

# Towards Overcoming the Limitation of GDP in the Digital Economy: Lessons from the UK's Endeavor and Other Recent Studies

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**Abstract:** Recent development of digital economy has brought discussions on its measure: What activities are emerged in the digital economy? What are produced by those activities? What amount are they? Whether activities emerged by the recent development digital economy are covered by the GDP? Those questions are raised throughout the world -- among national statistical offices, academics, analysts, and other people or organizations concerned.

This paper reviews recent challenges to capture the digital economy such as by statistical offices. Firstly, it focuses on noteworthy challenges by the Office for National Statistics (ONS), which is currently working on assessing the feasibility of developing statistics on the sharing economy, and then looks into issues of “free” products, challenged by other researchers.

Learning from the challenges on measuring the sharing economy by the ONS and the attempts on capturing “free” products by others, this paper considers conceptual framework, such as scope of digital economy, activities emerged and those classifications. Relationship between those activities and the current GDP framework are also discussed. Further, practical ideas to capture the digital economy are suggested.

**Keywords:** Digital economy, limitation of GDP, statistical offices, sharing economy, UK's endeavor.

## INTRODUCTION

The measurement of digital economy is one of the recent emerging issues among national statistical offices, academics, analysts, and other people or organizations concerned. For example, there is a discussion what the definition of digital economy is. The image or concept to the word “digital economy” would be not always the same. Each person could have different definition. When the definition differs, discussion on digital economy might be diversified, or sometimes it could get into confused. The discussion of the accuracy of GDP is one of the big issues, as well as the measurement of welfare – the quality of life. Ahmed *et al* (2016) presented eight measurement issues raised by digitalization (Fig. 1).

This paper mainly focuses on the sharing economy, consumers as producers, and free services, which are in the first, the second, and the fourth issues listed in the Fig.(1). The

1. New forms of intermediation of peer to peer services
2. Consumers as producers : blurring the production boundary
3. Consumer durables and investment
4. Free and subsidised consumer products
5. Free assets produces by households
6. Cross-border flows of intellectual property and knowledge based assets
7. E-commerce
8. Prices and Volumes

Source: Ahmed *et al* (2016)

**Fig. (1).** Eight measurement issues raised by digitalization.

Section 2 reviews recent challenges to capture the digital economy the Office for National Statistics (ONS), which is currently working on assessing the feasibility of developing statistics on the sharing economy. The definition of sharing economy, its terminology, possible data sources to use, and

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methodological idea for measuring digital economy are considered. In section 3, conceptual issues – the difference of the concept between GDP and welfare is discussed. By using a diagram prepared by the IMF (2018), those two differences are clearly explained. In section 4, challenges for capturing free services by the OECD (Ahmed *et al* (2017)) are explained. The section 5 shows an attempt of estimation of “free” products. Practical idea to capture the digital economy, using time-use survey, is considered. The section 6 concludes the paper.

## 2. RECENT CHALLENGES BY THE OFFICE FOR NATIONAL STATISTICS (ONS) ON THE SHARING ECONOMY

### 2.1. Background of ONS Challenges and their Progress up to Now

The Office for National Statistics (ONS) of the UK is currently working on the sharing economy to assess the feasibility of developing its statistics. The starting point of this project was from some publications (e.g., Coyle, 2016; Bean, 2016), requesting the development of statistics on the sharing economy. These reports raised questions to the accuracy of current national statistics in terms of their coverage; whether they reflect recent economic structural changes -- digital economy, especially the sharing economy. The sharing economy is not a new phenomenon, but seem to increase its share in the UK economy.

To answer those questions, as well as to respond recent increasing interests from policy-makers, industry experts and trade bodies, the ONS put the sharing economy as an important aspect of its work program. The ONS has already published reports and presented their progress (ONS, 2016a; ONS 2016b; ONS, 2017). In the latest report released in November 2017, the ONS has developed a conceptual framework to support the collection and dissemination of statistics on sharing economy activities. This paper reviews the report mainly focusing on the definition, terminology, possible data sources to use, and methodological idea for measuring digital economy.

### 2.2. Definition of “Sharing Economy”

In the report, the ONS firstly listed up characteristics of such activities and pointed out issues that could emerge in compiling national statistics towards defining the sharing economy. The characteristics are; 1) operating through an online platform through a website or an app; 2) enabling consumer-to-consumer transaction; 3) temporarily providing access to a good or services with no transfer of ownership – this exclude the second-hand economy in which goods are resold; and 4) utilizing an under-used asset. These characteristics can blur the lines between personal and commercial. The ONS raised car-sharing as an example of peer-to-peer activities. It used to be regarded as “personal.” However, this activity can commercialize by utilizing an online platform such as Uber. The ONS also pointed out that the platform can blur the difference between full-time and casual labor, as well as between employee and self-employed.

Under such situation where there is no widely-accepted definition of the sharing economy, the ONS proposed the definition of sharing economy as “the sharing of under assets through completing peer-to-peer transactions that are only viable through digital intermediation, allowing parties to benefit from usage outside of the primary use of that asset.” As the ONS mentioned in the report, such an attempt to create the definition of sharing economy might help our understanding of its activities and give us new insights how to measure sharing-economy activities.

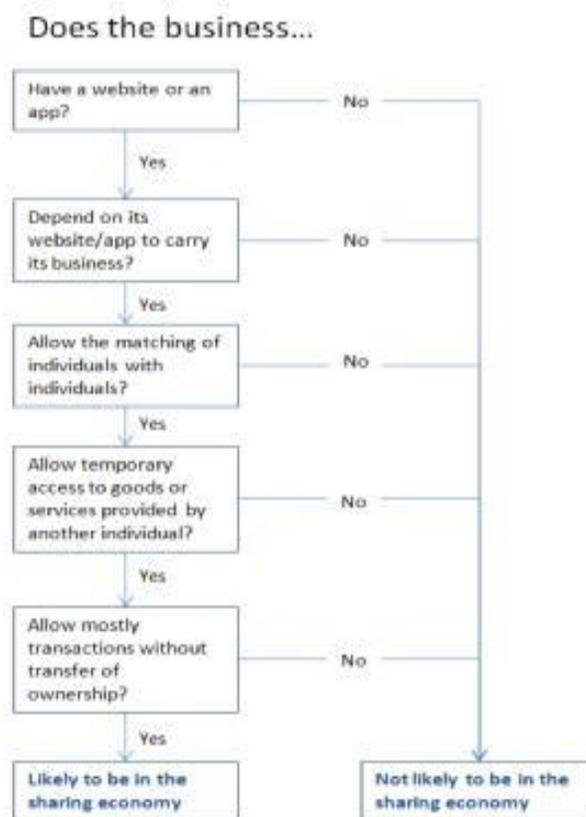
### 2.3. Terminological Issue; is it “Sharing Economy,” “Collaborative Economy,” or “gig Economy” ?

The ONS also took care of a terminological debate relating to the definition of “sharing economy.” There are several popular terms in expressing this kind of activities, such as “sharing economy,”

“collaborative economy,” or “gig economy.” The ONS has opted for the term “sharing economy” as it is perhaps the term which is the most popular and representative of the activities the ONS is looking to measure.

### 2.4. Development of a Decision Tree to Identify Sharing-Economy Businesses

In addition to the definition of the sharing economy, the ONS attempted to identify sharing-economy businesses by developing a decision tree as follows:



Source: ONS (2017).

Fig. (2). Decision tree for identifying sharing economy businesses.

## 2.5. Current Available Data Sources and Potential Future Sources of Information

The ONS looked into current available data sources; 1) E-commerce Survey, and 2) Annual Business Survey. The sharing economy businesses are sampled from those surveys and compared with responses from non-sharing economy in the sample. In addition, the ONS considers possible sources of information; 1) collected information by the questions on the sharing economy in the Opinion and Lifestyle Survey; 2) further development of sharing economy questions tested in the Labour Force Survey; and 3) redesign of Living Costs and Food Survey.

The ONS also posed another idea using time-use surveys, which are used to collect information on how much time individuals spend undertaking different activities. The ONS is working for exploring a new form of time-use survey specially adapted to capture activities performed for sharing-economy purposes and other aspects of the modern digital economy. The information about time spent on the activities could be used as the basis for estimating of the value of the sharing economy. If successful, the ONS will release its results towards the end of 2018.

Another aspect of challenges for not always based on monetary transactions was also pointed out; individuals might be swapping goods or services, with no money being transferred. Although the internationally-agreed definition of GDP excludes non-monetary transactions, such as the provision of free goods or services, by donating, lending, or swapping, the ONS showed its interests to study such area as well.

## 3. DIFFERENCE BETWEEN THE CONCEPT OF GDP AND WELFARE

### 3.1. What is the Concept of GDP?

When trying capture the phenomena emerged by digital economy, conceptual issue must be clarified, especially for “free” products. There are a lot of discussions mixed up the concept of GDP and welfare. As some papers are already explained (Ahmad et al (2016), IMF (2018)), those two are different.

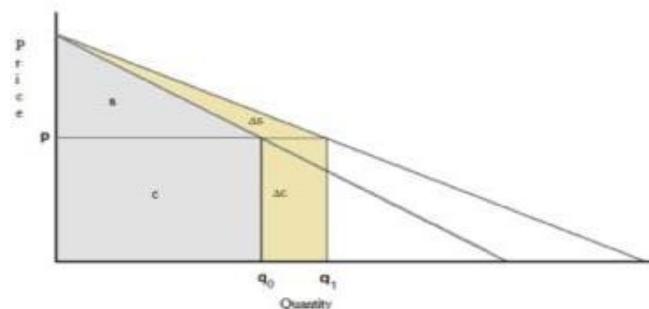
For example, the IMF (2018) pointed out that GDP is a measure of production, specifically market and near-market production valued at market prices<sup>1</sup>. Three approaches, which, conceptually, yield the same answer, are used to estimate this production. GDP may be estimated by: (a) aggregating the value added all resident producers (and adjusting for taxes and subsidies on products), (b) adding final expenditures on household consumption, capital formation, government consumption, and net exports ( $C + I + G + X - M$ ), or (c) adding the income from production distributed to the suppliers of labor and capital or paid as taxes.

<sup>1</sup> Free services of governments and nonprofit institutions serving households are valued at the cost of production.

Ahmed et al (2016) stressed that consumer valuation should not attempt to measure total consumer welfare arising from the use of free digital products, just as the value of traditional market products is not a measure of consumer welfare. Measures of the total value of consumer welfare such as consumer surplus are at odds with the conceptual basis of measuring GDP and income, let alone any welfare measure that goes beyond consumption and encompasses quality-of-life dimensions.

### 3.2. What is the Difference between the Concept of GDP and Welfare?

This section discusses the difference of the concept between GDP and welfare. The total welfare from digital products includes consumer surplus, but consumption recorded in GDP does not. The IMF (2018) presented a diagram to illustrate the difference between the two (Fig. 3). In the diagram below, the initial position of demand curve implies a quantity consumed at price  $p$  of  $q_0$ , making consumption equal to the area of rectangle  $c$ . Consumer surplus, defined as the excess of the willingness-to-pay over the amount paid, is given by the part of the area under the demand curve that is above the price line, the triangle labelled  $s$ . Welfare is measured by the area under the demand curve out to  $q_0$ ,  $c + s$ . Therefore, the level of consumption, measured by price times quantity, underestimate welfare because it excludes the consumer surplus.



Source: IMF (2018).

Fig. (3). Effect of increase in income on consumption and welfare.

When the demand curve to shift to the right, quantity consumed becomes  $q_1$ . In the case where the price is constant, nominal consumption growth, given by  $(c + c)/c$ , equals real consumption growth,  $q_1/q_0$ . Welfare growth, given by  $(c + c + s + s)/(c + s)$ , also equals real consumption growth.

### 3.3. How Amount is Counted as Welfare?

There is a good example of estimation in Brynjolfsson et al (2017), as IMF (2018) cited. Online discrete choice experiments in the paper found that the median amounts that Internet users in the United States would accept to agree to forego digital products are large (Table 1). If household consumption in U.S. GDP were adjusted to include the total consumer surplus of Internet users, its level would increase by about 30 percent. The total welfare from digital products includes consumer surplus, but consumptions recorded in GDP does not. Therefore, comparisons of the total welfare from digital

**Table 1. Median annual consumer surplus from free digital goods, Internet users in the United States in 2016.**

(U.S. dollars)

Digital Product	Willingness-to-Accept
Search engines	\$14,760
E-mail	6,139
Digital maps	2,693
Online videos	991
E-commerce	634
Social media	205
Messaging	135
Music	140
<b>TOTAL</b>	<b>25,697</b>
<i>Memo: Household disposable income per capita in U.S.</i>	<i>43,469</i>

Sources: Brynjolfsson *et al.* (2017), IMF (2018).

products to household consumption or GDP may give an exaggerated impression of the scale of the potential mis-measurement. Nominal GDP is not – and should not be confused with – a measure of welfare.

### 3.4. How Should Products are Treated, Especially when they are “Free” ?

Free products, produced by volunteers, by consumers themselves (“self-service”) are not counted in the GDP, because they are out of the boundary of the definition of GDP – the international standard; the System of National Accounts (2008 SNA), while those by platforms funded by advertising and the collection of user data, are not directly counted in the GDP. If counting those free products to the GDP, they should be counted from three dimensions; (a) production side, (b) expenditure side, and (c) income (distribution) side, consistent with the international accounting rules. The current definition of GDP based on the 2008 SNA is well-organized for key policy questions involving income, employment, monetary policy, potential government revenue, investment and productivity. Changing the definition of GDP in any fundamental way would create more problems than it would solve. For example, putting non-market production by household in GDP could mask important changes in market output, such as the start of a recession.

Nevertheless, digital products from volunteers, and users of digital products as inputs in household production for own consumption, raise some important production boundary questions. Because rapid increases in free digital services and household non-market production made possible by digitalization have widened the gap between GDP growth and household welfare growth. Measures of non-market production and other welfare indicators “beyond GDP” could answer questions such as the impact of digitalization on the welfare of different segments of the population, and how digitalization has changed the way households use their time.

Such indicators “beyond GDP” to supplement the current GDP could be an idea for a better understanding of digital economy.

### 4. CHALLENGES TO MEASURE “FREE” PRODUCTS BY OECD

As OECD (Ahmad *et al.* (2017)) mentioned, free digital products for consumers – such as apps for smart phones, email, search engines, and much of the contents on the Internet – are frequently put forward as examples of output that goes unnoticed in GDP figures despite its contribution to consumer welfare. Although these services are included in GDP in an indirect way, as part of the prices paid for the items that are advertised, this indirect approach means that estimates of household consumption do not explicitly capture these benefits; rather they are captured indirectly through higher costs of advertised products.

Recent emerging free services (e.g., provided by Googles), with a business model funded via advertising, have received high attentions in the discussions of GDP, actually they are not a new type of services though. Traditional free media services, such as television and radio, have also the same business model -- funded via advertising. However, recent discussions have been activated because of the recent rapid increase of such digital free services, and the emergence of a new type of free services – funded via the acquisition of large amounts of information, such as consumers’ preferences, characteristics, and spending patterns. There is a growing recognition that estimates of the value of free services received by households would be useful, as a means of providing improved insights on consumer welfare through a system of satellite accounts. In Ahmad *et al.* (2017), two types of free services, funded via advertising and data acquisition were considered as follows.

**Table 2. User valuation approach: Value of Facebook user data in 2016.**

Area	Number of new users (Millions)	Number of active users (Millions)	Value (Millions of USD)			
			Digital identity	Digital footprint	Total	Total Users willing to pay (15%)
			A	B	C	D
Worldwide	269	1 757	9 684	168 672	178 356	26 753
US & Canada	12	227	432	21 744	22 176	3 326
Europe	26	341	936	32 736	33 672	5 051
Asia-Pacific	133	620	4 788	59 472	64 260	9 639
Rest of the World	97	570	3 492	54 672	58 164	8 725

Source: Ahmad *et al* (2017).

**Table 3. Business valuation approach: Value of Facebook users' data in 2016.**

Area	Number of new users (Millions)	Number of active users (Millions)	Value (Millions of USD)		
			Digital identity	Digital footprint	Total
			A	B	C
Worldwide	269	1 757	142	8 120	8 263
US & Canada	12	227	6	1 047	1 053
Europe	26	341	14	1 576	1 590
Asia-Pacific	133	620	70	2 863	2 934
Rest of the World	97	570	51	2 632	2 683

Source: Ahmad *et al* (2017).

#### 4.1. Financing via Advertising

For an estimation of the impact of media activities financing via advertising on GDP growth, a simple approach is presented in Ahmed *et al* (2017). It is to assigning a value to the free products provided to household, by assuming that it equals the revenue that the producers of these products receive from advertisers. The results of the impact estimated to the growth were small – close to zero on average annual growth from 2009-2013 in OECD countries. The United States showed the most positive impact with increasing 0.07 percentage points to economic growth on average over the period 2009-2013. While Greece shows the most negative impact with declining 0.17 percentage points on average.

#### 4.2. Financing via Data and Databases

In addition to the approach of financing via advertising, Ahmed *et al* (2017) challenged three types of estimations for free services via data acquisition; 1) data valuation based on transaction with users of online services; 2) data valuation by businesses; and 3) data valuation by the shareholders.

##### 4.2.1. Data Valuation Based on Transactions with users of Online Services

As the first estimation for free services via data acquisition in Ahmad *et al* (2017), data valuation based on transaction with users of online services was considered.

This approach estimated the value that Facebook's new and ongoing users might assign to their personal information based on prices that users of online services have paid to protect, or accepted to reveal, their data. The value of users' identity and tracking data, the survey result in 2013, and the number of users were used. For the value of users' identity and tracking data, prices of USD 36 and USD 96 were respectively used. The former used the annual fee that users pay to FastMail as a proxy, while the latter used the annual payment by Datacoup for the right to access a person's digital identity and footprint. The survey result in 2013 was the survey of Facebook users by Greenlight – only 15% of respondents said that they would be prepared to pay Facebook to see no advertisements, with 8%, saying they would pay USD 10 per month. The results of estimation of Facebook are shown below (Table 2).

**Table 4.** Estimates of the stock user data value based on market capitalization and revenues. Facebook and Twitter, 2016.

Company name	Facebook	Twitter
Market capitalisation - Dec 2016 (Billions of USD)	330	12
Number of users (Millions of USD)	1 757	315
Revenue (Billions of USD)	28	3
Per user valuation (USD)	188	37
Average Revenue Per User - ARPU (USD)	16	8

Source: Ahmad *et al* (2017).

**Table 5.** Participation rate in activities and average time spent in activities for participants for use of smartphones and PCs by sex, by kind of activity (2016) – weekly average.

Kind of activity using smartphone/PC	Participation rate (%)			Average time for participants (hours minutes)		
	Total	Male	Female	Total	Male	Female
Total	50.4	53.8	47.2	3.35	4.12	2.54
Paid work	13.1	18.2	8.4	4.59	5.12	4.32
Unpaid work	6.2	4.1	8.1	0.44	0.54	0.39
Housework	3.7	2.0	5.4	0.38	1.07	0.32
Child care	1.0	0.5	1.4	0.38	1.01	0.30
Shopping and using services	1.9	1.5	2.2	0.33	0.33	0.33
Schoolwork, learning, self-education, and training	2.0	2.0	1.9	2.01	2.22	1.49
Personal care	11.0	10.2	11.8	0.33	0.30	0.35
Free time	45.0	47.1	43.0	2.11	2.27	1.55
Social life	8.1	6.4	9.8	0.56	1.05	0.49
Entertainment, hobbies and culture	34.5	37.5	31.7	1.46	1.58	1.31
Mass media	21.5	21.6	21.3	1.22	1.33	1.12
Other	1.6	1.3	1.9	0.48	0.47	0.47

Source: MIC (2017).

The result of this estimation showed that the impact on growth rates from including these free services in the accounts was likely to be negligible. For example, for the US and Canada, the total value of USD 22.2 billion amounted to around 0.1% of GDP. In addition, if taking account the survey in 2013 – there were only 15% of users prepared to pay Facebook without seeing advertisements, the impact of including free services would be closer to 0.01% of GDP.

#### 4.2.2. Data Valuation by Business

As the second estimation for free services via data acquisition in Ahmad *et al* (2017), data valuation by businesses was challenged. The value of different kinds of user data released by the Financial Times and the number of users of each company were used. The results of estimation of Facebook are shown below (Table 3).

This estimation approach by company was extended to include some other major providers of free digital services (Facebook, Twitter, Instagram, LinkedIn, and Gmail). The

results suggested that the value of use data as a share of GDP was quite marginal. It was around 0.02% at the global level, although this excludes other major providers of free digital services such as those in China.

#### 4.2.3. Data Valuation by the Shareholders

As the third estimation for free services via data acquisition in Ahmad *et al* (2017), data valuation by the shareholders was studied. The value of a company when acquired was used under the assumption that the asset of the company acquired would be the dataset on registered individuals. For example, at the time WhatsApp acquired by Facebook, the stock of data on each user registered with WhatsApp was estimated its worth as around USD 30.

In addition, the official quarterly financial reports and other information freely available, such as the value of the market capitalisation, the number of users, and the revenue, were used to estimate the “per user valuation”, and the “average revenue per user” as below (Table 4).

**Table 6. Value of “Free” Products in Finland, Estimated by Using Time-use Survey.**

	Estimated value of "free" Products (Million EUR)		Private Consumption Expenditure, Current Price (Million EUR)	Gross Domestic Product, Current Price (Million EUR)	Polupation Over 10 Years Old (Persons)	Average earnings, all Sectors Total (EUR/month)
	Lower-Bound	Upper-Bound				
2000	1,743	3,486	65,139	136,261	4,563,416	2,037
2001	1,834	3,668	68,771	144,437	4,586,332	2,133
2002	1,911	3,823	71,741	148,289	4,608,637	2,212
2003	2,001	4,002	75,526	151,569	4,629,880	2,305
2004	2,091	4,183	78,511	158,477	4,653,484	2,397
2005	2,190	4,380	81,876	164,387	4,677,215	2,497
2006	2,265	4,529	86,330	172,614	4,699,609	2,570
2007	2,349	4,698	91,052	186,584	4,722,607	2,653
2008	2,503	5,007	96,100	193,711	4,744,494	2,814
2009	2,640	5,281	95,212	181,029	4,765,527	2,955
2010	2,697	5,393	99,553	187,100	4,784,308	3,006
2011	2,775	5,550	105,771	196,869	4,805,174	3,080
2012	2,881	5,762	109,108	199,793	4,825,611	3,184
2013	2,962	5,924	111,277	203,338	4,847,391	3,259
2014	3,014	6,027	113,635	205,474	4,867,444	3,302
2015	3,061	6,122	115,916	209,604	4,885,212	3,342
2016	3,101	6,203	119,005	216,111	4,906,863	3,371
2017	3,136	6,271	121,874	223,843	4,924,556	3,396

Source: Author's calculation based on statistics published by Statistics Finland.

## 5. IDEA FOR DEVELOPPING INDICATORS “BEYOND GDP” TAKING INTO ACCOUNT “FREE” PRODUCTS

### 5.1. Idea for Estimation using Time-Use Survey

Taking the idea from the ONS challenges mentioned in the section 2.5, this section attempts an estimation of “free” products in Finland. In this estimation, the time-use survey of Japan for the year of 2016 is used as a proxy. In the survey, an item for the time use of smartphone and PCs is available.

Looking at the proportion of persons who used smartphones and PCs (participation rate in activities) by kind of activity, the participation rate in activities of people who used these devices during their “Free time” was highest at 45.0%. On the other hand, looking at the average use time of people who did use these devices (average time spent in activities for participants), use time was the longest for people who used these devices during “Paid work” at 4 hours and 59 minutes (Table 5).

In the survey, the average time spent using smartphone and PCs for all persons (specifically, populations of 10 years and over) is also available, which is 90 minutes. Although, as the average time spent using smartphone and PCs by kind of activity for all persons is not available, the assumption is made. The half of its total – 45 minutes is regarded as the time spent for final consumption by household.

### 5.2. Tentative Result of Estimation for Finland

The value of “free” products spent by household in Finland is estimated by the time spend using smartphone and PCs, average earnings, and population (i.e., [value] = [time spend] x [average earnings] x [population]). The time spent using smartphone and PCs (45 minutes) is used for the upper-bound, while the half of it (22.5 minutes) is set for the lower-bound, taking into account that smartphone and PCs are often used in parallel with other activities (Table 6).

The tentative result shows the share of value of “free” products to private consumption expenditure at current price from 2000 to 2017 is around 5% for the upper-bound, and around 2.5% for the lower-band, while that to GDP is around 2.5–3.0% for the upper-bound, and around 1.5% for the lower-band (Table 7).

**Table 7: The share of value of “free” products to private consumption expenditure, and to GDP in Finland, estimated by using time-use survey**

	Estimated Value of "Free" Products/Private Consumption Expenditure (%)		Estimated Value of "Free" Products/ Gross Domestic Product (%)	
	Lower-bound	Upper-bound	Lower-bound	Upper-bound
2000	2.68	5.35	1.28	2.56
2001	2.67	5.33	1.27	2.54
2002	2.66	5.33	1.29	2.58
2003	2.65	5.30	1.32	2.64
2004	2.66	5.33	1.32	2.64
2005	2.67	5.35	1.33	2.66
2006	2.62	5.25	1.31	2.62
2007	2.58	5.16	1.26	2.52
2008	2.60	5.21	1.29	2.58
2009	2.77	5.55	1.46	2.92
2010	2.71	5.42	1.44	2.88
2011	2.62	5.25	1.41	2.82
2012	2.64	5.28	1.44	2.88
2013	2.66	5.32	1.46	2.91
2014	2.65	5.30	1.47	2.93
2015	2.64	5.28	1.46	2.92
2016	2.61	5.21	1.44	2.87
2017	2.57	5.15	1.40	2.80

Source: Author's calculation based on statistics published by Statistics Finland.

## CONCLUSION

Recent development of digital economy has brought a lot of discussions. The measurement of digital economy is one of the recent emerging issues among national statistical offices, academics, analysts, and other people or organizations concerned.

This paper mainly focuses on the sharing economy, consumers as producers, and free services. Firstly, this paper reviews recent challenges to capture the digital economy such as by statistical offices, mainly focusing on noteworthy challenges by the Office for National Statistics (ONS), which is currently working on assessing the feasibility of developing statistics on the sharing economy. The definition of sharing economy, its terminology, possible data sources to use, and methodological idea for measuring digital economy are considered. Secondly, conceptual issues – the difference of the concept between GDP and welfare is discussed. By using a diagram prepared by the IMF (2018), those two differences are clearly explained. Thirdly, challenges for capturing “free” products by the OECD (Ahmed *et al* (2017)), and an attempt using the time-use survey, the estimated value of “free” products spent by household in Finland are explained.

The results of estimations of “free” products are varied. The attempt to estimate “free” products consumed by the household in Finland needs to further studies, especially in terms of time series data of time-use survey with disaggregated categories. The double counting issue is also necessary to be solved. The ONS studies to be published towards the end of 2018 would be import reference to improve the estimation using time-use survey.

## ACKNOWLEDGEMENTS

The research leading to these results is the part of a project: Platform Value Now: Value capturing in the fast emerging platform ecosystems, supported by the Strategic Research Council at the Academy of Finland [grant number 293446].

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Received: October 01, 2018

Accepted: November 01, 2018

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