Free Services from the Digital Economy: Do We Need to Measure Their Value and How?

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Abstract – For several years now, the economy has seen a change in consumption habits, driven by the development of digital technology. New products and services and new economic models have emerged, and value chains have changed. This raises many questions for national accounting, including how to take new forms of free services into account. There are three possible options for trying to assign these services a monetary value: *(a)* on the basis of the advertising income for those services that are indirectly financed through advertising, *(b)* direct valuation of the service provided to the users, by assessing their willingness to pay or by using the standard methods for valuing time spent on domestic tasks, and *(c)* valuing the data generated through the use of these services, which constitute another way of guaranteeing the immediate and long-term profitability of such services. Beyond practical difficulties of their implementation, another issue is that the three options do not all answer the same questions, which ultimately raises the issue of the purpose of the national accounts.

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The economy has been experiencing a radical transformation in recent years as a result of the increasing use of information technologies. These technologies are changing consumption habits. In 2018, 88% of the French population (57.3 million people) were internet users and 58% were active on social networks.[1] The average time spent on the internet in France in 2019 reportedly reached or even surpassed that spent in front of the television,[2] at 3 hours 20 minutes per day, including 1 hour 22 minutes on social media. This has been made possible with the emergence of new players and new economic models in which prices have seemingly lost a large part of their usual significance. Some services can be accessed at very low prices, while others are entirely free of charge, at least in appearance, since in practice, several free or pseudo-free models can be combined: fully free and funded by donations or open-source funding, different types of pseudo-free services funded by advertising and/or data collection, or even freemium models with chargeable add-on options. *Wikipedia*'s services are a perfect example of an entirely free service funded mainly by donors. *Facebook*'s services are indirectly funded by advertising and data collection. *YouTube* is funded through advertising and data collection, but also offers users the option of paying a fee for ad-free use and makes occasional payments to some content providers.

These phenomena are not entirely unprecedented. Renewing and diversifying goods and services have always been one of the main drivers of growth, and free or pseudo-free services are not new: television broadcasting, for example, has existed for a long time. However, the development of the internet and the capacity of networks to exchange large quantities of information on a massive scale (scalability) has created a technological breakthrough that has allowed these networks to reach unprecedented sizes, while also raising the question of how to include these in the national accounts. As there are no direct monetary transactions between the producer and end user, these free or pseudo-free services offered by the digital economy do indeed appear to be a glaring gap in the statistics of household consumption and, in the same way, seem to be "missing" from the GDP.

In reality, although the national accounts aim to describe the economic reality as accurately as possible, they do this primarily using market transactions. There are just two exceptions to this rule: public service production and the inclusion of imputed rental income for the housing services that owner-occupiers provide for themselves. These two exceptions are due to the need for international comparability: production and living standards must not appear lower in countries with strong public sector development or with high rates of home ownership. These two derogations can also be explained by the fact that it is possible to manage them with relatively natural imputation rules: assessment at production cost for public services and reference to market rents for imputed rents. There are no equivalents for the other types of free or non-market services. As it is, the treatment of these services follows the very minimal recording criteria that were agreed in the SNA 2008 (System of National Accounts) and implemented at European level in the ESA 2010 (European System of Accounts). Pseudo-free services funded by advertising are not included in household consumption: only advertising costs are accounted for as intermediate consumption by the advertising companies that rely on them. And those services that are truly free are only included up to their apparent production costs, ignoring any voluntary contributions from which they may benefit.

It is, therefore, true that the "digital replacements" currently in progress translate into a form of household consumption that is not included in the GDP, and which could, all other things being equal, even lower it. This calls us to question these criteria adopted by the SNA 2008 and ESA 2010 and the questions that we must address are many and complex. Do we need to assign a value for final consumption expenditure to households to reflect the free services from which they benefit? In the case of advertising companies that sponsor these services, do we need to consider that this is just one cost among others (recorded as intermediate consumption) or is this also, to some extent, an investment (gross fixed capital formation)? Where this financing of free services is supplemented by or fully reliant on data collection, do we need to consider that these data are a form of production by households leaving digital footprints or can we see this as an "inert raw material", the production of which does not merit valuation?

This article is going to show the complexity of these questions by considering the three potential ways of measuring the value of the free services currently at issue, which have, in

1. *Hootsuite and We Are Social 2018 Digital Report.*
2. *Sources: Zenith Media, 2019.*

some instances, been subject to initial attempts at implementation. These are: *(a)* measuring value on the basis of advertising income for those services that are indirectly financed through advertising, *(b)* directly assessing the service provided to the users, by assessing their willingness to pay or by using the standard methods for valuing the time spent on domestic tasks, and lastly *(c)* valuing the data generated through the use of these services, which constitute another way of guaranteeing the immediate and long-term profitability of such services. Our general guiding principle will be to ask what exactly it is that we want to measure. The fact that free services are not included in the GDP does not necessarily mean that they are underestimated or that we must systematically find ways of supplementing this with indirect valuations of these free services; this depends on how we want to use this indicator.

1. First Proposal: Using Advertising Income to Measure the Value of the Free Services That Are Indirectly Financed through Advertising

1.1. A Debate Dating Back to the 1980s

The first option for measuring the value of free services is based on measuring the advertising income that funds them, which corresponds to a traditional "input" approach used in the national accounts (cost-based valuation). Even if this gives the impression of putting things in a new light, this topic is nothing new for national accountants, as this question had already been raised under the same terms for measuring the value of recreational television programmes funded through this same advertising channel. This is what is known as a two-sided market (see Box 1), with one side aimed at the advertisers and the other at television viewers benefitting from free-of-charge broadcasting of recreational programmes funded by the advertising expenditure of these advertisers. If this form of recreational leisure is a substitute for purchasing tickets for performances, do we need to find a way to prevent this substitution from being considered in the national accounts as a drop in both consumption and production?

Until now, the predominant stance has been that such a correction was not necessary, at least in nominal terms, given that the consumer was already paying indirectly for this service through the heightened prices of the products "sponsored" by advertising, which cover these costs. This was, for example, the stance taken by Okun (1971). He recognised that valuing consumer expenditure on television broadcasting at zero was the "most puzzling single consequence" of the rules for processing the intermediate expenditure of companies. Although he accepted that these services are part of consumption, his view was that, as the services are not paid for on the market, they cannot be assessed and should therefore not be added to the GDP. He believed that "so long as radio and TV programs are free goods to the consumer, it is as meaningless to put a price tag on what comes over the airwaves as it is to put a price tag on air itself".

Several economists have, however, advocated for the opposite (in particular, Jaszi, 1973, Eisner, 1978 and Kendrick, 1971) as they believed it necessary to impute a value for these sponsored services from which consumers benefit. This option was developed in greater detail by Cremeans (1981), who proposed a scheme for extended measures of consumption and income by imputing flows so as to better account for household consumption of television programming that is, on the surface, free of charge. Cremeans underlines the specific nature of this type of exchange "in kind", which explains why it is not included in market flows.

Box 1 – **Two-Sided Markets**

A two-sided market refers to the activities of intermediation platforms that enhance positive externalities either one-way (audience platforms) from users to advertisers, or cross-cutting (marketplaces, application platforms, etc.) by targeting two or more markets at the same time and forming the two sides of the market. There are several examples of the latter phenomenon: intermediation between readers and advertisers by the media or between card-holding consumers and merchants *via* credit cards. In this model, the pricing on each side covers the interdependence between the two. The platform must have at least two distinct user groups or "sides" that produce mutually positive externalities. In terms of pricing, users on the side with the greatest price sensitivity (internet users) are charged a lower price than the marginal cost; the price may even be zero (free service) or negative (subsidised). Users on the other side of the market, who have a lower price elasticity (advertisers) are charged a price higher than the marginal cost. This creates cross-subsidies between the two sides.

In his scheme, which requires the creation of a new subcategory of services (listening to advertising services), advertising companies buy entertainment services from television companies in order to remunerate in kind the service of listening to advertising messages provided by households. Advertisers thus buy this listening service from households and remunerate them in kind through the benefit of entertainment programmes.

This scheme leads us to consider households that watch the television as a display enterprise selling time and entertainment space to television companies. This is described in Vanoli (2002, Box 28), who proposes a variation on the theory. Working from the initial idea that advertising expenditures cover the actual cost of both advertising programmes and entertainment programmes, he proposes a three-part scheme that implicitly represents a two-sided market:

- Advertisers consume a service (for which a value may be imputed) provided by households when they listen to advertising messages and a message broadcasting service (not imputed) provided by the television company.

- The television company provides an advertising programme broadcasting service to the advertisers and an (imputed) entertainment programme broadcasting service to households.

- Households consume the entertainment programme service provided by the television company in exchange for providing the service of listening to advertising messages from advertisers.

In the more recent context of digitalisation, and working from the observation that the "free services" and information from the internet that are funded by advertising income have a major impact on consumer behaviour, Nakamura & Soloveichik (2015) propose a new scheme for imputing such values that is relatively similar to those suggested by Crameans and Vanoli. That approach, however, is not based on costs, but on time spent. Cost-based approaches are often criticised for not taking markup-type margin behaviour into consideration; this is the type of pitfall that an approach based on time spent can avoid. By separating time spent viewing advertising from income per hour created by that same advertising, they give value to the time spent by households (distinguished from that spent by companies, which would be intermediate consumption) watching the adverts themselves, by considering this to be an act of production remunerated by the advertising company, which, in turn, pays for a right to broadcast with a broadcasting company. By taking all media into account, they identify a partial compensation (general equilibrium effect), but with a global effect that, ultimately, proves to be fairly negligible: between 1980 and 2013, they note an increase in the global growth rate of 0.018% per year.

This estimate does not include the consumer surplus and corresponds to a relatively conventional value imputation in the national accounts, in a similar way to imputed rents. The partial compensatory effect observed by the authors calls into question the "net" effect (in volume) on the advertising market made possible by the development of communication channels formerly owned by other operators (Tech Giants *vs.* historical operators).

1.2. Advertising Expenditure: Intermediate Consumption or Investment?

Of course, there are other possible ways of taking advertising expenditure into account. And even if this forces us to re-examine the issue of treating advertising costs as intermediate consumption for advertising companies, can we not instead choose to see these costs as intangible investments? After all, advertising influences consumers in various ways. It allows companies to influence the distinctive attributes of a brand, which are points of reference for consumers and often bring with them an ecosystem of values. Even in the background, advertising relies on people's memory structures, and its effects continue beyond the short term. Thanks to these characteristics, advertising helps to give value to a "brand" asset and a "produced" asset and contributes to advertisers' future return potential through a cluster of intangible assets that they hold or support. These intangible assets can act in various ways, for example by consolidating or strengthening a market position, or even increasing price positioning. Nakamura (2005), for example, observes that advertising increases company sales in the long term and should be considered as an investment in brand image.

Considering advertising in a new light, as an investment, is therefore another way of recording it in the GDP. There may, of course, be objections to this in the fact that "brand" assets are not considered as investments in the ESA 2010 on the basis that this is a zero-sum game in which the main impact of investments

in a brand is observed in terms of market shares between product classes that are close substitutes without net value creation, and therefore without the associated net revenue stream. However, this argument is contested by Corrado & Hao (2014), who deem that there is no proof supporting the zero-sum view, especially in an innovation economy with conveyors of market power between economic actors.

Therefore, if we consider that there is a net investment here, we could initially record an investment by the brands (*via* the advertisers), which would then lead us to record the production of a usage service, which, for the brands whose value has been increased through advertising, would consist in raising their prices in accordance with consumer trends (increased by the brand's intangible assets) in purchasing the sponsored product. The extra cost generated here would be equivalent to a form of royalty collected by the brands over time through the management of their intangible assets.

1.3. If There's No Such Thing as a Free Lunch, Who Pays at the End of the Day?

In order to decide between these various valuation options, we propose drawing up a typology of the situations, distinguishing between those that potentially fall into the categories of final consumption, intermediate consumption and intangible investments. Rather than describing all the relationships within the categories, we will simplify the relationship by considering a direct link between the upstream party (the advertiser issuing the advertising) and the downstream party (the consumer benefitting from access to a free, sponsored service). This simplification requires us to assume that there is intermediate consumption at the level of the companies playing an intermediary role (advertising agencies, content providers, etc.) at the point where the two sides of the market meet. Households benefit from a free service (recreational television programmes, for example) in the short-term (immediately). For the advertiser, advertising is a short-term cost; however, that cost can be recorded either as intermediate consumption or as an investment.[3] This is not a neutral choice; it has an impact on GDP as intermediate consumption is substracted from production when calculating the added value, whereas investment is added to the final expenditure. There is still uncertainty as to whether the advertiser will offset these costs through its sales prices or the quality of its service, depending on its production function. We can therefore define two stakeholders on this two-sided market:

- On the household side: recreational services that households access may potentially be recorded immediately as household consumption. The influence exerted by advertising may also lead to final consumption deferred in the medium or long term.

- On the advertiser side: they "sponsor" these recreational services, the expenses incurred immediately have expected benefits (in their revenues) that could be recorded in the short term as intermediate consumption, and in the medium-long term in the form of investments (gross fixed capital formation).

What are the advertisers' reasons for advertising? Either they expect financial benefits, or this is not the case, or in a very indirect way. The legitimacy of imputing a value for household consumption expenditure could depend on the way in which advertisers pass on their advertising costs in their prices:

- If this translates into a change only in price, whatever the term, the cost of the advertising is already included in the extra cost of the sponsored products or brands. This extra cost may be likened to a form of "tax", which of course generates more apparent consumption in terms of value, but not in terms of volume. It does not, therefore, seem legitimate[4] to assign an additional consumption expenditure to households for free sponsored services (as this risks counting these twice). Although there is ultimately no impact on volume, we may still be tempted to impute some value for volume in respect of the recreational service itself. This brings us back to the question of the objectives of measuring this.

- If this does not translate into a change in market prices, either this involves redistribution within a zero-sum market (constant volume, no extra cost of sponsored products), or an expansion of the market (increased total volume of sales, uncertain impact on the potential extra cost of sponsored products) through repositioning of the stakeholders. The consumers are the

3. Here, we do not believe it is possible to record this as individual company consumption expenditure, as the existence of this was rejected by the SNA 2008.

4. Legitimate in the sense that the users do not pay for this indirectly elsewhere and are the net beneficiaries (as the free service is of greater value to them than the cost). However, as these costs are difficult to measure due to the many factors involved and the fact they are sometimes difficult to identify (cost of viewing the advertising, the windfall effect of time spent in front of the television, etc.).

net beneficiaries in this situation as they access a service free of charge without this indirectly leading to an increase in the prices of the goods and services consumed. In this case, it would be legitimate to impute a value for part of the additional household consumption expenditure for free sponsored services; however, which part is still unknown.

This probably leads to segmentation by the types of goods sold by the advertisers: luxury goods should probably see more of a change in terms of prices and volumes, while budget goods are likely to see a greater change solely in terms of volumes. Where there is no expectation of financial benefits (for example, political influence, reputation management), we can assume that there may be future consumption connected with the broadcasting of the advertising, in which case this would only translate into potential profitability of the underlying intangible assets. We cannot, however, exclude the possibility that this translates into future consumption choices. In this case, this brings us back to the expectation of implicit financial benefits in the medium and long term.

Nevertheless, the approaches attempting to use the measured value of advertising as a basis suggest, at best, a prospect of profitability for the advertisers by attempting to identify who ultimately bears the cost (either the advertisers or the consumers in the form of a tax). These approaches therefore appear to miss the core subject: quantifying the benefit that the consumer gains from recreational services funded by this advertising.

1.4. Direct Imputation of Household Consumption Expenditure: Pros and Cons

There are several factual arguments in favour of imputing a value for expenditure for consumption of recreational services, so as to translate this benefit that households gain from these services into financial terms. An initial argument holds that if the consumer were to pay a fee to remove advertising, such as in *YouTube*'s "Premium" service, which offers users the option to pay a fee of around €10 per month to watch videos without adverts and offline on mobile devices, and gives access to exclusive content, we would record this amount as household consumption. Likewise, an ad-free newspaper would cost more for the consumer and would mechanically increase their consumption expenditure.

Furthermore, the methodological concepts that apply to the non-market sector consolidate this type of treatment, even if the transposition of this non-market treatment to the market sector does not always appear to be straightforward (Box 2 *infra*). In the case of free or almost-free public services, for example when cities make public transport services free of charge, the subsidised part of the expenditure is not included in household consumption expenditure but is, to a certain extent, reallocated as public administrations consumption expenditure *via* a transfer scheme. This mechanism makes the analogy with the principle of a tax quite clear. Indeed, where a public service stops charging for a service, there is still an instance of production recorded in the national accounts. The transition to a free service either has no impact on the production (if it is initially commercial) or changes it to a certain extent due to the difference between the market and non-market valuations (on the basis of costs). The production is therefore almost unchanged but, conversely, on the income and demand side, there is a drop in gross disposable income (GDI) and consumption in the amount of the price of the service. This is reconciled through adjusted gross disposable income by reallocating to households the public service made available to them. The transition to a free service does not, therefore, mean that the service production disappears; it simply changes the structure of the flows, specifically the distribution between consumption among households and consumption expenditure of government agencies.

Although, by analogy, we can consider that the rise in prices generated by advertising can, in some respects, be likened to an advertising "tax", it is nevertheless useful to highlight its specific nature: this would be a tax levied by companies on households (in return for their funding of free recreational services) and not the more traditional notion of tax that passes through public administrations (which play an intermediary role) and is ultimately redistributed among households.

Under the second hypothesis, which assumes that advertising increases the price of the advertised goods, any goods or services would include an immaterial "extra cost" associated specifically with reputation of the brand or the product itself, an extra cost acquired in part through advertising. In this case, this would purely affect the price, and have no impact on volumes. However, Nakamura & Soloveichik (2015) believe that the notion that the cost of the advertising is included in the products consumed supposes that consumers will automatically

Box 2 – **Free Services in the Market and Non-Market Sectors: A Smokescreen Analogy?**

The analogy between the rules of the non-market sector and the potentially equivalent treatment methods in the market sector can be called into question. Indeed, Robert Eisner (1988) notes that "Where we do not count production, we do not have a component of national income, with the curious exception of output related to government subsidies or losses in government enterprises." He believes that identifying the purchases of the various actors (households, companies, government agencies) as intermediate products results in anomalies regarding the sometimes changing identity of the purchasers. Hence, "the police services purchased by government are final products and are included in the GDP, while services of guards or watchmen purchased by a company are not; they are presumably resold as part of the business production in which they are used." Eisner believes that "in general, the difficulties arise from the inadequacy of market sales and purchases as measures of production". The government agency sector has specific features that, due to their nature, require conventional processing. It is therefore sensible to consider the analogy between the processing carried out in market and non-market sectors with caution.

purchase the sponsored products, yet, there is no legal obligation to buy, even if we were able to assume that this effect must be seen partly at the macroeconomic level, otherwise advertising would not be an economic incentive. Imputing a value for household consumption expenditure would, in this case, result in double counting. Cremeans (1981), on the other hand, does not fully reject the principle of potential double counting, drawing an analogy with the non-market example of VAT treatment (which suggests an analogy with an advertising "tax"). However, here once again, the parallel with processing in the non-market sector is not necessarily self-evident (cf. Box 2).

We can also conceive of other ways of measuring the value of free services, for example by calculating the time spent on these services, or even by trying to directly quantify the welfare gained from these services. The characteristic common to both of these ways of measuring value is an attempt to quantify the service provided to users.

2. Second Proposal: Direct Evaluations of the Service Provided to Users

Measuring the value of free services through, for example, an attention-based service raises the question of where to set the boundaries, and of what it is that we actually want to measure. A first option consists in valuing the time that a person dedicates to accessing content, in the form of opportunity cost, on the basis of an equivalent in terms of salary as a shadow price for the entertainment service, similar to the way in which the value of domestic activities is measured. The second approach consists in quantifying the "welfare" that consumers gain from the free service by evaluating their willingness to pay to access a service, or willingness to accept compensation to forgo access to a service.

2.1. Measuring the Value of Free Services on the Basis of the Time Spent in the Form of Opportunity Cost: At What Cost, and Where Do We Stop?

Brynjolfsson & Oh (2012) go beyond imputation in accounting terms by considering that even when people do not pay cash, they must still pay "attention", or spend time. They measure a consumer surplus through an opportunity cost of time spent on the internet by incorporating an annual quality effect of the digitalisation of the economy as well as substitution elasticities among media and between online and offline activity. They estimate the increase in consumer surplus created by free internet services to be over $100 billion per year in the United States (i.e. a 0.74% increase of the rate of annual GDP growth between 2007 and 2011). This estimate is significantly higher than that of Nakamura & Soloveichik (2015). These authors consider that most of the welfare gained from internet-based digital services would be overlooked by purely monetary approaches.

But where do we set the boundaries for measuring the value of attention time? The question of the accounting scope to be used for a potential imputation poses the risk of including non-digital contributions, for example widening the perimeter to include all leisure activities, or even the entire knowledge-based economy. For example, should we reclassify training as an intangible investment, or even education as a whole (Jorgenson & Fraumeni, 1992), and what about anything that can contribute to enhancing human capital?

In an approach similar to that of Brynjolfsson & Oh (2012) but with a wider scope, Goolsbee & Klenow (2006) suggest, for example, measuring the value of the internet on the basis of the time spent using it. Noting that the digitalisation of the economy has, in particular, led to an increase in the time spent by internet users on their computers, they use data on time spent online to estimate the welfare gains, which leads them to impute an additional consumption of between 2,500 and 3,800 dollars for the median household. They assess the opportunity cost of time spent on the internet and, using a simple utility model, calculate the consumer surplus associated with internet access, which differs from a more conventional approach based on costs (internet subscription and computer equipment, modem, etc.). This approach is based on the calculation of the consumer surplus, meaning it has a welfare focus and incorporates a measure of the value of leisure time in particular.

More specifically, this approach requires to consider that time spent on the internet is, in part, equivalent to productive activities (for example, booking a trip yourself rather than going to a travel agent) and that the measurement of its value is just one specific case of the more general valuation of domestic work. If we followed through with this approach, we would stumble upon the age-old problem of the value of all time spent performing domestic work. This question was recently addressed again by Roy (2013). Using the 1998 French Time Use Survey, she determines that the contribution of domestic work to household welfare makes a contribution to national production equivalent to 17.5% of GDP (and 27% of GDP under a broader definition of domestic work). This valuation is based on costs, by calculating the product of the number of hours of domestic work and a market price (the gross hourly minimum wage). It may seem preferable to use the opportunity cost, i.e. the wages of the person on the labour market, but, in reality, this approach would measure the wage differences between categories of individuals – and, across time, the change in wages – rather than the actual value of domestic work. In 2011, the OECD also highlighted the highly sensitive nature of assessing production from domestic services at the value attributed to the labour cost. Imputing an equivalent value in terms of time spent is itself, therefore, a complex issue.

2.2. Measuring the Value of Free Services on the Basis of Willingness to Pay or Accept Compensation: An Exhaustive Scope, Clear Objectives, but Tools Are Still Limited

More recently, and believing once again that the official statistics lack a growing portion of the real value created in our economy, Brynjolfsson *et al.* (2019) refined the previous approaches by suggesting a measure of new and free goods (which are generally insufficiently recorded in the national accounts) based on an empirical measurement framework of the willingness to accept compensation to forgo a service over a given period. This approach quantifies the benefits rather than the costs and defines an extension to GDP within a new indicator "GDP-B". This methodology is applied to several empirical examples and allows estimating the additional welfare gains associated with the use of *Facebook*, for example, between 0.05 and 0.11 percentage point of the US GDP-B growth per year in 2017. The benefit of this approach is that it allows us to include all types of free services: it is not limited to the advertising model, which ignores the value of digital services produced without compensation (e.g. *Wikipedia*), and neither does it arbitrarily impute an opportunity cost, which could be said to have questionable legitimacy.

While this method appears to be more substantive than previous works, it also highlights the limits of a macro assessment based on micro samples and questions the additivity of the utility. Indeed, one of the tests of willingness to accept compensation was carried out with a restricted sample of platforms (*Instagram*, *Snapchat*, *Skype*, *WhatsApp*, *Maps*, *LinkedIn*, *Twitter* and *Facebook*) and revealed that, by far, the most important value (five times greater than *Facebook* in second place) is that attributed to *WhatsApp* (€536 per month, compared with €97 for *Facebook* and €59 for *Maps*, and just €0.18 for *Skype*). The interviewees also stated that, for them, *WhatsApp* was an almost indispensable communication platform. We can assume that the smaller the number of substitutable services among those both within the suggested sample and beyond, the higher the suggested value; there need only be one service outside the survey that is fully capable of replacing a service within the scope of the study for the latter to lose a significant percentage of its value. For example, as *Skype* offers a similar service to *FaceTime*, which was not part of the sample, we can theoretically assume that this made a considerable

contribution to reducing the value of *Skype*. Even if the authors were to make corrections to manage this phenomenon, the resulting sampling effect seems to limit this type of evaluation, preventing us from extrapolating and then imputing a value for the entire economy.

2.3. Regarding the Questions that the Suggested Imputations Aim to Answer, the Proposed Approaches Face Several Pitfalls

The different imputations that we have just reviewed all aim to answer several questions, but these answers may be called into question. The first obstacle is the difficulty in establishing the volume-price splits. The approaches developed by Cremeans and Vanoli are methods for measuring the value of the attention service provided by households in viewing advertising, at a level close to the underlying advertising cost, which shifts from intermediate to final consumption and therefore increases GDP in line with the as yet unspecified volume-price split. The approach suggested by Nakamura & Soloveichik incorporates a deflator (the US deflator), which is based on a combination of "input" and "output" prices, but the compensation between valuations of the various media generally neutralises, by an effect of general equilibrium, the effects of the transition from paid financing and financing through advertising (and vice-versa) on real GDP (e.g. *YouTube*'s "Premium" service). This neutralising effect tends to strengthen one of the hypotheses mentioned above, that of a redistribution of market shares among market operators within a relatively stable perimeter, i.e. a relative positioning of the stakeholders on the market without increasing the size of the market. Finally, the consumer surplus approach suggested by Brynjolfsson & Oh (2012) seems instead to identify a quality effect for consumers, leaving aside any potential price effect, in the sense that the cost of the advertising is partly included in the extra cost of the sponsored products or brands. Here again, what do we actually want to measure? A "missing" consumption or the increased gain for users? The approaches put forward by Brynjolfsson & Oh (2012) and Brynjolfsson *et al.* (2019) seem to be the clearest in terms of the objectives pursued.

But why do we need to measure the value of time spent on domestic tasks, and where do we set the boundaries? Even though digital innovations are recorded as zero consumption in the national accounts, these services, even when they are free, can contribute to consumer welfare. While GDP is not intended to account directly for household welfare, consumption of free services appears for many observers to be a factor that is "missing" from GDP growth and assessments of productivity. However, it is difficult to measure the unobservable value created by activities on the internet, especially free activity, and the different types of proxy proposed do not allow us to clearly identify the question that this type of imputation is attempting to answer. Can we consider the time spent watching adverts to be a measure of the benefit gained from viewing the rest of the programmes? Or is this just, in a purely accounting-based logic, a potential way of accounting for this that neutralises the impact on real GDP of the transition from paid financing to advertising-based financing, without asking ourselves the question of what we are actually measuring in either case? Whatever the answer, we can see that the various answers put forward already include an approach for measuring the value of time spent doing something.

The different methods presented often combine welfare approaches with the more traditional output approach, which may contradict the conceptual framework for measuring GDP and income. Imputing a value for an attention service is not without problems: it increases household income (this service is produced by households) and therefore GDP; however, imputations of this kind tend to disrupt the added value and the underlying employment statistics. This is the case, for example, with imputed rents, which we may be tempted to take from the analysis of productivity. Coyle *et al.* (2018) also report that the imputed income could not truly have a monetary equivalent as it could not be saved or spent on anything elses, nor be fiscally taxed, which weakens the relevance of the GDP conceptual framework. This raises the additional question of the volume-price split, for which Bean (2016) suggests directly evaluating ("output" method) the volume growth in attention time, valued through the increase in the volume of data streams. This proxy, while interesting, does however raise the conceptual question of taking quality effects into account.

The issue of expanding the scope of GDP is a recurring one for national accountants and generally comes up against the risk of an uncontrollable expansion in all directions. This is why the international bodies have historically recommended expanding GDP within the specific framework of satellite accounts, outside of the main scope. To address the issue of what it is we actually want to measure, the Stiglitz-Sen-Fitoussi Commission (Stigltitz *et al.*, 2009) proposed a clarification

by differentiating between means and ends. The goods and services included in GDP or which are eligible to be included are classified as means. The notions of welfare and well-being are in the results category. The results are obtained by jointly implementing GDP components and other means, in particular time available, valuation of intangibles, factors of the social and natural environment, etc.

At this stage, we have examined two of the three conceivable solutions that attempt to give a monetary value to free services (direct assessments of the service provided to users, and valuation through advertising revenue). We will now look at the third option, which is relatively more recent and which, at the time of writing this article, is experiencing a marked increase in popularity.

3. A Third Solution in the Attempt to Attribute a Monetary Value to Free Services: Valuing the Data Generated Through the Use of These Services

According to Varian (2018), data have at least one characteristic in common with oil: they have to be refined to be useful. Without this, they have no intrinsic value. However, unlike oil, data are non-rival, even if they can be made partly excludable through general conditions of use or intellectual property regulations. Varian proposes a pyramid, which is a variation of the "data→ information→ knowledge→ wisdom" hierarchy set forth by Akerlof (1989). In Varian's scheme, data are collected and stored; they are then tidied up and analysed, which allows us to create information (stored in documents), which, once learned, creates knowledge for humans, which ultimately leads to action. In many cases, the data often existed well before we were interested in measuring their value (or in valuing them in new ways), in the form of a deposit of raw materials, of sorts. However, unlike deposits, fresh data can be generated, supplemented, increased and refined, as in the case of the *ImageNet* database, which has fostered recent advances in artificial intelligence. For Varian, data are not innately knowledge assets but can become information assets. This would make data a new production factor. According to Bean (2016), personal data become a production factor, in the same way as physical and intangible capital, which contributes to the productivity and competitiveness of market and non-market producers and creates a substantial surplus for the consumer.

In numerous cases, advertising and data collection both indirectly subsidise recreational services in respect of which we may want to impute a value for household consumption expenditure. Advertising and data collection are partly substitutable (Cecere *et al.*, 2018) and the analogy between the two models offers the prospect, by determining the value of the data, of suggesting an alternative method of measuring the value of free services. In the case of the financing of free services through data collection, the service provider is financed by reselling or immediately using these data or even by building an asset (databases containing the data produced by users, network of internet users, etc.), the value of which can then be increased in the production of services using these data. But is financing through data a simple substitute for financing through advertising? Indeed, in both cases, we may want to explicitly show household consumption expenditure in respect of the free (sponsored) services from which households benefit and intermediate consumption and investment expenditure on the part of the companies that subsidise these services. But these operations probably have quite different characteristics (see Table below).

3.1. Complementarity of Economic Models and Validity of Measuring the Value of Data in the Sphere of Free, Sponsored Services

Cecere *et al.* (2018) highlight the fact that 17.7% of *Google Play Store* applications in 2015 used personal data as a monetisation strategy, which is considerably less than the 32.4% that are financed through advertising, but still a very substantial figure. The data collected and valued include, in particular, user geolocation, contacts and access to SMS. However, in their sample, 53.3% of applications do not have a monetisation strategy, specifically because some are produced by non-market players (such as *Wikipedia*) or are used as "business cards" for the developers or may even be created directly by brands as a means of communication, advertising and influence. The authors are of the opinion that while advertising and integrated purchases are traditional commercial strategies in the internet economy, personal data can complement or even replace these commercial models. The notion of measuring the value of sponsored free services through the collection of data is largely the same as that of advertising-based funding; moreover, one platform monetisation strategy may often incorporate both models in an interlinked and complementary

Table – **Symmetry between financing through advertising and financing through data collection**

Two-sided market	Accounting classification	Indirect financing through advertising	Indirect financing through data and personal data collection
Household side	Potential classification as final consumption expenditure (FC)	Immediate consumption of free service + potential deferred effect of consumption of sponsored products and brand influence	Immediate consumption of free service
Company side	Potential classification of part of the costs as intermediate consumption (IC)	Short-term purchase of sponsored product	Better targeted advertising in the short-term, resale of personal data collected
	Potential classification of part of the costs as investment expenditure (GFCF)	Medium- and long-term effects linked to the brand, logic of influence	Later indirect value measurements, for example through artificial intelligence and algorithms and valuation of intangible assets (organisational, brands, etc.) linked to data

Notes : The companies may be advertisers in the case of an advertising model, or data collectors.

way. Indeed, 7.4% of applications use both advertising and data collection in their monetisation strategy. Consequently, there is no uniformity of economic models, which complicates the standardisation of data valuation methods.

The scalability of networks has increased the scope of free services, irrespective of whether they are financed through advertising or not, using data collection and processing. This new financing (or value measurement) channel is both an immediate profit-generating tool for companies (such as targeted marketing) and a potential future way of increasing value through new and future uses of big data and artificial intelligence. On the basis of this observation, Coyle *et al.* (2018) note that the acquisition of data and creation of free services with the aim of attracting and keeping users through network effects is characteristic of an investment, and recommend that there is a deeper consideration of the way in which the output generated through use of personal data is measured. Currently, however, as mentioned by Ahmad & Schreyer (2016), only the digitalisation of the data and not the inherent value of the data itself can be recorded as an investment in the national accounts, even though it is this intrinsic value that gives rise to the value measurement that justifies the provision of the free service. Imputing values for this type of asset in the national accounts would pave the way for a more general expansion of knowledge capitalisation, the scope of which seems to be difficult to pin down, which undoubtedly explains the reluctance of the community of national accountants to adopt this type of approach. But to claim to incorporate the national accounts framework, these assets would need to be compatible with the scope of "production".

3.2. Generating Data: Is This "Production" in the Conventional Sense of the Term?

The notion of production in the national accounts does not always overlap with the intuitive notion of production of value. This can be seen, for example, in the case of imputed rents, where we record a production of value solely on the basis of being an owner, which deviates from the intuitive idea of productive activity (see Blanchet, this issue). We can legitimately question the notion of "production" by users providing their personal data or leaving traces of their digital activity. This is not work *per se*, but instead a case of providing information, which can be used for multiple ends (targeted marketing, political targeting, various studies, algorithm training, etc.), some of which are still unknown at the time of collection, which could also justify its classification as an asset due to its potential production of future services.

The choice to integrate "data generation" into the scope of production could depend on the nature of the data and the way in which they have been generated. Some data would probably be classified as a produced intangible asset, for example data regarding a car journey generated through GPS tracking, or the construction of personal notoriety on social networks, while others would be a non-produced intangible asset (such as exchanges on social media). Seen in this light, we could consider, in the national accounts, that social networks (by way

of example) pay a rental fee to households for the right to use the non-produced asset created by their personal data, in the same way that we pay rent for the right to occupy undeveloped land, which is a non-produced asset. We should, nevertheless, note that income from the holding of non-produced assets is not considered as production in the national accounts. The digital economy is likely to lead to the registration of new intangible assets, but their production by households does not appear to be as straightforward. We could consider that household consumption of free services produces, whether voluntarily or as a by-product,[5] data that become a factor of production that underlies the intangible assets. Measuring the value of these assets does not, however, seem an easy task.

3.3. Measuring the Value of Data: A Delicate Exercise Due to the Nature of the Underlying Markets

Li *et al.* (2019) believe that data may have a very high and probably increasing value in the near future with 5G and the "Internet of Things" accelerating the accumulation of data, in terms of both type and volume. In order to make this observation, the authors examined several types of online platform that rely on commercial models of data valuation.

However, where this entails a specific shift to numerical values, measuring the value of the data can seem a complex task owing to the nature of the network effects that come with the "platformisation" of the economy, on both two-sided and multi-sided markets. The arrival of the internet and the capacity of networks to exchange large quantities of information on a massive scale (scalability) has created a technological breakthrough. A significant part of the collaborative economy is based on a model of two-sided markets (cf. Box 1), which has largely contributed to the democratisation of the "free service" model. The networks have unique economic properties; the higher the number of users of a networked service, the greater benefit of that service for a user. Hence, a user's decision to participate in a networked service depends on the number of service users and that decision increases the benefit for the existing users. The free nature and ease of use of the service are key factors in triggering these network effects. Once these have been triggered, growth becomes self-sustaining due to the snowball effect and the network reaches a key profitability threshold, which, once passed, increases the profits of the network organiser.

Yet, where the provision of free services allows operators to increase their network effects, the creation of value is not necessarily immediately visible and can sometimes take very indirect forms, which are difficult to quantify. Indeed, these operators increase the value of the intangible assets, but only disclose the value when transactions take place, which means they are often not accessible in real time and are difficult to transpose from one situation to another. Hence, as highlighted by the OECD (2013), the monetary, economic and social value of personal data is likely to be governed by non-linear principles, with increasing returns to scale. Furthermore, Brynjolfsson *et al.* (2019) believe that it would be helpful to further take the network effects into account when evaluating GDP-B.

Thus, the value of data is highly dependent on the context in which they are used. Indeed, while the value of a data record may be very low at an individual level, its value increases as more records are added to the database, as these data can be matched to other data, and information can be inferred from these data to further increase the amount of information available. Thus, for Li *et al.* (2019), unlike R&D activities which depreciate as they become obsolete, data can gain in value and generate new values by combining datasets. In this way, the aggregate value of a set of data is greater than the sum of its components (increasing returns). This is a unique functionality that changes the paradigm of asset depreciation over time and raises unprecedented challenges in terms of measuring value. In this regard, for Brynjolfsson *et al.* (2018), the fact that there is no depreciation means that the intangibles themselves generate intangibles, in a cumulative logic. This would, therefore, be a case of positive externalities. So, what consumption of fixed capital should we apply? This is a novel characteristic of the underlying intangible assets.

Since 2013, the OECD has examined several methodologies for measuring and estimating the monetary value of personal data. The first approach consists in examining the market capitalisations, income or net profit per individual record for the companies whose economic models are primarily based on personal data. However, the data on market capitalisation result in evaluations that can be highly variable. The OECD believes that the most direct way of determining the value of personal data is at the

5. A by-product is technologically fully linked to the production of another product.

intersection between supply and demand, and consists in evaluating the market price at which personal data are legitimately offered and sold. However, this market price is only visible at the time of purchase/sale, and often does not have a real equivalent as there is no true market. An alternative method, based on an observable counterfactual, consists in evaluating the economic costs of data theft. The costs associated with a loss of personal data can provide an assessment of their value; however, the OECD notes that the figures reported here still vary to a considerable extent. More recently, the OECD proposed other types of valuation, for example a cost-based approach (taking into account the costs of production together with a markup) or even an income-based approach. However, this last approach requires hypotheses regarding future cash flows and depreciation costs, which appear to be difficult to determine. In all of these cases, before moving towards an evaluation, it seems to be necessary to define the scope of produced assets and non-produced assets (and non-assets) in the light of the current SNA regulations, even if this means adjusting the boundaries in its future updated version. Assessing the potential value of data as a factor of production that underlies the intangible assets therefore seems to be a major challenge in measuring and understanding the future revolution in artificial intelligence and its implications for changes in productivity.

But if the cost of free services funded by data may, to some extent, be likened to an investment for the companies that rely on this economic model, how do we take purely free services into account?

3.4. Does Measuring the Value of Data Answer the Question of How to Measure the Value of Purely Free Services?

The model of "purely" free services is, on the surface, similar to the notion of volunteer work, but it can also help to increase the value of the intangible assets through data, sometimes without the initial explicit intention of doing so. The distinction between purely free models on the one hand, and free models supported by advertising and/or data collection, on the other, does not take into account the value of the underlying asset, which should appear as an additional wealth-management approach (but closely linked). Indeed, even though there are no market or even monetisation transactions, the content itself and the interaction with internet users may be valued. The platforms collect data produced or left by users (with the aid of cookies, for example) and infer information that improves the depth and quality of their understanding of the users. If the "purely" free model is, on the surface, similar to the idea of volunteering, with digital services, this creates a new economic component: the accumulation of knowledge, data, and their potential valuations as intangible assets.

We will take the example of *Microsoft*'s purchase of *GitHub* in 2018 for $7.5 billion. *GitHub* is a web-based hosting and code-sharing platform. The main service offered by *GitHub* is the provision of repositories accessible online, which is the reason for its enormous popularity for open source projects. *GitHub* is a flagship free-software platform with a culture that advocates the values of transparency, sharing and no-fee and operates mainly from voluntary contributions. Setting aside the pay-to-use section of the platform (which is limited), *GitHub* has no production nor consumption in the national accounts, yet its value was set at $7.5 billion. While *GitHub*'s (public and private) data, which are often free-to-access codes, do not have an intrinsic value, the site's volunteers have interacted and generated data, specifically programming code, which is a valuable resource in the field of big data and artificial intelligence that can be used, for example to automate code generation or improve automated bug detection. The purchase of the data on the site is also an aid that allows *Microsoft* to measure the value of different types of intangible assets (specifically marketing, brand and organisational assets). Indeed, *Microsoft* will benefit from potential synergies with the tools of its own community and will be able to strategically develop its brand image thanks to this shift towards the free software community. This goes back to the dichotomy in which the volunteers have assumed the roles of both consumers and producers on the site, at least in the sense that their consumption has generated, either voluntarily or as a by-product, data output that underlies intangible assets.

Several of the provisions laid down in the SNA 1993 (6.47 and 6.86), and recalled in Article 3.22(c) of the SNA 2008, could apply to this type of situation by allowing for the recording as gross fixed capital formation of the participation of informal unincorporated groups of households in a collective service (for example communal construction activities for the community). Here, this would be a case of own-account production by households. As the majority of inputs are provided free of charge

in such cases, the SNA 1993 recommended retaining a value estimate based on the wage levels for the remuneration of similar types of work, i.e. the use of professionals for the same work. This valuation could, however, be quite extensive.

The difficulties in taking "free services" into account in the central framework for the national accounts surely result, in part, from the hybrid nature of these services at the crossroads between the flow accounts and the balance sheets.

3.5. Generally Speaking, the Flow Approach Should Be More Systematically Linked to a Stock (Asset) Approach in Order to Assess the Reality of Some New Economic Models

For Li *et al.* (2019), the sheer disparity between the *Facebook* IPO in 2011 (value of its total assets: $6.3 billion) and its market valuation in 2013 ($104 billion) highlights the huge amount of its intangible assets, and, in particular, the value of the underlying data. These valuations can be very high, even where these companies are making heavy losses, as in the case of the "ubiquity now, revenue later" models (such as *Uber*), which use investments (venture capital) to rapidly gain market share by offering free or cut-price services. However, the central system of the national accounts records "transaction values" which have, since the SNA 1993, been distinguished from the conventional use of the expression "market values". This means that the properties attributed by neo-classical economic theory to market values cannot be transposed directly to the empirical transaction values.

According to Bean (2016), the digital economy has made it more difficult to measure economic production due to the transition from highly capital-intensive production to highly knowledge-intensive production, with a proliferation of intangible assets. The new characteristics of investments in intangibles are described by Haskel & Westlake (2019) as follows: "The intangible, knowledge-based assets that intangible investment builds have different properties relative to tangible assets: they are more likely to be scalable and have sunk costs; and their benefits are more likely to spill over and exhibit synergies with other intangibles".

The national accounts do, however, capture part of these intangibles. Notably, since the ESA 2010 was introduced, R&D expenditure has been recorded as an investment, rather than as intermediate consumption as before. Likewise, the datasets are already partly taken into account in the concepts laid down in the SNA 2008. With a revolution of artificial intelligence on the horizon and the changes it may bring, there seems to be an urgent need to build complementary reference indicators for intangibles in order to provide new insights into the way in which these phenomena, which are known but difficult to observe, are increasingly helping to shape economic dynamics.

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The issue of measuring the value of free services clearly does not have an obvious solution, but instead several types of potential solution depending on the objectives pursued. Yet the changes in the organisation of these pseudo-markets may, one day, come to the aid of the national accountants, whether in the form of spontaneous changes or changes resulting from regulatory policies to which these markets may be subject.

The platforms based on a free model are *de facto* in a "price-taker" position, which tends to standardise the value of the service provided for users; however, some users may be more active than others and contribute more actively to the reputation and the content value of some platforms. Users are often also consumers of the content on these sites, but there is nothing that guarantees a balance in this relationship; indeed, there are asymmetries as already mentioned, which are fairly characteristic of typical principal-agent problems. In some cases, the service provided may be significantly inferior to the contribution of the user, who can only request compensation from the platform in rare cases, even where that platform explicitly monetises the user's data "production", or even their personal data. For Li *et al.* (2019), online platform companies capture the majority of the benefits associated with data as they know how to exploit their value, whereas consumers lack the knowledge to give value to their own data. We would therefore be in a case of incomplete contracts. As these asymmetries are sometimes obvious, there are, despite everything, one-off cases of monetary compensation, whether direct or indirect. *YouTube*'s monetisation contracts are one example of this. These remunerate the most active YouTubers depending on their audience, or more indirectly *via* the recognition and notoriety that some influencers may acquire, which

may lead to free products and various invitations (trips, etc.). However, this article will not further examine the question of the value associated with acquired notoriety, which is more similar to an intangible asset for the household.

Can we rely on one proposal for measuring the value of free services, in particular, to steer economic policy? If we consider that measuring user willingness to accept compensation to maintain access to a free service (Brynjolfsson *et al.*, 2019) is probably the most accurate approach to assessing the value of the service provided (marginal cost), we can take a two-pronged approach by evaluating the "extra advertising cost"[6] and the benefits associated with data[7] on the basis of the amounts that platforms would be willing to pay not to part with the data generated by their users. This principle would be compatible with the logic of data portability and could be applied to flows as well as assets, which is important for buyback between platforms. An initial step has already been taken in this direction: the General Data Protection Regulation (GDPR) has, since May 2018, given companies the role of data "custodians" and not owners, and the responsibility of guaranteeing the portability of personal data. This theoretical extra cost cannot be quantified and would likely vary quickly on the basis of multiple parameters (notoriety, trends, etc.). However, this could be used as a basis for the public regulator to reflect on this. For example, the regulator could establish an option right granted to website users, who would then be able to individually or collectively request financial compensation in exchange for storing their data on the site. If this were refused, this would lead to the removal of the account and all information regarding that individual or produced by them. This "pay to keep" model could be applied to the private sector, but should not affect public data, as measuring the value of the latter is already of implicit benefit to the common good. The emergence of economic actors assuming the role of intermediaries on this market would lead to the definition and establishment of an option right approaching the marginal cost of the free service.

Generally speaking, while it is difficult to fully comprehend the notion of value of free services and to introduce a measure of it in the national accounts today, this may be partly because there are still significant asymmetries and the economic vectors underlying this market have yet to be fully formed. The economic policies of the future in this sector may offer statisticians the opportunity to evaluate such phenomena, even though it will not resolve the matter in its entirety. □

6. The extra advertising cost corresponds to collecting the willingness to pay the consumers who have been "influenced" by the advertising. This can, therefore, be likened to a sort of "produced" goodwill in terms of intangible investment (i.e. the gap between the acquisition price and the economic value of the goods in the absence of advertising).

7. The benefits associated with the data correspond to the revenue made from the data and their use, net of fees incurred in acquiring them (platform costs, service costs, etc.).

BIBLIOGRAPHY

Ahmad, N. & Schreyer, P. (2016). Measuring GDP in a Digitalised Economy. OECD*, Statistics Working Papers*, 2016/07. http://dx.doi.org/10.1787/5jlwqd81d09r-en

Akerlof, G.A. (1989). The economic of illusion. *Economics & Politics*, 1: 1–15. https://doi.org/10.1111/j.1468-0343.1989.tb00002.x

Bean, C. (2016). *Independent Review of UK Economic Statistics*. Cabinet Office, United Kingdom. https://www.gov.uk/government/publications/independent-review-of-uk-economic-statistics-interim-report

Blanchet, D. (2020). What Should the Concept of Domestic Production Mean in Globalized Economies? *Economie et Statistique / Economics and Statistics*, this issue.

Brynjolfsson, E. & Oh, J. (2012). The Attention Economy: Measuring the Value of Free Digital Services on the Internet. AIS Electronic Library. https://www.semanticscholar.org/paper/The-Attention-Economy%3A-Measuring-the-Value-of-Free-Brynjolfsson-Oh/9ff9bec84357dacc286b570937a955f358a9a8b5

Brynjolfsson, E., Eggers, F. & Guannamaneni, A. (2018). New Measures of the Economy: Measuring Welfare with Massive Online Choice Experiments - A Brief Introduction. *AEA Papers and Proceedings 2018, American Economic Review*, 108, 473–476. https://www.pnas.org/content/116/15/7250

Brynjolfsson, E., Diewert, E., Fox. K., Eggers, F. & Collis, A. (2019). GDP-B: Accounting for the Value of New and Free Goods in the Digital Economy. *NBER Working Paper*. https://www.nber.org/papers/w25695

Cecere, G., Le Guel, F. & Lefrere, V. (2018). Economics of free mobile applications: Personal data as a monetization strategy. Communication à la 16ème Conférence de IAOS OECD.
https://www.slideshare.net/StatsCommunications/iaos-2018-economics-of-free-mobile-applications-personal-data-g-cecere-f-le-guel-v-lefrere

Coyle, D., Riley, R. & Reinsdorf, M. (2018). Perspectives on Measuring the Digital Economy. Presentation at ESCoE. https://www.escoe.ac.uk/escoe-conference-economic-measurement-2018/

Corrado, C. & Hao, J. (2014). Brands as Productive Assets: Concepts, Measurement, and Global Trends. *World Intellectual Property Organization Economics & Statistics Series Economic Research, Working Paper* No. 13

Cremeans, J. (1980). Consumer Services Provided by Business through Advertising-Supported Media in the United States. *Review of Income and Wealth*, 26, 151–174. https://doi.org/10.1111/j.1475-4991.1980.tb00151.x

Eisner, R. (1978). Total Income in the United States, 1959 and 1969. *Review of Income and Wealth*, 24(1), p. 49. https://doi.org/10.1111/j.1475-4991.1978.tb00031.x

Eisner, R. (1988). Extended Accounts for National Income and Product. *Journal of Economic Literature*, 26(4), 1611–1684. https://www.jstor.org/stable/2726857

Goolsbee, A. & Klenow, P.J. (2006). Valuing Consumer Products by the Time Spent Using Them: An Application to the Internet. *American Economic Review*, 96(2), 108–113. https://doi.org/10.1257/000282806777212521

Haskel, J. & Westlake, S. (2017). *Capitalism without Capital: The Rise of the Intangible Economy.* Princeton University Press.

Jaszi, G. & Juster, T. (1973). A Framework for the Measurement of Economic and Social Performance. *In: The Measurement of Economic and Social Performance*. New York: Milton Moss, p. 50, and Jaszi, Comment, p. 89.

Jorgenson, D. & Fraumeni, B. (1992). Investment in Education and U.S. Economic Growth. *The Scandinavian Journal of Economics*, 94, S51-S70. https://doi.org/10.2307/3440246

Kendrick, J.W. (1971). Expanding Imputed Values in the National Income and Product Accounts. *Review of Income and Wealth*, 25(4), 349–364. https://doi.org/10.1111/j.1475-4991.1979.tb00112.x

Li, W., Nirei, M. & Yamana, K. (2019). Value of Data: There's No Such Thing as a Free Lunch in the Digital Economy. *U.S. Bureau of Economic Analysis Working Papers*.
https://www.bea.gov/research/papers/2018/value-data-theres-no-such-thing-free-lunch-digital-economy

Nakamura, L. & Soloveichik, R. (2015). Valuing "free" media across countries in GDP. *Federal Reserve Bank of Philadelphia* Working Papers 15-25. http://papers.ssrn.com/abstract=2631621

OECD (2013). Measuring the Internet Economy: A Contribution to the Research Agenda. *OECD Digital Economy Papers*, No. 226. http://dx.doi.org/10.1787/5k43gjg6r8jf-en

OECD (2013). Exploring the Economics of Personal Data: A Survey of Methodologies for Measuring Monetary Value. *OECD Digital Economy Papers*, No. 220. http://dx.doi.org/10.1787/5k486qtxldmq-en

Okun, A. M. (1971). The Mirage of Steady Inflation. Brookings Papers on Economic Activity*, Economic Studies Program, The Brookings Institution*, vol. 2(2), pp. 485–498.

Roy, D. (2013). La contribution du travail domestique au bien-être matériel des ménages : une quantification à partir de l'enquête Emploi du Temps. *INSEE, Document de travail* N° F1104.
https://www.insee.fr/fr/statistiques/1380932

Stiglitz, J., Sen A. & Fitoussi, J.-P. (2009). *Report by the Commission on the Measurement of Economic Performance and Social Progress*.
https://www.ladocumentationfrancaise.fr/var/storage/rapports-publics/094000427.pdf

Vanoli, A. (2002). *Une histoire de la comptabilité nationale*. Paris : La Découverte, Collection Grands Repères Manuels.

Varian, H. (2018). Artificial Intelligence and Antitrust: competition, regulation and pluralism in the online World. Presentation in Florence. https://fsr.eui.eu/event/competition-regulation-pluralism-online-world/