CONSEQUENCES OF THE DIGITAL ECONOMY: TRANSFORMATION OF THE GROWTH CONCEPT

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ABSTRACT

The digital economy is transforming the traditional concepts of economic growth.The recent reversal trend in GDP growth of ICT leaders can be attributed to effective utilization of soft innovation resources in Finland and adherence to traditional resources in Singapore.Confronting a productivity decline in the digital economy, global information and communication technology (ICT) leaders are transforming business models into those with uncaptured GDP creation. This can be attributed tothe harnessing soft innovation resourcesagainst a productivity decline. This in turn activates a self-propagating function and induces supra-functionality beyond economic value corresponding to a shift in people's preferences. It also contributes to removingstructural impediments in GDP growth.Empirical analyses utilizing the development trajectories of 500 global ICT firms and also world ICT leadersFinland and Singapore demonstratedthese hypothetical views andprovided an insightful suggestion as to overcome aproductivity decline in the digital economy.

KEYWORDS

Digital economy, soft innovation resources, structural impediments in growth, global ICT firms, Finland and Singapore

1. INTRODUCTION

The dramatic advancement of the Internet has generated the digital economy, which has provided us with extraordinary services and welfare never anticipated before[1]. However, contrary to such accomplishments, productivity in industrialized countries has been confronted with an apparent decline[2] [3] [4].

Confronting such circumstances, leading global information and communication technology (ICT) firms have been endeavoring to transform into a new business model that creates uncaptured GDP [5].

Authors in previous studies stressed the significance of increasing dependence on uncaptured GDP by postulating that the Internet promotes a free culture that provides utility and happiness to people through its consumption but cannot be captured through GDP data, which measure economic values. ThisInternet-emergedadded valueofproviding people with utility and happiness, which extends beyond economic value, is defined as uncaptured GDP [6] [7] [8].

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Aforementioned transformation in global ICT firms can be considered a spontaneous creation of uncaptured GDP, not merely depending passively on the Internet-emerged uncaptured GDP, by harnessing the vigor of soft innovation resources such as sleeping/untapped resources, trust, memory and dreamutilization of which is not necessary within the reach of GDP accounting [9]. This in turn activates a self-propagating function and induces supra-functionalitybeyond economic value corresponding to a shift in people's preferences [10].

Utilization of soft innovation resources also contributes to removing structural impediments in GDP growth such as conflict between public, employers and labor union, and also disparity of gender. Thus, uncaptured GDP dependence contributes to overcoming economic stagnation.

To date, a large number of studies have attempted to identify the structural sources of the issues stemming fromthe GDP as a measurement tool in representing the true picture of a digital economy(e.g., [3], [11]. [12], [13], [14],[15]) and also the state of soft innovation resources utilization (e.g., [16], [17], [18]). However, no study has provided rational answers to this fundamental question [19].

In light of the foregoing, following the preceding analysis [5], on the basis of empirical analyses utilizing the development trajectories of 500 global ICT firms and also world ICT leaders Finland and Singapore, this paper attempts to demonstrate these hypothetical views, and shed light on the new national and business model overcoming a productivity decline in the digital economy.

It was found that the recent reversal in GDP growth of ICT leaders can be attributed to effective utilization of soft innovation resources in Finland and adherence to traditional resources in Singapore. Thisprovides an insightful suggestion as to overcome a productivity decline in the digital economy.

Section 2 over reviews consequences of the digital economy. Disruptive business model against productivity decline is analyzed in Section 3. Section 4 elucidates dynamism leading to recent reversal in GDP growth of ICT leaders. Section 5 summarizes the noteworthy findings, policy suggestions, and future research.

2. CONSEQUENCES OF THE DIGITAL ECONOMY

2.1. ECONOMIC GROWTH AND HAPPINESS/WELFARE IN WORLD DIGITAL LEADERS

Finland and Singapore have been maintaining world digital leaders position as demonstrated in **Table 1**. Table 1 compares ICT rank in 140 countries in the world by using Networked Readiness Index (*NRI*) which demonstrates Finland and Singapore share top position.

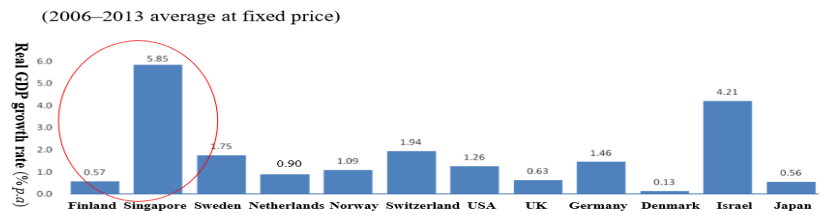
Note : *NRI* evaluates digital advancement of nations by multi-layer indices consists of 4 sub-index (environment, readiness, usage and impact), 10 pillars and 55 indicators

Table 1.World digital leaders by ICT rank (2013-2016)

2013	1 Finland	2 Singapore	7 UK	9 USA	13 Germany	21 Japan
2014	1 Finland	2 Singapore	7 USA	9 UK	12 Germany	16 Japan
2015	1 Singapore	2 Finland	7 USA	8 UK	10 Japan	13 Germany
2016	1 Singapore	2 Finland	5 USA	8 UK	10 Japan	15 Germany

Figures indicate world rank by Networked Readiness Index (*NRI*).
Source: The Global Information Technology Report (WEF, annual issues).

Fig. 1 compares state of economic growth and happiness/welfare in world digital leaders in 2013.Comparing top two world digital leaders Finland and Singapore we note that while Finland enjoyed high level of happiness/welfare under the great stagnation as its GDP growth rate was among the lowest in world digital leaders, Singapore accomplishedconspicuously high economic growth in a choking society with the lowest level of happiness/welfare level among 12 digital leaders compared.



World Rank/level		FIN	SGP	SWE	NLD	NOR	CHE	USA	UK	DEU	DNK	ISR	JPN
ICT (rank)		1	2	3	4	5	6	7	9	12	13	15	16
Global competitiveness (rank)		3	2	6	8	11	1	5	10	4	15	27	9
Happiness / Welfare	Inequality (GINI index)	19	45	30	28	38	26	47	39	35	41	34	41
	Birth rate	1.9	1.2	1.9	1.8	1.9	1.5	2.1	1.9	1.4	2.9	1.4	2.9
	Happiness (Score)	7.5	6.5	7.5	7.5	7.7	7.6	7.1	6.9	6.7	7.3	6.1	7.3

Figure 1. Growth rate, competitiveness and happiness/welfare in ICT advanced countries (2013).

This observation prompts us the following hypothetical view that “the well-being of the Finnish people has developed in a more positive direction than one might conclude by GDP data [20].

2.2. Trajectory Management Of Digital Leaders

With such a hypothetical view, **Table 2** compares the change in the latest institutional state of six digital leaders by comparing between the state in 2013 and 2016.

Table 2. Institutional state of six ICT advanced countries in the digital economy (2016)

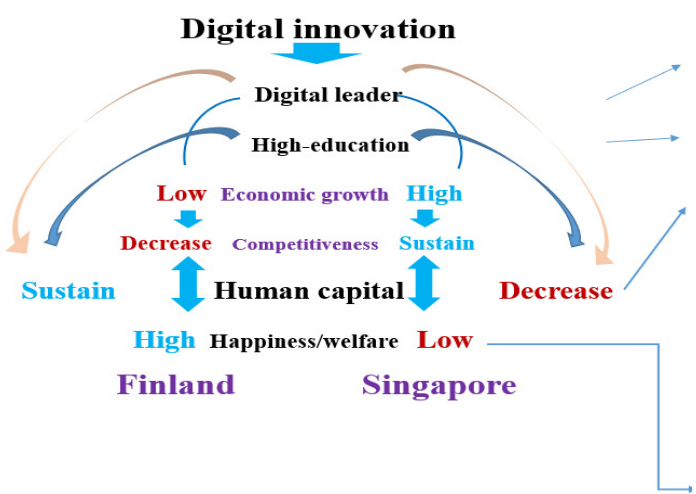
		Finland	Singapore	USA	UK	Germany	Japan	References
Population (million) * 2015		5.5	5.5	321.6	65.1	81.9	126.9	The Global Competitiveness Report 2016-2017 World Economic Forum (WEF, 2016)
ICT (Rank out of 139)		2 <1>	1 <2>	5 <9>	8 <7>	15 <13>	10 <21>	The Global Information Technology Report 2016 (WEF, 2016)
Human capital (Rank out of 130)		1 <2>	13 <3>	24 <16>	19 <8>	11 <6>	4 <15>	The Human Capital Report 2016 (WEF, 2016)
Global competitiveness (Rank out of 138)		10 <3>	2 <2>	3 <5>	7 <10>	5 <4>	8 <9>	The Global Competitiveness Report 2016-2017 (WEF, 2016)
GDP per capita (1000 US$) *2015		42.0	52.9	55.8	43.8	41.0	32.5	The Global Competitiveness Report 2016-2017 (WEF, 2016)
GDP growth rate (% pa at fixed prices) Average	2006-2013	0.57	5.85	1.26	0.63	1.46	0.56	World Economic Outlook Database (IMF, annual issues)
	2014-2017	0.95	2.51	2.20	2.19	1.73	1.02	
Trust (Rank out of 21) *2013		2	7	5	12	16	19	Global Teachers Status Index (Varkey Gems Foundation, 2014)
Gender parity (Rank out of 144)		2	55	45	20	13	111	Global Gender Gap Report 2016 (WEF, 2016)
Happiness *2015-2017 (Rank out of 156)<2010-2012>		1 <7>	34 <30>	18 <17>	19 <22>	15 <26>	54 <43>	World Happiness Report 2013, 2018 (The Earth Institute, Columbia University. et. al., 2013, 2018)
Inequality (GINI index) *2010 state		19	45	47	39	35	34	Distribution of Household Income Source (ILO, 2012)

Figures in <>indicate the state in 2013.

Looking at Table 2 we note that by utilizing the advancement of digital economy, Singapore and Finland maintain world digital leaders position as their world ICT ranks are 1st and 2nd. However, noteworthy contrast appeared in their human capital and global competitiveness positions. While both leaders shared the world top positions in these factors in 2013, they changed to reversal directions during the period between 2013 and 2016. While Finland maintains the top position in human capital, Singapore demonstrated dramatic decrease. On the contrary, while Singapore maintains the top position in global competitiveness, Finland demonstrated remarkable decrease in this rank.

2.3. Consequence of the Digital Economy (Change from 2013 to 2016)

Based on the review of change in the institutional state between 2013 and 2016, **Fig. 2** identifies consequences of the digital economy focusing on the contrasting change between world digital leaders Finland and Singapore.



		Finland	Singapore
Population (million) * 2015		5.5	5.5
ICT (Rank out of 139)		2 <1>	1 <2>
Quality of primary education (Rank out of 138)		← 1 <1>	4 → <3>
Quality of higher education system (Rank out of 138)		← 3 <2>	2 → <3>
Human capital (Rank out of 130)		← 1 <2>	13 ↓ <3>
Global competitiveness (Rank out of 138)		↓ 10 <3>	2 → <2>
GDP per capita (1000 US$) *2015		42.0	52.9
GDP growth rate (% pa at fixed prices) Average	2006-2013	↑ 0.57	5.85 ↓
	2014-2017	0.95	2.51
	2016-2017	↑ 2.35	2.27 ↓
Trust (Rank out of 21) *2013		2	7
Gender parity (Rank out of 144)		2	55
Happiness (Rank out of 156) *2015-2017 <2010-2012>		↑ 1 <7>	34 ↓ <30>
Inequality (GINI index) *2010 state		19	45

Figure 2. Consequences of the digital economy – Contrast between Finland and Singapore (2013 and 2016).

Looking at Figure 2 we note that while both countries maintain world leading position in digital innovation as top and the second in ICT ranking as reviewed in Table 1 and also education level, they changed to reversal directions during the period between 2013 and 2016 in human capital and global competitiveness. While Finland improved human capital rank from the second to top, Singapore decreased from the third to 13th. On the contrary, while Singapore maintained the second rank in global competitiveness, Finland decreased from the third to 10th. Contrast in GDP growth rate, Singapore's decreasing trend and Finland's recovering trend can be another noteworthy contrast.

On the basis of these reviews, it can besuggested that digital economy transforms the traditional concepts of economic growth and competitiveness, ICT's correspondence to digital economy, and systems efficiency of higher education. This further suggests the increasing significance of uncaptured GDP creation and its possible contribution to removing structural impediments in growth.

3. DISRUPTIVE BUSINESS MODEL AGAINST PRODUCTIVITY DECILE

3.1. FUNCTIONALITY DEVELOPMENT INDUCED BY SELF-PROPAGATING FUNCTION

3.1.1 MODEL CONSTRUCTION

Following the preceding analysis [5], development trajectory of digital value created by the global ICT firms in an Internet of things (IoT) society was analyzed by means of the techno-economic approach.

Digital value (*V*) is governed by gross R&D (*R*) in the global ICT firms in an IoT society [5]. Given the logistic growth nature of ICT, *V* can be developed by an *R&D* -driven logistic growth function.

$$V \approx F(R), \quad \frac{dV(R)}{dR} = \frac{\partial V(R)}{\partial R} \cdot \frac{dR}{dR} = \frac{\partial V(R)}{\partial R} = aV(R)\left(1 - \frac{V(R)}{N}\right) \qquad (1)$$

where *N*: carrying capacity (upper limit of diffusion); and *a*: velocity of diffusion.

Equation (1) develops the following simple logistic growth function (*SLG*):

$$V_s(R) = \frac{N}{1+be^{-aR}} \qquad (2)$$

where *b*: coefficient indicating the initial level of diffusion.

Particular innovation which creates new carrying capacity *N*(*R*) during the process of diffusion:

$$\frac{dV(R)}{dR} = aV(R)\left(1 - \frac{V(R)}{N(R)}\right) \qquad (3)$$

Equation (3) develops the following logistic growth within a dynamic carrying capacity function (*LGDCC*) which incorporates self-propagating function as carrying capacity increases as *V*(*R*) increasesas depicted in equation (5) [21]:

$$V_L(R) = \frac{N_k}{1+be^{-aR}+\frac{b_k}{1-a_k/a}e^{-a_kR}} \qquad (4)$$

$$N_L(R) = V_L(R)\left(\frac{1}{1-\frac{1}{a}\cdot\frac{\Delta V_L(R)}{V_L(R)}}\right) \Delta V_L(R) = \frac{dV_L(R)}{dR} \qquad (5)$$

Induced by this self-propagating function, functionality (*FD*) spirally increases as *V*(*R*) increases as depicted in equation (6):

$$FD = \frac{N_L(R)}{V_L(R)} = \frac{1}{1-\frac{1}{a}\cdot\frac{\Delta V_L(R)}{V_L(R)}} \qquad (6)$$

As far as the development trajectory depends on *SLG* trajectory, its digital value ($V_S(R)$) saturates with upper limit depicted by fixed *N* without self-propagating function,once the trajectory shifts to *LGDCC*,it can continue to increase supported by self-propagating function and led by dynamically enhancing upper limit$N_L(R)$. Therefore, the magnitude of self-propagating function (*MSPF*) can be estimated by the ratio of$N_L(R)$ and $V_S(R)$as follows [18]:

$$MSPF = \frac{N_L(R)}{V_S(R)} = \frac{V_L(R)}{V_S(R)} \cdot \left(\frac{1}{1-\frac{1}{a}\cdot\frac{\Delta V_L(R)}{V_L(R)}}\right) \qquad (7)$$

3.1.2 Empirical Analysis

Based on this approach and utilizing the EU Industrial R&D Investment Scoreboard (EU) and annual reports of ICT firms [5], digital value creation trajectory initiated by 500 global ICT firms in 2016 amidst an IoTsociety was analyzed. **Table 3** summarizes the result of the development trajectory based on *LGDCC* function as depicted in equation (4).

Table 3. Estimate of $R\&D$-driven digital value creation trajectory in 500 global ICT firms (2016)

$$V_L(R) = \frac{N_k}{1 + be^{-aR} + \frac{b_k}{1 - a_k/a} e^{-a_k R}}$$

N_k	a	b	a_k	b_k	$adj.R^2$
102.23	0.77	15.84	0.43	1.32	0.999
(178.83)	(26.13)	(9.72)	(7.06)	(2.53)	

Table 3 demonstrates statistically significant and confirms the self-propagating trajectory in $R\&D$-driven digital value creation in 500 global ICT firms in 2016.

Confronting productivity decline in the digital economy, leading global ICT firms have been endeavoring to transform into a new business model that creates uncaptured GDP spontaneously [5]. **Fig. 3** demonstrates the dynamism of this transformation. As a consequence of high-dependency on ICT that incorporates two-faced nature, highly R&D intensive firms confront apparent decline in their marginal productivity of ICT as illustrated in the lower part of Fig. 3.(see **Note**) [5].

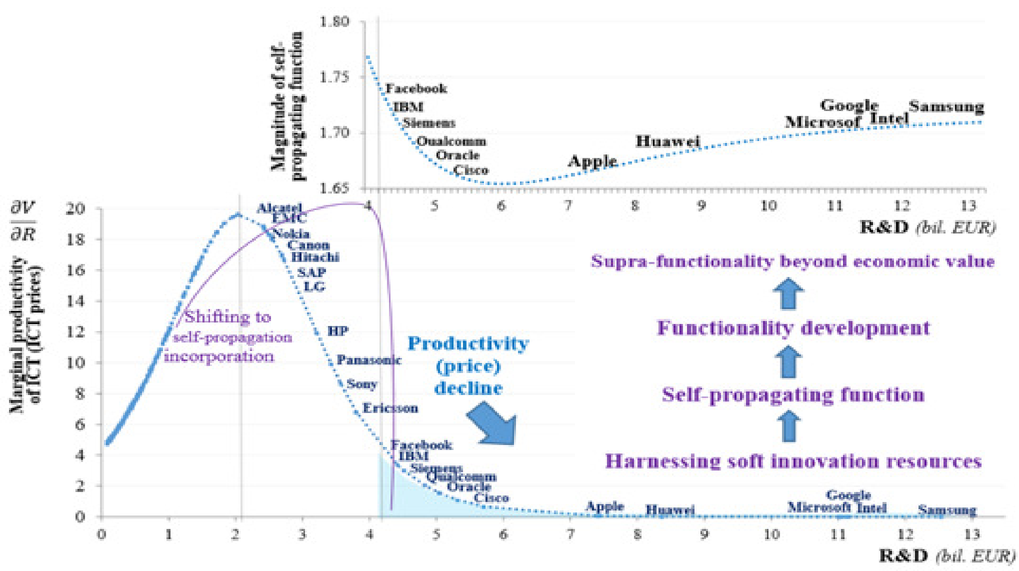


Figure 3. Dynamism in transforming productivity decline into supra-functionality in leading global ICT firms(2016).

Note Marginal Productivity decline in LGDCC function

LGDCC function by equation (4) can be approximated by the following *SLG* function [22]:

$$V_L(R)=\frac{N_k}{1+be^{-aR}+\frac{b_k}{1-a_k/a}e^{-a_kR}}\approx\frac{N_k}{1+b'^{e^{-a'R}}}a'=a\left(1-\frac{b_k}{b}\right),$$

$$b'=b\left(1+\frac{b_k}{b}\cdot\frac{1}{1-\frac{a_k}{a}}\right)\quad b'^{e^{-a'R}}\equiv\frac{1}{x}$$

Therefore , $\frac{d\frac{\partial V_L}{\partial R}}{dR}<0$ when $R>\frac{\ln b'}{a'}\approx\frac{\ln b\left(1+\frac{b_k}{b}\cdot\frac{1}{1-\frac{a_k}{a}}\right)}{a\left(1-\frac{b_k}{b}\right)}=4.2$ (marginal productivity of ICT declines as R&D increases)

$$\frac{\partial V_L}{\partial R}=a'^{N_k}\frac{x}{(1+x)^3},\ \frac{d\frac{\partial V_L}{\partial R}}{dx}=\frac{d\frac{\partial V_L}{\partial R}}{dR}\cdot\frac{1}{a'x}=a'N_k\cdot\frac{(1-x)}{(1+x)^3},\ \frac{d\frac{\partial V_L}{\partial R}}{dR}=0\ \ when\ x=1\ (R=\frac{\ln b'}{a'})$$

This inflection level is much higher than that of in *SLG* function without self-propagating function [5] which implies global ICT firms can avoid productivity decline to some extent by attempting to increase self-propagating function as illustrated in the lower left of Fig. 3. However, excessive dependence on R&D necessitates effective utilization of soft innovation resources for compensating productivity decline.

Against such circumstances, highly R&D intensive firms endeavor to effective utilization of following soft innovation resources rather than depending on further ICT R&D:

- Driving force of eople's preferences shift to supra-functionality beyond economic value
- Sleeping resources (similar to ridesharing revolution by Uber)
- Trust by overdrawing past information
- Utmost gratification ever experienced
- Past memory and future dream
- Untapped resources and vision

Since effective utilization of these soft innovation resources activate self-propagating function indigenous to ICT as illustrated in **Fig. 4** ([16], [17], [18], [23]),this utilization induces functionality development leading to developing supra-functionality beyond economic value (**Fig. 5** [10]) which corresponds to people's preferences shift as illustrated in **Fig.6**[24].

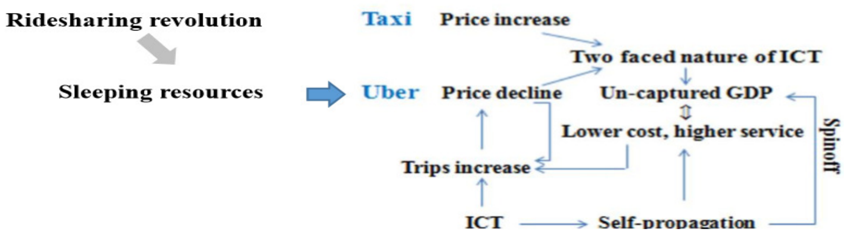


Figure 4. Activation of self-propagating function by means of effective utilization of soft innovation resources: A case of sleeping resources through ridesharing revolution by Uber.

Fig. 5 illustrates basic concept of supra-functionality beyond economic value encompassing social, cultural, aspirational, tribal and emotional values.

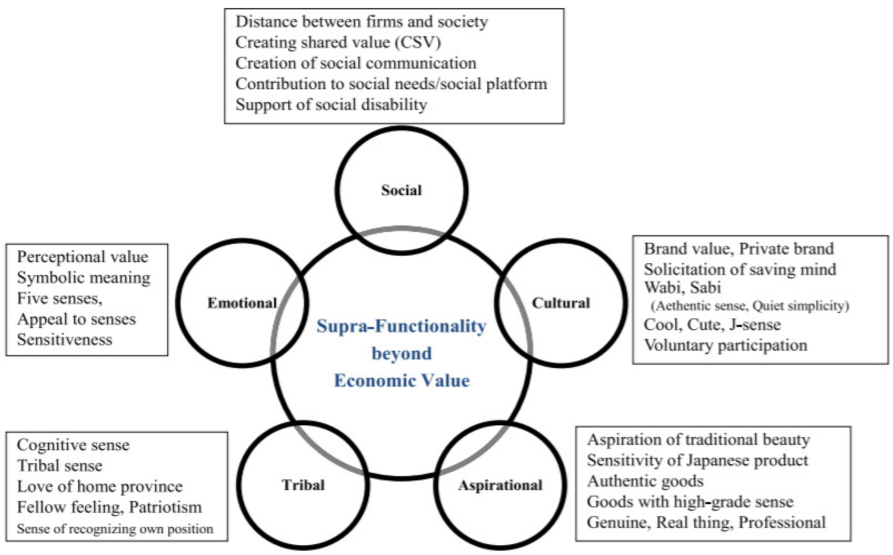


Figure. 5. Basic concept of supra-functionality beyond economic value.

Fig. 6 demonstrates trend in people's preferences shift in Japan which is sensitive to historical paradigm change over the period 1972-2012.

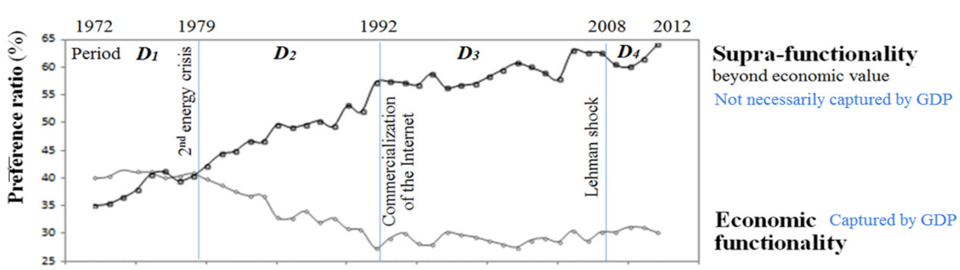


Figure. 6. Trends in the shift of preferences in Japan (1972-2012).

Source: National Survey of Lifestyle Preferences, annual issues (Japan Cabinet Office, 2012).

3.2. TRANSFORMATIVE DIRECTION OF ICT-DRIVEN DISRUPTIVE BUSINESS MODEL

Based on the preceding review, **Fig. 7** summarizes the noteworthy transformative direction of ICT-driven disruptive business models accomplished by seven highly R&D intensive leading global ICT firms in response to marginal productivity decline [9]. Such accomplishments can be attributed to effective utilization of soft innovation resources rather to further ICT R&D. This can be identified as a soft value addition corresponding to creation of uncaptured GDP. This utilization is survival strategy for highly R&D intensive global ICT firms against apparent productivity decline and also essential for the spin-off from traditional product of things (PoT)-driven innovation to new IoT-oriented co-evolutional innovation.

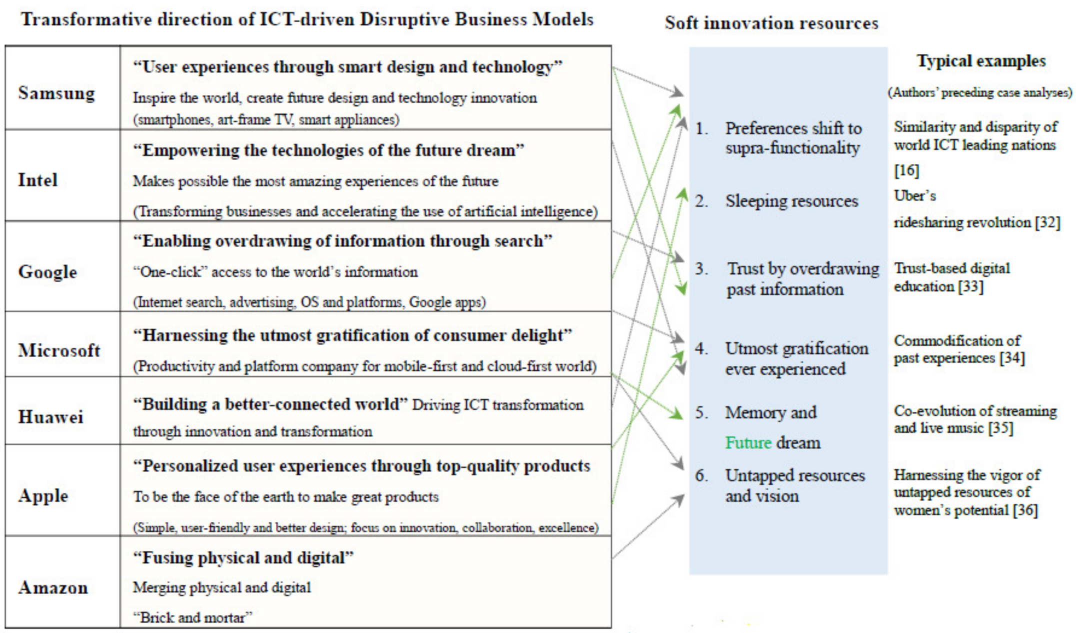


Figure. 7. Transformative direction of ICT-driven disruptive business models.

Amazon is included in this model as its market capitalization is conspicuous while R&D investment is not so remarkable.

3.3. Spontaneous Creation of Uncaptured GDP

Such endeavour toward transformative direction towards an IoT society leads to a new stream of digital solution-driven disruptive business model that creates uncaptured GDP spontaneously not merely depending on it passively.

Locomotive power of this stream can largely be attributed to effective utilization of soft innovation resources which activates self-propagating function identical to ICT and induces functionality development leading to supra-functionality beyond economic value corresponding to people's preferences shift.

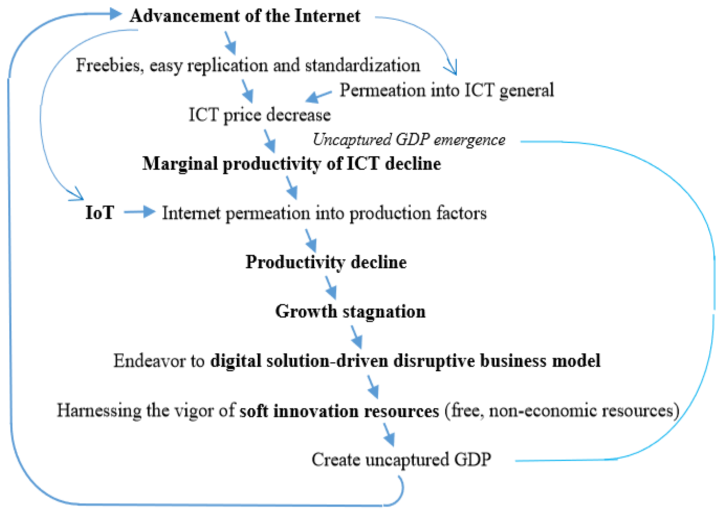


Figure. 8. Scheme of spontaneous creation of uncaptured GDP.

This shift accelerates a shift from a PoT society to an IoT society by inducing further advancement of the Internet which increases further dependency on uncaptured GDP. At the same time, supra-functionality beyond economic value also accelerates uncaptured GDP dependence as illustrated in **Fig. 9**.

Furthermore, effective utilization of soft innovation resources which triggered the above dynamism contributes to removing structural impediments in captured GDP growth such as conflict between public, employers and labour union, and also disparity of gender. Thus, spontaneous creation of uncaptured GDP through effective utilization of soft innovation resources contributes to overcoming economic stagnation by its hybrid functions as illustrated in Fig. 9

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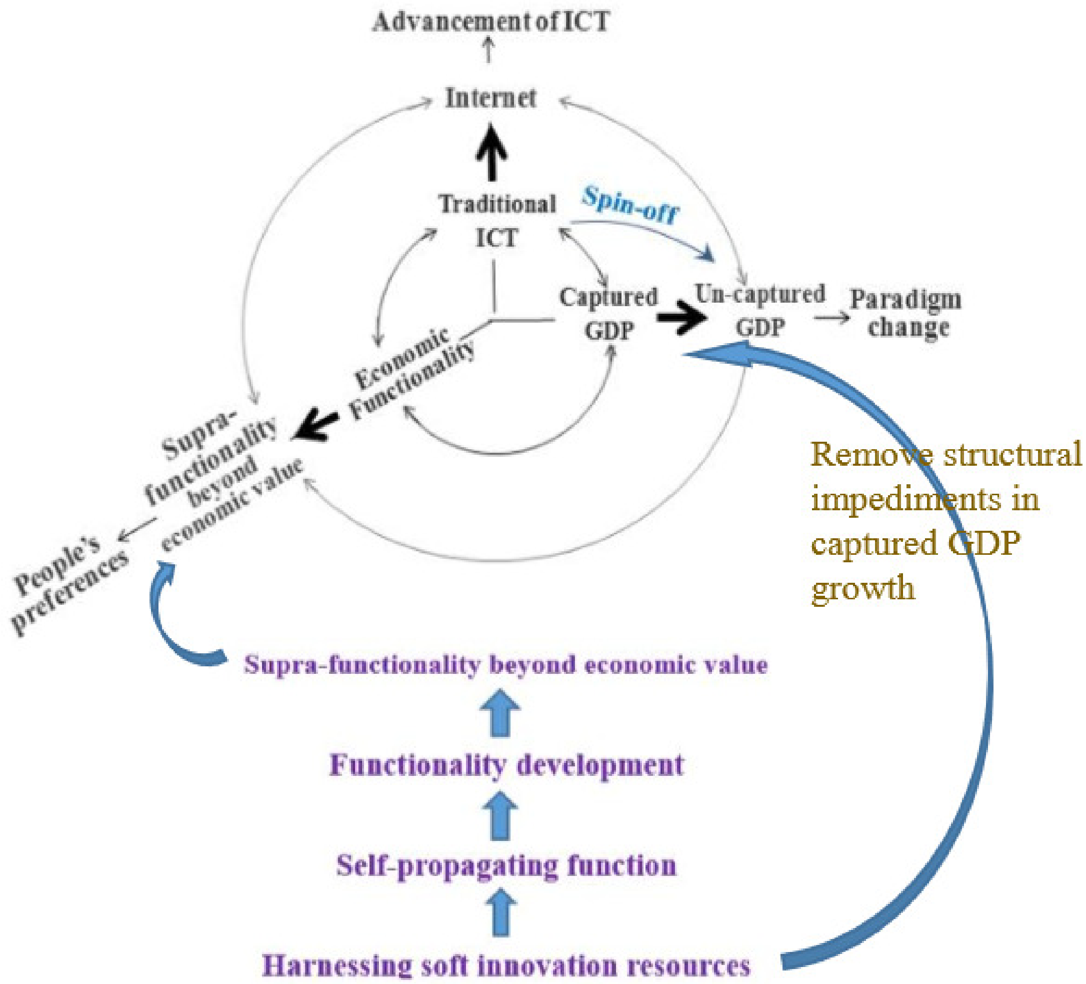

Figure. 9. Hybrid role of soft innovation resources: Creation of uncaptured GDP and remove structural impediments in captured GDP growth.

4. Reversal in GDP Growth between Digital Leaders

Inspired by the foregoing findings, effects of effective utilization of soft innovation resources in removing structural impediments in GDP growth were investigated by analyzing the recent reversal trend in GDP growth of world ICT leaders Finland and Singapore.

Fig. 10 compares trends in real GDP growth rate in world digital leaders Finland and Singapore over the period 1980-2017.

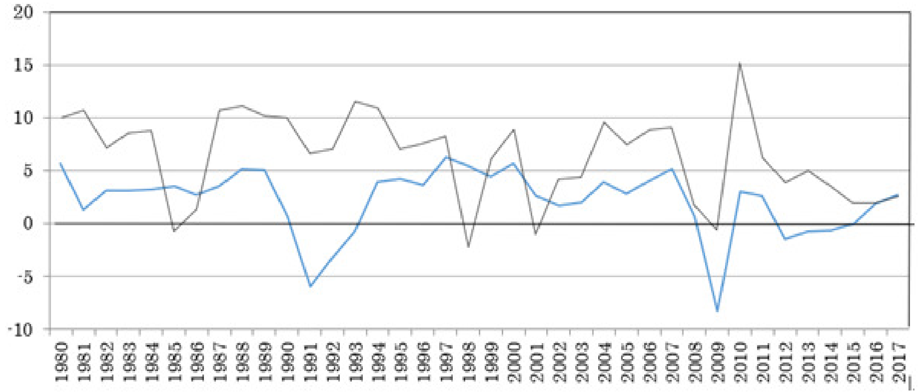

Figure. 10. Trends in real GDP growth rate in Finland and Singapore (1980-2017).

Values in 2017 are estimates as of October 2017.
Source: IMF (2017),

While Singapore exceeded GDP growth rate to that of Finland for long years, reversal trend can be observed very recent as highlighted in **Fig. 11**.

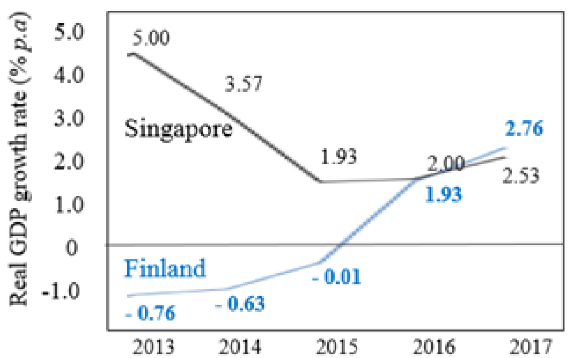

Figure. 11. Recent reversal in GDP growth of digital leaders (2013-2017).

Source: Same as Figure 10.

Note Absolute values of this trends, particularly of in 2017 should be carefully traced as this Figurebased on IMF's estimated trend as of October 1997 in order to analyze the trends using the consistent statistics.

Aiming at elucidating the structural source of suchreversal, **Table 4** analyzes contribution to expenditure on GDP growth rate in two digital leaders over the period 2013-2017.

Table 4 Contribution to expenditure on GDP growth in Finland and Singapore (2013 – 2017)
- real growth rate (% *p.a*).

Finland	2013	2014	2015	2016	2017
Private consumption	-2.09	0.11	1.50	0.83	0.96
Government consumption	2.28	0.00	0.10	0.37	0.32
Gross fixed capital	-9.50	-0.11	0.20	**1.19**	**1.49**
Net exports of goods and services	8.45	-0.63	-1.98	-0.18	0.53
Others (inventories andnet acquisitions of variables)	0.10	0.00	0.17	-0.28	-0.54
Total	**-0.76**	**-0.63**	**-0.01**	**1.93**	**2.76**

Original source: National Accounts of Finland (Statistics Finland, 2018).

Singapore	2013	2014	2015	2016	2017
Private consumption	1.27	1.37	1.40	0.33	0.98
Government consumption	0.98	]0.00	0.61	0.17	0.35
Gross fixed capital	1.67	1.74	0.44	**-0.08**	**-0.42**
Net exports of goods and services	1.27	1.56	1.58	0.92	-0.56
Others (inventories and net acquisitions of variables)	-0.19	-1.10	-2.10	0.66	2.18
Total	**5.00**	**3.57**	**1.93**	**2.00**	**2.53**

Original source:National Accounts of Singapore (Department of Statistics Singapore, 2018). Adjusted to IMF statistics using the share of respective contribution by respective statistics.

Looking at Table 4 we note that, contrary to Singapore, Finland's recent GDP growth recovery can largely be attributed to its gross fixed capital formation to which negative contribution in Singapore.

With such contrasting observation, **Table 5** and **Fig. 12** compares trends in share of intellectual property products out of fixed capital formation in both countries over the last decade.

Table 5. Trends in share of intellectual property products out of gross fixed capital formation in Finland and Singapore (2006-2017) - %

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Finland	22.9	22.0	22.4	24.1	24.1	22.2	21.4	21.7	22.1	20.9	18.8	
Singapore	17.3	15.2	14.1	15.0	14.6	14.5	14.6	18.9	23.2	22.7	21.5	22.9

Sources: Same as original sources of Table 4.

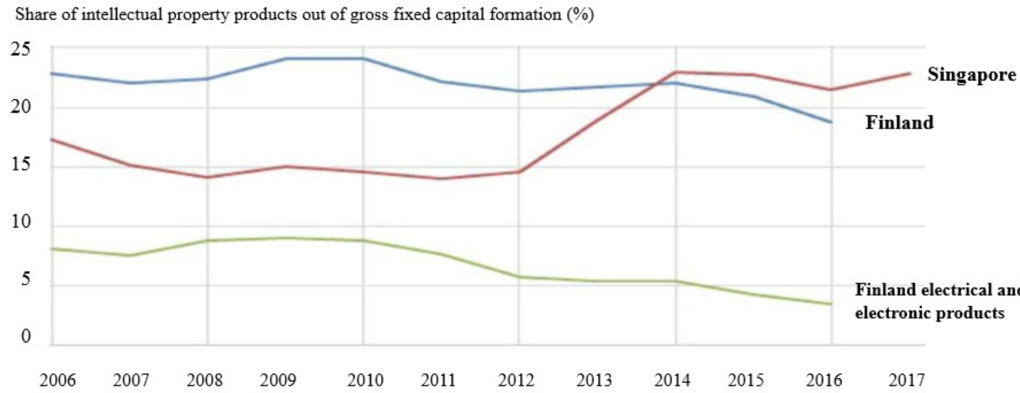

Figure 12. Trends in share of intellectual property products out of gross fixed capital formation in Finland and Singapore (2006-2017) - %

Sources: Same as original sources of Table 4

Note In order to distinguish utilization of soft innovation resources and traditional ICT R&D investment, the latter was measured by intellectual property products (IPP) in the national accountas IPP encompasses (i) R&D, (ii) software and data bases, (iii) mineral exploration and evaluation, and (iv) entertainment, literary or artistic originals.

Table 5 and Fig. 12 demonstrates that contrary to increasing share in Singapore, Finland hasbeen shifting to less dependent on intellectual property products in its gross fixed capital formation. Fig. 11 also demonstrates that this trend in Finland is typical in manufacturing sector, particularly in electrical and electronics sector which takes leading role in digital innovation.

This trend demonstrates contrasting trajectories in two digital leaders: Higher dependency on soft innovation resources rather on ICT R&D in Finland and cling to ICT R&D in Singapore.

Table 6 compares institutional systems between Finland and Singapore relevant to utilization of soft innovation resources.

Table 6 demonstrates clear contrast in these systems. While Finland demonstrates extremely higher trusting relationship than Singapore, it suffers rigid non-flexible labor-employer relations. It suffers the world most rigid wage determination.

Finland can be appreciated in harnessing women’s potential in working life which contributes to its world top level gender balance state. It can largely be appreciated as a consequence of effective utilization of soft innovation resources, untapped resources by means of the advancement of digital innovation.

Table 6 Noteworthy contrast in the state of institution relevant to soft innovation resources utilization between Finland and Singapore *(2017)*

Soft innovation resources	Finland	Singapore	References
Trusting relationship			
Willingness to delegate authority	4	17	The Global Competitiveness Report 2017-2018 (WEF, 2018)
Trust in teachers *(2013 out of 21 countries)*	2	7	Global Teachers Status Index (Varkey Gems Foundation, 2014)
Labor-employer relations			
Cooperation in labor-employer relations	22	2	The Global Competitiveness Report 2017-2018 (WEF, 2018)
Flexibility of wage determination	137	5	The Global Competitiveness Report 2017-2018 (WEF, 2018)
Women in working life			
Women in labor force	10	73	The Global Competitiveness Report 2017-2018 (WEF, 2018)
Gender balance index *(2016)*	2	55	The Global Gender Gap Report 2016 (WEF, 2016)

Figures indicate world rank out of 140 countries otherwise indicated.

Recent noteworthy improvements in Finland on the effective utilization of soft innovation resources can be highlighted particularly to trust and untapped resources utilization.

Finland had the most rigid wage negotiation system in the world as revealed in Table 6which impeded its growth and competitiveness for long years. High costs and rigid labor markets have been seen a major obstacle for spurring growth in the country which has been pressured by a decline in Nokia's initiative, recession in neighboring Russia and a fast-aging population.

In light of such long lasting stagnation and understanding of the significant role of trust, after years of negotiations and strikes, Finland government convinced the country's unions in June 2016 to accept the reform pact. This pact leads to increase annual working hours, lower holiday bonuses, freeze wages for a year and increase pension contributions for workers while lowering them for employers. The government has promised to sweeten the deal with tax cuts. This historic ambitious decision to shift away from centralized wage-setting toward company-level labor deals can largely be appreciated as a consequence of effective utilization of soft innovation resource, trust.

Another noteworthy accomplishment can be highlighted gender balance improvement. Finland succeeded in constructing co-evolution between ICT advancement and promotion and activation of female potential in business [18] thereby appreciated as world top level in its Gender Balance Index (WEF). This also can be attributed to utilization of soft innovation resources leading to harnessing untapped resources.

On the basis of the foregoing observation and analysis, dynamism for hybrid management in creating uncaptured GDP and removing structural impediments in captured GDP growth can be summarized as illustrated in **Fig. 13**.

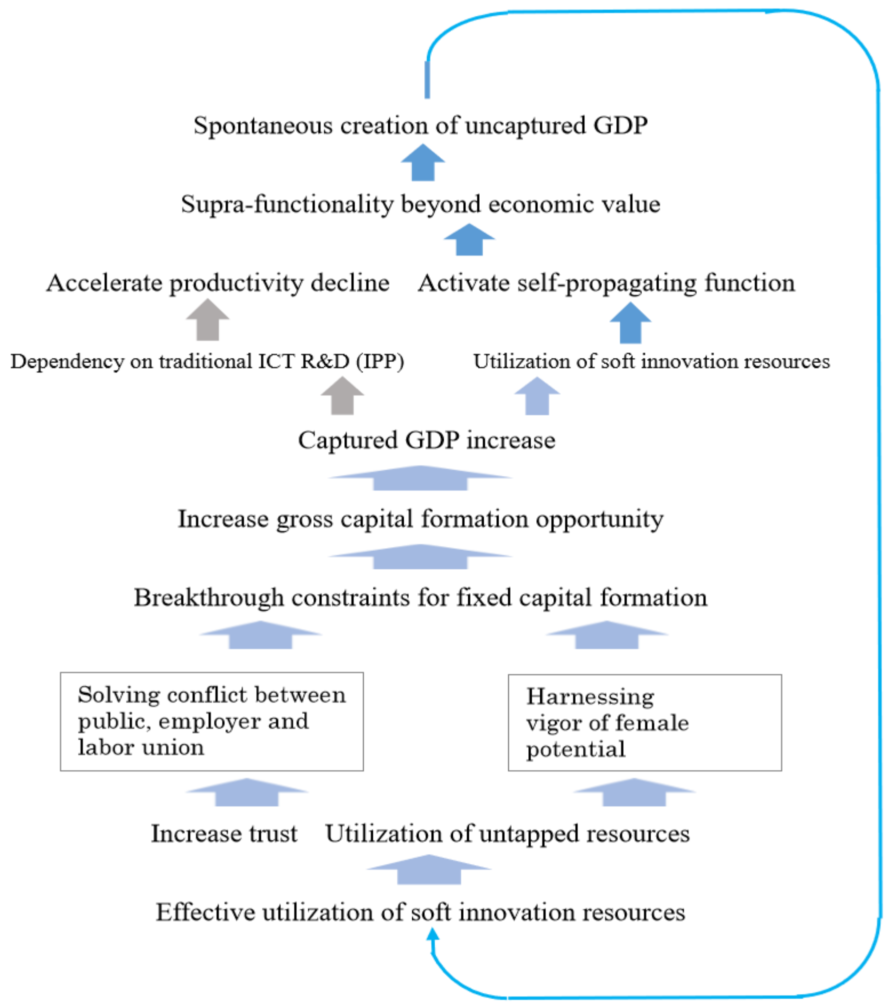

Figure 13. Dynamism for hybrid management in creating uncaptured GDP and removing structural impediments in GDP growth.

5. Conclusion

In light ofa noteworthy endeavor initiated by global ICT leaders against an apparent productivity decline as a consequence of the advancement of the digital economy, dynamism enabling to overcome such a decline was analyzed.

Following preceding analysis and utilizing the findings obtained from the development trajectories of 500 global ICT firms as well as world ICT leaders Finland and Singapore, unknown dynamism of spontaneous creation of uncaptured GDP and suggestion to overcome productivity decline in the digital economy were investigated.

Noteworthy findings include:

1. Digital economy transforms the traditional concepts of economic growth and competitiveness.
2. Confronting a productivity decline in the digital economy, globalICT leaders are transforming business models into those with uncaptured GDP creation.
3. This can be attributed to the harnessing soft innovation resources against a productivity decline.
4. This in turn activates a self-propagating function and induces supra-functionality beyond economic value corresponding to a shift in people's preferences.
5. It also contributes to removing structural impediments in GDP growth.
6. The recent reversal in GDP growth of ICT leaders Finland and Singapore can be attributed to this contribution.
7. Thus, uncaptured GDP dependence by harnessing soft innovation resources contributesto overcoming economic stagnation by its hybrid functions.

These findings give rise to the following insightful suggestions for optimal trajectory managementin the digital economy both national and firm levels:

1. Transformation of the growth concept as consequences of the digital economy should be realized.
2. Given that leading global ICT firms have been endeavoring to transform their business models by harnessing the vigor of soft innovation resources, forefront of effective utilization of these resources should be further investigated.
3. Possible soft innovation resources existing in various disciplines should be explored and mechanism in activating self-propagating function should be elucidated.
4. Based on the above endeavors, attempts to apply such resources in further removing structural impediments in GDP growth should be endeavored.
5. In addition, further efforts in applying dynamism of harnessing the vigor of soft innovation resources to overcome the limitation of the GDP statistics in measuring the advancement of the digital economy should be continued.

This analysis provides new insights for overcoming a productivity decline in the digital economy. Future works should focus on further international and time series reviews on the broader applicability of the hypothetical views postulated by this paper.

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REFERENCES

[1] Department of Broadband, Communications and the Digital Economy (DBCDE), (2009)Digital Economy Future Directions, DBCDE, Camberra.

[2] OECD, (2016)OECD Observer: The Digital Economy, OECD, Paris.

[3] US Council on Competitiveness., (2016)No Recovery: An Analysis on Long-term U.S. Productivity Decline, Washington, D.C.

[4] The World Bank, (2016) Digital Dividends, The World Bank, Washington D.C.

[5] Watanabe, C., Moriya, K., Tou, Y. & Neittaanmäki, P., (2018) "Structural Sources of a Productivity Decline in the Digital Economy," International Journal of Managing Information Technology, Vol. 10, No. 1, pp 1-20.

[6] Watanabe, C., Naveed, K. & Zhao, W., (2015) "New Paradigm of ICT Productivity: Increasing Role of Un-captured GDP and Growing Anger of Consumers," Technology in Society, Vol.41, pp 21–44.

[7] Watanabe, C., Naveed, K. & Neittaanmäki, P., (2015) "Dependency on Un-captured GDP as a Source of Resilience beyond Economic Value in Countries with Advanced ICT Infrastructure: Similarities and Disparities between Finland and Singapore," Technology in Society, Vol. 42, pp 104–122.

[8] Watanabe, C., Naveed, K., Neittaanmäki, P. & Tou, Y., (2016) "Operationalization of Un-captured GDP: The Innovation Stream under New Global Mega-trends," Technology in Society, Vol.45, pp 58–77.

[9] Naveed, K., Watanabe, C. & Neittaanmäki, P., (2018) "The Transformative Direction of Innovation toward an IoT-based Society: Increasing Dependency on Uncaptured GDP in Global ICT Firms," Technology in Society, Vol.53 (in print).

[10] McDonagh, D., (2008)Satisfying Needs beyond the Functional: The Changing Needs of the Silver Market Consumer. Presented at the International Symposium on the Silver Market Phenomenon – Business Opportunities and Responsibilities in the Aging Society, Tokyo, Japan.

[11] Feldstein, M., (2017) Understanding the Real Growth of GDP, Personal Income, and Productivity. Journal of Economic Perspectives, Vol. 31, No. 2, pp 145-164.

[12] Syverson, C., (2017)"Challenges to Mismeasurement Explanations for the US Productivity Slowdown," Journal of Economic Perspectives, Vol. 31, No. 2, pp 165-186.

[13] Groshen, E.L., Moyer, B.C., Aizcorbe, A.M., Bradley, R., Friedman, D.M., (2017)"How Government Statistics Adjust for Potential Biases from Quality Change and New Goods in an Age of Digital Technologies: A View from the Trenches," Journal of Economic Perspectives, Vol. 31, No. 2, pp 187-210.

[14] Byrne, D., Corrado, C., (2016)ICT Prices and ICT Services: What do They Tell about Productivity and Technology? Economic Program Working Paper Series, EPWP #16-05, The Conference Board, New York.

[15] Dervis, K. and Qureshi, Z., (2016)The Productivity Slump - Fact or Fiction: The Measurement Debate, Global Economy and Development at Brookings, Washington, D.C.

[16] Watanabe, C., Naveed, K., Neittaanmäki, P. & Tou, Y., (2016) "Co-evolution of Three Mega Trends Nature Uncaptured GDP: Uber's Ride-sharing Revolution," Technology in Society, Vol.46, pp 164–185.

[17] Watanabe, C., Naveed, K. & Neittaanmäki, P., (2016) ”Co-evolution between Trust in Teachers and Higher Education toward Digitally-rich Learning Environments,” Technology in Society, Vol.48, pp 70–96.

[18] Watanabe, C., Naveed, K. & Neittaanmäki,P., (2017) ”ICT-driven Disruptive Innovation Nurtures Uncaptured GDP: Harnessing Woemen’s Potential as Untapped Resources,” Technology in Society, Vol.51, pp 81–101.

[19] International Monetary Fund (IMF), (2017)Measuring the Digital Economy: IMF Statistical Forum, IMF, Washington D.C.

[20] Ylhainen, I., (2017) Challenges of Measuring the Digital Economy. https://www.sitra.fi/en/articles/challenges-measuring-digital-economy/

[21] Watanabe, C., Kondo, R., Ouchi, N., Wei, H. and Griffy-Brown, C., (2004)“Institutional Elasticity as a Significant Driver of IT Functionality Development,”Technological Forecasting and Social Change, Vol. 71, No. 7, pp 723-750.

[22] Watanabe, C., Lei, S. and Ouchi, N., (2009)“Fusing Indigenous Technology Development and Market Learning for Greater Functionality Development: An Empirical Analysis of the Growth Trajectory of Canon Printers,”Technovation, Vol. 29, No. 2, pp 265-283.

[23] Naveed, K., Watanabe, C. & Neittaanmäki, P., (2017) ”Co-evolution between Streaming and Live Music Leads a Way to the Sustainable Growth of Music Industry: Lessons from the US Experiences,” Technology in Society, Vol.50, pp 1-19.

[24] Japan Cabinet Office (JCO), (2012) National Survey of Lifestyle Preferences, JCO, Tokyo.

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