Distribution Services and the Digital Economy: Implications for GDP Measurement, Productivity and Household Welfare*

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Comments Welcome.

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Abstract:

I identify here important changes in how retailing functions are performed due to the penetration of the digital economy. First, in the distribution of goods for final consumption the same functions as before are performed independently of stores and their location. Second, in the distribution of inputs for household production of services the core products that consumers pay for explicitly are transformed from tangible goods into intangible services. Third, in the distribution of services, selected aspects of the retail function are performed digitally whereas others are not. Finally, for some subcategories of service products where consumption and distribution are separable activities it becomes possible to distribute the service entirely in digital form. These features of the digital economy have important implications for GDP measurement, productivity and household welfare in the retail sector and in all service sectors of the economy. They even have minor ones for GDP measurement in the manufacturing sector. The paper develops these implications systematically and separately with respect to the distribution of goods and services. Finally, this analysis provides support for applying to the digital economy Robert Gordon's characterization of recent innovations as having a lesser impact on economic growth than the great inventions of the past with respect to their impact on distribution.

Key Words: distribution services, Internet, retail, GDP measurement, productivity, household welfare

JEL codes: E 01; E02; L1; L16; L80; L81

1. Introduction

This paper focuses on how the digital economy affects retailing activities and its consequent impact on GDP measurement, firm productivity and household welfare. Our approach lies in between two broad strands of literature: a macro oriented one and a micro oriented one. The macro oriented strand has emphasized two issues directly (GDP measurement and productivity) and a third issue less directly (household welfare) while relying on national income accounting data. Recent contributions in this area stress GDP measurement implications of the digital economy, the productivity of recent innovations relative to past ones with respect to their impact on growth, and the role of mismeasurement as an explanation for the productivity slowdown (e.g., Ahmad and Schreyer, 2016; Gordon, 2016: Ch. 17; Byrne, Fernald and Reinsdorf, 2016). These are recent examples from of a long-standing research area that continues to thrive on this topic (e.g., Hulten and Nakamura 2017).

By contrast, the micro oriented literature is of more recent vintage and, not surprisingly, stresses micro oriented issues, methodology and data. For instance, a recent session on the Internet at the 2017 AEA meetings has papers that evaluate the value of online retail accounting for local variability in demand while relying on data from one retailer (Quan and Williams, 2016), and economies of density in supply underlying the expansion of Amazon's distribution network (Houde, Newberry and Seim, 2016). Our approach has in common with the macro approach its focus on national income accounting data and on analyzing the implications of the digital economy for GDP measurement, productivity and household welfare. With respect to the micro approach, our communality lies on an explicit and rigorous analysis of demand and supply of retailing activities in whatever sector they take place.

While our approach focuses initially in one aggregate sector, the retail sector, it is able to draw implications about the impact of the digital economy for all service sectors in the national income accounting system. According to the CIA Factbook in 2016 service sectors were 70.5 % of GDP in the European Union and 79.5 % in the US. For expository reasons it is convenient to start by considering what is the output of the retail sector. GDP is an output concept: Namely, the set of final products of goods and/or services produced by a geographical unit over a calendar period. Similarly, productivity is a measure of the output produced with a given set of inputs over a calendar period. Finally, a measure of household welfare is the output that can be consumed over a calendar period. Thus, it is useful to be clear on what is the output we are discussing. Because retailing is an intermediation activity linking producers to consumers, the nature of its output and its measurement emerges most clearly in the setting of the retail sector.

Our starting point is, thus, to define the output of the retail sector at the conceptual and measurement level and discuss its linking of producers to consumers through the supply and demand for distribution services. It turns out that the nature of this linking differs from an accounting perspective depending on whether the products are physical items or intangible services. This distinction in turn has a crucial impact on the provision of distribution services in a brick and mortar (B&M) economy and in a digital economy. For, the latter eliminates the need to bundle most distribution services with the product transacted at a given location in space for core products transacted as physical items. Thus, the digital economy generates two important changes in how the distribution sector affects the economy. Namely, 1) the store and its location, or geography, lose its essential role in the distribution system; 2) the performance of the retailing function in the distribution of service products can't be ignored in service sectors and must be

recognized explicitly for understanding impacts on GDP measurement, productivity and household welfare of the introduction of the digital economy.

We proceed by considering two cases: First, with respect to the distribution of goods we draw three implications on how the retailing of goods changes due to the penetration of the digital economy. That is, one for each of our three economic variables of interest. Second, with respect to the distribution of services we draw three implications on how the retailing of services changes as result of the digital economy and its consequences for the same three economic concepts or variables of interests. In the latter case, however, each set of consequences differs according to the nature of the services product and the role of distribution services in its provision.

Hence, we draw one set of implications for core service products previously distributed through physical items. Subsequently we draw another set for service sectors providing specific distribution services such as assurance of product delivery at the desired time and offsite information. Finally, we draw the last set for distribution services provided digitally without changing the nature of the core service product sold in the services sector. A brief conclusion discusses overall implications of our analysis with an emphasis on measurement issues.

There are two somewhat related points useful for the reader to keep in mind throughout our discussion. First, an extreme characterization of some earlier literature on the digital economy and GDP is that either it is all there or most of what matters is there; at the other extreme is the characterization that most of what matters is not there and, thus, we need a new approach. I disagree with both extreme characterizations: some aspects of the digital economy are in current measures of GDP although researchers often look in the wrong places or devote insufficient effort to find them when looking at published data; other aspects of the digital

economy are subsumed in the published data but are difficult if not impossible to identify separately or directly for reasons we make explicit.

Second, in order to be systematic in this process I rely on ISIC Rev.4 (2008) classifications and definitions in all abstract discussions. In principle these classifications are supposed to be followed by all countries' statistical agencies. Most, if not all countries have cross walk tables indicating how their own classifications relate to the ISIC classification. Thus, the general points made here are relevant for any country. Furthermore, when using any numerical illustration in the text I have relied on US numbers through the cross walk table relating the NAICS (2012) classification to the above version of ISIC at the relevant levels of aggregation, which ranged from the two-digit to the six-digit level.

2. What is the Output of the Retail Sector?

In the US national income accounts constructed by the Bureau of Economic Analysis (BEA) the retail gross margin, defined as sales minus the cost of goods sold, is the gross output of the retail trade. For example, Yuskavage (2006) provides a detailed measurement oriented discussion of the concept, including descriptions of how it applies to disaggregated categories under NAICS. Triplett and Bosworth (2004, Ch.8 and comment by Ratchford) provide an overview of conceptual and measurement issues associated with the concept and Betancourt (2004: Ch.4, Section 1) provides a conceptually focused discussion of issues associated with generating a gross output or value added production function for the retail sector. These discussions underlie our choice of the retail gross margin as the output concept measured in GDP that best represents the output of the retail sector for our current purposes. It is the best indicator of the distribution services provided to consumers by the retail sector during a given calendar

period of analysis; And, it reflects the value of capital, labor, energy, materials and other services used to produce these distribution services.

Our discussion departs from this concept to consider the distribution services that make up this aggregate identified as the output of the retail sector and measured by the retail gross margin in GDP. The economics and marketing literature on retailing has identified five broad categories of distribution services as outputs (Bucklin,1973; Betancourt and Gautschi, 1988; Oi, 1992; and Kopalle et al. 2009). These outputs are accessibility of location (for acquiring products), information (about prices, hours and product characteristics), assortment (breadth in terms of product categories and depth in terms of variety within a product category), assurance of product delivery (at the desired time and in the desired form of acquisition) and ambiance (in terms of the experience provided by the shopping environment). It takes resources to produce higher levels of each of these outputs, which increases retail costs, and they are present at some level in every retail transaction.

From an economic perspective, each of these distribution services plays a dual role in the system that affects the functioning of retail and other service markets. On the supply side, they play a role as outputs, described briefly in the previous paragraph. On the demand side, they play a role as fixed inputs in the household production functions of consumers. Hence, they increase consumers' demand for goods or core services that come associated with higher levels of these distribution services. For, they reduce effort or resources that the household would have to employ in acquiring products and in one case may yield satisfaction directly. Market outcomes in retail and other service markets depend on both roles. A detailed recent discussion of these roles is available (Betancourt 2016). In the present context, however, the main implication of this dual role is that an important, perhaps the most important economic function of the retail sector can

be identified as providing 'the goods or core services' sold to consumers in conjunction with this set of five broad distribution services.

3.How Does the Output of the Retail Sector Change Due to the Digital Economy?

While some level of each of these five outputs is associated with any retail transaction, a critical difference between the B&M economy and the digital economy is in the manner of provision of these five outputs. According to Betancourt and Gautschi (1993) one of two defining features of retailing is that these distribution services usually come in a bundle with the product sold and directly paid for by customers. In a B&M economy this bundling with the goods sold takes place by having to provide or distribute them to consumers, with the exception of information through advertising, jointly at the same location where the products are sold and/or acquired by the consumer, Betancourt et al 2016, Table 1. On the other hand, a defining feature of the digital economy is that each of these five distribution services can be produced, distributed and consumed separately or unbundled from the location where the products are sold or acquired by the consumer in terms of physical acquisition of, or property rights over the product (Betancourt et al 2016, Proposition 1).

Thus, **Essential Difference I** is that in a digital economy the term location of products sold becomes an ambiguous term with respect to both physical acquisition of the product and acquisition of property rights over the product! One of its main economic consequences is an end to the 'tyranny of geography' at the store level by the digital economy in its fulfilling of a most important retail function. In less lyrical terms, there are enormous cost savings underlying the provision of any given level of assortment by online distributors. These cost savings are the most substantial source of productivity advantages held by online retailers. A detailed discussion is

available (Betancourt 2016: Section 3, “Two Important Economic consequences of Separability”).

In order to make additional progress, with respect to GDP measurement in particular, we have to differentiate between the retailing of goods and the retailing of core services as products. The reason is that ‘the cost of goods sold’ is a well-defined concept with respect to goods as products to be distributed that the consumer pays for directly but, in general, it is not a well-defined concept with respect to services as the core product to be distributed that the consumer pays for directly. This difference is labeled type I separability (Betancourt et al 2016). Goods have type I separability; Services lack type I separability. By the way, this is consistent with the assumptions and procedures usually employed by BEA for the retail sector. On the other hand, BLS measures retail trade output by sales. It has at times argued implicitly that these BEA procedures can violate an assumption of separability in terms of production function properties without differentiating between goods and services (Manser 2005). Since the assumption is generally valid in the case of goods, at least from an accounting perspective, but not in the case of services, it makes no sense to ignore type I separability in our context.

Using goods as the core product, we can write the profit equation for a retailer as follows:

$$\Pi = p_R\, Q - C_R\,(v, Q, D) - p_W\, Q, \qquad (1)$$

where Q is the volume or quantity of goods sold, p_R is the retail price, p_W is the wholesale price, v is a vector of input prices for capital services, labor services, materials, energy and other services used in the production of D, which is the level of distribution services provided to consumers by the retail sector. Thus, the first term on the right hand side equals sales, the third

term on the right hand side equals the 'cost of goods sold' and the second term represents the costs of retailing which equal the retail gross margin in the absence of above normal profits.

Using services as the core product, however, we have to write the profit equation as follows:

$\Pi = p_R Q - C_S (v^*, Q, D),$ (2)

where Q is the volume or quantity of the core service sold, p_R is the retail price of the core service, v* is a vector of the prices of inputs require to produce D, the distribution services provided to consumers, as well as those required to produce the quantity or volume of the core service. What is the reason for this difference between equations 1 and 2? When services are the core product, it is difficult if not impossible to separate the costs of distribution from the costs of production even from an accounting perspective.

An example helps illustrate why a few items associated with household production of services have type I separability and services don't have it as well as **Essential Difference II** between retailing in a brick and mortar economy and retailing in a digital economy. Suppose the household/ producer demands the enjoyment of recorded music, which is to be satisfied, among other items, by the acquisition of the core product recorded music. The household acquires recorded music through a physical item such as an old-fashioned vinyl record, or more recent but similarly 'old-fashioned' tapes or compact disks. It uses the physical item to produce the service enjoyment of recorded music. The costs of distribution of the physical item are separable from the costs of production of this item with the same level of ease or difficulty as one would have for any goods used directly for consumption purposes. Because the core product transacted enjoys type I separability.

On the other hand, the household can also acquire recorded music electronically in the digital economy, e.g., via applications available for mobile phones, tablets or fixed personal computers. In this second situation, it becomes impossible to separate the costs of reproduction of the core product acquired, which is the recorded music, from the costs of distribution of this core product. This alternative distribution mechanism for what some would argue is conceptually the same core product, i.e., recorded music, lacks type I separability.[1]

Thus**, Essential Difference II** is that in a digital economy core service products distributed electronically lack type I separability. One of its main economic consequences is the end of the tyranny of ignorance in the performance of the retailing function for core service products distributed electronically. Indeed, this second difference has been recognized, albeit implicitly by ISIC Rev.4 (2008), for instance, in terms of our example of recorded music.

The classification of retailing recorded music via physical items in brick and mortar stores is retailing class category 4762, while the *reproduction* of recorded media from master copies is included in manufacturing class category 1820. On the other hand, the classification of recorded music distributed via the digital economy is included in information and communications class category 5920. The latter is defined to include, among other things, sound recording service activities in a studio or elsewhere as well as distributing sound recordings to wholesalers, retailers or "directly to consumers." The former case separates the *reproduction* of the physical item used for distribution of recorded music, and places it in a manufacturing category, from its distribution of the item at stores. The latter case, however, does not separate

[1] Others would argue that there are quality differences in the core product distributed digitally. Whether or not this is the case makes no difference for our argument at this point. Regardless of how the core product is distributed, its function for the household remains the same: namely, be an input into the production of entertainment. A similar issue arises in the distribution of information items such as books and newspapers.

reproduction of recorded music from its distribution. It includes *reproduction* as distribution in Internet music publishing.

More generally, the distribution activity (Betancourt 2004, p.1) "…encompasses any mechanism for making available goods and services to consumers." Thus, the performance of the retailing function in many other 'industrial categories' corresponding to service industries besides the retail sector is a widespread phenomenon in both the brick and mortar economy and the digital economy. While the B&M economy ignores its existence, by assuming that all of a service sector's activity is a production or transformative function, the digital economy forces recognition of its existence more frequently, just as our example in the *reproduction* of recorded music illustrates. This general feature of the digital economy applies, of course, to many other activities in the information sector besides recorded music as well as to other service sectors. We return to this topic in later sections of the paper.

4. Implications of the Digital Economy for GDP Measurement, Productivity and HH Welfare in the Distribution of Goods.

The distribution of goods exhibits type I separability and this provides the basis for a second different type of separability that has profound implications for GDP measurement, productivity and household welfare in the retail sector. We refer to this other type of separability as strong type II separability. This type of separability simply means that, when distributing goods through the Internet, **all** five broad distribution services associated with any retail transaction can be produced, distributed and consumed separately in space and time when distributing goods through the Internet (Betancourt et al 2016, Proposition 1).

We address in this section the main implications of strong type II separability generated by the digital economy for the distribution of goods in a systematic manner. First, let us consider GDP measurement. Perhaps the most important and dramatic implication of strong type II separability in this context is that all of the distribution services provided by the retail sector in the distribution of goods could be outsourced by the producers of these goods. It is educational to see what this implies in an extreme example where a goods manufacturer wants a distribution channel relying exclusively on the Internet rather than on a B&M channel.

When the production, distribution and consumption of all of the distribution services provided by the retailing activity are separate across space and time, there is no physical limitation to the outsourcing of each of the five distribution services provided in a retailing activity to another firm. Furthermore, since type I separability allows the production activity to be separated from the distribution activity and this is a necessary condition for strong type II separability, there is no physical or accounting limitation in outsourcing the distribution activity, encompassing all of the five distribution services, to another firm. Indeed, this is one of the alternatives made available by web hosting services such as 1x1 in Germany and ipage in the US. It also underlies the provision of consumption goods, or physical items such as books or compact disks used by households to provide entertainment services, via Amazon. The above example implies that any goods' producer can do so depending on managerial objectives.

An interesting implication of the above discussion for GDP measurement, however, is that it generates three alternative possibilities for the impact of the digital economy on the distribution sector. One extreme alternative is for the producer to outsource the entire distribution function to a webhosting service. This case would generate a decrease in the gross output of the corresponding B&M retail sub-sector and an increase in the value added of the web hosting

service. This increase would appear in sub-category 6311 under the ISIC Rev. 4 classification system. Another alternative would be to place some but not all of the distribution functions in the web hosting service and keep the remaining ones in the B&M retail subsector. Measurement outcomes would be the same in term of classifications but, of course, would differ in terms of magnitudes. Finally, a third alternative would be to keep some of the distribution functions in the B&M retail subsector but switch some of the others to an Internet retailer such as Amazon, which under the ISIC Rev. 4 classification system is a non-store retailer placed in sub-category 4791.

If producers of goods were to choose the first or second alternative, the value of a retail sector contribution to GDP, as usually measured in the B&M economy, would decrease substantially in both cases. For, the gross output associated with these distribution activities would now be captured in the value added of the information sector (category ISIC 63) and warehouse sector (ISIC 52) and transportation sector (ISIC 53) rather than in the retail sector (ISIC 47). On the other hand, in the third case, there would just be a switch within retail subsectors from the brick and mortar ones (all ISIC. Rev4.47 but ISIC 4791) to the non-store Internet retailers (ISIC. Rev4.4791). Thus, we have

Implication I of the Digital Economy in the distribution of Goods: GDP Measurement. When web hosting service companies take over the distribution function completely or partially due to the penetration of the digital economy in the retail sector, the measured value of the retail sector's contribution to GDP in the distribution of goods decreases. Concurrently, the value of the contribution to GDP of the information and warehouse and transportation services sectors increase. On the other hand, if non-store Internet retailers take over the distribution function due to the penetration of the digital economy, the measured value of the retail sector's contribution to

GDP increases. While this alternative can also increase value added in the transportation sector, it would have little or no impact on the warehousing and information sectors. This helps understand one misleading aspect of the frequent criticism that the impact of the digital economy fails to be captured in GDP through the information sector (e.g., Brynjolfsson 2017). It gets captured in the distribution sector through non-store Internet retailers.

We now consider the impact of these changes in the distribution of goods by the retail sector on the productivity of firms in this sector and in the other main sectors affected by these changes in the distribution of goods. It is traditional in the measurement of retail productivity by the Bureau of Labor Statistics to rely on labor productivity measures such as output per worker, where the numerator is sales or revenues. A recent discussion of the strengths and weaknesses of partial and total productivity measures as well as their relation to each other, including when they move together, is available in Murray (2016). Our discussion of productivity relies on labor productivity measures due to their greater availability and reliability in this setting relative to other measures.

Just as in the case of GDP measurement, it is useful to consider simple examples to highlight relevant issues. The decrease in the distribution of goods through the B&M economy associated with the substitution of its retailing activities by the digital economy has two potential effects on sales of the retail sector that affect measured productivity in the sector. We consider first as an example the case of goods that were previously sold in B&M stores (ISIC 47 except for ISIC 479), which are now sold through Internet retailers (ISIC 4791). Subsequently, we consider the case of firms in the retail sector classified as B&M retailers (ISIC 47 except for ISIC 479) but that add an Internet channel to their store offerings,

Example I. Sales of firms in B&M retailers go down and productivity decreases because 'economies of massed reserves' in stores (Oi, 1992) suggests the need for slack capacity in the form of labor is required so the number of workers will decrease slowly and it is unlikely to do so enough to compensate for the decrease in sales. Revenues or sales for firms in the Internet retail subsector increase. Economies of scale, e.g., in the form of economies of density (Holmes 2011) recently identified in the context of Amazon (Houde, Newbery and Seim 2016), associated with Internet retailing suggest that the number of workers will increase by a smaller proportion, which leads to an increase in productivity for firms in that retail subsector. Similarly, economies of scope in providing assortment identified in the cost savings noted earlier (Betancourt 2016) increase the productivity of online firms and online channels relative to B&M ones. An increase in measured productivity in the transportation sector, which must now deliver the goods sold through Internet retailers, is likely as the increase in their sales will be greater than the increase in labor required to accomplish these tasks in the presence of economies of scale for firms in these sectors.

Example II. The added Internet channel can expand sales considerably by reaching a much wider set of geographically dispersed consumers; it also lowers the costs of holding inventories at the stores by allowing managers to offer infrequently purchase items through the Internet channel without having to store them at every store. In so far as sales increase in greater proportion than the increased labor necessary to provide the added Internet channel, the productivity of these firms in the retail sector increases due to the increased penetration of the digital economy in the retail sector. This productivity increase in the retail sector is larger if it is also possible to shift the transportation costs of items to consumers when shipping to their

homes, or of sharing these costs with more frequently purchased items when shipping for pick-up at their B&M stores.

According to the revised estimates in the annual survey of retail trade for the US in 2015 [Estimated Annual Retail Trade Sales – Total and E-commerce: 1998-2015], E-commerce in the category of electronic shopping and mail order houses in the US grew from about $4 billion in 1998 to $ 256 billion in 2014. E-commerce in all the other categories of retail trade grew from about $0.97 billion in 1998 to $ 42.4 billion in 2014, calculated by subtracting the former category from the total in the same survey. The former figures correspond to example I and the latter to example II. Both examples imply a rate of growth of sales per year that exceeds 25%. These growth rates suggest that productivity in the retail sector increased quite rapidly as a result of the increased penetration of the digital economy, since the increase in total retail trade sales for the mainly B&M economy during the period went from $ 2,582 billion in 1998 to$ 4,639 billion in 2014, yielding an annual growth rate of 3.7%.[2]

Unfortunately, these growth rates represent an overestimate of the rate of growth of actual E-commerce sales due to BEA's definition of E-commerce. The latter classifies as E-commerce, according to footnote 1 of the table, "… any sales of goods and services where the buyer places an order, or the price and terms of sale are negotiated over an Internet, mobile device (M-commerce), extranet, Electronic data Interchange (EDI), or other comparable online system. Payment may or may not be made online." If a mail order customer used to place the order by phone, acquire the information via the catalog and paid by regular mail and with the advent of the Internet switches to placing the order by Internet but continues to pay by regular

[2] Part of the reason for the slower growth of total retail sales is also due to the complete and partial outsourcing discussed earlier, in connection with Implication I, and ignored in the present discussion. The magnitude of this complete or partial outsourcing to the information sector, however, is hard to estimate with published data.

mail, the sales associated with the order now becomes E-commerce sales. Similarly, if a B&M customer switches to place an order through the Internet instead of at the store but pays by regular mail or upon picking up the good at the store, this becomes an E-commerce sale y this definition. Over the period 1998-2015 the extent of this overestimate is likely to have decreased because more aspects of the transaction, including payment, are likely to have taken place online. With this caveat, we have

Implication II of the Digital Economy in the Distribution of Goods: Productivity. The productivity of firms in the retail sector increases due to the increased penetration of the digital economy. Furthermore, economies of scale, density and capital or equipment biased technical change in the transportation and warehousing sector due to the increased penetration of the digital economy suggest that labor productivity also increases in these sectors. Finally, productivity in the economy as a whole should also increase whenever outsourcing of the distribution function for goods switches the performance of the retail function from the B&M retail sector to the information services sector for similar reasons to those discussed in the example of electronic shopping.[3]

Before discussing household welfare, it is useful to discuss implication II with reference to the discussion about the output of retailing in section 2. There I argued that the gross margin is the appropriate measure of the output of retailing. While there is no information on the gross margin for e-commerce firms published in the annual survey of retail trade (ARTS, 2015), there is information on the gross margin for total retail trade as well as for the category of electronic shopping and mail order houses. The former category reflects mainly B&M retailing and the

[3] Incidentally, a recent and controversial change in the organization of work in retailing that increases productivity has been the introduction and spread of just in time scheduling practices for their often part-time labor (Ippolito and Watkins, 2016). Nonetheless, the differential effect between B&M retailing and Internet retailing is not clear.

latter e-commerce retailing. In Table 1 we provide evidence on the gross margin differences in these two categories between 1993 and 2015 in the distribution of goods. In the first five years these differences averaged about 15%; in the next 8 years, they averaged about 12%; and in the last seven years about 10%.

These differences capture substantial advantages in productivity with respect to providing the distribution services generating the cost of retailing as well as profits from monopoly power and taxation advantages available to Internet channels in the distribution of goods. Since the taxation advantages of online sales (Goolsbee 2000) have not been eliminated yet in most states (e.g., see proposed Marketplace Fairness Act 2017), the declining trend in the difference mainly reflects increasing online competition that seems to have stabilized around a 10% differential. That is, unless one wants to argue for decreasing productivity of the Internet relative to the B&M sector in generating a unit of sales during the period. This latter argument would seem unattractive to most economists.

[Table 1 goes here]

In order to look at what has happened to employment in the retail sector we can look at the BLS, B-1 Employment Series over the same 1993- 2015 period which provides employment data in seasonally adjusted numbers as of December for the total retail trade. While the BLS does not publish this information for the same category of mail order and electronic shopping, it does publish this information for the broader category of non-store retailers, which contains the former, over the same period. It suffices for our purposes and is presented in Table 2. The latter is used below to calculate estimates of labor productivity in each sector over the period1998 - 2014 using the correct measure of output, the gross margin, rather than the incorrect one, sales.

[Table 2 goes here]

Figures from the corresponding gross margin table in the same survey as the sales figures reveal a growth in the gross margin of total retail trade from $716 billion in 1998 to $1, 286 billion in 2014, or an annual compound growth rate of about 3.7% which is the same as the growth rate of total retail trade sales after rounding. This rate can be compared to a growth in the gross margin of electronic shopping and mail order houses from about $33 billion in 1998 to about $151 billion in 2014. These figures yield an annual growth rate of about 10%, or almost thrice the rate of growth of the gross margin for the total retail trade. Nevertheless, this rate is substantially less than the growth rate of sales for the two e-commerce categories during this period.

While this comparison leaves the broad implications for productivity captured in Implication II unaffected, it suggests caution in any detailed productivity analysis using sales rather than the gross margin. For, in terms of labor productivity the denominator would be the same but the levels and path of the numerator could differ dramatically in the two cases. Using the growth rate of labor over the period 1998-2014 in Table 2 yields a labor productivity growth rate for the total retail trade sector of 3.3% (3.7-0.43); Using the growth rate of labor for the non-store retail trade in Table 2 over this period as an estimate yields a labor productivity growth rate for mail order and electronic shopping sector of 9.48% (10. - 0.52). These figures are based on the gross margin. If we were to use e-commerce sales as the measure of output, labor productivity would be more than twice as large as that implied by using the gross margin.

Let us consider now the implications of the digital economy for household welfare due to the changes it generates in the distribution of goods by the retail sector. First, and perhaps foremost, there is a shifting of monetary costs in acquiring physical possession of the goods by

households from the retailer to the household. In the B&M economy, the household transports itself to the store location and the costs of doing so are not included in measured GDP. Nonetheless, these costs incurred by the household affect its welfare. In the digital economy, either there are no physical stores, as in the example of complete outsourcing of the distribution function or in electronic shopping through the Internet, or the goods are available at a B&M location.

What happens to household welfare depends on a variety of factors. An important one is the pricing policy for shipping adopted by firms in the digital economy. If the shipping is free or provided at a price below the transport cost of the household to the nearest store, household welfare increases. If the shipping is not free and provided at a higher cost than the household's transport cost to the nearest store, household welfare decreases. Since households are heterogeneous with respect to their location relative to store locations, the impact on household welfare will also be heterogeneous. Indeed, pricing policies are often step functions, i.e. have flat zones, over a given delivery area. Hence, the impact within a flat zone could be all households better off or all households worse off or welfare heterogeneity within the flat zone, depending on the household's location relative to other opportunity cost factors.

One can speculate, however, that households located farther away from stores, e.g., rural households, are more likely to incur welfare losses. Pricing policies that discriminate in favor of consumers that buy more goods through the Internet, usually the well to do as in Amazon Prime, are likely to improve their welfare at the expense of other consumers, thus becoming a source of inequality. These considerations also highlight the importance of allowing consumers to pick-up goods at a store when purchasing through the Internet merely provides another distribution

channel to the B&M one. It is noteworthy that Wal-Mart just announced a pick-up discount for households picking up online-only items at a store (Halzack 2017).

Penetration of the digital economy provides additional benefits and costs to households that can affect their welfare. For instance, due to the lower costs of producing assortment and some types of information, much higher levels of these distribution services are provided in the digital economy. Of course, sensory dependent products (Degerau, Rangaswmy and Wu 2000) or goods especially dependent on tact, taste or smell for their evaluation are disadvantaged since the Internet is less suitable for their evaluation than actual inspection (e.g., Pauwels et al 2011; Betancourt et al 2016, Proposition 3). A notable disadvantage of the Internet for household welfare in some settings is the need to wait for acquiring the product rather than immediate acquisition at the store. Finally, the costs of Internet access and data usage are substantial, heterogeneous in similar ways to the pricing ones discussed earlier as well as with respect to their impact on different size households.

Implication III of the Digital Economy in the Distribution of Services: Household Welfare. The impact of the digital economy through the distribution of goods on household welfare is heterogeneous. In terms of accessibility of location for acquiring the product it is beneficial for households in urban areas that purchase a broad variety of goods but less likely to be so for households in rural areas and/or with low purchasing power. Even in the latter case, however, the higher level of information, assortment and assurance of product delivery in the desired form provided by the digital economy increases these households' welfare. Whether or not this is enough to compensate these households for the higher costs of shipping and waiting is an empirical question unlikely to yield an answer with the same sign for every household.

5. Implications of the Digital Economy for GDP Measurement, Productivity and HH Welfare in the Distribution of Services.

In analyzing the implications of the digital economy for the distribution of goods as a core product we emphasized the role of strong type II separability, because it allows the separation in space and time of the production distribution and consumption of **all** five broad distribution services associated with the retailing function. In analyzing the implications of the digital economy for the distribution of core service products we will emphasize the role of weak type II separability, which is defined by any situation where it is possible to separate in space and time the production, distribution and consumption of **some but not all** five broad distribution services associated with the retailing function.

5.1 Goods that Become Services through the Distribution Process.

Just as in previous sections, examples are useful in making our basic points. We start here with a familiar example, the enjoyment of entertainment services by the household using recorded music as an input. Digital distribution of recorded music lacks type I separability, because the costs of reproduction of the core service product, recorded music, could not be separated from the costs of direct distribution of the product to consumers electronically. An immediate implication for GDP measurement of the expansion of the digital economy in this example is a shrinking of measured output of the retail sector as gross output decreases in ISIC, Rev.4 retail subcategory 4762 whenever the purchase of recorded music takes place digitally through services such as Spotify or i-Tunes instead of trough record, tapes or compact disks. Of course, this also implies an increase in the output of ISIC Rev. 4 information and telecommunication services category 5920 as well as a decrease in the output of the manufacturing sector in ISIC, Rev.4 category 1820.

If the digital distribution of recorded music takes place through firms in the retail sector (e.g., Amazon), however, the same lack of type I separability leads to different implications for GDP measurement. While there is a decrease in ISIC Rev.4 category 4762 of the retail sector, there will be an increase in ISIC Rev.4 retail category 4791 or non-store retailers. For, this is where Amazon is placed as a retailer. Furthermore, there would be no change in ISIC Rev.4 information and telecommunications sector category 5920 and there would be a decrease in ISIC Rev. 4 manufacturing category 1820.

More generally, as the digital economy spreads, output in retail categories that distribute physical items for consumers to use in producing entertainment services are expected to decline or grow more slowly than output in categories that distribute electronically these core service products directly to consumers. This forecast applies to items such as films, books, newspapers, records, tapes or compact disks. Digital distribution of these core service products generates increases in the output of the information and communications sector. Of course, a similar slow down or decreases in output would also be expected in the categories of manufacturing and transportation relevant for the reproduction of the latter goods. Not surprisingly, the implications for GDP measurement are quite similar to what we found with respect to recorded music in our discussion of the distribution of goods. Nonetheless, in practice one expects the penetration of the digital economy in these cases to be more visible initially on reallocation within the retail sector and subsequently between the retail sector and the information sector. For, in the example of Amazon it does not require the creation of a new firm in contrast to the example of Spotify.

We provide some evidence on this process in tables 3 and 4 below. Table 3 shows that distribution of books and magazines through E-Commerce in the retail sector is visible from 1999 and is over 80% of the total revenues by 2014. The same is true for distribution of music

and videos. On the other hand, table 4 shows that distribution of books and video and sound through E-commerce in the information sector is not visible prior to 2013. Moreover, the magnitudes of the revenues for music and videos distributed through E-commerce are less than half of those distributed through the retail sector in 2013. In contrast revenues from books distributed through the information sector are more than twice the amount of those distributed through E-commerce in the retail sector in 2013.

(Tables 3 and 4 go here)

Drawing implications for productivity and HH welfare, however, is somewhat more complex because they can vary with the nature of the demand for and supply of the particular information products (Smith and Zentner 2016). For instance, these authors show the substantial impact that the introduction of file sharing had in decreasing total sales of both physical and digital music due to piracy (Figure 18.1, p. 436), but it is not clear which of the two decreased by more as a result of file sharing and this would affect conclusions about productivity. Similarly, at the level of the product it does matter for HH welfare whether or not one assumes quality remains constant when you change from distribution of inputs as goods or physical items such as vinyl records or books to direct digital distribution to consumers as core service products. Views on quality would vary with the heterogeneity of consumer preferences with respect to music and reading enjoyment and with the evolution of technology in both the physical and digital realm.

Implication I of the Digital Economy in the Distribution of Services: Switch to Digital Distribution of Core Products Previously Distributed as Physical Items.

Retail products distributed as goods through physical items become core service products due to digital distribution. There are two different implications for GDP measurement depending on who is doing the digital distribution. If done through firms in the information sector, there is an

increase in GDP value added in the relevant subsectors of the information and communications sector as well as a decrease in the gross output of the relevant B&M subsectors of the retail sector and of value added in relevant subsectors of the transportation and wholesaling sector and of the manufacturing sector. If done through firms in the retail sector, there is an in increase in the gross output of non-store retailers and a decrease in the gross output of the B&M subsectors as well as of value added in relevant subsector of transportation, wholesaling and manufacturing with no appreciable change in the information sector. The latter is most likely to be the case in the early stages of digital penetration. While there will also be a tendency for productivity and household welfare to increase as a result, specific supply and demand considerations that affect market conditions for these products could generate a variety of outcomes in some cases.

An alternative way of describing the switch to digital distribution associated with information and related products is as a change from distributing goods to distributing services as core products. That is, from distributing products exhibiting type II strong separability to distributing products lacking type II strong separability. Notwithstanding, this change is not the only impact of the digital economy on the services sector through the retailing function. Equally important or perhaps more important, the penetration of the digital economy on services through the retailing function affects all service sectors besides the retail and information and communications sectors. The latter make up well over 50% of the economy as measured by GDP (e.g., Betancourt 2004: fn 1, pp.220-21). While these service sectors may lack strong type II separability, just as the information and communications sector does, they all have weak type II separability with respect to distribution services. That is, it is possible to separate in space and time the production, distribution and consumption of at least one but not all of these five broad

distribution services. This feature allows a substantial expansion of the digital economy in service sectors through the performance of retailing functions.

5.2 Penetration of the Digital Economy in Services through Provision of Assurance of Product Delivery at the Desired Time and Offsite Information.

Just as in earlier sections, a simple example from a familiar service sector other than the standard retail sector, namely restaurants, helps the exposition. Restaurants correspond to sub-category 561 of ISIC, Rev. 4. (2008) or more generally to the food and beverage service category (56). Restaurants provide a service where the costs of production and distribution of the service, the enjoyment of a meal, are difficult to separate and penetration by the digital economy affects the separation of production and distribution with respect to GDP measurement, productivity and household welfare. That is, restaurants lack type I separability, which implies they also lack strong type II separability.

Consider the distribution service assurance of product delivery at the desired time for a restaurant. Both before and after the Internet the production of this distribution service required the design of an efficient procedure that expedites the seating of consumers with varying arrival times. Before the Internet, however, this distribution service would be distributed to customers jointly in space and time with the generation of consumption opportunities for customers, i.e., at the restaurant during working hours. For example, a potential patron could call a restaurant from her home and, thus, assure the enjoyment of the meal at the desired time by making a reservation at the restaurant. Here, consumption of the distribution service is separate in space and time from its distribution and production. The latter take place jointly in space and time at the restaurant.

What the Internet allows the digital economy to do is create an intermediary in the form of a two- sided platform, e.g., Open Table, that separates the production of the distribution

service, which still takes place at the restaurant, from its distribution in space and time. Distribution now takes place wherever the servers for Open Table are located at whatever time the customer contacts them. Consumption of the distribution service continues to take place at the customer's home if the reservations is made through a fixed computer at home or wherever the customer is located if through a mobile phone. While production of the distribution service is still located at the restaurant, the distribution of this service takes place through its computer connection to the Open table servers located elsewhere.

More generally, Open Table and similar intermediaries in other countries, e.g., *Busco Restaurantes* in Spain, are intermediaries specializing in the distribution of a distribution service, assurance of product delivery at the desired time. Their existence becomes possible due to the Internet's ability to separate the production, distribution and consumption of this service in space and time: namely, due to weak type II separability in the distribution of the core service product (enjoyment of meals) that the consumer pays for in the food and beverages sector. Incidentally, this example also illustrates a general feature of type II separability (both weak and strong) easy to overlook. Namely, the fact it exists does not imply that it must be employed, i.e., some restaurants don't accept reservations while many others do but some can refuse to participate in Open Table. Indeed, others may both use Open Table and accept reservations directly.

An implication of this restaurant example for GDP measurement is an initial direct decrease in the value added of the restaurant sector, since fewer resources need to be devoted to the provision of reservations, and an increase in the value added of the sub-sector where Open Table is included, which is ISIC Rev. 4. Sub-category 9609 (personal services not elsewhere classified). Since a higher level of this distribution service is a likely consequence of this digitalization, however, increases in the demand for meal enjoyments at restaurants are also

likely. Thus, one should also observe an indirect effect that increases value added for the restaurant sector.

Productivity in the restaurant sector should increase due to the specialization of tasks in restaurant labor. Economies of scale and increased capital intensity in the personal services sector should also lead to an increase in this sector's productivity from incorporating Open Table. Finally, household welfare should improve because those households taking advantage of this feature would experience higher levels of the distribution service due to the increased access to reservations at any time from any place. Furthermore, more households should also be able to enjoy this service at a lower cost as in the case of reservations for out of town restaurants.

Similar considerations with respect to reservations, which are a mechanism for providing assurance of product delivery at the desired time, apply to any service sector where reservations are useful and employed. The most obvious example is, of course, the Accommodations sector, e.g., hotel reservations. Interestingly the implications for GDP measurement would lead to an increase in value added in the sector as well as in productivity within the sector. For, the reservations operations of large hotel chains even if separate in space and time from any particular establishment remain as part of the activities of the sector. Productivity increases due to the specialization of this task into a reservations operation and the much larger scale of operations. Finally, household welfare also increases since their possibilities for making reservations are no longer limited to the hours of operations of the reservations desk of a particular accommodations establishment.

Along these lines mention should also be made of the role of the implications for GDP measurement of the digital economy with respect to reservations in the administrative and support service activities (ISIC, Rev. 4 2008, category 79). Travel agencies classification is sub-

category 791; reservation services classification is sub-category 799. Some reservation agencies in sub-category 799, e.g., Travelocity, are intermediaries where customers make airlines, hotel and car reservations exclusively through the Internet. These intermediaries expand due to the increased penetration of the digital economy whereas B&M travel agencies in sub-category 791 contract. Hence, the initial impact on GDP measurement on the value added of category 79 is the net result of value added increases in sub-category 799 and value added decreases in sub-category 791.

Similarly, the aggregate impact on productivity will be given by the difference between the change in sales for subcategory 799 and subcategory 791 divided by the changes in employment in these two subcategories that result from this substitution. Finally, household welfare is likely to increase since households control the timing and duration of effort in making their own airline, car and hotel reservations relative to going through a travel agent. This assumes, of course, the prices paid are the same or lower than those they would have received through a travel agent. Incidentally, households who don't value this benefit would continue to patronize the travel agencies remaining in existence, which are likely to be fewer than before as a result of the Internet.

Implication II of the Digital Economy in the Distribution of Services: Assurance of Product Delivery at the Desired Time and Offsite Information Can Be Provided Digitally in All Service Sectors. In all service sectors for which consumers value increased certainty of receiving the core service product at a particular time and place through the provision of assurance of product delivery at the desired time or offsite information, penetration of the digital economy increases GDP value added as illustrated for either the personal services sector (Open Table example) and/or the service sector involved, Accommodations (hotel example) and

Administrative and Service activities (Travelocity example). Such increases in value added are likely to be more than sufficient to compensate for any decreases in value added of prior mechanisms for providing this distribution service as a core service product for two reasons. Because of the greater ability of the digital economy to provide higher levels of assurance of product delivery at the desired time and offsite information to every consumer with Internet access (24/7) and to the much lower costs of reaching a far higher number of customers through the Internet. Productivity and household welfare are also likely to be much higher in these service sectors as a result.

Table 5 illustrates the process with published US data for the Personal and Laundry services sector, where Open Table is classified, and for Travel Arrangements and Reservation Services sector, where travel services both offline and online, e.g., Travelocity, are classified. The first and third row of the table illustrate the growth of the total category in each sector during the period 2004-2015 (2.2% and 3.54% respectively). The second and fourth row of the Table illustrate the growth of online activities through E-commerce in each category over the same period (12.09% and 8.65%, respectively). Clearly online restaurant reservations are penetrating more rapidly in their category than online travel arrangements and reservations in theirs. Nonetheless, online restaurant reservations are a much smaller percentage of revenues in their category (less than 3%) than online travel arrangements are in theirs (over 33%). Equally noticeable, online revenues in the former category are less than 25 % of online revenues in the latter category.

(table 5 goes here)

Implication V applies, of course, in a much wider setting than just the three service sectors illustrated by the discussions above. For instance, medical services in the form of

laboratory tests provided by specialized companies, e.g., Quest Diagnostics, have appointments handled through the Internet in a form similar to what hotels do for reservations. Thus, similar considerations in their digital provision are also valid for them and for any other services sector that can rely on appointments for its provision of the service. Yet, they are difficult if not impossible to measure with published data. Indeed, even if the data were more disaggregated across classifications it is unlikely to be available. Because it would require disaggregation within the activities of firms to become measurable, just as in the case of hotel accommodations.

Along the same lines, other distribution services or some of their aspects that can be easy to digitalize would have similar implications to assurance of product delivery at the desired time. The most obvious one is information. Indeed, information through offsite advertising is the only one of these distribution services where production, distribution and consumption of the service was available separately in space and time before the Internet (Betancourt et al 2016: Table 1). All services offered in the market can make use of providing information through advertising with respect to prices as well as other product characteristics. Thus, implication V is also applicable to these settings since it is feasible to provide most advertising information through digital means.

Other aspects of assurance of product delivery (in the desired form) or of information (on site provision) are more difficult if not impossible to provide separately in space and time from the core service (for example surgical services or custom fitting services for suits). Similarly, accessibility of location for acquiring the product and assortment of products for services are difficult to provide remotely or 'separately' in space from the core service. While these services may seem available separately or remotely in some cases, they usually entail a change in the nature of the product or core service.

For instance, in the case of restaurants increased accessibility of location for acquiring the product through home delivery is a possibility but restaurants that offer this alternative usually have a different menu in recognition that some meals don't travel well, which changes the assortment of meal products offered. Indeed, many restaurants fail to provide a home delivery alternative. Similarly, in the case of hotels the offer of different assortments through variations in the quality of the core service, e.g., identified by hotel systems with different stars assigned to different hotels within a chain, implies a different level of accessibility of location for each assortment alternative identified by the star system.

5.3 Penetration of the Digital Economy in Services and the Role of Ambiance.

Indeed, a lack of separability that requires changes in the nature of the core service product, due to the need for bundling a distribution service with the core service product, comes out most starkly with respect to our fifth distribution service: namely, ambiance. "Distribution services are difficult to define and measure with precision. Perhaps the most difficult one to define and measure is what may be labelled ambiance. It determines the level of psychic costs imposed on the consumer by the nature of the retail environment." (Betancourt 2004, p.19). One reason for this greater difficulty is that the other four distribution services are outputs of the retail systems with the following property: increases in their provision lower the consumer's opportunity costs of engaging in purchasing activities in terms of time spent on these activities. On the other hand, ambiance is an output of the retail system that often lowers the opportunity costs of engaging in purchasing activities directly in terms of utility. Thus, changes in ambiance of a retail environment in the case of services are often a mechanism for changes in joint consumption with the core service being provided for purchase such as meal enjoyment or accommodation services enjoyment.

We conclude this section with a discussion of an example that illustrates the issue of changing the nature of the core service product where ambiance plays a critical role in doing so: namely, tertiary educational services (ISIC, Rev.4 2008, subcategory 853). In an insightful article on the economics of online post-secondary education, Hoxby (2014) identifies two highly stylized models of post-secondary education: nonselective ones (NSPE) and highly selective ones (HSPE). She proceeds to characterize the two models in terms of stylized facts and discusses the sustainability of the two models as well as of the role that massive open online courses can play in the two models. She defines HSPE institutions as those in Barron's most competitive categories by having their median students at or above the 95^{th} percentile in the college assessments tests; she defines NSPE institutions as those requiring only a high school diploma or GED for admission or as open enrollment institutions. Other alternatives are a weighted average of these two extremes.

From our perspective, a key difference between the two extreme models that she identifies and provides evidence for are the role of student- instructor interaction and/or student-student interaction. That is, Hoxby argues and provides evidence on the absence of these two interactions in the NSPE model and their presence as 'fairly ubiquitous' in the HSPE model. These interactions then define two different core service products in the two models: certificates in the case of the NSPE model and a college degree in the case of HSPE model. We would also add as a key difference to her basic argument the existence of a significant role for alumni in creating a bond between the institution and the current student in the case of HSPE, which is absent in the case of NSPE.

In our terminology, a stylized NSPE model provides as low a level of ambiance output as possible and a HSPE model provides a level as high as possible. In so doing, participation in a

NSPE is essentially a purchasing activity to acquire educational services in the form of certificates; participation in a HSPE is essentially a joint consumption/investment and purchasing activity to acquire educational services in the form of a college degree. Hoxby argues also that introducing massive open online courses (MOOC) is easy in the NSPE model and difficult in the HSPE one.

Our perspective provides an important rationale for this difference that applies elsewhere in the services sector: namely, MOOC courses change the nature of the output of the institution in HSPE by lowering the level of ambiance (interaction possibilities) through its joint provision of direct utility in consumption activities and in purchasing activities, which are largely absent in MOOC. On the other hand, it has no impact in altering the ambiance of the existing output in NSPE because it has no impact in terms of consumption activities while providing a similar level of ambiance to what it did before in terms of purchasing activities. Thus, in the latter case it becomes a mechanism for increasing the level of the same type of output, namely certificates.

Interestingly, BEA seems to have adopted this criterion implicitly in its decision of what to include for reporting E-commerce in the education category (NAICS 61). Its table 9, the relevant part of which is reproduced below as table 6, excludes primary, secondary, and higher education (NAICS 6111-13) from the table while including business and computer and management training, technical and trade schools, other schools and instructions and educational support services (NAICS 6114-17). Table 6 shows that the online sector in the NSPE model identified by Hoxby grew by 8.86% between 2009 and 2015 whereas in the whole NSPE sector, including B&M, it grew by 5.22%.

(Table 6 goes here)

Implication III of the Digital Economy in the Distribution of Services: Possibility of Digital Distribution of a Core Service Product in Services Sectors without a Change in the Nature of Output through Ambiance.

Weak type II separability with respect to a distribution service allows easy penetration of the digital economy in segments of services sectors where its existence does not imply a change in the nature of the core service provided by the services sector. For those segments of sectors where it is possible, it can lead to a substantial expansion of E-commerce's contribution to GDP with a consequent increase in productivity and household welfare within those segments of the sector.

While this penetration of the digital economy is possible in some segments of every services sector, its feasibility has limits imposed by the requirement that the nature of the core service product remain unaffected. This limitation is more binding in segments where joint consumption between the distribution service and the core service product is important such as is often typical in the case of ambiance but it can also affect aspects of all the other four distribution services in any one sector as our examples for restaurants and accommodation services indicated. Even in the case of service sectors where ambiance is important such as educational services, however, it is possible to find subsectors suitable for digital provision where joint consumption between ambiance and the core service product becomes irrelevant from the consumer's perspective.

6. Overall Implications of Distribution Services' Role in the Digital Economy

One subtle but important implication of our analysis is to reveal a basic similarity with respect to the distribution of core products that is independent of whether these products are goods or services. This basic similarity is that, regardless of the nature of the core product, in

any retail transaction the same five broad categories of distribution services are outputs at some level when linking producers and consumers, i.e. the distribution function performed is the same for goods and services. On the other hand, a similarly subtle and important implication of our analysis is to reveal a basic difference that depends on whether the core product is a tangible good or an intangible service.

For, how the distribution function takes place varies dramatically when the core product is a tangible item from when the core product is an intangible service product viewed as final consumption. In the case of tangible items, the core product enjoys type I separability; in the case of intangible services, the core product does not have this property. Hence, for services the distribution function fails to exist in accounting terms, by being absorbed into the costs of production. Nevertheless, the distribution function continues to happen in real terms. Whether the core product is a final consumption good or a tangible good used as the main input for the household production of intangible services, e.g., entertainments services, makes no difference in terms of how the item can be distributed.

Two broad implications for international trade follow from the role of distribution services in the digital economy. Since type I separability is necessary for strong type II separability, or the ability to separate in space and time the production distribution and consumption of all five broad distribution services, the possibility of completely outsourcing the distribution function is available only for goods as core products. It is not available for services as core products. Not surprisingly, this feature limits the ability of completely outsourcing the distribution function across national boundaries; it is impossible to accomplish for core service products in general. Nevertheless, due to type II weak separability, distribution across national boundaries is not only feasible but relatively easy to accomplish technically with respect to

aspects of some of the five broad distribution services for all core service products: for instance, assurance of product delivery at the desired time, offsite information provision, and accessibility of location for acquiring the product.

Several specific implications for GDP measurement follow from the role of distribution services in the digital economy. Namely, penetration of the digital economy in the distribution of final consumption goods decreases the gross output of the B&M subsectors of the retail sector and increases the gross output of the non-store retail subsector, as well as the value added in the information and communications sector and the transportation and warehousing sector. The latter is a result of the same conceptual distribution activities taking place in different GDP accounting sectors, i.e., due to a change in how they take place.

A similar phenomenon occurs due to penetration of the digital economy in the retailing of inputs distributed via physical items to households for production of entertainment of various types (e.g., recorded music). An exception in this case is that there is a decrease in the value added of the transportation or warehousing sector as well as in the sector previously manufacturing the physical items, since these activities cease to exist due to digital distribution. Finally, the penetration of the digital economy in services sector can increase E-commerce substantially within those sectors or subsectors where there is no change in the core service product in question. It does so to a much lesser extent when digitalization affects the nature of a core service product consumed jointly with a distribution service, just as in the example of ambiance illustrated with respect to online education.

Measurement issues are important in the ability of researchers to detect and/or interpret the changes implied by the penetration of the digital economy. At the practical level the observability some changes in GDP measurement due to penetration of the digital economy

would vary by country and level of aggregation in the classification. Observability at the two-digit level is likely for changes in the distribution of goods in the retail subsector but not necessarily in other subsectors such as information and communications or manufacturing due to aggregation issues. Nevertheless, the changes in subsectors other than retail could become observable at the four- digit level, e.g., the decrease in the manufacturing of products to distribute recorded music due to the penetration of the digital economy ISIC Rev.4 subcategory 1820. Whether this would be the case or not, however, could vary from country to country. But the ISIC Rev. 4 (2008) classification is the same regardless. Hence, when coupled with the crosswalk tables used by statistical agencies, e.g., those in France and the US, it provides a mechanism for pursuing the measurement of these changes by researchers and interested observers in any country with cross walk tables.

Similarly, some changes due to the digital economy may not be directly observable at the four-digit level but may become observable in some countries at the six-digit level. For example, book publishing at the four-digit level is described in the structure and explanatory notes to ISIC Rev. 4 (2008) subcategory 5811 (https://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=27&Lg=1&Co=5811) to include print as well as electronic publishing. In the same vein, music publishing at the four-digit level is described in this same source, sub-category 5920 (https://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=27&Lg=1&Co=5920) to include distributing sound recordings to wholesalers retailers or directly to the public. Use of the cross walk between ISIC Rev.4 and NAICS (2012) shows that NAICS 519130 includes Internet book publishing and Internet music publishing without traditional music publishing whereas NAICS 443142 includes prerecorded tapes, compact disks and record stores and NAICS 451211 includes book stores.

Productivity implications due to the penetration of the digital economy are subject to caveats. Undoubtedly, there is a powerful tendency for productivity to increase in all cases because higher levels of distribution services are feasible for two reasons: 24/7 availability in production, distribution and consumption of distribution services; and, the ability to reach a far greater number of consumers at lower costs. The latter arise due to economies of scale, scope and density as well as the elimination of the 'tyranny' of geography through B&M stores. Perhaps, the most important general caveat in the case of retailing, however, is that the behavior of the gross margin differs from the behavior of sales whereas the number of workers in the sector remains the same. Thus, labor productivity measures will yield a very different pattern depending on what one chooses as the measure of output for the numerator.

Household welfare implications of digital economy penetration are likely to be not only more nuanced but also more heterogeneous across households than productivity is among firms. Just as in the case of productivity, there will be a tendency to improve welfare and for the same reasons; namely the provision of higher levels of distribution services for households that enjoyed them due to retail purchases through digital means. Nevertheless, variety in pricing policies, including some that allow substantial price discrimination across the income distribution (Amazon Prime) together with heterogeneity in location and preferences suggest even more caveats in generalizing about household welfare than with respect to productivity. Moreover, if one were to include implications for household welfare of labor changes for households working in the affected industries these implications would be even more heterogeneous.

With respect to broader questions raised in the literature, an important implication of our analysis is to provide support for Robert Gordon's argument (2016, Ch.17) that foreseeable

innovations may have less impact on economic growth than the great inventions of the past. Our analysis shows that many improvements associated with the impact of the digital economy on the services sector in general arise through the veil of the 'tyranny' of ignorance. That is, the retailing function takes place in all services sector and substantial aspects of productivity improvements in these sectors have come due to the digital economy improvements in the provision of distribution services.

Failure to acknowledge this feature of innovations is due to the practice of assuming away the distribution function in accounting schemes for services because of the inability to measure distribution costs separately from production costs, i.e., because of lack of type I separability. Nevertheless, these innovations have been taking place by facilitating distribution for consumption purposes in service sectors over the last twenty or twenty-five years. How much further impact on economic growth is left?

A related phenomenon with respect to the impact of national income accounting practices arises with respect to the contribution of profits to value added in national income: it usually assumes zero above normal profits. Accounting practice is to impose the assumption in constructing the data (Barkai 2017). Over the last 30 years, however, concentration has increased substantially. One of the conclusions of Barkai's incorporation of above normal profits in constructing the data is that the declines in the share of labor and capital are the result of increased mark-ups due to increase industrial concentration. This contradicts earlier explanations of the decline in the labor share as an efficiency outcome.

Even ignoring sales as a measure of output, reliance on gross margins or value added usually fail to incorporate the role of concentration in generating above normal profits. If there is one thing penetration of the digital economy has generated in the distribution sector is

concentration, e.g., in book distribution. Measures of output relying on gross margins in retailing measure the provision of distribution services by this sector when there are no above normal profits; if there are above normal profits, the gross margins reflect the provision of distribution services as well as the above normal profits generated by higher mark-ups due to the higher concentration. In the latest annual survey of retail trade released in early 2017, gross margins as a percentage of sales are at least 8% (15%) higher for electronic shopping and mail order houses than for the total retail trade every year from 1998 to 2015 (from 1993 to 1997).

To conclude, we have emphasized the retail sector in our discussion but similar issues apply to the wholesale sector. Indeed, the penetration of the digital economy started earlier in wholesaling than in retailing. For example, by 1999 e-commerce sales of merchant wholesalers in the US were ten times larger than e-commerce sales in the US retail sector (Betancourt 2004: fn 26; p.159). From the perspective of providing distribution services, wholesalers need to provide some level of the same five distribution services to retailers with the goods they wholesale as retailer do for consumers. There are, however, two important differences. One is that in providing ambiance issues of joint consumption are or should be negligible, only purchasing activities are relevant. Another is that assuming the consumer (retailer in this case) is a price taker of goods' prices and a quantity taker of levels of distribution services is often inapplicable in this setting. Wal-Mart's evolution provides historical evidence for this assertion (Vance and Scott, 1994); economic evidence and rationales are also available (Basker, 2004; Betancourt 2004: pp173-180).

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TABLES

Table 1. Retail Gross Margins as a Percentage of Sales: 1993-2015.

Year	**1993**	**1994**	**1995**	**1996**	**1997**
Ret. GM/S (total)	27.9	28.0	28.0	27.7	27.6
Ret. GM/S (E-C&MO)	44.7	44.6	43.7	44.0	42.7
Year	**1998**	**2000**	**2002**	**2004**	**2006**
Ret. GM/S (total)	27.7	27.5	27.7	28.5	27.8
Ret. GM/S (E-C&MO)	40.9	38.6	39.1	38.9	38.6
Year	**2008**	**2010**	**2012**	**2014**	**2015**
Ret. GM/S (total)	26.8	28.3	27.6	27.7	28.7
Ret. GM/S (E-C&MO)	37.1	36.7	37.2	39.1	39.0

Source: US Bureau of the Census: Annual Retail Trade Survey – 2015.

Table 2: Retail Trade Employment,1993- 2015 (thousands, seasonally adjusted, December)

Year	**1993**	**1998**	**2010**	**2014**	**2015**
Total Retail Trade	13,163.3	14,472.7	14, 473.7	15, 491.4	15, 677.7
Non-Store Retailers	401.4	460.1	424.4	500.1	546.4

Source: US Bureau of Labor Statistics, B-1 Employment Series.

Table 3. Books, Music through Retail Sector: Tot & E-CM, 1999-2014, (millions of $)

Year	**1999**	**2004**	**2009**	**2012**	**2013**	**2014**
B&Ma. Tot	3434	4930	7569	10991	11444	11579
B&Ma. E-CM	1439	2270	6000	9778	10249	10828
Mu&Vi Tot	4250	3591	6107	9914	11263	S
Mu&Vi E_CM	762	1480	5064	8964	10325	S

Source: US Bureau of the Census, Annual Survey of Retail Trade 2015-Electronic Shopping and Mail Order Houses (NAICS 4541) Sales by Merchandise Line. (S means that the estimate does not meet publication standards).

Table 4. Books, Music through Information Sector: Other Information Services (NAICS 519) & Motion Picture & Sound Recording Industries (NAICS 512) Total & E-CM: 2012 - 2015, (millions of $)

Year	**2012**	**2013**	**2014**	**2015**
Books, etc., 519: Tot	94,027	103,331	115,882	132,740
Books, etc., 519: E-CM	NA	28,537	33,211	40,495
Video & Sound 512: Tot	91,974	95,084	94,475	98,982
Video & Sound 512: E-CM	NA	4,509	4,646	5,836

Source: US Bureau of the Census, Annual Survey of Services (Table 9). (NA means that the data was not available for electronic commerce until after this year)

Table 5. Assurance of Product delivery at the Desired Time in Two Service Sectors: Personal & Laundry Services, NAICS 8129 (Open Table); Travel Arrangements and Reservation Services, NAICS 5615 (millions of $)

Year	**2004**	**2008**	**2012**	**2015**
NAICS 8129: Tot	75,043	82,833	87,030	101,406
NAICS 8129: E-CM	825	1,382	2,151	2,894
NAICS 5615: Tot	27,822	32,697	34,346	40,786
NAICS 5615: E-CM	5,980	8,311	10,661	14,893

Source: US Bureau of the Census, Annual Survey of Services (Table 9).

Table 6. Revenues from Educational Services (NAICS 61) in NSPE Subsectors*. Total & E-Commerce: 2009-2015 (millions of $)

Year	**2009**	**2011**	**2013**	**2015**
E-Commerce	3,150	3,838	4,723	5,242
Total	45,635	51,971	55,188	61,934

*Excludes primary, secondary and higher education (NAICS 6111-13); includes business and computer and management training, technical and trade schools, other schools and instructions and educational support services (NAICS 6114-17).

Source: Annual Services Survey 2015, Table 9.