) can be considered to be a producer surplus by reflecting actual explicit economic

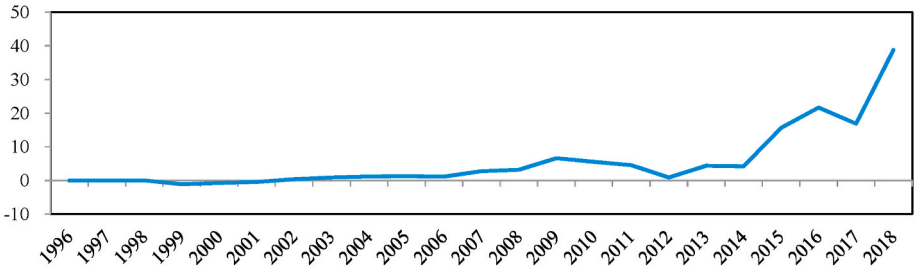


Fig. 5. Trend in Amazon's Free Cash Flow per Share (1996–2018) – US$ bil.

Table 3
Long-term sustained growth in free cash flow per share for Amazon (2002–2018).

$$\frac{FCF}{N} = A \cdot e^{\lambda t} \quad \ln\frac{FCF}{N} = \ln A + \lambda t$$

$$\ln\frac{FCF}{N} = \underset{(-5.17)}{-5.71} + \underset{(6.41)}{0.29\, D_1 t} + \underset{(7.20)}{0.56\, D_2 t} + \underset{(4.19)}{4.77\, D_1} \qquad adj.\ R^2\ 0.900 \qquad DW\ 2.01$$

t: Time trend;λ : Growth rate; A: Scale Factor; D: Dummy variables (D_1: 2002–2011 = 1, others = 0; D_2: 2012–2018 = 0; others = 1).
The figures in parentheses indicate t-statistics: all are significant at the 1% level.

accomplishments represented by sales and earnings affordable to R&D investment, the third item, the *PFCR* can be considered to be an investor surplus, where investors bet on a higher reaction to the actual economic accomplishments. This surplus is similar to a consumer surplus, where consumers pay a higher price than the actual market price for attractive goods and services.

Amazon shows the highest level of *PFCR,* as demonstrated in Table 4 and Fig. 6.

Based on these notable observations, the trend in the magnitude of the composition of market capitalization in Google, Apple, and Amazon over the period of 2002–2018 is compared by taking logarithms of equation (2) (Facebook is not included as its IPO was in 2012). Fig. 7 demonstrates this comparison. Looking at this figure, we note that Amazon demonstrates the highest magnitude of investors surplus and that this led to it having the highest growth in market capitalization.

3.5. Dynamism of market value creation by the PFCR

As orchestrated by Bezos, Amazon's financial focus on *FCPS* emerges R&D significantly, as demonstrated in Table 5.

Emerged R&D instills the expectation and the dream of Amazon's advancement, leading to significant enhancements in its stock prices, S_P, as demonstrated in Table 6.

Throughout this process, *FCPS* induces stock prices, as demonstrated in Table 7, and thus leads to subsequent high levels of the *PFCR,* as demonstrated in Fig. 6.

Fig. 8 illustrates this dynamism.

This dynamism leads to the institutional systems-driven R&D-inducing system as illustrated in Fig. 9. While it is generally postulated that a producer surplus, typically intiated by an increase in sales and free cash flow, induces R&D, Fig. 9 suggests that investors bet on Amazon's solid growth, expecting it to be accomplished through its aggressive R&D, and thereby, an investor surplus significantly induces R&D in Amazon.

4. Market inducement of R&D

4.1. Market capitalization as a total surplus

On the basis of the preceding analysis, market capitalization, which reflects the value of institutional systems inducing vigorous R&D as reviewed earlier, can be depicted as follows:

$$M = M(P, I) \tag{3}$$

where M: market capitalization; P: producer surplus; and I: investor surplus.

Equation (3) can be developed as follows:

$$M = \frac{\partial M}{\partial P}\cdot P + \frac{\partial M}{\partial I}\cdot I = \frac{\partial M}{\partial R}\cdot\frac{\partial R}{\partial P}\cdot P + \frac{\partial M}{\partial R}\cdot\frac{\partial R}{\partial I}\cdot I \tag{4}$$

The elasticity of market capitalization to R&D[4] can be depicted as follows:

$$\varepsilon_{RM} = \frac{\partial R}{\partial M}\cdot\frac{M}{R} = \frac{\partial R}{\partial M}\left(\frac{\partial M}{\partial R}\cdot\frac{\partial R}{\partial P}\cdot\frac{P}{R}\right) + \frac{\partial R}{\partial M}\left(\frac{\partial M}{\partial R}\cdot\frac{\partial R}{\partial I}\cdot\frac{I}{R}\right) = \frac{\partial R}{\partial P}\cdot\frac{P}{R} + \frac{\partial R}{\partial I}\cdot\frac{I}{R}$$
$$= \varepsilon_{RP} + \varepsilon_{RI} \tag{5}$$

where ε_{RM}, ε_{RP} *and* ε_{RI} are the elasticity of market capital to R&D, producer surplus to R&D, and investor surplus to R&D, respectively.

On the basis of the analysis in Section 3, a production surplus and an investor surplus can be proxied as follows[5]:

$$P = N\cdot\frac{FCF}{N} = FCF \tag{6}$$

$$I = \frac{S_p}{FCF/N} = \frac{Sp\cdot N}{FCF} = \frac{MC}{FCF} \tag{7}$$

Utilizing the following correlation analysis, the respective elasticity in equation (5) for GAFA is analyzed as summarized in Tables 8 and 9:

$$\ln R = a_M + \varepsilon_{RM}\ln M \tag{8}$$

$$\ln R = a_P + \varepsilon_{RP}\ln P \tag{9}$$

$$\varepsilon_{RI} = \varepsilon_{RM} - \varepsilon_{RP} \tag{10}$$

[4] Elasticity of *MC* to *R* (*MC* elasticity to *R*), ε_{RM} implies a 1% increase in *MC* increases ε_{RM}% increase in *R* and represents the efficiency of *MC* in inducing *R*.

[5] In this case, since.$M = P{\cdot}I$, $\frac{\partial R}{\partial M} = \frac{\partial R}{\partial PI} = \frac{\partial P}{\partial PI}\cdot\frac{\partial R}{\partial P} + \frac{\partial I}{\partial PI}\cdot\frac{\partial R}{\partial I} = \frac{1}{\frac{\partial PI}{\partial P}}\cdot\frac{\partial R}{\partial P} + \frac{1}{\frac{\partial PI}{\partial I}}\cdot\frac{\partial R}{\partial I} = \frac{1}{I}\cdot\frac{\partial R}{\partial P} + \frac{1}{P}\cdot\frac{\partial R}{\partial I}\varepsilon_{RM} = \frac{\partial R}{\partial M}\cdot\frac{M}{R} = \frac{M}{R}\left(\frac{1}{I}\cdot\frac{\partial R}{\partial P} + \frac{1}{P}\cdot\frac{\partial R}{\partial I}\right) = \frac{1}{I}\cdot\frac{\partial R}{\partial P}\cdot\frac{PI}{R} + \frac{1}{P}\cdot\frac{\partial R}{\partial I}\cdot\frac{PI}{R} = \frac{\partial R}{\partial P}\cdot\frac{P}{R} + \frac{\partial R}{\partial I}\cdot\frac{I}{R} = \varepsilon_{RP} + \varepsilon_{RI}$

Table 4

Comparison of Price Free Cash Ratio (*PFCR*) for GAFA (2015–2018) – US$ bil. $\boldsymbol{PFCR} = \frac{\boldsymbol{Sp}}{\boldsymbol{FCF}/\boldsymbol{N}} = \frac{\boldsymbol{MC}}{\boldsymbol{FCF}}$

	Google			Apple			Facebook			Amazon		
	MC	FCF	PFCR	MC	FCF	PFCR	MC	FCF	PFCR	MC	FCF	PFCR
2015	431.6	16.4	26.3	646.8	69.8	9.3	278.5	7.8	35.7	232.8	7.5	31.2
2016	528.2	24.8	21.3	574.2	53.5	10.7	359.9	11.6	31.0	345.4	10.5	33.0
2017	660.7	23.6	28.0	781.0	51.8	15.1	478.8	17.5	27.4	481.2	8.3	57.9
2018	768.0	21.3	36.0	871.9	64.1	13.6	471.9	15.4	30.7	814.9	19.4	42.0
Average 2015–2018	597.1	21.5	27.9	718.5	59.8	12.2	397.3	13.1	31.2	468.6	11.4	41.0

MC depends on the average value of 4 quarters of the year.

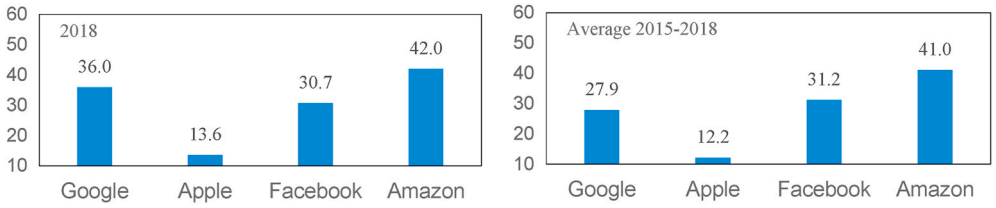


Fig. 6. Comparison of price free cash raios (*PFCRs*) for GAFA.

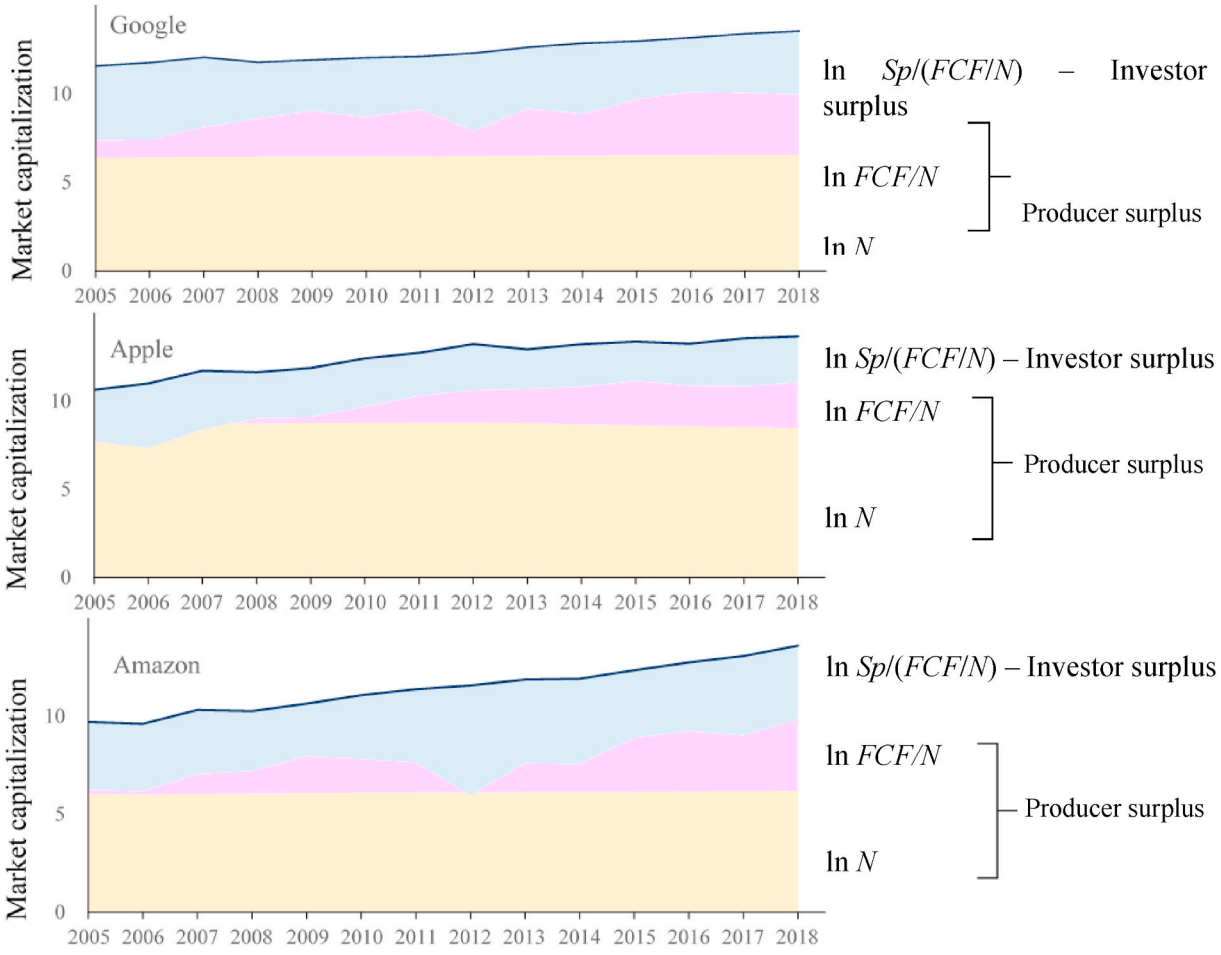


Fig. 7. Trend in the Magnitude of the Composition of Market Capitalization for Google, Apple, and Amazon (2002–2018) – Logarithmic scale.

In this analysis, while the quarterly data of R&D (*R*), free cash flow (*FCF*), the number of shares outstanding (*N*), and stock prices (*Sp*) are based, in order to represent the actual market state of the year examined by avoiding seasonal fluctuations, quarterly data are converted to annual data by summing the values of *R* and *FCF* for the four quarters, while the average values for the four quarters of the respective year are used for *N* and S_p. Therefore, the annual value for market capitalization is represented by the value measured by multiplying the above *N* by S_p.

Table 5
Correlation between Free Cash Flow per Share (*FCPS*) and R&D for Amazon (2002–2018).

$$\ln RD = 5.92 + 1.25\ln FCPS + 2.67D \quad adj.R^2\ 0.848 \quad DW\ 1.15$$
$$(24.27)\ (9.50) \qquad (3.78)$$

RD: R&D investment; *FCPS*: Free cash flow per share; *D*: Dummy variable (2012 = 1, other = 0).
The figures in parentheses indicate t-statistics: all are significant at the 1% level.

Table 6
Correlation between R&D and stock prices for Amazon (2002–2018).

$$\ln Sp = -1.07 + 0.79\ln R \quad adj.\ R^2\ 0.958 \quad DW\ 1.54$$
$$(-3.29)\ \ (19.02)$$

S_p: Stock prices; *R*: R&D investment.
The figures in parentheses indicate t-statistics: all are significant at the 1% level.

Utilizing the above results, the elasticity of investor surplus (ε_{RI}) was measured taking the balance between the elasticity of market capitalization to R&D and that of producer surplus to R&D,[6] thereby, the composition of the elasticity of market capitalization to R&D for GAFA was compared, as summarized in Table 9.

Fig. 10 illustrates this result and compares the composition of the elasticity of market capitalization to R&D for GAFA.

Looking at Fig. 10, we note that Amazon demonstrates the highest elasticity of investor surplus to R&D investment among GAFA, and that this high level of elasticity leads to its high level of elasticity of market capitalization to R&D investment (second after Google).

While Amazon has maintained the highest level of an investor surplus, as demonstrated in Figs. 6 and 7, its highest elasticity to R&D supports the idea that investors bet on Amazon's solid growth, which is expected to be realized by its large amount of aggressive R&D investment that is supported and endorsed by its institutional systems, as illustrated in Fig. 9.

5. Implications of an investor surplus

Table 7
Correlation between free cash flow per share (*FCPS*) and stock prices for Amazon (2002–2018).

$$\ln Sp = 5.25 + 0.71\ D_1 \ln FCPS + 0.49\ D_2 \ln FCPS - 1.63\ D_1 \quad adj.\ R^2 \quad 0.948 \quad DW \quad 1.09$$
$$(22.57)\ \ (6.74) \qquad (5.20) \qquad (-6.25)$$

D: Dummy variables (D_1: 2000–2011 = 1, others = 0; D_2: 2012–2018 = 0; others = 1).
The figures in parentheses indicate t-statistics: all are significant at the 1% level.

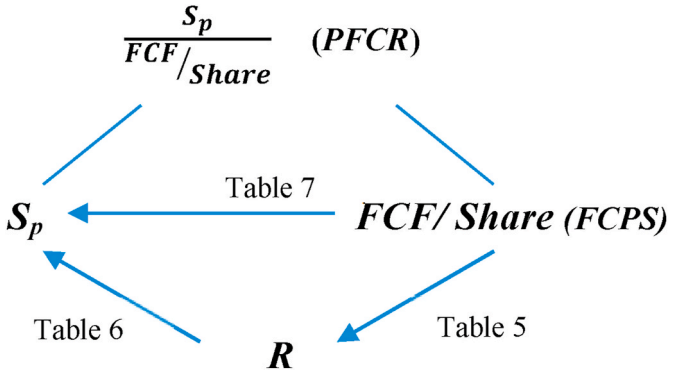
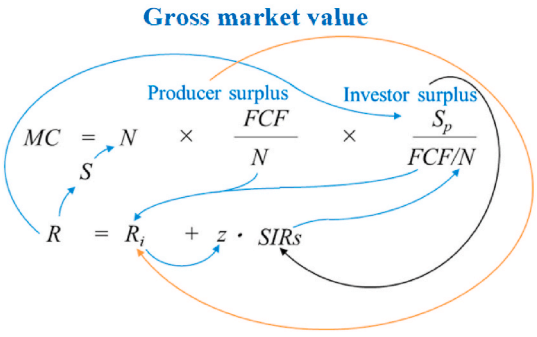


Fig. 8. Dynamism leading to high level of price free cash ratio (*PFCR*) for Amazon.

As reviewed earlier, market capitalization represents gross market value, which reflects the value of the institutional systems of the company that induce large amounts of aggressive R&D investment in Amazon. Corresponding to the current corporate governance doctorine [25], this gross value can be decomposed into a producer surplus and an investor surplus. While the former represents actual objective economic performance, primarily reflecting captured GDP, the latter is highly subjective and reflects largely uncaptured GDP in the digital economy, where customers' preferences have been shifting to supra-functionality beyond economic value.

The analysis in the preceding section highlights Amazon's significant role as an investor surplus and supported the idea that investors bet on the continuation of Amazon's solid growth by means of its aggressive investment in large amounts of R&D, supported and endorsed by its institutional systems.

Based on these observations, an objective analysis of the dynamism of an investor surplus in encouraging investors to bet on overly



MC: Market capitalization,
N: Number of shares outstanding,
S_p: Stock prices,
FCF: Free cash flow,
S: Sales,
R: Gross R&D, R_i: Indigenous R&D,
z: Assimilation capacity,
SIRs: Soft innovation resources
Shifts in preferences, Sleeping resources, Drawing upon past information, Providing utmost gratification ever experienced, Memory and future dreams, Untapped resources and vision

Fig. 9. Institutional systems-driven R&D-Inducing system in Amazon.

[6] Average values during the examined period were presented by using period weight.

Table 8a
Correlation between market capitalization and R&D for GAFA (2005–2018). $\ln R = a_M + \varepsilon_{RM1} D_1 \ln M + \varepsilon_{RM2}(1 - D_1)\ln M + b_M D_1 + d_M D_2$

	a_M	ε_{RM1}	ε_{RM2}	b_M	d_M	*adj.* R^2	*DW*
Google	−4.69 (−7.24)	1.99 (6.31)	1.08 (21.15)	−11.67 (−3.17)	−0.26 (−2.84)	0.992	2.39
Apple	−7.15 (−7.02)	0.32 (1.50)*	1.21 (15.46)	10.08 (3.89)	−0.58 (−5.13)	0.978	1.58
Facebook	−6.29 (−7.50)	1.07 (15.92)			−0.32 (−2.83)	0.921	1.16
Amazon	−5.93 (−6.77)	1.21 (16.46)			0.68 (2.72)	0.963	1.79

a_M, b_M, d_M: Coefficient.
D: Dummy variables (D_1: Google: 2005–2007 = 1, others = 0; Apple: 2005–2007 = 1, others = 0; D_2: Google: 2005, 2009 = 1, others = 0). Apple: 2010–2012 = 1, others = 0; Facebook: 2014 = 1, others = 0; Amazon: 2006, 2008 = 1, others = 0.).
Facebook is between 2012 and 2018 for reference.
The figures in parentheses indicate t-statistics: all are significant at the 1% level except * 10%.

Table 8b
Correlation between producer surplus and R&D for GAFA (2005–2018). $\ln R = a_P + \varepsilon_{RP1} D_1 \ln P + \varepsilon_{RP2}(1 - D_1)\ln P + b_P D_1 + d_P D_2$

	a_P	ε_{RP1}	ε_{RP2}	b_P	d_P	*adj.* R^2	*DW*
Google	3.39 (1.99) *	1.04 (2.78)	0.62 (3.38)	−4.30 (−1.26) *	−1.03 (−2.55)	0.866	1.97
Apple	1.18 (2.05)	0.67 (11.17)			0.88 (4.82)	0.950	1.61
Facebook	2.21 (2.90)	0.20 (1.81) *	0.65 (6.73)	2.36 (2.29)		0.908	1.39
Amazon	5.51 (6.58)	0.70 (3.82)	0.47 (4.70)	−3.59 (−2.28)		0.946	1.94

a_M, b_M, d_M: Coefficient.
D: Dummy variables (D_1: Google: 2005–2008 = 1, others = 0; Facebook: 2012–2013 = 1, others = 0; Amazon: 2005–20011 = 1, others = 0; D_2: Google: 2012 = 1, others = 0; Apple: 2016–2018 = 1. Others = 0).
Facebook is between 2012 and 2018 for reference.
The figures in parentheses indicate t-statistics: all are significant at the 1% level except * 10%.

Table 9
Composition of the Elasticity of Market Capitalization to R&D for GAFA. (2005–2018) – Average value using period weight.

	ε_{RM}	ε_{RP}	$\boldsymbol{\varepsilon_{RI}}$
Google	1.28	0.74	**0.54**
Apple	1.02	0.67	**0.35**
Facebook	1.07	0.53	**0.54**
Amazon	1.21	0.59	**0.62**

* Facebook is between 2012 and 2018 for reference.

optimistic future prospects of Amazon, initiated by aggressive R&D investment, is attempted in this section.

5.1. Convincing objective evidence of promising returns on R&D

Confronting the dilemmas of R&D expansion and productivity decline in the digital economy [1,2], and also the increasing dependence on uncaptured GDP toward supra-functionality beyond economic value, investors are skeptical about the returns on aggressive R&D investment [9,10].

Under such circumstances, Amazon has been making every effort to provide investors and customers with convincing evidence of the promising returns expected to be gained from such R&D.

The number of patent applications can be considered to be one of the notable objective outcomes that convince investors/customers of promising returns from R&D investment. Amazon has been making intensive efforts to convince them in this way.

Table 10 analyzes the correlation between R&D investment and subsequent patent applications for GAFA over the period of 2004–2018.

Amazon demonstrates an extremely strong correlation between them and a high level of R&D elasticity to patent applications, as illustrated in Fig. 11.

Table 10 and Fig. 11 demonstrate that Amazon generates patents most significantly through its aggressive R&D. This high level of

Table 10
Correlation between R&D and Patent Applications for GAFA (2004–2018). $\ln PAT = a + b \ln R + c\ D$.

	a	b	c	*adj.* R^2	DW
Google	3.91 (6.44)	0.47 (6.74)	0.44 (2.23)	0.771	1.00
Apple	2.54 (6.31)	0.66 (13.19)	−0.46 (−2.98)	0.932	1.00
Facebook	2.37 (2.79)	0.55 (5.23)		0.790	2.77
Amazon	−2.76 (−8.05)	1.07 (25.87)		0.981	1.39

PAT: Patent application; *D*: Dummy variables (D_{google}: 2005, 2015 = 1, others = 0; D_{apple}: 2006, 2018 = 1, others = 0); *a, b, c*: coefficient (*b* indicates R&D elasticity to patent application).
The figures in parentheses indicate t-statistics: all are significant at the 1% level.

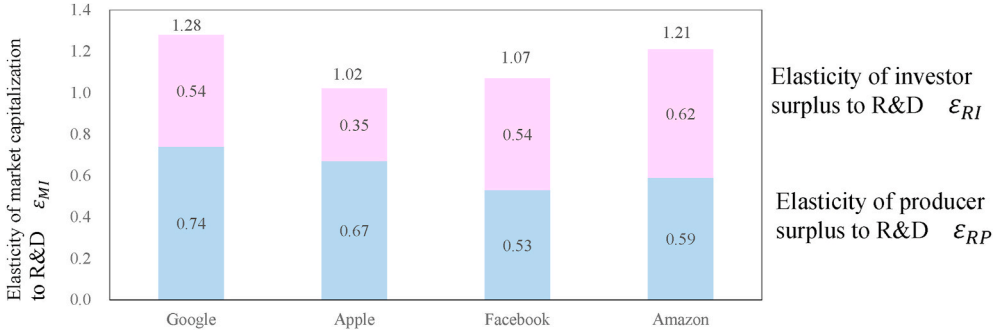


Fig. 10. Composition of the Elasticity of Market Capitalization to R&D for GAFA (2005–2018). * Facebook is between 2012 and 2018 for reference.

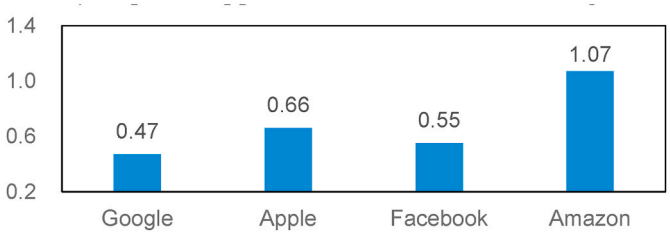


Fig. 11. R&D elasticity to patent application for GAFA (2014–2018).

elasticity instills investors with confidence to bet on Amazon's future success based on sustained growth by means of R&D investment.

Since statistics on patent applications objectively reflect business performance, this elasticity supports to improve the objectivity of an investor surplus.

5.2. Dynamism Leveraging the expectations of stakeholders

Based on its unique business model and ambitious endeavour toward customer-centric R&D-driven advancement, Amazon has developed its comprehensive empire chain, big data collection system, and the architecture for participation, harnessing the power of users and leading to user-driven innovation. This innovation, in turn, accelerates the advancement of the Internet. Advanced Internet awakens and induces environmentally friendly soft innovation resources (*SIRs*).[7] Since *SIRs* are considered to be a condensate and crystal of the advancement of the Internet [2], in line with Metcalfe's law,[8] the magnitude of *SIRs* is proportional to the interactios with users. Therefore, Amazon's user-driven innovation strongly awakens and induces broad areas of *SIRs* in a marketplace, as exemplified below, consisting of Internet-based resources that have been either sleeping or untapped, and it results in multisided interaction in the markets where the consumer is looking for functionality beyond economic value. For example, Amazon has been contributing to current global significant tasks to attain the sustainable development goals (*SDGs*), and its cloud service, Amazon Web Services (AWS), has helped 16 startups worldwide to achieve their *SDGs*.

(i) Shifts in preferences toward supra-functionality beyond economic value, *SDGs*.

(*The biggest river* - e.g., Amazon Web Service: AWS (2002))

(ii) Sleeping resources

(*All stakeholders working together* - e.g., Amazon Flex (2015))

(iii) Drawing upon past information and fostering trust

(*Carrying every product from A to Z* - e.g., Amazon Prime (2005))

(iv) Providing the most gratification ever experienced

(*Fusing net and real* - e.g., Amazon Go (2016))

(v) Memory and future dreams

(*Brick and mortar retailer* - e.g., Amazon Kindle (2007))

(vi) Untapped resources and vision

(*Instilling dreams in customers* - e.g., Amazon Echo (2014))

With distinct assimilation capacity supported by rapidly increasing R&D investment [6], Amazon has assimilated these broad SIRs, leading to a significant increase in gross R&D, consisting of indigenous R&D and assimilated SIRs.[9]

Increased gross R&D contributes to significant growth, which activates a latent self-propagating function indigenous to ICT [32,40] leading to emerging supra-functionality beyond economic value that satisfies a shift in customers' preferences in the digital economy. Emerged supra-functionality accelerates user-driven innovation, which promotes further advancement of the Internet.

Thus, a notable virtuous cycle, *user-driven innovation → advancement of the Internet → awakening and inducement of SIRs in a marketplace → increase in gross R&D → activation of self-propagating function →emergence of supra-functionality beyond economic value → acceleration of user-driven innovation,* has been constructed, as illustrated in Fig. 12. Amazon has been making extensive efforts to reinforce this virtuous cycle in terms of acceleration, widening, appealing to stakeholders, and avoiding fragility. The acquisition of Whole Foods in 2017 aimed at capturing the growth engine with a brand value of *ESG*[10] corresponding to the current corporate governance doctrine for avoiding the fragility of sustainable growth derived from technological and financial risks and uncertainties as well as environmental change in corporate governance [7,41].

Institutional systems that orchestrate techno-financing systems, as reviewed in Section 2, enable this virtuous cycle, and given this, R&D-driven sustainable growth leading to increasing gross market value can be expected.

With this dynamism, investors bet on the continuation of Amazon's solid growth by means of its large amount of aggressive endeavours in R&D investment, as demonstrated by the high elasticity of investor surplus to R&D investment.

Amazon does not pay dividends and has prohibited share buybacks since 2012. Therefore, it is natural to raise the question as to what investors expect from Amazon's huge risk investment [8]?

The abovementioned dynamism provides a reasonable answer to this question, with significant implications for Amazon's investor surplus. First, investors incorporate not only shareholders but also broad stakeholders centered on users. Second, these stakeholders expect not only economic value but also supra-functionality beyond such value, encompassing social, cultural, and ecological values.

Thus, it can be concluded that Amazon leverages the expectations of a wide range of stakeholders by providing supra-functionality beyond economic value that satisfies a shift in users' preferences in the digital economy and thereby takes the initiative in terms of stakeholder capitalism. This initiative leads to the realization of an outstanding cash conversion cycle (CCC), which secure abundant free cash and enables aggressive R&D that excites investors.

6. Conclusion

As the digital economy progresses, securing R&D investment has determined competitiveness. Amazon, a company with a market capitalization of US$ 1 trillion since 2018, following Apple, has been a world leader in R&D investment since 2017. In 2018, it invested US$ 28.8 billion, 35% more than the second biggest investor, Google.

Such a remarkable accomplishment can be attributed to its institutional systems that orchestes techno-financing systems, which fuse a

[7] Amazon stressed that as Earth's most consumer-centric company, it works every day to offer the shopping experience with the lowest environmental impact on the planet [48,49].

[8] The effect of a telecommunication network is proportional to the square of the number of connected users of the system.

[9] This significant increase in Amazon's gross R&D corresponds to it becoming the world's top R&D company from 2017, by transforming routine or periodic alterations into significant improvement during its R&D process [6,50].

[10] Whole Foods has taken a pioneering initiative in its balanced *ESG* strategy: Environment-Social-Governance.

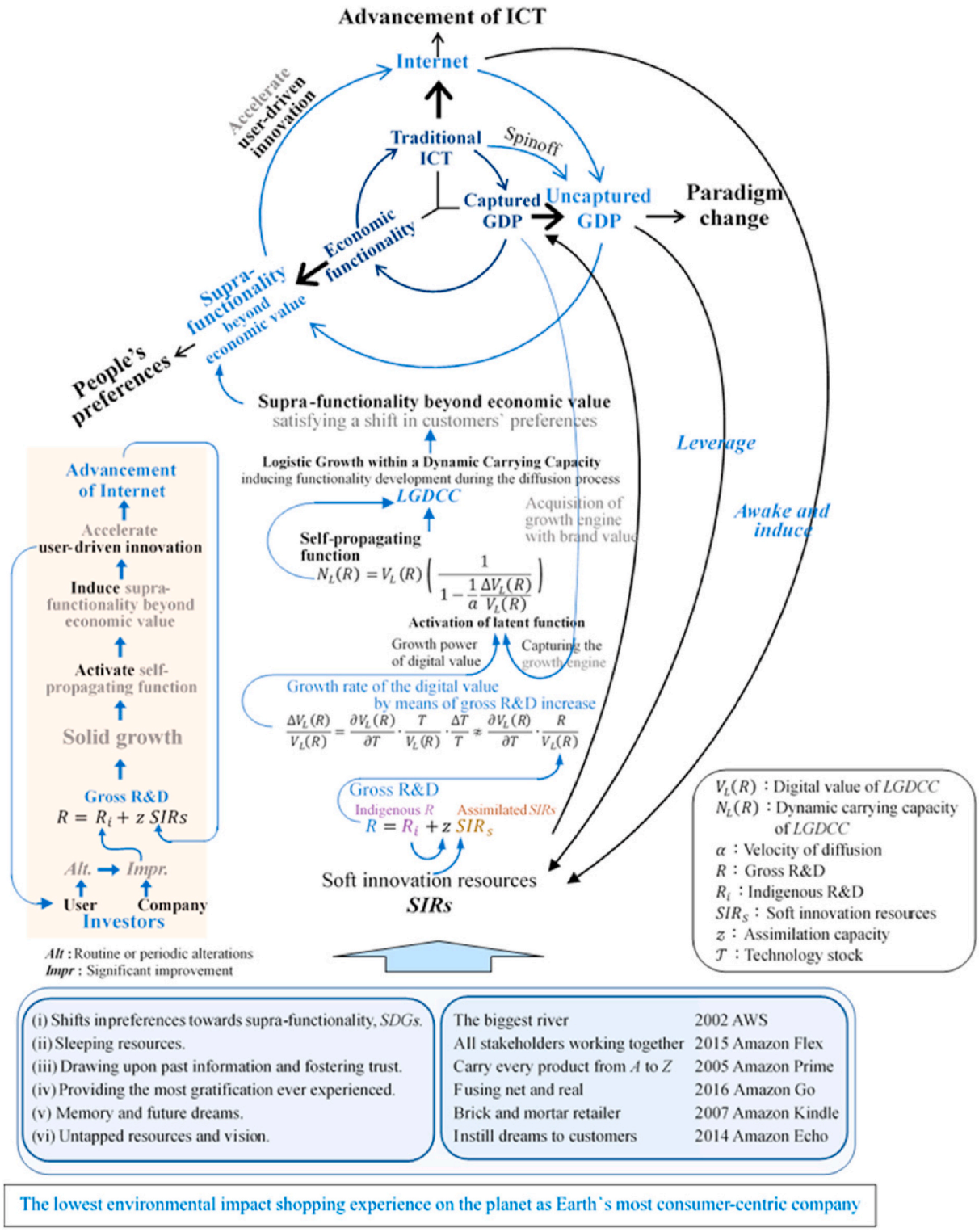


Fig. 12. Dynamism of an investor surplus in inducing R&D investment in Amazon.

unique R&D transformation system and a sophisticated financing system centered on the CCC. These institutional systems support and endorse aggressive investment in R&D which incorporates characteristics of uncertainty, long lead-times, and successive inflows of very large amounts of funding without interruption.

While some of this investment can be endorsed by Amazon's positive business results, such as sustained increases in sales and free cash flow, such a large amount of aggressive investment is beyond endorsement. In addition to actual economic performance, investors have been betting on a high level of risky investment with the expectation of Amazon's future success, trusting its R&D-inducing institutional systems.

While the former can be considered to be a general reaction to a producer surplus, the latter can be postulated as an investor surplus in which investors bet on overly optimistic future prospects instead of actual accomplishments. This is similar to a consumer surplus in which consumers pay more than the actual market price for attractive goods

and services.

In light of increasing concern on the elucidation of the inside of this dynamism, this paper attempted to elucidate the institutional systems that enable Amazon to invest a very large amount of financing resources in aggressive R&D.

Corresponding to the current corporate governance doctrine by introducing a concept of gross market value consisting of a producer surplus and an investor surplus, an intensive empirical analysis was conducted, focusing on the development trajectory of Amazon's techno-financing system over the last two decades, together with comparative analyses of the performance of the big four online service companies, Google, Apple, Facebook, and Amazon (GAFA).

A broadly applicable practical approach for measuring an investor surplus was developed and the following noteworthy findings were obtained:

(i) It was identified that among GAFA, Amazon demonstrated the highest dependence on an investor surplus, which suggests that investors are betting on the continuation of Amazon's solid growth by means of its aggressive investment in R&D, supported and endorsed by its institutional systems.
(ii) Amazon's investor surplus demonstrated a high elasticity to R&D investment and supported the above mentioned supposition.
(iii) It was demonstrated that Amazon's investors incorporate not only shareholders but also broad stakeholders centered on users, and that they expect not only economic value but also supra-functionality beyond such value, encompassing socio-cultural and ecological values.
(iv) Thus, Amazon has taken the initiative in terms of stakeholder capitalism leading it to realize an outstanding CCC and secure abundant free cash, enabling aggressive R&D that excites investors.

These findings give rise to the following insightful suggestions highlighting the significance of an investor surplus toward stakeholder capitalism:

(i) A mechanism for inducing an investor surplus should be further elucidated.
(ii) A dynamism for producing an investor surplus should be generalized.
(iii) The projection of such dynamism into national R&D policy should be undertaken.
(iv) Lessons from policy application should be provided to Amazon for the new monopoly in the digital economy.
(v) The theoretical framework of stakeholder capitalism should be further developed.

Future works should focus on the following points:

(i) In-depth comparative analysis of a similar investor surplus in global ICT leaders.
(ii) Deployment of a similar analysis in ICT-leading nations.
(iii) Development of standard metrics for assessing the state of stakeholder capitalism.
(iv) Development of an analytical approach identifying the optimal balance between a producer surplus and an investor surplus.
(v) Application of the above approach to the taxation of the digital economy.

Acknowledgement

The research leading to these results is the part of a project: Platform Value Now: Value Capturing in the Fast Emerging Platform Ecosystems, supported by the Strategic Research Council at the Academy of Finland [grant number 293446].

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.techsoc.2020.101290.

Appendix. Data Construction

Table A1a
Quarterly Trends in R&D-seeking Institutional Systems for GAFA (2005–2018) – US$ mil. Alphabet (Google)

	R&D	Free cash flow	Number of shares**	Stock price*	Market capitalization	*PFCR**
Mar-05	109	387	532	91	48,412	124
Jun-05	96	467	541	151	81,691	175
Sep-05	178	354	550	158	86,984	246
Dec-05	190	413	582	207	120,778	293
Mar-06	247	480	587	195	114,508	239
Jun-06	283	142	602	210	126,272	892
Sep-06	313	512	606	201	121,818	238
Dec-06	387	544	613	230	141,188	259
Mar-07	408	623	618	229	141,578	227
Jun-07	532	655	620	261	162,108	248
Sep-07	549	1080	622	284	176,379	163
Dec-07	631	1015	624	346	215,707	213
Mar-08	673	938	626	220	137,793	147
Jun-08	682	1069	627	263	165,041	154
Sep-08	705	1733	628	200	125,737	73
Dec-08	733	1754	629	154	96,711	55
Mar-09	642	1987	630	174	109,620	55
Jun-09	708	1470	631	211	133,055	91
Sep-09	758	2539	632	248	156,786	62
Dec-09	736	2510	634	310	196,490	78
Mar-10	818	2345	635	284	180,109	77

(continued on next page)

Table A1a (*continued*)

	R&D	Free cash flow	Number of shares**	Stock price*	Market capitalization	*PFCR**
Jun-10	898	1609	636	222	141,515	88
Sep-10	994	2128	637	263	167,367	79
Dec-10	1051	−86	639	297	189,857	−2208
Mar-11	1226	2282	642	293	188,476	83
Jun-11	1234	2602	644	253	163,011	63
Sep-11	1404	3270	646	258	166,276	51
Dec-11	1301	1073	648	323	209,197	195
Mar-12	1441	2995	650	321	208,393	70
Jun-12	1538	−6577	652	290	189,080	−29
Sep-12	1879	2607	655	377	247,076	95
Dec-12	1225	3753	661	354	233,750	62
Mar-13	1617	2179	660	397	262,193	120
Jun-13	1766	2044	665	440	292,709	143
Sep-13	1821	2767	667	438	292,220	106
Dec-13	1933	2863	670	560	375,256	131
Mar-14	2126	−901	673	557	374,808	−416
Jun-14	2238	2438	675	585	394,722	162
Sep-14	2655	2435	677	588	398,412	164
Dec-14	2813	3150	681	531	361,438	115
Mar-15	2753	3731	681	555	377,706	101
Jun-15	2789	4503	684	540	369,182	82
Sep-15	3230	3637	686	638	438,203	120
Dec-15	3510	4515	688	778	534,913	118
Mar-16	3367	5180	688	763	524,509	101
Jun-16	3363	6946	686	704	482,776	70
Sep-16	3596	7039	688	804	552,839	79
Dec-16	3622	5673	690	792	546,648	96
Mar-17	3942	6939	692	848	586,305	84
Jun-17	4172	4530	692	930	643,301	142
Sep-17	4205	6204	693	974	675,255	109
Dec-17	4306	5947	695	1053	731,692	123
Mar-18	5039	3093	695	1037	720,553	233
Jun-18	5114	4471	695	1129	784,719	176
Sep-18	5232	7910	696	1207	839,681	106
Dec-18	6034	5867	695	1045	726,498	124

1. Note for statistics.
1) Number of shares are based on the basic shares outstanding.
2) Price free cash ratio ($PFCR$) $= \frac{S_p}{FCF/N}$ where S_p: stock price; FCF: free cash flow; N: number of shares.
2. For the treatment of stock splits in April 2014, stock prices before April 2014 were adjusted.
Source: Alphabet [42].

Table A1b
Quarterly Trends in R&D-seeking Institutional Systems for GAFA (2005–2018) – US$ mil. Apple

	R&D	Free cash flow	Number of shares	Stock price	Market capitalization	*PFCR*
Mar-05	119	493	5657	6	33,659	68
Jun-05	145	409	5706	5	30,014	73
Sep-05	147	656	5750	8	44,045	67
Dec-05	182	201	5815	10	59,720	297
Mar-06	176	−318	5886	9	52,739	−166
Jun-06	175	770	5960	8	48,753	63
Sep-06	179	910	5978	11	65,758	72
Dec-06	184	1556	6004	12	72,768	47
Mar-07	183	528	6041	13	80,164	152
Jun-07	208	938	6068	17	105,765	113
Sep-07	207	1462	6096	22	133,624	91
Dec-07	246	2555	6131	28	173,507	68
Mar-08	273	978	6157	21	126,219	129
Jun-08	292	991	6186	24	147,969	149
Sep-08	298	3873	6210	16	100,850	26
Dec-08	315	3585	6224	12	75,871	21
Mar-09	319	725	6238	15	93,695	129
Jun-09	341	1998	6256	20	127,310	64
Sep-09	358	2638	6286	26	166,453	63
Dec-09	398	5400	6325	30	190,383	35
Mar-10	426	2029	6353	34	213,270	105
Jun-10	464	4175	6385	36	229,413	55
Sep-10	494	4870	6402	41	259,537	53
Dec-10	575	8510	6435	46	296,525	35
Mar-11	581	5563	6462	50	321,743	58
Jun-11	628	10,150	6483	48	310,860	31
Sep-11	645	5858	6498	54	353,946	60

(*continued on next page*)

Table A1b (*continued*)

	R&D	Free cash flow	Number of shares	Stock price	Market capitalization	*PFCR*
Dec-11	758	16,120	6517	58	377,074	23
Mar-12	841	12,470	6535	86	559,723	45
Jun-12	876	7226	6556	83	546,967	76
Sep-12	906	5635	6568	95	625,930	111
Dec-12	1010	20,970	6572	76	499,603	24
Mar-13	1119	10,200	6577	63	415,929	41
Jun-13	1178	5812	6430	57	364,260	63
Sep-13	1168	7602	6329	68	431,068	57
Dec-13	1330	20,630	6273	80	502,781	24
Mar-14	1422	12,050	6123	77	469,512	39
Jun-14	1603	7824	6013	93	558,788	71
Sep-14	1686	9398	5934	101	597,851	64
Dec-14	1895	30,460	5843	110	644,950	21
Mar-15	1918	16,600	5794	124	720,947	43
Jun-15	2034	12,900	5730	125	718,657	56
Sep-15	2220	9817	5647	110	622,864	63
Dec-15	2404	23,460	5559	105	585,140	25
Mar-16	2511	9002	5514	109	600,971	67
Jun-16	2560	7729	5443	96	520,351	67
Sep-16	2570	13,310	5367	113	606,739	46
Dec-16	2871	23,810	5299	116	613,730	26
Mar-17	2776	9681	5226	144	750,767	78
Jun-17	2937	6395	5195	144	748,184	117
Sep-17	2997	11,880	5149	154	793,564	67
Dec-17	3407	25,480	5113	169	865,273	34
Mar-18	3378	10,940	5025	168	843,095	77
Jun-18	3701	11,220	4882	185	903,707	81
Sep-18	3750	16,480	4802	226	1,084,003	66
Dec-18	3902	23,340	4736	158	747,057	32

1. Note for statistics: same as Alphabet.
Source: Apple [43].

Table A1c
Quarterly Trends in R&D-seeking Institutional Systems for GAFA (2005–2018) – US$ mil. Facebook

	R&D	Free cash flow	Number of shares	Stock price	Market capitalization	*PFCR*
Sep-12	244	79	2420	27	64,420	815
Dec-12	297	483	2372	26	60,676	126
Mar-13	293	392	2386	25	59,364	151
Jun-13	344	1054	2407	50	120,904	115
Sep-13	369	666	2430	55	132,800	199
Dec-13	409	748	2456	60	147,949	198
Mar-14	455	922	2545	67	171,253	186
Jun-14	492	872	2560	79	202,342	232
Sep-14	608	766	2587	78	201,838	263
Dec-14	1111	2935	2761	82	227,009	77
Mar-15	1062	1198	2784	86	238,784	199
Jun-15	1170	1331	2796	90	251,360	189
Sep-15	1271	1412	2808	105	293,885	208
Dec-15	1314	3856	2824	114	322,218	84
Mar-16	1343	2345	2843	114	324,898	139
Jun-16	1471	2670	2856	128	366,339	137
Sep-16	1542	2941	2871	115	330,309	112
Dec-16	1563	3661	2881	142	409,246	112
Mar-17	1834	3787	2891	151	436,483	115
Jun-17	1919	3916	2900	171	495,523	127
Sep-17	2052	4372	2904	176	512,440	117
Dec-17	1949	5408	2910	160	464,989	86
Mar-18	2238	5048	2906	194	564,694	112
Jun-18	2523	2838	2895	164	476,112	168
Sep-18	2657	4156	2885	131	378,195	91
Dec-18	2855	3317	2875	167	479,234	144

1. Note for statistics: same as Alphabet.
2. IPO was in May 2012.
Source: Facebook [44].

Table A1d
Quarterly Trends in R&D-seeking Institutional Systems for GAFA (2005–2018) – US$ mil. Amazon

	R&D	Free cash flow	Number of shares	Stock price	Market capitalization	*PFCR*
Mar-05	92	−320	410	34	14,051	−44
Jun-05	106	197	411	33	13,600	69
Sep-05	121	77	413	45	18,709	243
Dec-05	132	575	415	47	19,567	34
Mar-06	146	−349	417	37	15,233	−44
Jun-06	167	72	418	39	16,168	225
Sep-06	172	69	417	32	13,394	194
Dec-06	177	694	413	39	16,297	23
Mar-07	186	−313	412	40	16,393	−52
Jun-07	201	251	412	68	28,185	112
Sep-07	209	168	414	93	38,564	230
Dec-07	222	1075	416	93	38,538	36
Mar-08	234	−706	417	71	29,732	−42
Jun-08	258	278	420	73	30,799	111
Sep-08	264	323	427	73	31,069	96
Dec-08	277	1469	429	51	21,999	15
Mar-09	275	−640	429	73	31,506	−49
Jun-09	299	390	431	84	36,057	92
Sep-09	315	696	432	93	40,332	58
Dec-09	350	2474	439	135	59,054	24
Mar-10	366	−1238	445	136	60,418	−49
Jun-10	408	54	447	109	48,839	904
Sep-10	442	540	448	157	70,363	130
Dec-10	518	3160	447	180	80,460	25
Mar-11	579	−1884	451	180	81,239	−43
Jun-11	698	−10	453	204	92,634	−9263
Sep-11	769	267	454	216	98,168	368
Dec-11	862	3719	453	173	78,414	21
Mar-12	945	−2824	453	203	91,737	−32
Jun-12	1082	−63	451	228	102,986	−1635
Sep-12	1192	227	452	254	114,953	506
Dec-12	1345	3055	456	251	114,397	37
Mar-13	1383	−3042	455	266	121,253	−40
Jun-13	1586	24	456	278	126,627	5276
Sep-13	1734	350	457	313	142,876	408
Dec-13	1862	4699	460	399	183,443	39
Mar-14	1991	−3582	460	336	154,730	−43
Jun-14	2226	−428	461	325	149,724	−350
Sep-14	2423	389	463	322	149,290	384
Dec-14	2636	5570	465	310	144,313	26
Mar-15	2754	−2370	465	372	173,027	−73
Jun-15	3020	784	467	434	202,720	259
Sep-15	3197	1414	468	512	239,565	169
Dec-15	3569	6824	467	676	315,641	46
Mar-16	3526	−3132	471	594	279,604	−89
Jun-16	3880	1867	473	716	338,488	181
Sep-16	4135	2818	474	837	396,885	141
Dec-16	4544	7846	477	750	357,688	46
Mar-17	4813	−3767	477	887	422,880	−112
Jun-17	5549	736	479	968	463,672	630
Sep-17	5944	702	481	961	462,409	659
Dec-17	6314	8739	483	1169	564,854	65
Mar-18	6759	−4889	484	1447	700,513	−143
Jun-18	7247	4206	486	1700	826,103	196
Sep-18	7162	5236	488	2003	977,464	187
Dec-18	7669	12,740	490	1502	735,965	58

1. Note for statistics: same as Alphabet.
Source: Amazon [45,51–53].

Table A2
The Trend in the Number of Patent Application for GAFA (2004–2018)

Year	Google	Apple	Facebook	Amazon
2004	1783	534	186	24
2005	1587	565	188	55
2006	1813	645	209	46
2007	2202	925	221	60
2008	2003	1484	786	120
2009	1618	1685	236	143
2010	1791	2092	302	216
2011	1828	2451	333	306
2012	2980	3150	322	469

(*continued on next page*)

Table A2 (*continued*)

Year	Google	Apple	Facebook	Amazon
2013	4021	4368	749	806
2014	5338	4926	1055	1269
2015	6519	4429	933	1843
2016	5515	4935	1310	2249
2017	5237	4731	1780	2629
2018	4291	4407	1743	2732

Source: LexisNexis [46].

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