Technology in Society 51 (2017) 81–101

Contents lists available at ScienceDirect

Technology in Society

journal homepage: www.elsevier.com/locate/techsoc

ICT-driven disruptive innovation nurtures un-captured GDP – Harnessing women's potential as untapped resources

Chihiro Watanabe [a, b, *], Kashif Naveed [a], Pekka Neittaanmäki [a]

[a] Faculty of Information Technology, University of Jyväskylä, Finland
[b] International Institute for Applied Systems Analysis (IIASA), Austria

ARTICLE INFO

Article history:
Received 10 May 2017
Received in revised form
25 July 2017
Accepted 31 July 2017
Available online 5 August 2017

Keywords:
Gender balance
Women board members
Untapped resources
Trilateral co-evolution
Cultural dimensions

ABSTRACT

The harnessing of untapped resources has become essential for inclusive growth in digital economies particularly as developed economies continue to age demographically. The harnessing of women's potential is an urgent subject in this context, and successive initiatives have been flourishing in many countries.

However, given the institutional complexity of the issue, as well as considerable variety across nations, uniformed non-systematic approaches are hardly satisfactory in achieving a timely solution.

Against this back drop, this paper analyzed a new information communication technology (ICT)-driven disruptive innovation that may nurture un-captured GDP by harnessing untapped resources such as women's economic potential.

Using a unique dataset representing the state of gender balance improvement, an empirical numerical analysis of 44 countries was attempted. These countries were classified as emerging, industrialized, and with a specific culture based particularly on the traditions of a male-dominated society.

It was found that while industrialized countries, typically Finland, have achieved high performance in co-evolution between "econo-cultural development," ICT advancement, and gender balance improvement, emerging countries have been constrained by low ICT advancement. In addition, notwithstanding their high economic level, countries with a specific culture have been constrained by a traditional male-dominated culture, Japan being a typical case.

Based on these findings, lessons from industrialized countries for both emerging countries and countries with a specific culture were analyzed.

It was suggested that ICT should be strategically advanced depending on the state of what we are calling "econo-cultural development" for constructing co-evolution of gender balance improvement along with techno-economic development.

A new practical approach for harnessing untapped resources for sustainable growth was thus explored.

1. Introduction

The harnessing of untapped resources has become essential for inclusive growth[1] in digital economies that are rapidly aging. The harnessing of women's economic potential is urgent in this context.

Bridging the gender divide is not only a matter of fairness but also one of effective governance and inclusive growth [24]. It has been demonstrated that companies with more women board directors experienced higher financial performance [1]. Companies where women are most strongly represented at board or top-management level also perform best [16]. Women's presence in the labor market is increasingly significant for economic growth and development at both the national and enterprise levels. The growing participation of women in the labor market has been a major engine of global growth and competitiveness [10]. Thus, harnessing the vigor of women's potential is essential for inclusive economic growth in digital economies that are moving toward

* Corresponding author. Faculty of Information Technology, University of Jyväskylä, Finland.
E-mail address: watanabe.c.pqr@gmail.com (C. Watanabe).

[1] Inclusive growth is economic growth that creates opportunity for all segments of the population and distributes the dividends of increased prosperity, both in monetary and non-monetary terms, fairly across society [24].

http://dx.doi.org/10.1016/j.techsoc.2017.07.007
0160-791X/

aging societies. This can be seen as a soft engine for sustainable growth, substitutable for costly hard investment, which is particularly important for emerging economies [14]. For industrialized economies, this would help overcome the low growth and low birth rates of this era [15]. A growing body of evidence shows that utilizing the skills and talents of both men and women is beneficial for enterprises and society in general [10].

However, despite growing awareness of the benefits of gender equality in decision-making, the pace of progress in achieving this has been slow and varies considerably across countries [7,24,32]. The World Economic Forum [42] urged a fresh call to action to accelerate progress towards gender equality for harnessing female talent, half of the world's talent, towards the Fourth Industrial Revolution.

To date, a number of studies have identified the sources that impede gender balance improvement. The OECD [23] pointed to a range of external and internal barriers that present in all areas of the public domain, including: cultural barriers, structural barriers, lack of gender-disaggregated evidence and accountability mechanisms, and self-imposed barriers. The UNDP [29] revealed that while there is explicit evidence regarding a virtual cycle between economic growth and gender balance improvement, emerging countries cannot afford to overcome the constraints of low income. UNESCO [31] noted the limits of scientific resources in relation to women's initiatives. McKinsey & Company [17] stressed a clear link between gender equality in society and gender equality in the workplace as well as the proportion of women on executive committees and corporate performance.

Aligned with these increasing efforts regarding the points identified, and subsequent efforts aimed at providing effective solutions to eliminate impediments, a wealth of resources, good practices, organizational structures, and networks are already in place [10]. New initiatives have flourished in many areas [6].

However, given the institutional complexity of the issue, including considerable variety across nations, uniformed non-systematic approaches are hardly satisfactory in the achievement of a timely solution.

Moreover, a few papers have noted the significance of cultural dimensions in activating untapped female resources [2,4,27,40]. Hofstede [9] postulated that a nation's culture can be classified into five dimensions: “Power distance” (inequality), “Individualism” (the degree to which individuals are integrated into groups), “Masculinity” (the distribution of roles between the genders), “Uncertainty avoidance” (the extent to which a culture programs its members to feel either uncomfortable or comfortable in unstructured situations), and “Long-term orientation.” Wiles et al. [40] compared gender roles in magazine advertising in the Netherlands, Sweden and the US and identified that the “masculinity” of nations significantly influenced women's involvement in business. A similar observation was made by Daechun et al. [4] in their cross-cultural comparison of web advertisements between Korea and the US. Stedham et al. [27] also pointed out that in addition to “individualism” and “power distance,” “masculinity” clearly differentiated gender roles between Japan and the US. Carrasco et al. [2] supported a similar view in their analysis of the representation of women on boards in five European countries. All these analyses clearly identified the significance of cultural dimensions, particularly of “masculinity” and “individualism” in gender balance improvement (see Appendix 2 details of these concepts and survey results).

Furthermore, in line with the advancement of digital economies, the role of information and communication technology (ICT) in gender balance improvement has been broadly discussed. The United Nations [30] warned that while there was recognition of the potential of ICT as a tool for the promotion of gender equality and the empowerment of women, a “gender divide” had also been identified, reflected in the lower numbers of women accessing and using ICT compared with men. It also pointed out that unless this gender divide was specifically addressed, there was a risk that ICT might exacerbate existing inequalities between women and men, creating new forms of inequality. Webb et al. [39] alluded to similar dual possibilities. Moghaddam [19] maintained that identical roles for men and women were determined by cultural, social, and economic factors including ICT as a social product, and differed within and between cultures and countries. He stressed that ICT as a social product was not gender neutral, that ICT access and use were interwoven with socio-cultural issues, and that the gender gap was a product of all nations, albeit of a wider magnitude in developing countries. In light of these issues, Phumzile [25] highlighted the significance of ICT as a powerful means of advancing women's rights, empowerment, and gender equality, stressing that ICT use by women boosts countries' productivity and better meets women's socio-economic needs.

This paper was aimed at providing practical solutions in accordance with the institutional states of nations in the digital economy. It analyzed a possible trilateral co-evolution between economic growth, gender balance improvement, and digital innovation initiated by ICT advancement while taking into account the cultural dimensions of nations that block gender balance improvement.

Using a unique dataset representing the state of gender balance improvement in the function of economic growth, ICT advancement, and cultural dimensions, an empirical numerical analysis of 44 countries was undertaken. Through cluster analysis using the state of gender balance, income level, and the male-dominated cultural dimension, 44 countries were identified within one of the three clusters: emerging, industrialized, and with a specific culture.

It was found that while industrialized countries, such as Finland, have accomplished high performance in this trilateral co-evolution,

Table 1
Global rank of gender parity (2012–2016).

	1	2	3	4	G8 countries				Remarks
2016	Iceland	Finland	Norway	Sweden	DEU(13)	FRA(17)	GBR(20)	CAN(35)	Out of 144 countries
					USA(45)	ITA(50)	RUS(75)	JPN(111)	
2015	Iceland	Norway	Finland	Sweden	DEU(11)	FRA(15)	GBR(18)	USA(28)	idem 145
					CAN(30)	ITA(41)	RUS(75)	JPN(101)	
2014	Iceland	Finland	Norway	Sweden	DEU(12)	FRA(16)	CAN(19)	USA(20)	idem 142
					GBR(26)	ITA(69)	RUS(75)	JPN(104)	
2013	Iceland	Finland	Norway	Sweden	DEU(14)	GBR(18)	CAN(20)	USA(23)	idem 136
					FRA(45)	RUS(61)	ITA(71)	JPN(105)	
2012	Iceland	Finland	Norway	Sweden	DEU(13)	GBR(18)	CAN(21)	USA(22)	idem 135
					FRA(57)	RUS(59)	ITA(80)	JPN(101)	

* DEU: Germany, FRA: France, GBR: UK, CAN: Canada, ITA: Italy, RUS: Russia, JPN: Japan.
**Figures in parenthesis indicate rank.
Sources: The Global Gender Gap Report 2012–2016 (World Economic Forum, annual issues).

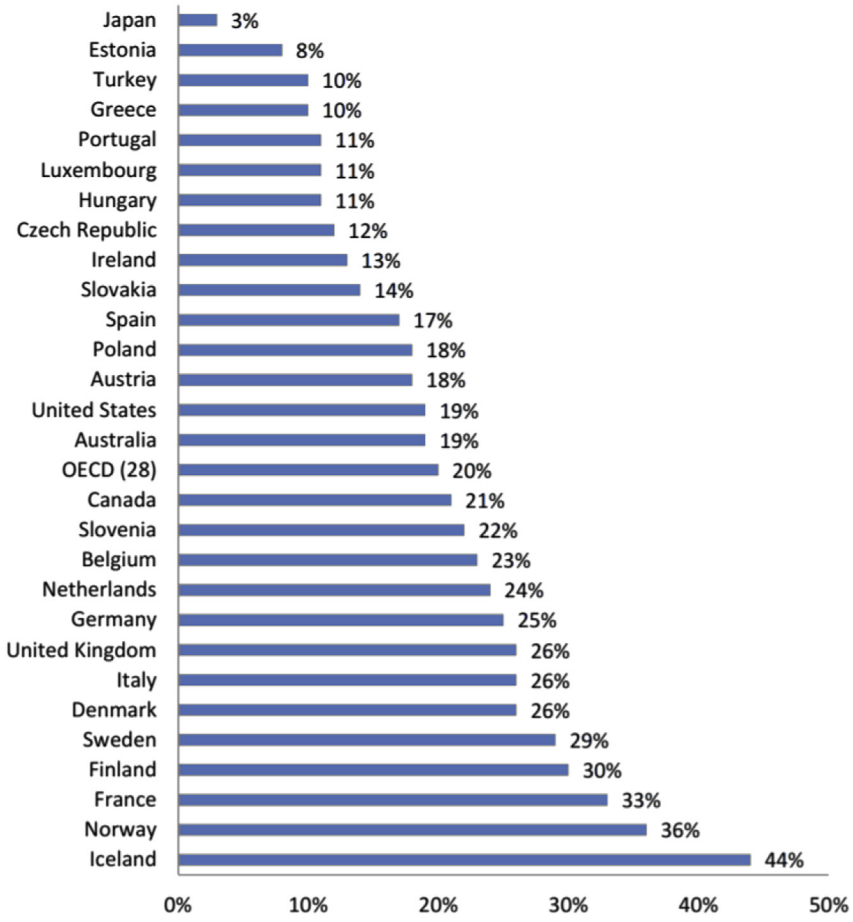

Fig. 1. Share of Women Board Members at Companies in the OECD 29 Countries (2015).
Source: Background Report, Conference on Improving Women's Access to Leadership [24].
Original sources: Database on Women and Men in Decision Making [5], Catalyst Census: Women Board Directors [3].

emerging countries have been constrained by low ICT advancement. Moreover, notwithstanding their high level of economy and ICT dependency, countries with a specific culture have been constrained by a traditional male-dominated culture, Japan being a typical case.

Based on these findings, there were several lessons that emerging economies and countries with a specific culture could learn from industrialized countries regarding success and failure in gender balance improvement.

It is suggested that ICT should be strategically advanced, depending on the state of what we refer to as "econo-cultural development" in constructing co-evolution with gender balance improvement.

A new practical approach for harnessing the potential resources for sustainable growth was thus explored.

This paper is organized as follows: Section 2 analyzes pathways to gender-balanced organizational leadership. Section 3 demonstrates gender-balanced leadership in the digital economy. Sections 4 and 5 address lessons from high-performance co-evolution in industrialized countries. Section 6 briefly summarizes noteworthy findings, implications, and suggestions for future studies.

2. Pathways to gender-balanced organizational leadership

2.1. The state of gender parity

Table 1 compares the global rank of gender parity over the period 2012–2016. It illustrates that while Iceland, Finland, Norway, and Sweden share the top four positions, Japan lags significantly behind. It is not only in the last position among G8 countries, but also lower than the 100th rank in all periods examined.

The contrast with respect to the state of gender parity corresponds to the share of female board members in companies that represents gender balanced corporate leadership [7,8,17,20,24]. Fig. 1 compares this share in the 29 OECD countries in 2015. It illustrates that Iceland, Finland, Norway, and Sweden which occupy the top global positions in the state of gender parity, also share the top five positions in terms of the share of female company board members, while Japan also ranks last in this domain. This

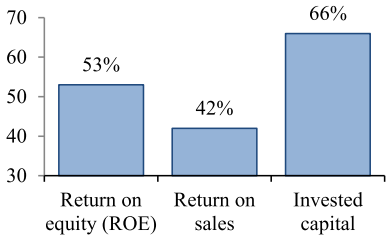

Fig. 2. Outperformance ratio of women board directors leadership in fortune 500 companies - comparison between highest and least share of WBDs (average in 2001–2004).
WBDs: Women board Directors.
Source: Catalyst, "corporate performance and Women's representation on boards [1].

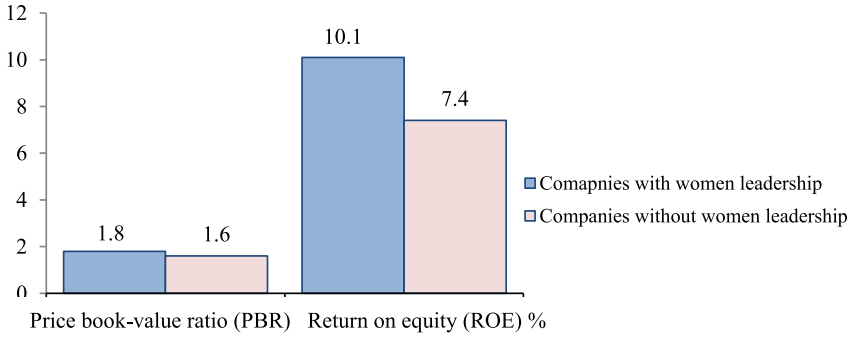

Fig. 3. Financial characteristics of companies with strong women leadership in MSCI world companies [20].
Source: MSCI ESG Research [20].

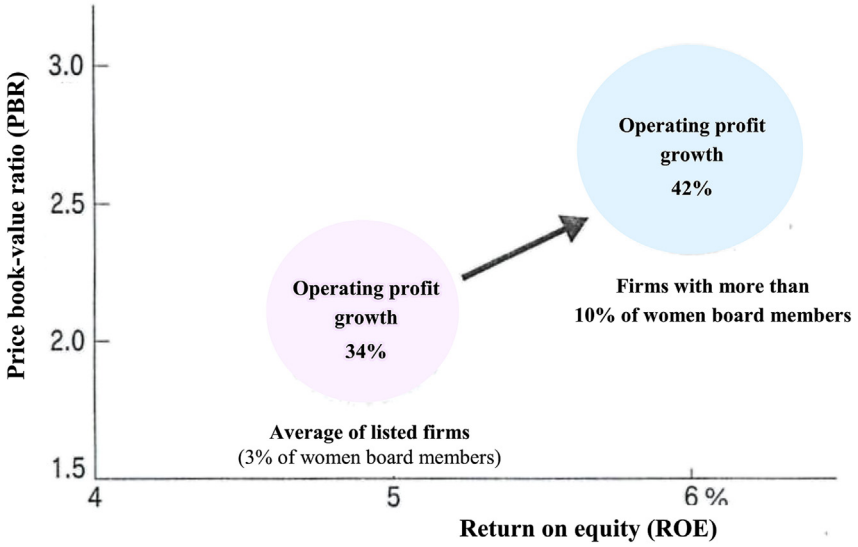

Fig. 4. Correlation between Share of Women Board Members and Business Performance in Japan's Firms (2015).
Circle size demonstrates the magnitude of operating profit growth.
Source: Nihon Keizai Shimbun [22].
All figures demonstrate significant corporate performance improvement by means of gender balance improvement, represented by the share increase in women board members.

correspondence suggests that the share of female company board members represents the state of gender balance. As reviewed earlier [16,17], demonstrated a clear link between the share of women board members, corporate performance, gender equality in the workplace, and gender equality in society. Gender equality in the workplace leads to higher economic performance, which in turn enhances gender equality in society.

2.2. Corporate performance improvement and gender-balanced leadership

Companies with a higher share of female board members experience higher financial performance.

Fig. 2 highlights this outperformance as 53%, 42%, and 66% higher in return on equity (ROE), return on sales, and invested capital, respectively, in Fortune 500 companies with the highest share of women board members compared with those of the lowest share.

A similar contrast can be observed in Fig. 3, which presents a similar comparison of premium returns and superior average valuation using price book-value ratios (PBR) and ROE in MSCI world companies. Companies with strong female leadership demonstrated higher performance than companies without, as 1.8% vs 1.6% and 10.1% vs 7.4%., respectively.

Fig. 4 presents further supportive evidence by comparing PBR, ROE, and operating profit growth between Japan's listed firms with a 3% proportion of women board members (average of listed firms) and those with more than a 10% proportion of women board members.

2.3. Intensity of gender balanced corporate leadership

2.3.1. Gender balance index

On the basis of the preceding review that an increase in the number of women board members contributes to the economic performance of a society, this sub-section assesses the effects of economic performance through gender balance improvement, the Gender Balance Index (GBI), which represents the state of gender balance and its affect on economic performance. Table 2 tabulates the GBI for 44 countries in 2013, with comparisons of similar values

Table 2
Gender balance index (GBI) in 44 countries (2013).

Country	Code	GMI (2013)	OECD (2015)*	WEF (2016)**
Norway	NOR	36.1	38	56
Sweden	SWE	27.0	27	41
Finland	FIN	26.8	28	43
France	FRA	18,3	33	49
South Africa	ZAF	17.9		
Denmark	DNK	17.2	24	35
Netherlands	NLD	17.0	25	32
Israel	ISR	15.7		
New Zealand	NZL	15.1		
Germany	DEU	14.1	24	33
Australia	AUS	14.0	19	24
USA	USA	14.0	19	24
Poland	POL	13.6	15	22
Canada	CAN	13.1	21	27
Turkey	TUR	12.7	9	11
UK	GBR	12.6	24	35
Austria	AUT	11.3	17	22
Switzerland	CHE	10.0	17	
Thailand	THA	9.7		
Hong Kong	HKG	9.5		
Spain	ESP	9.5	17	21
Belgium	BEL	9.2	23	30
Ireland	IRL	8.7	11	15
Czech Republic	CZE	8.6	7	14
China	CHN	8.4		
Italy	ITA	8.2	24	35
Philippines	PHL	7.9		
Greece	GRC	7.0	9	11
Singapore	SGP	6.9		
Malaysia	MYS	6.6		
India	IND	6.5		11
Peru	PER	6.3		
Columbia	COL	6.0		
Indonesia	IDN	6.0		
Mexico	MEX	5.8		
Brazil	BRA	5.1		
Russia	RUS	4.8		
Hungary	HUN	4.5	12	12
Taiwan	TWN	4.4		
Egypt	EGY	4.4		
Portugal	PRT	3.7	9	12
Chile	CHL	2.8		
Korea (Rep.)	KOR	1.9		
Japan	JPN	1.1	3	3

*Share of female board members at companies (%), **Value based on share of female in boards of publicly traded companies. Original sources are GBI: GMI Ratings' 2013 Women on Boards Survey [8], OECD: Background Report, Con-ference on Improving Women's Access to Leadership [24], and WEF: The Global Gender Gap Report 2016 [42].

surveyed by the OECD and WEF. The GBI depended on GMI Ratings' *2013 Women on Board Survey* [8] which includes data for 2013 on 5977 companies in 45 countries worldwide.[2]

In order to examine the reliability of the GBI, comparative analyses with similar data surveyed by the OECD and WEF were conducted. Fig. 5 compares these values with correlation analysis between the OECD data and the GBI as well as the WEF and the GBI. While there are number of differences in some countries' values (e.g., FRA, TUR, GBR, and ITA), as the three values did not depend on the same year or the same scope of companies, the GBI can be considered to represent the global gender balance position, with a reasonable correlation with those surveyed by the OECD and WEF.

Based on the foregoing examination, Fig. 6 demonstrates the 2013 GBI ranking for 44 countries.

[2] GBI covers 44 countries out of GMI Ratings' 45 countries by excluding Morocco due to unavailability of other relevant statistics.

2.3.2. Gender balance intensity

With an understanding that gender balance is sensitive to the income level of nations (e.g., Refs. [10,32,24]), and in order to compare a marginal GBI increase with an income level increase, Fig. 7 demonstrates gender balance intensity[3] by dividing the GBI by GDP per capita for the 44 countries (see Appendix 1 for details of the institutional states of the 44 countries).

Looking at Fig. 7 we note that while emerging countries with lower income levels, such as India, the Philippines, Indonesia, Thailand, and Egypt, demonstrate higher GBI intensity (higher marginal GBI increase by income increase), industrialized countries with higher income levels, such as European and North American countries, demonstrate relatively lower GBI intensity, suggesting that the GBI is not highly sensitive to income increases as in emerging countries. Interestingly enough is that highly industrialized countries such as Singapore, Switzerland, Korea, and Japan recorded the lowest ranks in GBI intensity, suggesting that their GBI is governed by particular cultural dimensions rather than income level.

2.4. Cultural barriers against gender balance

2.4.1. Cultural dimension of countries

As suggested in Fig. 7, GBI intensity is subject not only to income level but also to the cultural dimensions of countries. Among the cultural dimensions postulated by Hofstede [9], since "masculinity" (distribution of roles between the genders) and "individualism" (degree to which individuals are integrated into groups) are particularly significant for gender balance improvement, as reviewed earlier, it is considered that GBI intensity can be largely attributed to "masculinity" and "individualism" together with income level. Based on this understanding, intensified masculinity density (*IMD*), which represents a male-dominated society, is considered to impact substantially on GBI intensity. *IMD* can be estimated by the ratio of "masculinity" and "individualism intensity" as follows where individualism intensity is the ratio of "individualism" and income level.

$$\text{IMD} = \frac{M}{I/GDP\ per\ capita} = \frac{M}{I} \cdot GDP\ pr\ capita$$

where *M*: Masculinity; *I*: Individualism; *M/I*: Intensity of male-dominated society.

Fig. 8 presents intensified masculinity density in 44 countries in 2013.

Fig. 8 demonstrates that besides the four countries recording the lowest GBI intensity (Singapore, Switzerland, Korea, and Japan), Hong Kong, Taiwan, and Austria recorded the highest *IMD* levels. Based on this observation, aiming at identifying cluster governing the GBI, Table 3 compares the correlation between *IMD* and GBI intensity, with variations of clustering between the four lowest GBI intensity countries (SGP, CHE, KOR and JPN) and seven countries (4 + HKG, TWN, and AUT).[4] Table 3 demonstrates that the cluster of four countries demonstrates statistically most significant.

Based on the foregoing comparative assessment, Figs. 9 and 10 compare the correlation between *IMD* and GBI intensity in 44 countries in 2013, with and without clusters. This comparison

[3] This intensity demonstrates marginal GBI increase by GDP per capita increase as follows: $\ln Y = a + \alpha \ln X + \beta \ln W$ (see Fig 16) $\alpha = \frac{\partial \ln Y}{\partial \ln X} = \frac{\partial Y}{\partial X} \cdot \frac{X}{Y}$ *GBI intensity* $= \frac{Y}{X} = \frac{1}{\alpha} \cdot \frac{\partial Y}{\partial X}$ *where* X : *GDP per capita*, W : *Intensity of male dominated society*, Y : *GBI*.

[4] Since Fig. 7 demonstrates explicit clustering between MEX and FIN, countries with an intermediate GBI intensity level were clustered between FIN to JPN, excluding countries with the lowest GBI intensity level (4–7 countries).

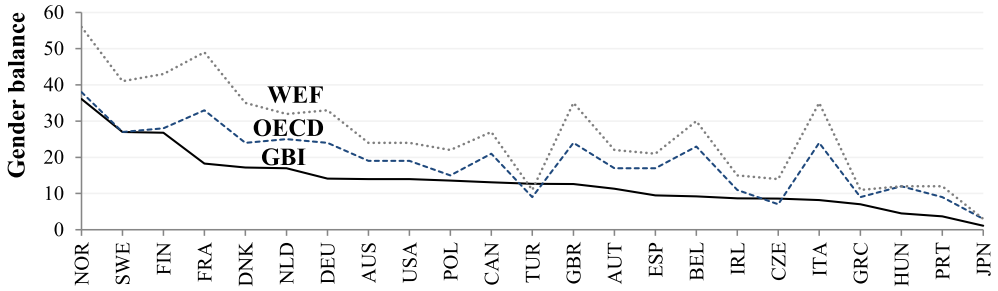

Fig. 5. Comparison of Gender Balance Measurement in 23 Countries.

$lnY = \underset{(-2.09)}{-0.789} + \underset{(8.56)}{1.12}\ lnOECD + \underset{(2.37)}{0.873}\ D \qquad adj.R^2\ 0.757$

Y: GBI; D: Dummy variable (TUR = 1, others = 0).

$lnY = \underset{(-2.89)}{-0.920} + \underset{(10.61)}{1.053}\ \ln WEF + \underset{(3.00)}{0.936}\ D \qquad adj.R^2\ 0.834$

D: Dummy variable (TUR = 1, others = 0).

The figures in parenthesis indicate t-statistics: all are significant at the 1% level.

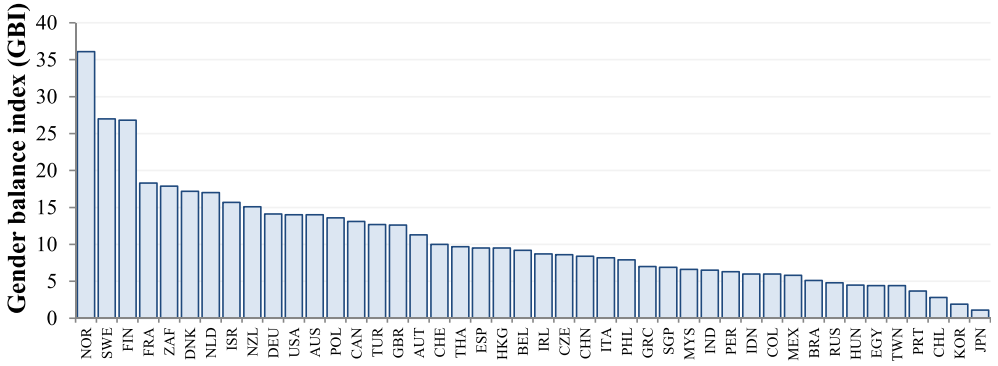

Fig. 6. Gender balance index (GBI) in 44 countries (2013).

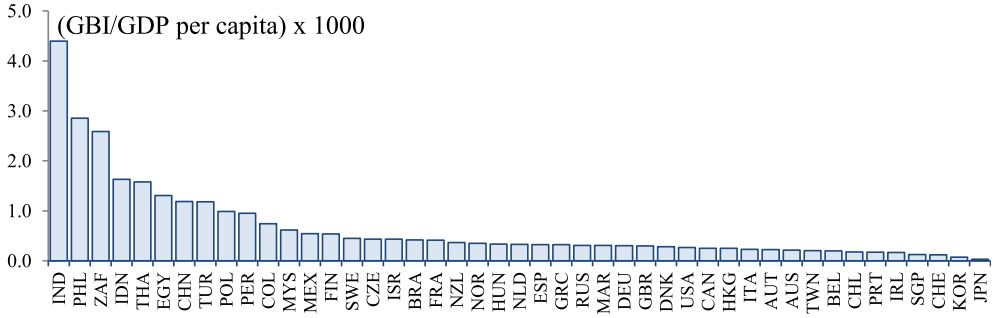

Fig. 7. Gender balance intensity in 44 countries (2013).

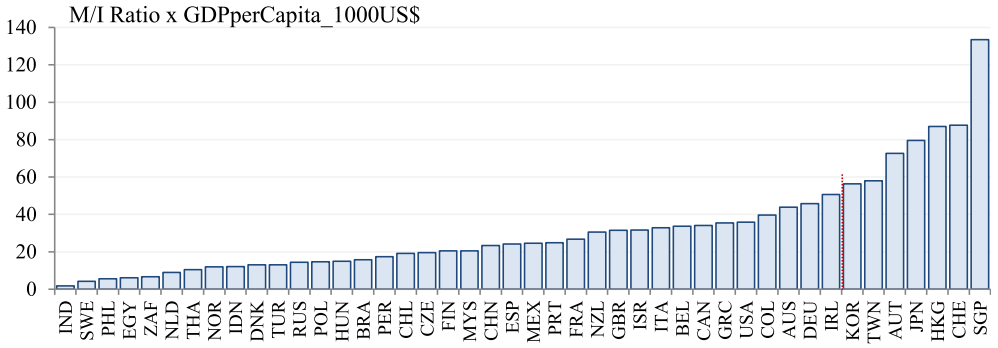

Fig. 8. Intensified masculinity density (*IMD*) in 44 countries (2013).

Table 3
Comparison of correlation between IMD and GBI intensity with variation of clustering of 44 countries (2013).

$$\ln\frac{GBI}{GDP\ per\ capita} = \underset{(3.13)}{0.926} - \underset{(-2.04)*}{0.252}D_1 \ln IMD - \underset{(-6.71)}{0.639}D_{21} \ln IMD - \underset{(-8.59)}{0.657}D_{31} \ln IMD - \underset{(-3.88)}{1.184}D \qquad adj.R^2\ 0.823 \quad AIC: -73.45$$

$$\ln\frac{GBI}{GDP\ per\ capita} = \underset{(3.13)}{0.912} - \underset{(-2.02)*}{0.246}D_1 \ln IMD - \underset{(-6.84)}{0.634}D_{22} \ln IMD - \underset{(-8.66)}{0.659}D_{32} \ln IMD - \underset{(-3.83)}{1.173}D \qquad adj.R^2\ 0.823 \quad AIC: -73.58$$

$$\ln\frac{GBI}{GDP\ per\ capita} = \underset{(3.04)}{0.857} - \underset{(-1.90)*}{0.226}D_1 \ln IMD - \underset{(-6.94)}{0.613}D_{23} \ln IMD - \underset{(-8.80)}{0.667}D_{33} \ln IMD - \underset{(-3.70)}{1.132}D \qquad adj.R^2\ 0.827 \quad AIC: -74.42$$

$$\ln\frac{GBI}{GDP\ per\ capita} = \underset{(2.94)}{0.778} - \underset{(-1.74)*}{0.195}D_1 \ln IMD - \underset{(-7.15)}{0.584}D_{24} \ln IMD - \underset{(-9.31)}{0.695}D_{34} \ln IMD - \underset{(-3.46)}{1.034}D \qquad adj.R^2\ 0.839 \quad AIC: -77.73$$

D_1 - D_3 and D are dummy variables.

D_1: (IND – MEX in Fig. 7) = 1, others = 0;
D_{21}: (FIN – JPN in Fig. 7) - D_{31} = 1, others = 0; D_{31}: HGK, AUT, TWN, **CHE, KOR, SGP, JPN** = 1, others = 0;
D_{22}: (FIN – JPN in Fig. 7) - D_{32} = 1, others = 0; D_{32}: HGK, AUT, **CHE, KOR, SGP, JPN** = 1, others = 0;
D_{23}: (FIN – JPN in Fig. 7) - D_{33} = 1, others = 0; D_{33}: HGK, **CHE, KOR, SGP, JPN** = 1, others = 0;
D_{24}: (FIN – JPN in Fig. 7) - D_{34} = 1, others = 0; D_{34}: **CHE, KOR, SGP, JPN** = 1, others = 0;
D: JPN and CHL = 1, others = 0.

The figures in parenthesis indicate t-statistics: all are significant at the 1% level except * 10%.

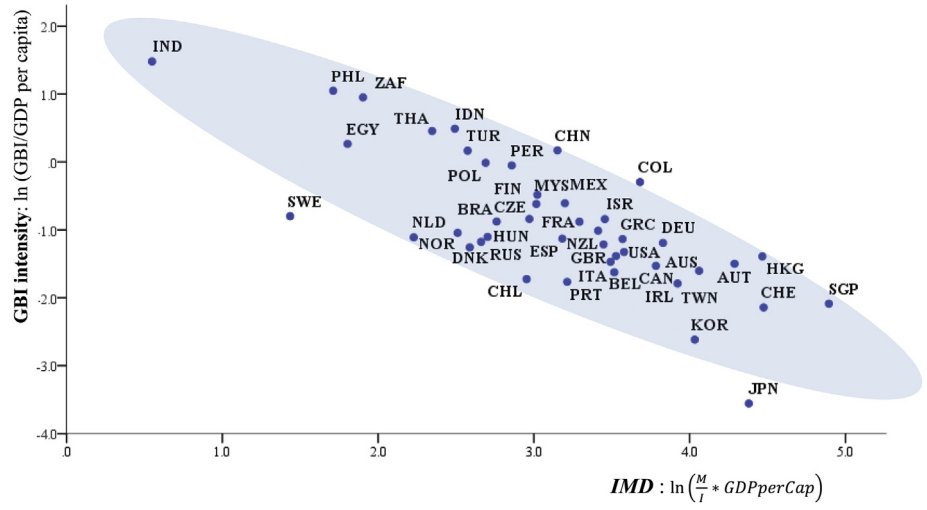

Fig. 9. Correlation between *IMD* and GBI intensity in 44 Countries without Clusters (2013).

$$\ln\left(\frac{GBI}{GDPperCapita}\right) = \underset{(6.56)}{1.903} - \underset{(-10.02)}{0.894} \ln\left(\frac{M}{I}*GDPperCap\right) - \underset{(-4.01)}{1.480}\,D_a + \underset{(2.95)}{1.090}\,D_b \qquad \boldsymbol{adj.R^2}\ 0.729$$

D_a and D_b are dummy variables. D_a: JPN, SWE = 1, others = 0; D_b: CHN, COL = 1, others = 0.
The figures in parenthesis indicate t-statistics: all are significant at the 1% level.

demonstrates the statistical significance of the correlation with the clusters and validates the clustering discussed based on cultural dimensions.

With this understanding, Fig. 11 demonstrates three clusters of gender balance intensity in 44 countries in 2013. The 44 countries can be classified into three groups: emerging countries (EMC), industrialized countries (INC), and countries with a specific culture (CSC).

The EMC column includes 13 countries with a lower GDP per capita level than US$10,000 (except POL: US$13,700). The INC column includes 27 countries with a higher GDP per capita level than US$ 20,000 (except BRA (12,260), HUN (13,560), RUS (15,560), and CHL (15,710)). Finland occupies the top position in this group. The CSC group includes four countries with the lowest level of GBI intensity: SGP, CHE, KOR, and JPN. While they are highly industrialized, they incorporate the traditions of a male-dominated society.

These analyses demonstrate that gender balance improvement is subject not only to income level but also to some cultural dimension of countries, particularly “masculinity” and “individualism.” Therefore, the issue of gender balance improvement should be discussed taking cultural elements into account.

3. Gender-balanced leadership in the digital economy

3.1. Co-evolution between the “econo-cultural” position, gender balance, and ICT advancement

Based on the understanding that harnessing women's potential by improving gender balance is essential for inclusive growth in the digital economy and that this issue is subject not only to income level but also to the cultural dimension - and following the findings obtained in the preceding section - the trilateral co-evolution between “econo-cultural development,” gender balance improvement, and ICT advancement was analyzed by taking the “econo-

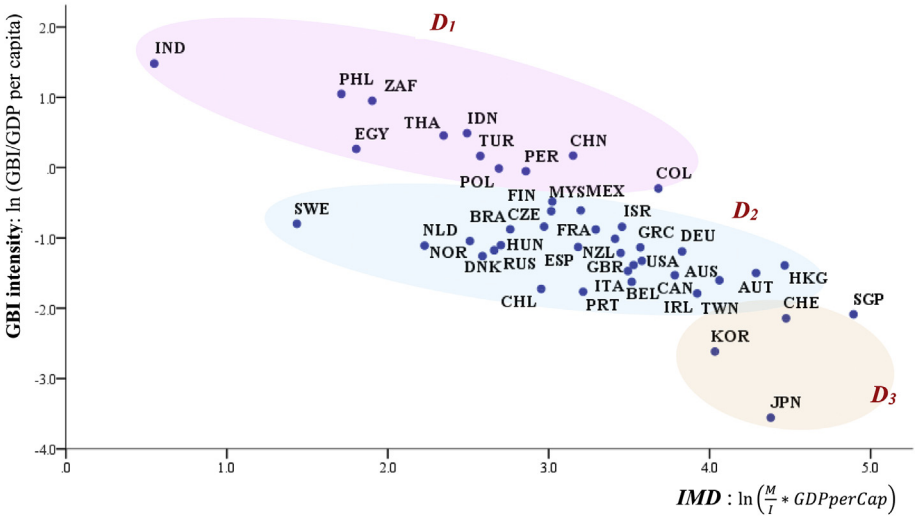

Fig. 10. Correlation between IMD and GBI intensity in 44 Countries with Clusters (2013).

$$\ln\left(\frac{GBI}{GDPperCapita}\right) = \underset{(2.94)}{0.778} - \underset{(-1.74)}{0.195}\ D_1 \ln\frac{M}{I}{*}GDPperCap - \underset{(-7.15)}{0.584}\ D_2 \ln\frac{M}{I}{*}GDPperCapita - \underset{(-9.31)}{0.695}\ D_3 \ln\frac{M}{I}{*}GDPperCapita - \underset{(-3.46)}{1.034}\ D \qquad \textbf{adj.}R^2\ 0.839$$

D_1- D_3 and D are dummy variables. D_1, D_2 and D_3 are correspond to D_1, D_{24} and D_{34} of Fig. 8, respectively.
D: JPN, CHL = 1, others = 0.
The figures in parenthesis indicate t-statistics: all are significant at the 1% level except * 10
%.

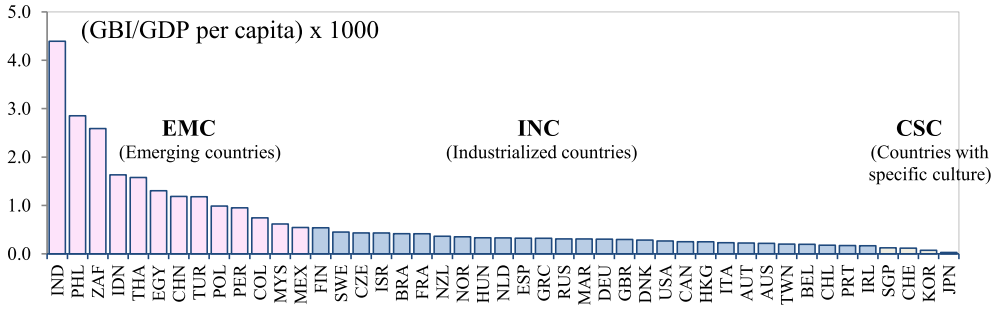

Fig. 11. Gender balance intensity in 44 countries by 3 clusters (2013).

cultural" position of respective countries into account. The GBI (Gender balance index) and the intensity of the male-dominated society (*IMS*: ratio of "masculinity" and "individualism") based on the cluster of EMC, INC, and CSC were used. "Econo-cultural development" was analyzed by means of income increase and improvement of the intensity of a male-dominated society.

Fig. 12 illustrates the dynamism inducing this trilateral co-evolution.

3.1.1. Contribution of gender balance improvement to economic growth

Fig. 13 illustrates the correlation between the GBI and GDP per capita, which is statistically significant. The EMC group demonstrates an extremely low elasticity[5] of gender balance improvement to GDP per capita, followed by the INC and CSC groups. This suggests that the EMC group pursues avenues toward economic growth other than through gender balance improvement. The higher income level of CSCs notwithstanding the lowest level of the GBI can be attributed to their highest elasticity and reveals the structural impediment blocking gender balance improvement.

3.1.2. Contribution of economic growth to ICT advancement

Fig. 14 illustrates the correlation between GDP per capita and ICT advancement, which is statistically significant. EMC, INC, and CSC share a similar level of elasticity, which suggests that all nations' ICT grows uniformly with income growth in the digital economy.

3.1.3. Gender balance improvement induced by ICT and blocked by the male-dominated society

While ICT advancement contributes to gender balance improvement, this improvement is blocked by cultural dimensions. Fig. 15 illustrates this multiple correlation, which is statistically significant.

CSCs demonstrate an extremely high negative elasticity of the intensity of male-dominated society to gender balance improvement. This can be a substantial source of the lowest level of gender balance improvement, notwithstanding a high level of income and

[5] Elasticity is the measurement of the responsiveness of an economic variable (X) to a change in Y. X elasticity to Y (elasticity of X to Y) ε_{YX} implies a 1% increase in X increases ε_{YX} % increase in Y and represents the efficiency of X as an inducement of Y.

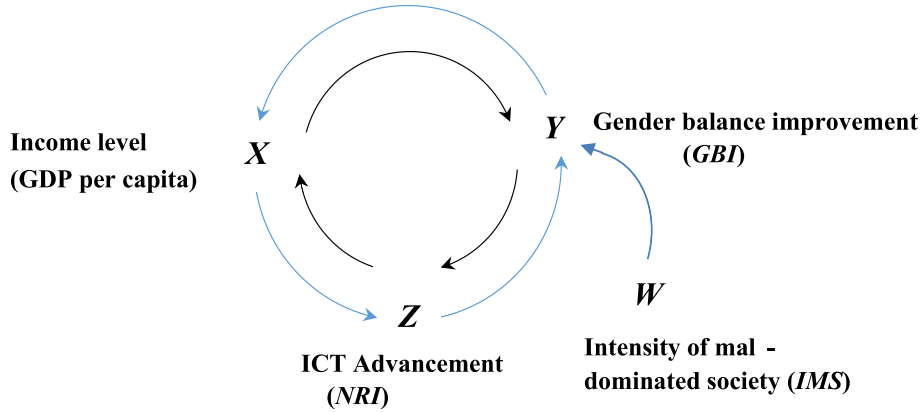

Fig. 12. Co-evolutionary Dynamism between the Econo-cultural Position, Gender Balance Improvement, and ICT Advancement.
GBI: Gender Balance Index, *NRI*: Networked Readiness Index, *IMS*: Intensity of male-dominated society (*M/I*).
Based on this dynamism, the following six co-evolutions were first analyzed:
1. Y →X Contribution of gender balance improvement to economic growth
2. X→Z Contribution of economic growth to ICT advancement
3. Z, W→Y Gender balance improvement induced by ICT and impeded by male-dominated society
4. X, W→Y Gender balance improvement supported by income growth and impeded by male-dominated society
5. Z→X ICT Contribution to income growth
6. Y→Z ICT Advancement stimulated by gender balance improvement.

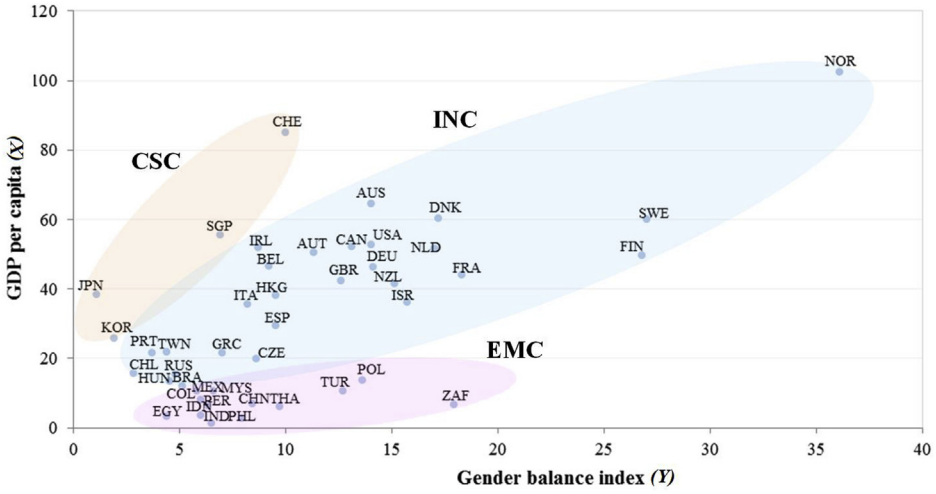

Fig. 13. Correlation between the GBI and GDP per Capita in 44 Countries (2013).
$lnX = \underset{(34.81)}{8.41} + \underset{(1.73)*}{0.21}\, D_1 lnY + \underset{(8.44)}{0.86}\, D_2 lnY + \underset{(7.60)}{1.26}\, D_3 lnY + \underset{(4.48)}{1.49}\, D_a - \underset{(-4.25)}{1.21}\, D_b \quad adj.R^2\ 0.866$
X: GDP per capita (x 10^3 US$); *Y*: Gender balance index, D_1, D_2 and D_3: Coefficient dummy variables corresponding to EMC, INC and CSC, respectively.
D_a, D_b: Dummy variable (D_a: *JPN, KOR = 1*, others = 0. D_b: IND, PHL = 1, others = 0).
The figures in parenthesis indicate *t*-statistics: all are significant at the 1% level except * 10%.

ICT. EMCs represent the highest elasticity of ICT to this balance, expecting us of its gender balance improvement once they achieve ICT advancement.

3.1.4. Gender balance improvement supported by income growth and blocked by the male-dominated society

Similar to Fig. 15, while income increase contributes to gender balance improvement, this improvement is blocked by cultural dimensions. Fig. 16 illustrates this multiple correlation, which is also statistically significant.

Similar to Fig. 15, CSCs demonstrate an extremely high negative elasticity of the intensity of male-dominated society to gender balance improvement, as this is considered to be a substantial source of their lowest level of gender balance improvement, despite the high level of income and ICT. EMCs record the highest elasticity of income to this balance, expecting us of its gender balance improvement once they achieve growth. Considering this alongside Fig. 15, the construction of the co-evolutional cycle as *ICT advancement →income growth→gender balance improvement* would be the key strategy for sustainable growth in EMCs.

3.1.5. ICT contribution to income growth

Fig. 17 illustrates a correlation between ICT advancement and GDP per capita, which is also statistically significant. INCs demonstrate the highest elasticity of ICT advancement to GDP per capita increase, followed by CSCs with an almost similar level. EMCs lag behind the two groups, suggesting that they require further improvement in the introduction and utilization of ICT.

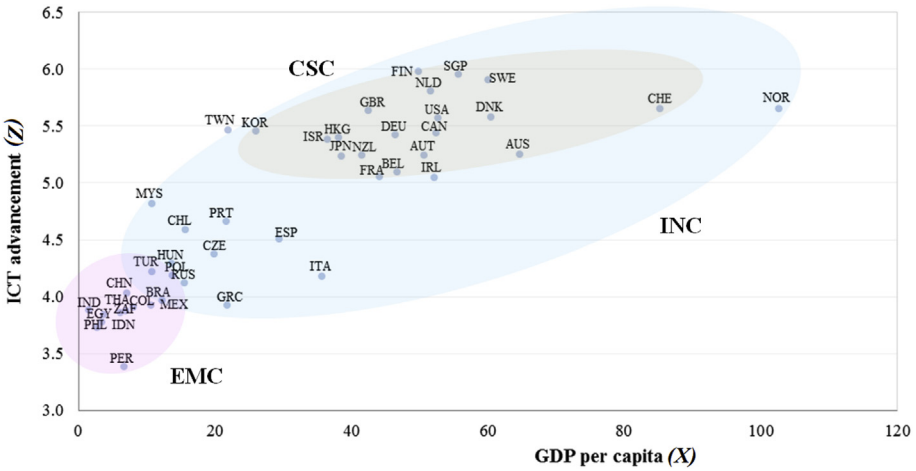

Fig. 14. Correlation between GDP per Capita and ICT Advancement in 44 Countries (2013).

$$lnZ = \underset{(1.58)*}{0.33} + \underset{(4.87)}{0.12}\, D_1 lnX + \underset{(6.10)}{0.12}\, D_2 lnX + \underset{(6.50)}{0.13}\, D_3 lnX \qquad \textbf{\textit{adj}.}\boldsymbol{R^2}\ 0.739$$

Z: ICT advancement (*NRI*); *X*: GDP per capita (x 10^3 US$), D_1, D_2 and D_3: Coefficient dummy variables corresponding to EMC, INC and CSC, respectively.
The figures in parenthesis indicate *t*-statistics: all are significant at the 1% level except * 10%.

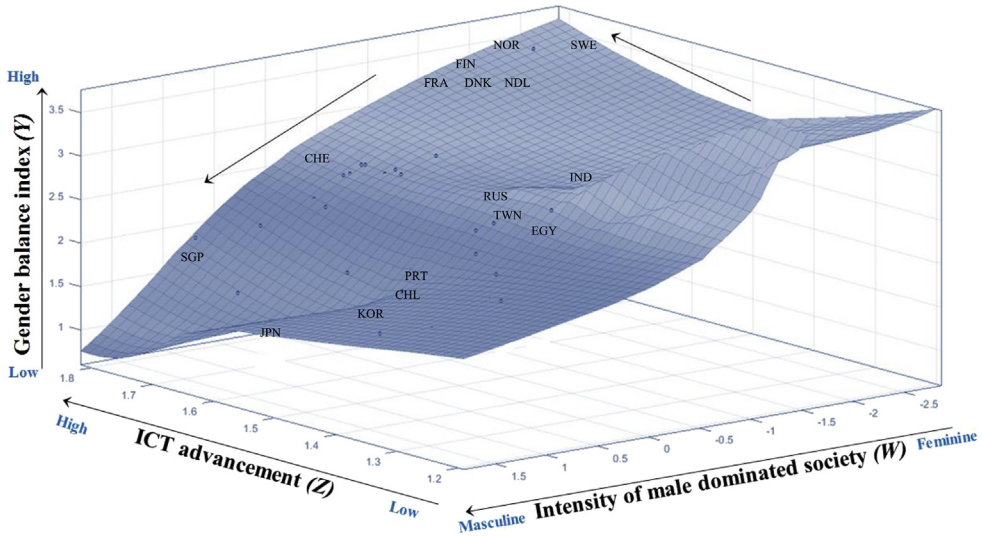

Fig. 15. Correlation between ICT Advancement, Intensity of Male-Dominated Society, and the GBI in 44 Countries (2013).

$$\ln Y = \underset{(-1.30)**}{-1.19} + \underset{(3.93)}{2.63}\, D_1 lnZ + \underset{(3.70)}{2.12}\, D_2 lnZ + \underset{(3.62)}{2.05}\, D_3 lnZ \qquad \textbf{\textit{adj}.}\boldsymbol{R^2}\ 0.734$$
$$\underset{(-1.96)*}{-0.41}\, D_1 lnW - \underset{(-4.01)}{0.37}\, D_2 lnW - \underset{(-4.26)}{2.49}\, D_3 lnW + \underset{(3.55)}{1.64}\, D$$

Y: Gender balance index; *W*: Intensity of male dominated society (*M/I*); *Z*: ICT advancement (*NRI*); all are rogarithymic value.
D_1, D_2 and D_3: Coefficient dummy variables corresponding to EMC, INC and CSC, respectively.
D: Dummy variable (SGP = 1, others = 0)
The figures in parenthesis indicate *t*-statistics: all are significant at the 1% level except * 5% and ** 15%.

3.1.6. ICT advancement stimulated by gender balance improvement

Fig. 18 illustrates a correlation between the GBI and ICT advancement, which is also statistically significant. INCs record the highest elasticity of gender balance improvement to ICT advancement, followed by CSCs and EMCs. This suggests EMC need dramatic advancements in women's ICT involvement and an increase in women's contribution to ICT advancement through effective ICT utilization and development.

3.2. Consequences of co-evolutionary dynamism

Fig. 19 illustrates trilateral co-evolutionary dynamism induced by the foregoing six co-evolutions.

Table 4 summarizes the elasticities of the trilateral co-evolution.

Looking at Table 4, we note that while EMCs demonstrate the highest level of elasticity of GDP per capita to gender balance improvement ($X \rightarrow Y$), due to an extremely low level of elasticity of gender balance improvement to ICT advancement ($Y \rightarrow Z$) and elasticity of ICT to GDP per capita ($Z \rightarrow X$), their performance regarding the trilateral co-evolution results in a low level. Contrary to this low performance by EMCs, INCs demonstrate explicit performance in their trilateral co-evolution. This can be attributed to their outperformed elasticity of gender balance improvement to ICT advancement ($Y \rightarrow Z$), supported by the lowest impediment of

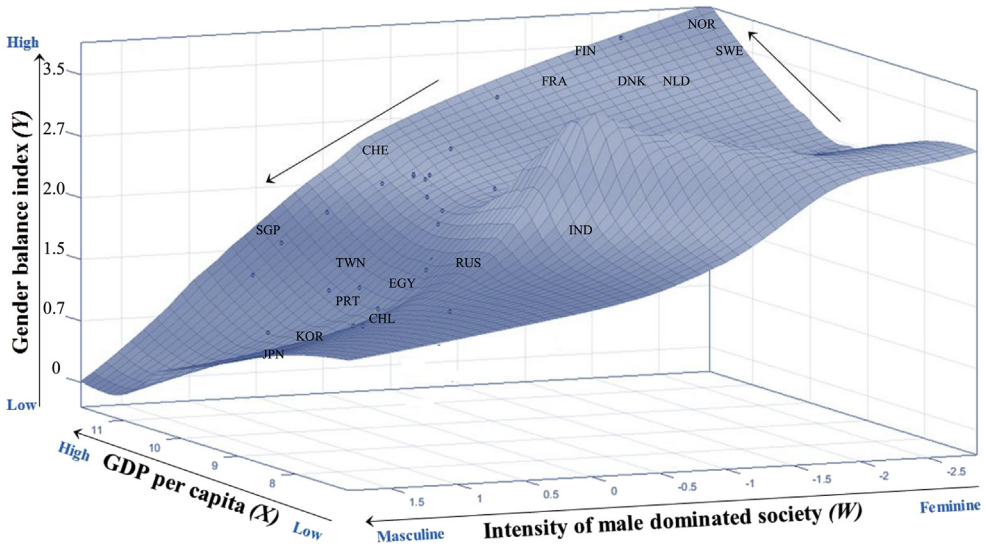

Fig. 16. Correlation between GDP per Capita, Intensity of Male-Dominated Society, and the GBI in 44 Countries (2013).

$$\ln Y = \underset{(-2.53)}{-2.35} + \underset{(5.13)}{0.56}\, D_1 lnX + \underset{(4.91)}{0.44}\, D_2 lnX + \underset{(4.92)}{0.41}\, D_3 lnX \quad \boldsymbol{adj.R^2}\ 0.794$$
$$\underset{(-2.60)*}{-0.48}\, D_1 lnW - \underset{(-3.87)}{0.32}\, D_2 lnW - \underset{(-1.92)**}{0.87}\, D_3 lnW + \underset{(-4.28)}{1.04}\, D$$

Y: Gender balance index; *W*: Intensity of male dominated society (*M/I*); *X*: GDP per capita; all of which represent logarithmic values.
D_1, D_2 and D_3: Coefficient dummy variables corresponding to EMC, INC and CSC, respectively.
D: Dummy variable (JPN, CHL = 1, others = 0)
The figures in parenthesis indicate *t*-statistics: all are significant at the 1% level except * 5% and ** 15%.

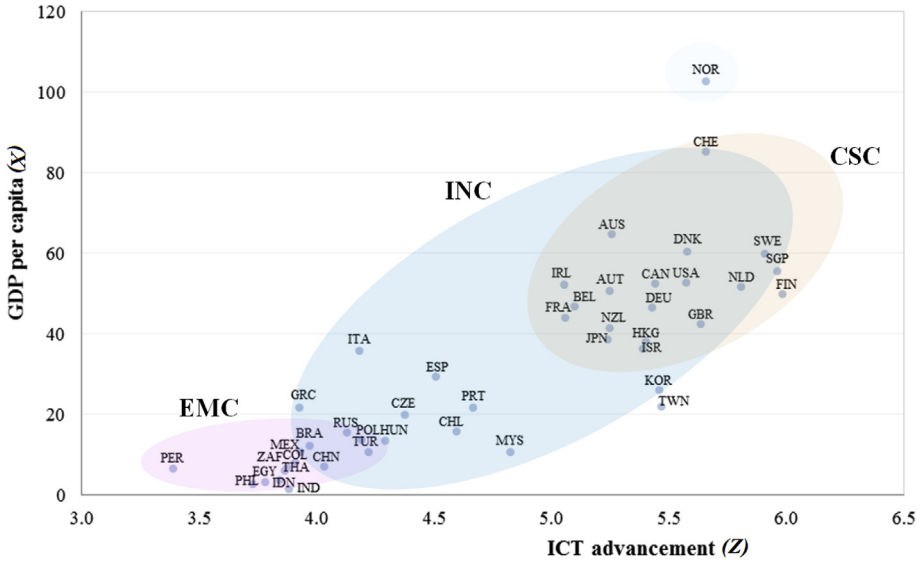

Fig. 17. Correlation between ICT Advancement and GDP per Capita in 44 Countries (2013).

$$lnX = \underset{(5.30)}{4.631} + \underset{(4.66)}{3.028}\, D_1 lnZ + \underset{(6.57)}{3.579}\, D_2 lnZ + \underset{(6.84)}{3.564}\, D_3 lnZ \quad \boldsymbol{adj.R^2}\ 0.815$$

The figures in parenthesis indicate *t*-statistics: all are significant at the 1% level
X: GDP per capita (x 10^3 US$); *Z*: ICT advancement (*NRI*),
D_1, D_2 and D_3: Coefficient dummy variables corresponding to EMC, INC, and CSC, respectively.
The figures in parenthesis indicate *t*-statistics: all are significant at the 1% level.
NOR is not included in the analysis.

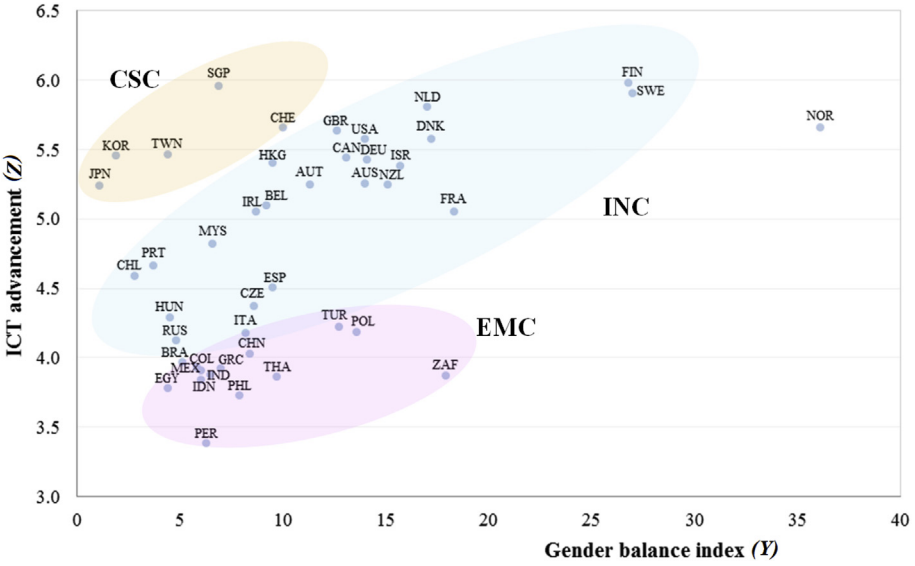

Fig. 18. Correlation between the GBI and ICT Advancement in 44 Countries (2013).

$$lnZ = \underset{(23.16)}{1.227} + \underset{(2.30^*)}{0.061}\, D_1 lnY + \underset{(7.19)}{0.162}\, D_2 lnY + \underset{(2.39^*)}{0.089}\, D_3 lnY + \underset{(5.47)}{0.351}\, D \quad \boldsymbol{adj.R^2}\ 0.771$$

Y:Gender balance index; *Z*: ICT advancement *(NRI)*, D_1, D_2 and D_3: Coefficient dummy variables corresponding to EMC, INC and CSC, respectively.
D: Dummy variable (*CHE, JPN, KOR, SGP, TWN* = 1, others = 0).
The figures in parenthesis indicate *t*-statistics: all are significant at the 1% level except * 2%.
NOR is not included in the analysis.

IMS ($W \rightarrow Y$). Finland, which has the leading position among INCs in terms of the highest GBI intensity, as demonstrated in Fig. 11, may provide insights into increasing this elasticity. CSCs demonstrate incredibly high impediments of IMS in GBI improvement ($W \rightarrow Y$), resulting in the lowest GBI intensity, as demonstrated in Fig. 11, notwithstanding the high level of elasticities of GBI and ICT to increases in GDP per capita ($Y \rightarrow X$ and $Z \rightarrow X$).

These findings serve as a call to learn from INCs, particularly Finland, possible measures to improve ICT-driven economic growth for EMCs and, in relation to IMS, to improve ICT advancement for CSCs [38].

4. Strategy for emerging countries – ICT-driven economic growth

Considering the significance of the role of ICT in gender balance improvement [30,39,19,25], Fig. 20 compares women's dependency on the Internet use (*WIU*). As anticipated, EMCs record an extremely low levels of this dependency (half the level of the other 2 groups). This fact suggests the significance of lessons from successful countries for further improving women's initiative and involvement in ICT development and utilization.

Since *WIU* largely depends on ICT advancement, as demonstrated in Table 5, ICT advancement would be the fundamental solution to enhance *WIU,* leading to women's further direct contribution to gender balance improvement [30].

This endorses the preceding postulate that the construction of a co-evolutional cycle as ICT advancement →income growth→ gender balance improvement would be the key sustainable growth strategy for EMCs.

Based on this understanding, provided that ICT incorporates a potential that enables all nations to attain a similar income level, Table 6 and Fig. 21 estimate possible ICT-driven income (GDP per capita) growth trajectories in EMCs, INCs and CSCs. The estimation was conducted by utilizing hybrid logistic growth model depicting identical development trajectories depending on countries' respective "econo-cultural" positions [21].

Given sufficient ICT advancement, Fig. 21 suggests that EMCs' ICT-driven income increase trajectory incorporates a rapid growth potential as it remains in the "early minority stage," with the potential of acceleration of its diffusion velocity [26].

From this observation, Fig. 22 estimates the potential income growth rate driven by ICT advancement.[6] Fig. 22 demonstrates that EMCs incorporate an extremely high growth potential (3 times higher than INCs and CSCs).

These analyses support the preceding postulate regarding co-evolutional cycles as ICT advancement →income growth →gender balance improvement would be the key sustainable growth strategy for EMCs and highlights the significance of ICT advancement for EMCs in triggering this virtuous cycle.

Given the shortage of indigenous capacity for due ICT advancement initiated by EMCs themselves, INCs and CSCs are expected to extend their ICT advancement capacity to those of EMCs in terms of growth; thus, they can expect to harness the vigor of EMCs' growth. Therefore, a co-evolutionary acclimatization structure can be expected to be constructed by harnessing the vigor of counterparts [19,30,36].

[6] The ICT-driven income logistic growth model can be depicted as follows: $\frac{dX}{dZ} = aX\left(1 - \frac{X}{N}\right)$ This can be developed to the following ICT-driven income growth rate: $\frac{\frac{dX}{dZ}}{X} = a\left(1 - \frac{X}{N}\right)$ where *X*: Income (GDP per capita), *Z*: ICT advancement, and *N*: carrying capacity.

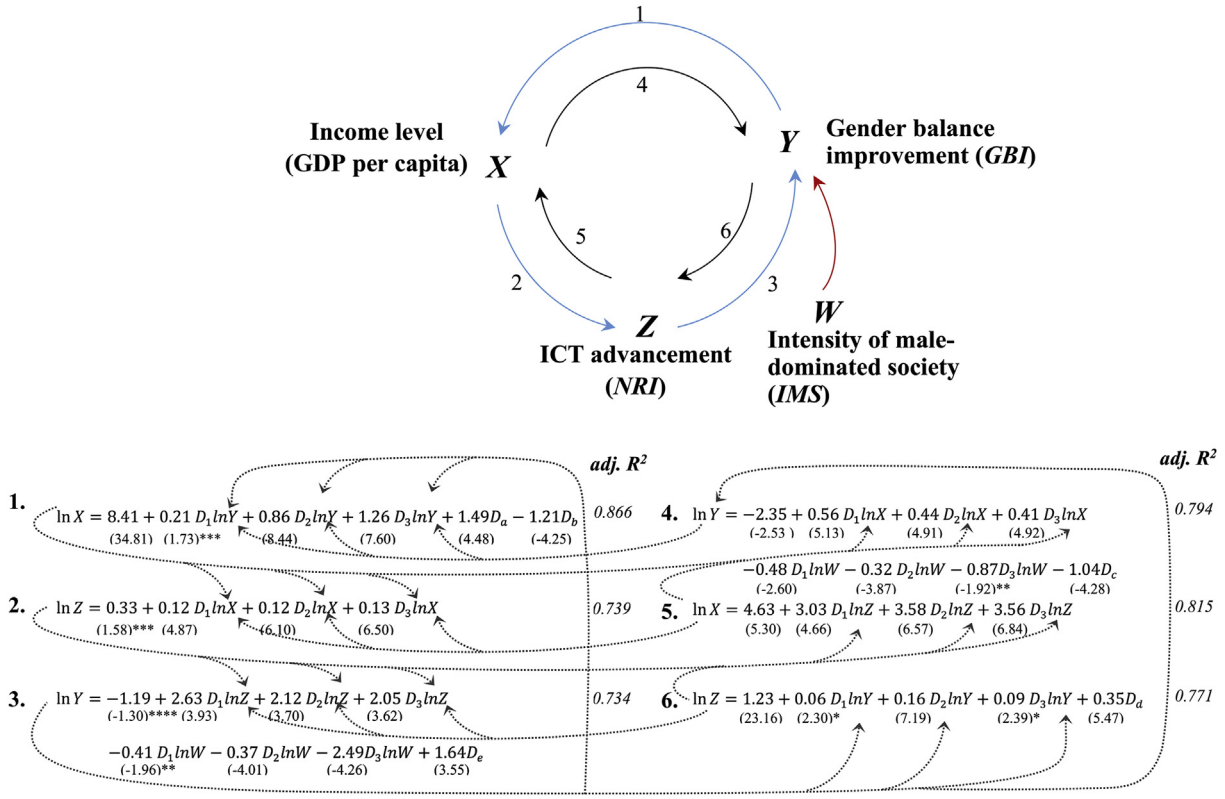

Fig. 19. Co-evolutionary Dynamism between the "Econo-cultural" Position, Gender Balance Improvement, and ICT Advancement in 44 countries (2013).
D: Dummy variables - D_1, D_2, D_3 (EMC, INC, CSC = 1, others = 0, respectively), D_a (JPN, KOR = 1, others = 0), D_b (IND, PHL = 1, others = 0), D_c (JPN, CHL = 1, others = 0), D_d (CHE, JPN, KOR, SGP, TWN = 1, others = 0), D_e (SGP = 1, others = 0).
The figures in parenthesis indicate t-statistics: all are significant at the 1% level except *2 %, **5%, ***10% and ****20%.

Table 4
Elasticities of Co-evolution in 44 countries (2013).

	Emerging countries (EMC)	Industrialized countries (INC)	Countries with specific culture (CSC)
1 $Y \rightarrow X$	0.21	0.86	1.26
2 $X \rightarrow Z$	0.12	0.12	0.13
3 $Z \rightarrow Y$	2.63	2.12	2.05
$W \rightarrow Y$	−0.41	−0.37	−2.49
4 $X \rightarrow Y$	0.56	0.44	0.41
$W \rightarrow Y$	−0.48	−0.32	−0.89
5 $Z \rightarrow X$	3.03	3.58	3.56
6 $Y \rightarrow Z$	0.06	0.16	0.09

X: Income level (GDP per capita), *Y*: Gender balance improvement (*GBI*).
Z: ICT advancement (*NRI*), *W*: Intensity of male-dominated society (*IMS*).

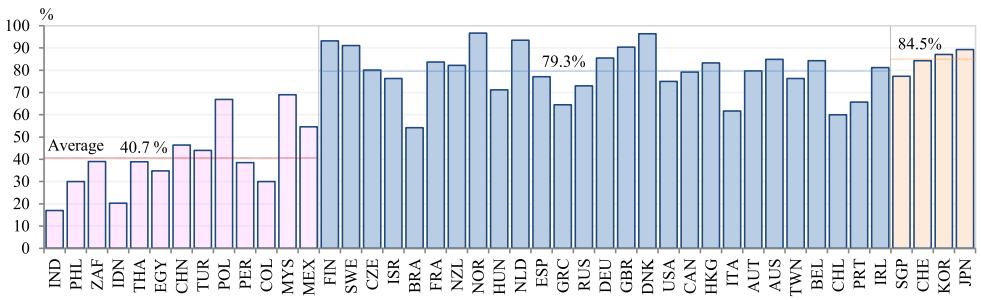

Fig. 20. Percentage of women using the internet in 44 countries (2013).
Source: ITU [10].

Table 5
Correlation between ICT advancement and Women's use of the internet (2013).

$$lnWIU = \underset{(7.13)}{2.576} + \underset{(2.86)}{0.770}\, D_1 lnNRI + \underset{(4.91)}{1.101}\, D_2 lnNRI + \underset{(5.01)}{1.080}\, D_3 lnNRI \qquad adj.\ R^2\ 0.805$$

where *WIU*: Women's dependency on the Internet use, and *NRI*: Networked readiness index.

The figures in parenthesis indicate t-statistics: all are significant at the 1% level.

Table 6
ICT-driven income growth trajectory in 44 countries (2013).
$X = \frac{N}{1+b_1 D_1 e^{-a_1 D_1 Z} + b_2 D_2 e^{-a_2 D_2 Z} + b_3 D_3 e^{-a_3 D_3 Z}} + cD_c + dD_d$

N	D_1		D_2		D_3		D		adj. R^2
	a_1	b_1	a_2	b_2	a_3	b_3	c	d	
71.764	2.519	2.079×10^5	1.335	0.736×10^3	1.811	1.724×10^4	37.610	−24.189	0.911
(3.33)	(1.14**)	(1.37*)	(2.70)	(3.63)	(1.41*)	(1.47*)	(7.45)	(-4.10)	

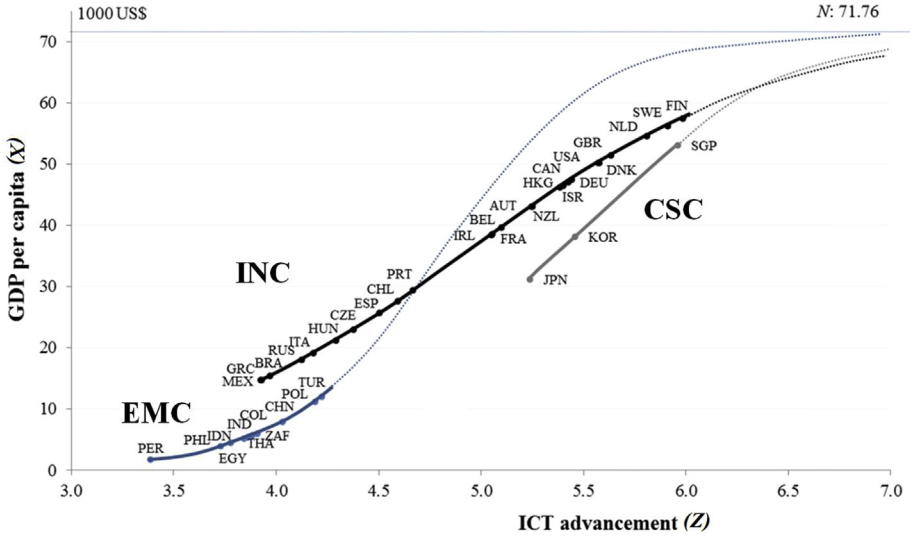

Fig. 21. Prospects of ICT-driven Income Growth Trajectories in 39 Countries.
39 countries excluding 5 countries treated D_c and D_d in Table 6 (NOR, CHE, AUS, TWN and MYS) are analyzed.

5. Strategy for countries with a specific culture – IMS and the improvement of ICT advancement

Realizing an explicit contrast between industrialized countries (INCs) and countries with a specific culture (CSCs) regarding gender balance improvement notwithstanding the non-substantial differences of income and ICT advancement levels, we have learned the following. It is essential for CSCs to learn extensive lessons from INCs in relation to gender-balanced organizational leadership, particularly ICT-driven trilateral co-evolution in enabling ICT

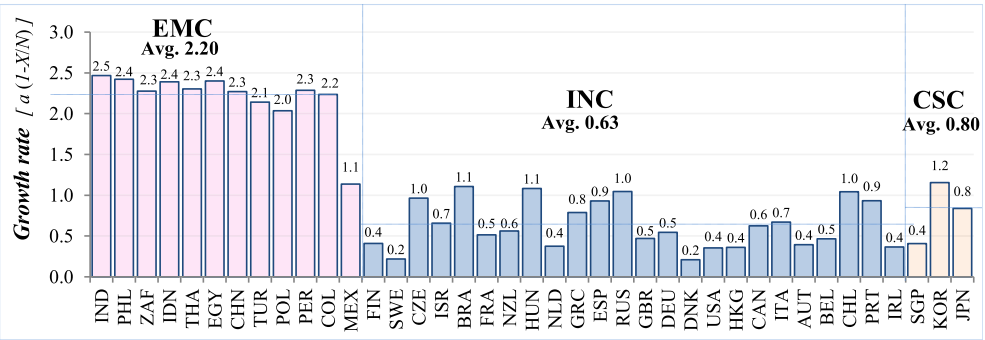

Fig. 22. Comparison of Growth Rate in 39 Countries (2013).

Growth rate is depicted by $\frac{dX/dZ}{X} = \frac{dX}{X} = a\left(1 - \frac{X}{N}\right)$ where *X:* GDP per capita, *Z*: ICT advancement (*NRI*),*N:* Carrying capacity, *and a*: coefficient (diffusion velocity). NOR, CHE, AUS, TWN and MYS are not included.

Table 7
Contrast between Finland and Japan in gender-balanced organization leadership (2013).

		Finland	Japan	Reference
State of gender parity		2	105	Global rank (WEF [41])
Gender balance improvement based on of the state of		26.8	1.1	GBI [8],
women board members		28.0*	3.0*	OECD [24] %
		43.0**	3.0**	WEF [42]
GDP per capita (US$1000)		49.8	38.6	IMF [11]
Institutional systems	Individualism	63	46	Hofstede Cultural Index
	Masculinity	26	95	([9] state)
	Mas./Ind. ratio	0.41	2.07	
Individual women using the Internet (%)		93.2	89.3	ITU [13]
Networked Readiness Index		1	21	Global rank (WEF [41])

*: 2015, **: 2016.

Table 8
Trends in the share of women directors in Finland and Japan (2001–2016) - %.

Finland																
2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average growth rate
5.0	6.0	7.0	8.5	10.5	12.0	13.5	15.0	16.0	18.0	19.0	21.5	22.5	23.0	24.0	25.0	11.6% *p.a*
Japan																
2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average growth rate
3.6	4.5	4.6	5.0	5.1	5.8	6.5	6.6	7.2	7.0	8.1	8.5	8.9	9.4	9.8	10.3	11.6% *p.a*

advancement while improving the intensity of the male-dominated society (*IMS*).

In this context, the contrasting trajectories between Finland (the leading INC) and Japan (typical among CSCs) may provide insightful suggestions for CSCs in terms of *IMS improving ICT advancement* trajectory management.

With this in mind, Table 7 demonstrates contrast between Finland and Japan in gender balanced organization leadership.

Based on this contrasting structure, institutional sources leading to contrasting trajectories with respect to women's leadership in the two countries were analyzed.

Table 8 and Fig. 23 demonstrate trends in the share of women directors in both countries over the period 2001–2016. It should be noted that due to differences between the surveys and corporate promotion systems between the two countries (since both trends are not necessarily dependent on the same scope of companies, and neither do they represent the same hierarchical position in the company), Table 8 and Fig. 23 should be compared by focusing on their trends rather on absolute values. Traditionally in Japan, directors are classified on a lower hierarchy than board members,[7] while much closer in Finland (almost same as the board members in this survey). Furthermore, contrary to Finland's scope of companies covering only listed companies, Japan's survey was based on all companies with more than 5 employees (private companies) or 10 employees (public companies), including many SMEs whose corporate hierarchy system did not necessarily correspond to that of the listed companies.

Some ten years ago, the corporate boards of large companies were dominated by men. Since then, the situation has changed considerably in Finland, as demonstrated in Table 8 and Fig. 23. Both the corporate sector and the Finnish government have contributed to a substantial increase in women's participation on

[7] The share of women executive officers in Japan in 2011 consisted of: (i) 15.3% senior staff, (ii) 8.1% directors, and (iii) 5.1% general managers. Board members in the Finnish hierarchy are specific senior members from the latter category.

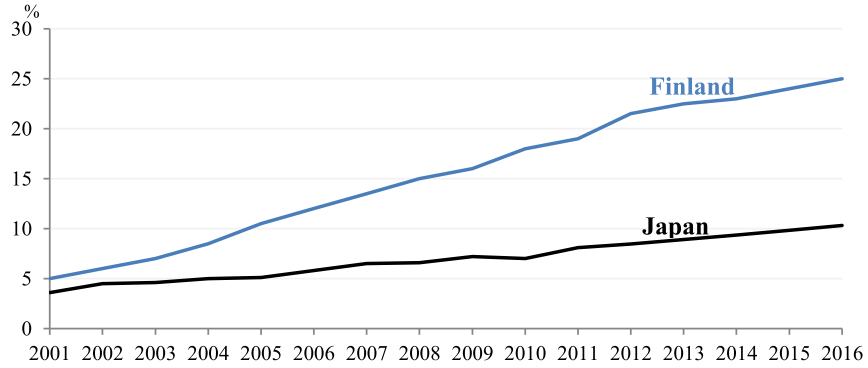

Fig. 23. Trends in the share of women directors in Finland and Japan *(2001–2016)* - %.s
ources: Same as Table 8.

corporate boards [7]. The number of women directors in Finland's listed companies is among the highest in the world, as demonstrated in Figs. 5 and 6. Finland's progress has been achieved without quota legislation. It was initiated by companies' interest in creating a balance, whereby the considerable number of higher educated women with excellent ICT skills (Fig. 20) and women's share in the workforce would also be reflected at the managerial level. In this way, companies could benefit from the best professionals as their board members and among executives. Based on this self-propagating virtuous cycle, a revised Corporate Governance Code entered into force in January 2016, thus accelerating the virtuous cycle by encouraging companies functional diversity measures [7].

This virtuous cycle can be attributed to the following co-evolution dynamism between gender balance improvement and ICT advancement as:

Awaking women's potential ability in higher education with excellent ICT skills → encouraging them to contribute to higher functional ICT development and utilization in their companies → leading to them being qualified managers → gaining a higher reputation for women → inducing further ICT advancement.

Contrary to Finland's conspicuous gender balance improvement, Japan is reported as one of the worst-ranking industrialized countries regarding women's representation, as demonstrated in Figs. 5 and 6.

Japanese Prime Minister Shinzo Abe set a goal to increase the percentage of women in executive positions in Japanese companies to more than 30% by 2020. However, Japan's pace of improvement

Table 9
Comparison of self-propagating function incorporating in Finland and Japan (2001–2016).

		N_k	a	b	a_k	b_k	$adj.R^2$
Finland	***SLG***	28.60 (32.31)	0.23 (17.63)	1.06 (28.60)			0.996
	LGDCC	44.84 (8.57)	0.29 (88.90)	3.91 (7.34)	0.05 (5.15)	1.11 (5.33)	0.999
Japan	***SLG***	18.15 (4.11)	0.10 (5.59)	2.95 (3.57)			0.990
	LGDCC	21.28 (8.60)	0.13 (2.78)	1.43 (3.10)	0.07 (0.01)#	1.04 (0.01)#	0.990

Y(z): Share of women directors (%): N_k: carrying capacity; *Z*: ICT advancement; *a, b,* a_k, b_k: coefficients. Figures in parenthesis indicate t-statistics: significant at the 1% level except #: in-significant level.

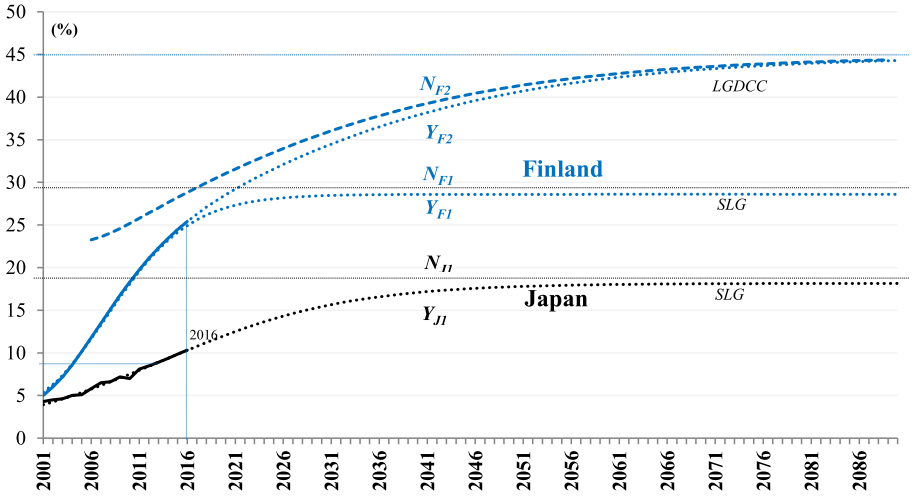

Fig. 24. Trends and Prospects of Women Directors Share in Finland and Japan - %.
Y_1: Trajectory without self-propagating function. Y_2: Trajectory with self-propagating function.
N_1: Carrying capacity in *SLG*. N_2: Carrying capacity in *LGDCC*.

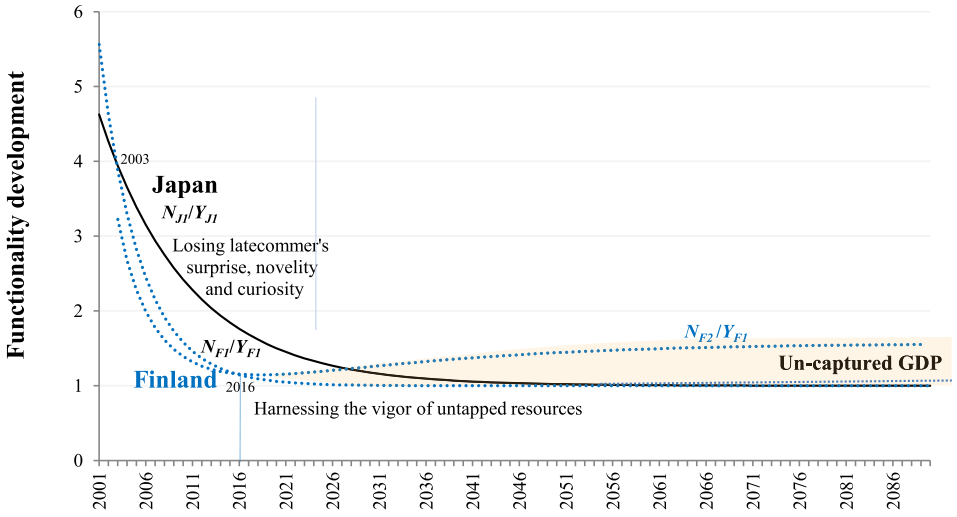

Fig. 25. Trends and prospects of functionality development by increasing women directors share in Finland and Japan.

was much slower than Finland's as demonstrated in Table 8. It was revealed that the institutional sources blocking Japan's improvement can be attributed to (i) the small number of female employees in the initial stage of employment (56%); (ii) the shortage of capable women possessing sufficient knowledge, experiences and decision making ability (47%); (iii) while there are women with potential capability, they have not yet satisfied sufficient necessary experiences for their positioning (30%); (iv) the majority of women retire before being promoted to board membership (26%); and (v) qualified women do not require promotion (17%) (Ref. [28]: The figures in parentheses indicate the share of multiple answers). All these attributes result from impediments by an ingrained male-dominated society.

Based on these observations, aiming at identifying the effects of "econo-cultural" systems contrasting ICT-driven gender balance improvement trajectories in the two countries, the incorporation of a self-propagating function in the respective trajectories was examined. Since this self-propagating function can be considered a core function of ICT [33–35], incorporation of this function demonstrates that gender balance improvement has been accomplished in a co-evolutionary manner.

As this self-propagating function can be attributed to its adaptability to ICT-driven logistic growth within a dynamic carrying capacity (*LGDCC*) function that increases functionality as grows, rather than the simple logistic growth (*SLG*) function that fades out functionality as grows [33], the fitness of two countries' *LGDCC* trajectories was compared.

Table 9 summarizes this comparison. Here, while Finland demonstrates a fit to ICT-driven *LGDCC*, Japan fits to a simple logistic growth (*SLG*) without this self-propagating feature.

Based on this analysis, Fig. 24 estimates the prospects of the share of women directors in Finland and Japan. Fig. 24 suggests that while the share of women directors remains 18% in Japan (Y_{J1}), Finland can expect to increase to levels as high as 45% (Y_{F2}). This high level can be attributed to the incorporation of the self-propagating function, without which the level would remain at 29% (Y_{F1}).

This contrast suggests the significance of the self-propagating function for sustainable gender balance improvement in the digital economy.

Fig. 25 illustrates the dynamism emerging as a result of this self-propagating function.

The self-propagating function can be attributed to the dynamism of increases in functionality development (*FD*) as growth increases (*Y* increase) [33]. *FD* can be estimated by the ratio of *N* and *Y* [34] where *N*: carrying capacity (N_1 by *SLG*, N_2 by *LGDCC*) and *Y*: share of women director (Y_1 by *SLG*, Y_2 by *LGDCC*).

Due to its traditional high intensity regarding its male-dominated society, Japan depends on *SLG*. Consequently, its *FD* (N_{J1}/Y_{J1}) continues to decline, resulting in a loss of latecomer surprise, novelty, and curiosity. On the contrary, Finland shifted from *SLG* to *LGDCC* in 2016, and its *FD* transformed from N_{F1}/Y_{F1} to N_{F2}/Y_{F1} in 2016, changing from a declining to an increasing trend.

Factors contrasting this FD decline in Japan and its increase in Finland can be identified as summarized in Table 10.

The lifting power of this FD increase can be attributed to the incorporation of the self-propagating function demonstrated by Finland in its *IMS improving ICT advancement*: *employment of higher educated women with excellent ICT skills → contribution to highly functioning ICT development and utilization in companies → leading to qualified management → gaining women's high reputation → further improvement of IMS.*

The discrepancy between N_{F1}/Y_{F1} and N_{F2}/Y_{F1} in Finland which has been remarkable from 2016, triggered by its shift from *SLG* to *LGDCC* can be considered similar to un-captured GDP [35,36]. Thus, Finland has been able to harness the vigor of women's potential as untapped economic resources and has explored the foregoing *IMS improving ICT advancement* trajectory.

ICT-driven "econo-cultural" disruptive innovation thus nurtures un-captured GDP, which corresponds to such business models as harnessing the vigor of untapped resources [36,37].

6. Conclusion

In light of the increasing significance of harnessing the vigor of women's potential in digital economies that are rapidly aging, an empirical numerical analysis focusing on the trilateral co-evolution between "econo-cultural development," gender balance improvement, and ICT advancement in 44 countries was attempted. Furthermore, the study aimed to present success lessons from well-balanced countries to countries incorporating structural constraints for balance improvement. To do this, a comparative analysis

Table 10
Factors decreasing and increasing functionality development in ICT-driven gender balance improvement in Japan and Finland.

Japan's FD decrease	Loss of identity, fresh attractiveness and latecomer surprise, novelty, and curiosity; the fading of fresh impacts that were initially expected; emerging disappointment.
Finland's FD increase	Exploring new identical, qualified, and epoch-making contributions leading to further gains in attractiveness and fresh impacts; adding new value; breaking the glass ceiling.

of ICT-driven gender balance improvement trajectories in Finland and Japan was conducted.

Consequently, the following noteworthy findings were obtained:

Gender balance improvement can be monitored using the Gender Balance Index (GBI) to ascertain the share of women on boards, which represents the state of gender parity. Since gender balance improvement is influenced by income level, gender balance intensity (GBI/GDP per capita) can be an effective supportive tool in identifying the state of gender balance improvement.

Furthermore, gender balance improvement is subject not only to income level but also to cultural dimensions, particularly to "muscularity" and "individualism." Taking these dimensions into account, the gender balance intensity level in 44 countries can be classified into emerging countries (EMC), industrialized countries (INC), and countries with a specific culture based particularly on the traditions of a male-dominated society (CSC).

INCs demonstrates explicit performance in the trilateral co-evolution between "econo-cultural development," gender balance improvement and ICT advancement. This explicit performance can be attributed to their high level of elasticity of gender balance improvement to ICT advancement.

EMCs remain at an extremely low level of this elasticity, resulting in the lowest performance in the trilateral co-evolution, notwithstanding the highest elasticity of growth to gender balance improvement. However, it is anticipated that once due sufficient ICT advancement prevails, a virtuous cycle leading to income growth and gender balance improvement can be expected.

Notwithstanding their high level of income and ICT advancement, CSCs remain at the lowest level of gender balance intensity, which can be attributed to their traditional high intensity male-dominated society.

Among INCs, Finland demonstrated conspicuous performance in this trilateral co-evolution by incorporating a self-propagating function in the gender balance improvement trajectory, while Japan (which lags significantly behind among 44 countries) was unable to incorporate this function primarily due to its male-dominated culture.

All suggest that ICT-driven "econo-cultural" disruptive innovation nurtures un-captured GDP, which corresponds to such business model as harnessing the vigor of untapped resources.

These findings give rise to the following insightful suggestions to respective countries about their successful trilateral co-evolution:

It should be realized the significance of harnessing the vigor of untapped economic resources incorporated in women's potential. In this context, we should recognize clear link between the share of women board members, corporate performance, gender quality in the workplace, and gender quality in society.

Every effort should focus on the construction of the trilateral co-evolution between "econo-cultural development," gender balance improvement, and ICT advancement.

The effective development and utilization of ICT should be of the highest priority for EMCs in constructing their trilateral co-evolution. The construction of a co-evolutionary acclimatization structure should be the significant endeavor for INCs and CSCs in this context.

Address cultural dimensions that block gender balance improvement efforts in CSCs by constructing an ICT advancement system in male-dominated societies. To do this, the construction of a self-propagating function should be challenged with the highest priority.

It should be noted that this construction should lead the way to enable the emergence of un-captured GDP, which in turn accelerates the harnessing of untapped resources.

Aiming at exploring a new systematic approach for improving gender balance, this paper attempted to explore a practical approach based on the prior exercises on the similar subject in the digital economy (e.g., harnessing the vigor of sleeping/untapped resources in sharing economy, trust-based digital education, resurgence of music industry).

Since this paper is the first step to exploring a practical approach to gender balance improvement supportive to whole stakeholders in different economies with heterogenous economic, cultural and digital development, it should be carefully noted that there remains strong requirement for further elegant research which should be endeavored based on the findings obtained by this first step approach.

The new approach regarding the intensity of the male-dominated society (IMS) was introduced with a focus on "masculinity" and "individualism" as cultural dimensions. Other factors such as work/employment culture, family issues, effects of tradition, and political factors remain unexplored. The effects of other cultural dimensions as "power distance," "uncertainty avoidance" and "long-term consideration" should also be examined.

Further work should focus on complementing unexplored analyses as well as in-depth analysis of success and failure trajectories with respect to gender balance improvement. Analyses of success and failure cases should be enriched. Micro dynamism of the IMS improving ICT development trajectory initiated by Finland should be further analyzed for operationalization in other countries, particularly CSCs.

Acknowledgement

The research leading to these results has received funding from the Strategic Research Council at the Academy of Finland under grant agreement 293446 – Platform Value Now: Value capturing in the fast emerging platform ecosystems.

Appendix 1. Institutional state of 44 countries analyzed

Table A1
State of Gender Balance, Cultural Dimension, and Internet Usage in 44 Countries (2013)
*Ind.: Individualism, Mas.: Masculinity. Original sources: GMI Ratings [8], IMF [12], Geert Hofstede [9], ITU [13].

Country	Country Code	Gender Balance Index (GMI)	GDP per capita (current US$)	GBI intensity (GBI/GDP per capita x1000)	Cultural dimension*			ICT Advancement (NRI)	Women Internet usage (%)
					Ind.	Mas.	Mas/Ind ratio		
Norway	NOR	36.1	102,564	0.35	69	8	0.12	5.66	96.7
Sweden	SWE	27.0	60,005	0.45	71	5	0.07	5.91	91.1
Finland	FIN	26.8	49,766	0.54	63	26	0.41	5.98	93.2
France	FRA	18,3	44,105	0.41	71	43	0.61	5.06	83.7
South Africa	ZAF	17.9	6,914	2.59	65	63	0.97	3.87	39.0
Denmark	DNK	17.2	60,494	0.28	74	16	0.22	5.58	96.4
Netherlands	NLD	17.0	51,595	0.33	80	14	0.18	5.81	93.5
Israel	ISR	15.7	36,410	0.43	54	47	0.87	5.39	76.3
New Zealand	NZL	15.1	41,555	0.36	79	58	0.73	5.25	82.2
Germany	DEU	14.1	46,475	0.30	67	66	0.99	5.43	85.5
Australia	AUS	14.0	64,664	0.22	90	61	0.68	5.26	84.9
USA	USA	14.0	52,705	0.27	91	62	0.68	5.57	75.0
Poland	POL	13.6	13,773	0.99	60	64	1.07	4.19	66.9
Canada	CAN	13.1	52,345	0.25	80	52	0.65	5.44	79.2
Turkey	TUR	12.7	10,761	1.18	37	45	1.22	4.22	44.0
UK	GBR	12.6	42,453	0.30	89	66	0.74	5.64	90.4
Austria	AUT	11.3	50,585	0.22	55	79	1.44	5.25	79.7
Switzerland	CHE	10.0	85,237	0.12	68	70	1.03	5.66	84.3
Thailand	THA	9.7	6,148	1.58	20	34	1.70	3.86	38.9
Hong Kong	HKG	9.5	38,170	0.25	25	57	2.28	5.40	83.3
Spain	ESP	9.5	29,397	0.32	51	42	0.82	4.51	77.1
Belgium	BEL	9.2	46,726	0.20	75	54	0.72	5.10	84.3
Ireland	IRL	8.7	52,094	0.17	70	68	0.97	5.05	81.2
Czech Republic	CZE	8.6	19,913	0.43	58	57	0.98	4.38	80.1
China	CHN	8.4	7,081	1.19	20	66	3.30	4.03	46.4
Italy	ITA	8.2	35,704	0.23	76	70	0.92	4.18	61.7
Philippines	PHL	7.9	2,769	2.85	32	64	2.00	3.73	30.0
Greece	GRC	7.0	21,773	0.32	35	57	1.63	3.93	64.5
Singapore	SGP	6.9	55,617	0.12	20	48	2.40	5.96	77.3
Malaysia	MYS	6.6	10,700	0.62	26	50	1.92	4.82	69.0
India	IND	6.5	1,480	4.39	48	56	1.17	3.88	17.0
Peru	PER	6.3	6,626	0.95	16	42	2.63	3.39	38.5
Columbia	COL	6.0	8,068	0.74	13	64	4.92	3.91	30.0
Indonesia	IDN	6.0	3,676	1.63	14	46	3.29	3.84	20.3
Mexico	MEX	5.8	10,659	0.54	30	69	2.30	3.93	54.6
Brazil	BRA	5.1	12,260	0.42	38	49	1.29	3.97	54.2
Russia	RUS	4.8	15,559	0.31	39	36	0.92	4.13	73.0
Hungary	HUN	4.5	13,564	0.33	80	88	1.10	4.29	71.2
Taiwan	TWN	4.4	21,888	0.20	17	45	2.65	5.47	76.3
Egypt	EGY	4.4	3,374	1.30	25	45	1.80	3.78	34.8
Portugal	PRT	3.7	21,626	0.17	27	31	1.15	4.67	65.7
Chile	CHL	2.8	15,714	0.18	23	28	1.22	4.59	60.0
Korea (Rep.)	KOR	1.9	25,998	0.07	18	39	2.17	5.46	87.1
Japan	JPN	1.1	38,552	0.03	46	95	2.07	5.24	89.3

*Ind. : Individualism, Mas.: Masculinity.

Original sources: GMI Ratings (2013), IMF (2014), Geert Hofstede (2014), ITU (2014).

Appendix 2. Hofstede's cultural dimensions of a nation

1. Five dimensions of a nation's culture

(1) **Power distance**: The power distance is defined as "the extent to which the less powerful members of organizations and institutions (like the family) accept and expect that power is distributed unequally." In this dimension, inequality and power is perceived from the followers, or the lower level. A higher degree of this Index indicates that hierarchy is clearly established and executed in society, without doubt or reason. A lower degree of the Index signifies that people question authority and attempt to distribute power.

(2) **Individualism**: Individualism explores the "degree to which people in a society are integrated into groups." Individualistic societies have loose ties that often only relates an individual

to his/her immediate family. Its counterpart, collectivism, describes a society in which tightly-integrated relationships tie extended families and others into in-groups. These in-groups are laced with undoubted loyalty and support each other when a conflict arises with another in-group.

(3) **Masculinity**: In this dimension, masculinity is defined as "a preference in society for achievement, heroism, assertiveness and material rewards for success." Its counterpart represents "a preference for cooperation, modesty, caring for the weak and quality of life." Women in the respective societies tend to display different values. In feminine societies, they share modest and caring views equally with men. In more masculine societies, women are more emphatic and competitive, but notably less emphatic than the men. In other words, they still recognize a gap between male and female values. This dimension is frequently viewed as taboo in highly masculine societies.

(4) **Uncertainty avoidance**: The uncertainty avoidance is defined as "a society's tolerance for ambiguity," in which people embrace or avert an event of something unexpected, unknown, or away from the status quo. Societies that score a high degree in this index opt for stiff codes of behavior, guidelines, laws, and generally rely on absolute Truth, or the belief that one lone Truth dictates everything and people know what it is. A lower degree in this index shows more acceptance of differing thoughts/ideas. Society tends to impose fewer regulations, ambiguity is more accustomed to, and the environment is more free-flowing.

(5) **Long-term orientation**: This dimension associates the connection of the past with the current and future actions/challenges. A lower degree of this index (short-term) indicates that traditions are honored and kept, while steadfastness is valued. Societies with a high degree in this index (long-term) views adaptation and circumstantial, pragmatic problem-solving as a necessity. A poor country that is short-term oriented usually has little to no economic development, while long-term oriented countries continue to develop to a point.

Source: Hofstede [9].

2. Governing cultural dimensions in gender balance improvement in business

Authors	Business fields	Countries examined	Governing cultural dimensions
[40]	Magazine advertising	Netherlands, Sweden and the US	Masculinity
[4]	Web advertisements	Korea and the US	Masculinity
[27]	Business management	Japan and the US	Individualism, Masculinity, Power distance
[2]	Women in boards	Five European countries	Individualism, Masculinity, Power distance

Appendix 3. Data construction

Table A2
Trends in the Share of Women Directors in Finland and Japan (1989–2016) - %.
Original source: Health, Labor and Welfare White Paper in Japan [18]. Values indicated in blue are based on complemental estimates utilizing GMI Ratings data.

Complementary estimates were conducted based on respective original estimate, taking into account the OECD and WEF surveys and utilizing data from EC and EMI Rating.

Finland

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
5.0	6.0	7.0	8.5	10.5	12.0	13.5	15.0	16.0	18.0	19.0	21.5	22.5	23.0	24.0	25.0

Original source: The 6th Women Directors and Executives Report 2016 (FINNCHAM, 2016).

Values indicated in blue are based on complemental estimates utilizing FINNCHAM and the EC's Report on Equality between Women and Men in the EU.

Japan

1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
2.0	2.0	2.3	2.9	2.5	2.6	2.8	3.1	3.7	3.2	3.4	4.0	3.6	4.5

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
4.6	5.0	5.1	5.8	6.5	6.6	7.2	7.0	8.1	8.5	8.9	9.4	9.8	10.3

Original source: Health, Labor and Welfare White Paper in Japan (Ministry of Health, Labor and Welfare of Japan, 2013).

Values indicated in blue are based on complemental estimates utilizing GMI Ratings data.

References

[1] Catalyst, Corporate Performance and Women's Representation on Boards, 2005. http://www.catalyst.org/media/companies-more-women-board-directors-experience-higher-financial-performance-accoeding-latest/. Retrieved 11 March 2017.
[2] A. Carrasco, C. Francoeur, I. Real, J. Laffarga, E. Ruiz-Barbadillo, Cultural differences and board gender diversity, HAL (2012) 2–28.
[3] Catalyst, Corporate Performance and Women's Representation on Boards, 2015. http://www.catalyst.org/knowledge/2015-catalyst-census-women-and-men-board-directors. Retrieved 10 March 2017.
[4] A. Daechun, S. Kim, Relating Hofstede's masculinity dimension to gender role portrayals in advertising, Int. Mark. Rev. 24 (2) (2007) 181–207.
[5] European Commission (EC), Database on Women and Men in Decision Making, EC, Brussel, 2016.
[6] European Commission (EC), 2017 Report on Equality between Women and Men in the EU, EC, Brussel, 2017.
[7] FINNCHAM, The Sixth Women Directors and Executives Report 2016-Women Directors on the Rise: Executive Positions Still Going to Men, FINNCHAM, Helsinki, 2016.
[8] GMI Ratings, 2013 Women on Boards Survey, GMI Ratings, New York, 2013.
[9] G. Hofstede, Cultures and Organizations, McGraw-Hill International, London, 2014.
[10] International Labour Organization (ILO), Women in Businesses and Management: Gaining Momentum, ILO, Geneva, 2015.
[11] International Monetary Fund (IMF), World Economic Outlook Database, IMF, Washington, D.C, 2013.
[12] International Monetary Fund (IMF), World Economic Outlook Database, IMF, Washington, D.C, 2014.
[13] International Telecommunication Union (ITU), World Telecommunication Indicators Database, ITU, Geneva, 2014.
[14] M. Jia, Z. Zhang, Critical mass of women on BODs, multiple identities, and corporate philanthropic disaster response: evidence from privacy owned Chinese firms, J. Bus. Ethics 118 (2) (2013) 303–317.
[15] H. Kim, How is South Korea closing the gender gap? World Econ. Forum (2015). http://www.weforum.org/agenda/2015/3qa-how-is-south-korea-closing-the-gender-gap. Retrieved 7 April 2017.
[16] McKinsey & Company, Women Matter 2007: Gender Diversity, a Corporate Performance Driver, McKinsey & Company, New York, 2007.
[17] McKinsey & Company, Women Matter 2016: Reinventing the Workplace to Unlock the Potential of Gender Diversity, McKinsey & Company, New York, 2016.
[18] Ministry of Health, Labor and Welfare of Japan (MHLW), Health, Labor and Welfare White Paper in Japan, MHLW, Tokyo, 2013.
[19] G.G. Moghaddam, Information technology and gender gap: toward a global view, Electron. Libr. 28 (5) (2010) 722–733.
[20] MSCI, Global trends in gender diversity on corporate boards, Women Boards (2015) 1–31. November 2015.
[21] K. Naveed, C. Watanabe, P. Neittaanmäki, Co-evolution between streaming and live music leads a way to the sustainable growth of music industry: lessons from the US experiences, Technol. Soc. 50 (2017) 1–19.
[22] Nihon Keizai Shimbun, Why Firms with Many Women Board Members Perform Better?, 2017. February 4, 2017.
[23] OECD, Women, Government and Policy Making in OECD Countries: Fostering Diversity for Inclusive Growth, OECD, Paris, 2014.
[24] OECD, Background Report: Conference on Improving Women's Access to Leadership, OECD, Paris, 2016.
[25] M.N. Phumzile, ICT as a Powerful Means to Advance Women's Rights Empowerment and Gender Equality, UN Broadband Commission Workshop Group on Gender, New York, 2013. September 2013.
[26] E. Rogers, Diffusion of Innovations, Simon and Schuster, New York, 1962.
[27] Y.E. Stedham, J.H. Yamamura, Measuring national culture: does gender matter? Women Manag. Rev. 19 (2) (2004) 233–243.
[28] The Japan Institute for Labor Policy and Training (JILPT), Survey on Career and Compatibility Support for Male and Female Full-time Employees, JILPT, Tokyo, 2013.
[29] UNDP, Promoting an Economic and Legal Environment for Women's Empowerment, Speech by Helen Clark, 2010. UN Women (2015), http://www.undp.org/content/undp/en/home/presscenter/speeches/2010/03/25/promoting-an-economic-andlegal-environment-for-womens-empowerment-.html.
[30] United Nations, Gender Equality and Empowerment of Women through ICT. Women 2000 and beyond, 2005 (United Nations, New York).
[31] United Nations Educational, Scientific and Cultural Organisation (UNESCO), Institute of Statistics, Women in Science, 2014. http://www.uis.unesco.org/_LAYOUTS/UNESCO/women-in-science/index.html#!lang=en.
[32] UNWomen, Collective Failure of Leadership on Progress for Women. Media Release, 2015. http//www.unwomen.org/en/news/stories/2015/3/collective-failure-of-leadership-on-progress-for-women. Retrieved 7 April 2017.
[33] C. Watanabe, R. Kondo, N. Ouchi, H. Wei, C. Griffy-Brown, Institutional elasticity as a significant driver of it functionality development, Technol. Forecast. Soc. Change 71 (7) (2004) 723–750.
[34] C. Watanabe, S. Lei, N. Ouchi, Fusing indigenous technology development and market learning for greater functionality development: an empirical analysis of the growth trajectory of canon printers, Technovation 29 (2) (2009) 265–283.
[35] C. Watanabe, K. Naveed, P. Neittaanmäki, Co-evolution of three mega-trends natures un-captured GDP: uber's ride-sharing revolution, Technol. Soc. 46 (2016) 164–185.
[36] C. Watanabe, K. Naveed, P. Neittaanmäki, Consolidated challenge to social demand for resilient platforms: lessons from Uber's global expansion, Technol. Soc. 48 (2017a) 33–53.
[37] C. Watanabe, K. Naveed, P. Neittaanmäki, B. Fox, Co-evolution between trust in teachers and higher education toward digitally-rich learning environments, Technol. Soc. 48 (2017b) 70–96.
[38] C. Watanabe, K. Naveed, P. Neittaanmäki, Harnessing Women's potential as a soft engine for growth: lessons from contrasting trajectories between Finland and Japan for growing economies, J. Technol. Manag. Grow. Econ. 8 (1) (2017c) 7–38.
[39] P. Webb, J. Young, Perhaps It's time for a fresh approacj to ICT gender research? J. Res. Pract. Inf. Technol. 37 (2) (2005) 147–160.
[40] J.A. Wiles, C. Wiles, A. Tjernlund, A comparison of gender role portrayals in magazine advertising: The Netherlands, Sweden and the USA, Eur. J. Mark. 29 (11) (1995) 35–49.
[41] World Economic Forum (WEF), The Global Gender Gap Report 2013, WEF, Geneva, 2013.
[42] World Economic Forum (WEF), The Global Gender Gap Report 2016, WEF, Geneva, 2016.

Chihiro Watanabe graduated from University of Tokyo, Japan and is currently Professor Emeritus of Tokyo Institute of Technology, Research Professor of University of Jyväskylä, Finland, and also a Research Scholar, International Institute for Applied Systems Analysis (IIASA). (watanabe.c.pqr@gmail.com)

Kashif Naveed is currently doing his Ph.D. in Economics and Business Administration from the University of Jyväskylä, Finland and he also completed his Masters of Science degree in Economics and Business Administration from the same university. Previously he has Bachelor's of Science degree in Computer Science from the Hamdard University Karachi, Pakistan. (kashif.naveed.dr@gmail.com)

Pekka Neittaanmäki graduated from the University of Jyväskylä in Mathematics and is currently Professor and a Dean of the Faculty of Information Technology, University of Jyväskylä, Finland. (pekka.neittaanmaki@jyu.fi)