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John Lourenze Poquiz

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DISCUSSION PAPER

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Keywords: welfare measurement, illegal downloads, free goods, National Accounts, digital piracy

JEL classification: C13, C82, D60, E01, O47

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The goal of this paper is to measure the value derived by households from digital piracy. Our measurement strategy employs the price of paid digital goods and services (e.g. Spotify, Netflix) as a proxy for the shadow price of their illegally acquired counterparts. This is a common method for the valuation of non-market activity for national accounting purposes and is also the methodology endorsed by the European Commission in 2016 for the valuation of ecosystem services for environmental accounting. To estimate the number of individuals engaged in digital piracy, we used information from the United Kingdom's Intellectual Property Office annual Piracy Tracker, which provides an estimate of the proportion of the UK population that engages in digital piracy. We find that, on average, the gross value from the piracy of music, video, live sports, software, computer games, and ebooks was between £3.6 billion and £7.5 billion in 2021. We also find that while the value from the final consumption of communication services has been consistently rising in the past five years, the gross value from the digital piracy of media has been falling. Our data shows that the growth in the value of final consumption from communication services would have been slower by 0.2 percentage points in 2021 had the value from the consumption of pirated content been accounted for in the estimates.

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1 Introduction

Since macroeconomic aggregates such as Gross Domestic Product only account for economic activities with market prices, this set of statistics tends to miss the benefits households receive from the consumption of free internet services such as personal email, chat, and online news, among others. As such, various efforts have been made by economists (and statisticians) to quantify the value individuals derive from free internet products. Most of the research in this area focuses on social media (see Brynjolfsson et al. (2019a) and Schreyer (2021)) and advertising-supported services such as online maps and search engines (see Hulten and Nakamura (2017) and Van Elp and Mushkudiani (2019)). None of the studies, however, tackle the value from the consumption of content accessed through digital piracy.

We can view the consumption of content from digital piracy as a form of "free" service provided through the internet. One of the reasons why researchers are interested in measuring the value of free digital goods is due to their ability to provide households with utility, even though the consumption of these goods is not explicitly reflected in official statistics. One can argue that products and services acquired through digital piracy—while illegal—also improve household utility, despite being missed by National Accounts estimates as part of household consumption. While some of these websites earn revenues by displaying ads, and the revenues from these websites are already included in GDP, we believe these earnings underestimate the value derived by households from the consumption of products. Considering that the marginal cost of production of each content is close to zero, the value derived from an additional user of these sites may be understated in GDP. Moreover, since these sites generate revenues from advertising, their income would be embedded as part of the intermediate consumption of the products they advertise and not household consumption. As such, policymakers would not be able to examine how the production of these content affects consumer welfare.

The goal of this paper is to measure and examine the value derived by households from digital piracy. As our measurement strategy, we employ the price of paid digital goods and services (i.e. Spotify, Netflix, etc.) as a proxy for the shadow price of their illegally acquired counterparts (i.e. illegal streaming, torrent, etc.). Market substitutes have been applied by compilers of the National Accounts to impute for the implicit price of other non-market goods such as the rental from owner-occupied housing, extraction of groundwater

from wells, and agricultural production for own consumption. The use of prices for similar markets is also the strategy endorsed by the European Commission for the valuation of ecosystem services for environmental accounting (see European Commission (2016)). This strategy ensures that our estimates would be consistent with the accounting principles of the SNA. To estimate the number of individuals engaged in digital piracy, we used information from the UK's Intellectual Property Office annual Piracy Tracker. The report provides estimates on the share of the UK's population that engages in digital piracy. This dataset is unique to the UK and is based on a survey employing a representative sample of the country's online population. The survey is conducted annually and allows us to generate estimates that are consistent across time.

We find that the gross value from the piracy of music, video (TV series and movies), live sports, software, computer games, and ebooks was between £3.6 billion and £7.5 billion in 2021. We also find that while the value from the final consumption of communication services has been consistently rising in the past five years, the gross value from the digital piracy of media is falling. Our data shows that the growth in the value of the final consumption from communication services would have been slower by 0.2 percentage points in 2021 had the value from the consumption of pirated content been accounted for in the estimates. Therefore, it is likely that official statistics are overstating the growth in welfare from communication services since they are not accounting for the value of digital piracy.

While the SNA mostly considers market goods as part of GDP, it also recommends that a select group of non-market services, such as government services and services from owner-occupied housing, should be considered as part of production. That said, the majority of non-market production such as household production for own use (with the exception of agricultural households) and ecosystem services are still not considered as part of GDP. The value derived by households from the consumption of these non-market services is compiled in separate sets of statistics called Satellite Accounts. As such, this paper does not recommend that the value from pirated content should be included in GDP. Rather, our goal is to develop a methodology for a possible Satellite Account that incorporates the value of free digital services.

This study contributes to three areas of research. First, it contributes to the growing number of research which aims to measure the value of free digital goods. In recent years, there have been a number of studies in this area Brynjolfsson et al. (2019a,b); Jamison

and Wang (2021). These studies employ binary choice experiments to estimate the value attached by households to free digital goods such as social media, messaging apps, and other online services with no explicit cost upon consumption. In the UK, Nguyen and Coyle (2020) used an online survey representative of the UK's internet population to find out how much compensation households are willing to receive to give up certain digital goods. Meanwhile, research by Soloveichik (2015, 2019); Nakamura and Soloveichik (2015); Van Elp and Mushkudiani (2019) estimates the aggregate value derived by households from free digital goods by employing the advertising and marketing cost incurred to produce them. This paper extends the measurement literature by focusing on the value of media accessed through digital piracy. To the best of our knowledge, none of the earlier studies have paid attention to internet services accessed through illegal means. This paper also extends the measurement literature by employing the price of paid digital products as a proxy for the value of their pirated counterparts, which are often acquired with little to no explicit cost to the user. While this strategy has been applied in the core National Accounts and environmental accounting, to our knowledge, only Poquiz (2022) have used this strategy for digital goods, and that paper did not focus on piracy.

This paper also contributes to the literature on the measurement of illegal activities. According to the SNA, all production activity—whether legal or not—should be included as part of the National Accounts estimates. Many of these activities fall under production by households as an unincorporated enterprise. Various efforts have been made to incorporate the value of illegal activity in the National Accounts. Countries that have engaged in these attempts include the United Kingdom (see Abramsky and Drew (2014)), The Balkans (see Blades (2011)), The Netherlands and Romania (see Dragusin (2015)), and the United States (see Soloveichik (2019)), among others. This paper extends the literature on the measurement of illegal activities by generating estimates for the value of digital piracy in the UK.

This study also contributes to the empirical literature that attempts to measure the impact of piracy. Most of the studies in this area focus on the displacement of sales in creative industries. The studies by Peitz and Waelbroeck (2004), Zentner (2005), and Liebowitz (2008) found that piracy of music negatively impacts album sales. Meanwhile, Rob and Waldfogel (2006) argued that illegal access to media actually improves welfare by reducing deadweight loss. This paper contributes to the literature on the impact of digital piracy by quantifying the dollar-value of welfare received by households from the

consumption of pirated media. None of the earlier research has examined the aggregate welfare impact of digital piracy, especially in the context of the National Accounts.

The outline of this paper is as follows. The next section explains the rationale for measuring the value of digital piracy based on the SNA framework. Section 3 summarizes the literature on the impact of piracy. Section 4 discusses our empirical strategy. In section 5, we present the data, and in section 6, we discuss our results. We end this paper with our conclusions and ways forward.

2 Why measure the value of digital piracy?

The internet provides a number of free services that substitute for market activities (see Coyle (2015)). For instance, instead of buying maps, travelers would rather access Google Maps or Citymapper to find their way around. In such cases, travelers receive the same (or even better) level of benefit without incurring explicit costs. However, this weakens the ability of official statistics, such as GDP and Household Final Consumption, to reflect welfare changes, since households are gaining utility from the consumption of goods and services that do not have a market and are therefore not explicitly reflected in the National Accounts.

The popularity of free digital services has motivated a strand of the measurement literature to account for the value derived by households from these services (see Corrigan et al. (2018), Brynjolfsson et al. (2019b), Brynjolfsson et al. (2019a), Nguyen and Coyle (2020), Jamison and Wang (2021), Nakamura and Soloveichik (2015), Nakamura et al. (2017), Van Elp and Mushkudiani (2019), and Van Elp et al. (2022)). The goal of these studies is to generate aggregates that capture the value of these services and partially address the current weakness of GDP estimates in terms of serving as an indicator of welfare.

One can argue that digital piracy can also cause this substitution. Dejean (2009) observed that music sales have been falling since the late 1990s. A number of studies attribute this decline to the rise of file-sharing networks that make it easier to download songs instead of buying albums (Peitz and Waelbroeck (2004), Zentner (2005), and Liebowitz (2008)).

By imputing for the value derived by households from the consumption of media accessed through piracy, it would be possible to better measure welfare changes contributed

by the creative industries such as film and music. But is it even proper to measure services from digital piracy as part of output and consumption? For one, they are illegal. Second, they cause negative externalities such as revenue losses for industries.

The National Accounts do not discriminate between legal and illegal consumption. Even though digital piracy is a form of intellectual property infringement and is therefore illegal in most countries, final consumption of a service still transpires. Paragraph 25.25 of the 2008 SNA writes:

> [I]n principle, the fact that an activity may be illegal is not a reason to exclude it from the production boundary. In some countries, the difficulties of capturing illegal activities may mean that they are either not well covered or deliberately ignored on pragmatic grounds. However, some countries ignoring the production of drugs, for instance, would seriously underestimate the overall level of economic activity (see United Nations and others (2009)).

There have been substantial efforts aimed at improving the measurement of illegal activities in National Accounts estimates (see Abramsky and Drew (2014), Blades (2011), Sturgess et al. (2018), Kazemier et al. (2013), Dragusin (2015), and Soloveichik (2019)). For the UK, two categories of illegal activities are included by the Office for National Statistics in their GDP estimates. These are illegal drugs and prostitution (see Abramsky and Drew (2014)).

Furthermore, while digital piracy could cause negative externalities such as loss in revenues to creative industries (see the literature review of Dejean (2009)), the National Accounts statistics have long included other transactions that also cause negative effects on individuals and society. For instance, even though cigarettes have been known to cause negative effects on a person's health, the consumption of cigarettes is still included in GDP as part of household final consumption.

It stands to reason that if there are efforts to estimate the value from the consumption of free digital goods, the value from digital piracy should be taken into consideration as well. Based on the accounting principles of the SNA, there is no reason why the value from digital piracy should be excluded in attempts to measure welfare from the internet. Generating such measures would also provide us with a more complete picture of welfare changes in the digital era.

Not all illegal activities are considered part of the production boundary in the National Accounts. For example, the SNA (see paragraph 3.97) argues that theft should not be regarded as a form of production because 1) it does not produce any value; assets are simply transferred from one entity to another, and 2) theft is not considered a "voluntary transaction." The same argument applies to embezzlement. While most legal systems consider digital piracy as "intellectual property theft," we contend that production occurs. When individuals watch a movie via illegal streaming sites, value is created for the viewer. Unlike theft, which only involves asset transfer, in this case, value is generated, similar to how leisure services are created when individuals watch Netflix. Furthermore, we only consider the value from the consumption of leisure services in this exercise (i.e., services from watching pirated content), which is a voluntary activity.

3 Literature on the impact of digital piracy

Various studies have been conducted aimed at evaluating the impact of digital piracy on society. Most of them, however, were focused on assessing its impact on sales in the creative industry.

Dejean (2009) explains that there are two types of piracy. The first is called *hard goods piracy*. This involves the duplication of the physical medium containing intangible assets, such as CDs and DVDs. The second type of piracy involves the replication of intellectual property through the internet using file sharing. Dejean (2009) referred to this as *digital piracy* or piracy through *peer-to-peer* (P2P) networks. Because of how the expansion of broadband access has improved internet download speeds globally, most of the recent empirical studies are aimed at examining the impact of piracy from P2P networks.

Due to the lack of data on infringement in the 80s and 90s, early studies on the effects of piracy were mostly focused on developing theoretical models that predict the impact on copying. In an analytic model, Johnson (1985) showed that copying, in the context of hard piracy, reduces social welfare. Restrictions that are successful in inhibiting piracy, on the other hand, improve overall surplus. The theoretical literature notes two ways on how economic welfare is reduced due to piracy. First, the cost of originals could increase in order to internalize the cost of infringement (see Ordover and Willig (1978), Liebowitz (1985), and Besen and Kirby (1989)). Second, due to network effects, piracy could cause the value of originals to increase, following a rise in demand (see Besen and Kirby (1989)

and Takeyama (1994)).

Some of the first empirical studies that aimed to evaluate the effects of digital piracy on outcomes employed the spread of broadband networks as a proxy for IP infringement activity. Again, this is due to the lack of reliable data at the time. Country-level studies by Peitz and Waelbroeck (2004) and Zentner (2005) found that digital piracy played a relevant role in the decline in CD sales. A city-level analysis by Liebowitz (2008) corroborated these results, concluding that file sharing is responsible for the drop in music industry sales. At the time of these studies, low-cost streaming services, such as Spotify, were not as widespread as they are today. As such, the decline in CD sales from an increase in paid music streaming is not likely.

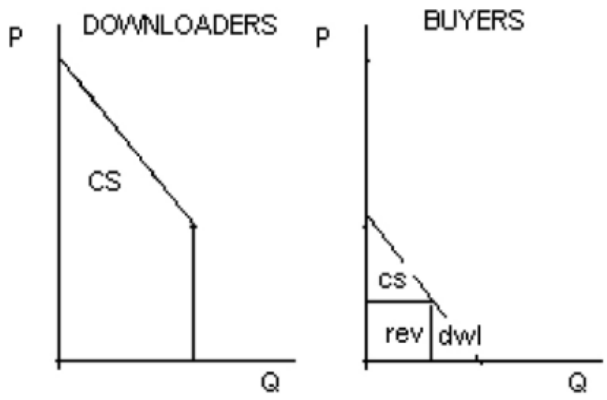
While research employing broadband usage as a proxy painted digital piracy as the cause of the decline in the output of creative industries, results from studies using direct measures of IP infringement are less conclusive. Oberholzer-Gee and Strumpf (2007) examines the impact of the number of illegal album downloads from the portal OpenNap on their sales. In order to address endogeneity, the authors used data on international school holidays as an instrument for illegal downloads. They found that the number of downloads from the portal does not cause a significant change in album sales. Meanwhile, Blackburn (2007) argued that P2P piracy has two potential externalities. First, digital copies are able to substitute for originals, causing declines in sales. Second, file sharing causes a penetration effect that allows for sales of creative output to increase. The study found that substitution effect is greater for well-known artists. Meanwhile, penetration effect benefits artists that are less known. Since total sales in the music industry are driven by sales of popular artists, the decline in overall sales is likely due to the substitution effect.

Meanwhile, results from micro-level studies provide evidence that file sharing negatively impacts sales in the creative industry. Zentner (2006) employed internet sophistication and the internet speed as an instrument for P2P network usage. They found that the use of these networks reduces the likelihood of music purchases by 30 percent. Using data from the US Consumer Expenditure Survey, Michel (2006) and Seung-Hyun (2005) found that P2P networks negatively impact creative industry sales.

Rob and Waldfogel (2006) takes a more nuanced analysis by examining the welfare effects of digital piracy. They argue that illegal download of media actually improves consumer welfare by reducing deadweight loss (see Figure 1). In their survey of 500 students,

they found that respondents generally download albums that are more expensive than their willingness to pay. P2P networks allowed these students access to music that they would not have been able to purchase in the first place. They conclude their findings by saying: "[w]hile downloading reduces expenditure (on hit albums, 1999–2003) by $25 per capita in the subsample for which we perform a direct welfare analysis of downloading, it raises sample consumers' welfare associated with these albums by $70 per capita."

Figure 1: Reduction of deadweight loss from digital piracy



Notes: Figure sourced from Rob and Waldfogel (2006).

Some scholars have also generated estimates of the dollar-value of industry loss due to piracy. Most of these estimates are based on displacement rates from regressions that evaluate the effects of illegal downloads and industry sales. Blackburn (2007) estimated that reducing P2P network activities by 30 percent would enable the music industry to gain around US$260 million in revenues. Meanwhile, De Vany and Walls (2007) found that the US movie industry loses US$41.7 million annually from piracy. These estimates are generated using back-of-the-envelope calculations, based on a certain hypothesized relationship between piracy and revenues. However, they do not provide an estimate of the value of illegally accessed creative content.

A report released by Blackburn et al. (2019) calculated both industry loss from piracy and the value of illegally accessed content in the US. Based on a displacement rate of 14 percent, they estimated that piracy cost the country's film and TV industry between US$29.2 billion to US$71.0 billion. Their estimates also show that the value of digital content was US$166.6 billion for film content and US$200 billion for TV content. They arrived at these estimates by calculating the average industry revenue per movie and per

TV episode, and then multiplying the average revenues by the number of illegally accessed movies and TV episodes.

While the report by Blackburn et al. (2019) was mostly focused on the industry revenues displaced by piracy, it is, to the best of our knowledge, the only study that attempts to generate the aggregate value of pirated content. The main drawback of their methodology is how they value each unit of pirated content. TV and film companies receive revenues from sources other than payment for content. For instance, film companies also generate revenues from merchandise and ad placement, which is on top of their earnings from ticket sales and DVD sales. This may cause the average revenues per content to be a biased estimator of the exchange value for creative output. We address this gap in the literature by using the price of paid products as a proxy of the value derived by households from the consumption of illegally acquired media. In the succeeding section, we discuss the measurement strategy we employ for the estimation.

4 Measurement strategy

Non-market valuation is not new to the compilation of the National Accounts. A number of non-market goods and services are currently included in the GDP estimates for most countries. These non-market services include government services, services by non-profit institutions, agricultural consumption by farming households, and the imputed rent from owner-occupied housing, among others. Moreover, some Satellite Accounts also incorporate non-market activities as part of their extensions to the central SNA framework. These Accounts include the Environmental Satellite Accounts and Health Accounts.

The SNA recommends two methods for the accounting of non-market goods and services. These are 1) the use of production cost, and 2) the use of market substitutes. Cost of production is employed for measuring the value of government services and non-profit institutions serving households, while the price of substitutes is employed for groundwater, agricultural products for own use, and barter transactions. Compilers of the Household Satellite Accounts also use this strategy to value household services such as childcare.

For this paper, we employ the price of substitute goods as our source of valuation of digital piracy products. While the use of the cost production is also a valid measurement strategy for non-market valuation, this approach is limited in terms of capturing the welfare improvements if the marginal cost of producing the service is zero (or close to

zero). Meanwhile, the use of substitutes provides us with an alternative method to measure the value from digital piracy since similar products can easily be identified in the market. Moreover, the valuation would be consistent with National Accounting practice. The SNA writes:

> "When market prices for transactions are not observable, valuation according to market-price-equivalents provides an approximation to market prices. In such cases, **market prices of the same or similar items, when such prices exist, will provide a good basis for applying the principle of market prices.** Generally, market prices should be taken from the markets where the same or similar items are currently traded in sufficient numbers and in similar circumstances. If there is no appropriate market in which a particular good or service is currently traded, the valuation of a transaction involving that good or service may be derived from the market prices of similar goods and services by making adjustments for quality and other differences." (2008 SNA, par 3.123)

In this paper, we measure the value of digital piracy for seven types of products, namely music, live sports, software, computer games, ebooks, film, and TV. We employ the paid version of these products as a proxy for the value of their pirated counterparts. This strategy is similar to Poquiz (2022), which employed the price of paid versions of digital services as a proxy for their free counterparts. The European Commission (2016) also recommends the use of this method for the valuation of ecosystem services for the compilation of Environmental Satellite Accounts.

For TV, film, music, and sports, we employ the price of paid media content as a proxy for the shadow price of pirated media. Paid media is priced differently depending on the popularity of the content and/or the artist, making it difficult to determine an average price that represents access to certain media. The recent popularity of streaming services makes this task simpler. Services such as Spotify, Netflix, and Amazon Prime allow users to access unlimited content for a fixed monthly fee. This fee represents the value consumers derive from having the option to watch or listen to creative content for a certain period. One can argue that P2P networks provide similar services. For instance, an individual can watch unlimited movies and TV series from illegal streaming sites such as 123Movies, FMovies, and similar portals. As such, we employ the price of these streaming services as a

proxy for the shadow price of illegally accessed media. Here, we assume that paid streaming services and illegal streaming services are substitutes. However, we must note that this strategy would likely provide *conservative* estimates of the value of digital content. The libraries of paid streaming services such as Netflix and Disney Plus are limited, in contrast to illegal streaming sites, which often host a materially larger library of content. We argue, however, that this does not invalidate our strategy because the limitation of paid streaming is likely offset by the disutility from accessing illegal media, which we will discuss in the following section.

To estimate software, computer games, and ebook piracy, we employ information from the Personal and Household Finances survey of the UK's Office for National Statistics. In particular, we use data in Workbook 1 (Detailed Expenditure and Trends), which includes information on weekly household expenditures for certain items. We use expenditures on software, videogames, and books as a proxy for the value of software, videogames, and ebook piracy, respectively. We multiply the weekly value to estimate monthly expenditures per household. Since these expenditure values are for the household, we divide the estimated monthly expenditures by the average household size (based on ONS data) to arrive at the value for each individual.

To arrive at the implicit price of illegally accessed music, TV and film, and live sports, $\hat{p}^d$, we take the weighted average of each paid streaming service, p^p:

$$\hat{p}^d_{it} = \sum_{j=1}^{J} (p^p_{ijt} \times \theta_{ijt}) \tag{1}$$

where t is an index representing the year, i is an index representing the type of content (video, music, sports), j is an index representing providers of paid content (Netflix, Disney Plus, etc), and θ_{ij} representing the market share of each content provider. We derive the market share of each provider by taking the ratio of their subscribers to the sum total number of subscribers across all providers. To arrive at the gross value of illegal media consumption, we multiply the estimate of the shadow price of pirated content in equation 1 to a measure of volume. Since the price that we used for the computation of the shadow price is based on the price per user, by extension, the measure of volume we need for the estimation of gross value should also be based on the number of users. As such, we assume that households derived utility just by having access to illegal streaming. The gross value of pirated content can be expressed as,

$$\hat{V}_{it}^{d} = \hat{p}_{it}^{d} \hat{q}_{it}^{d} \tag{2}$$

where the gross value V_t is the product of the shadow price $\hat{p}_{it}^{d}$ of the free media i and its measure of volume $\hat{q}_{it}^{d}$ at time t. Since these estimates makes no reference to intermediate consumption, we interpret these figures as the gross value of consumption in the expenditure side of the National Accounts.

We apply the same principles to derive the value of illegally-downloaded software, computer games, and ebooks. Instead of using a price as an indicator of value, we employ the monthly expenditures of households from the Personal and Household Finances survey. This places a revealed preference assumption on our estimation strategy. We assume that the average monthly expenditures reflect the value derived by households from the consumption of these products.

5 Data

In this section, we present the data employed for the estimation of the gross value from digital piracy. The goal is to generate estimates for the years 2016 to 2021, though this methodology could extend the estimates further back in time (as long as data on prices and the volume measure for infringement are available).

To estimate the gross value from the consumption of digital piracy, we multiply the shadow price of illegal media consumption with a measure of volume, $\hat{q}_{it}^{d}$. Since the proxy price we employ in this exercise is based on the number of users, one can argue that the appropriate measure of volume is the number of users of digital piracy.

Figure 2: Online Copyright Infringement Tracker Report of the UK's IPO

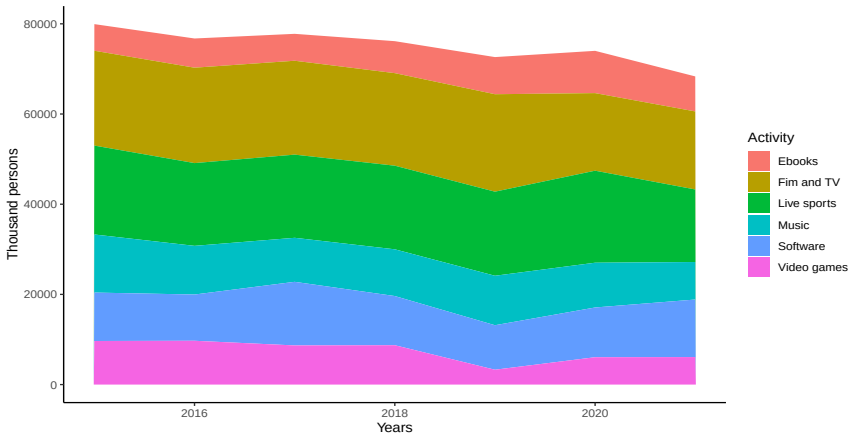
0%	Wave 5 (2015)	Wave 6 (2016)	Wave 7 (2017)	Wave 8 (2018)	Wave 9 (2019)	Wave 10 (2020)	Wave 11 (2021)
Music	27%	31%	32%	33%	40%	37%	42%
TV programmes	32%	33%	35%	31%	42%	42%	44%
Films	20%	22%	26%	28%	34%	42%	45%
Video games	8%	8%	9%	10%	11%	11%	13%
Software	6%	6%	8%	8%	9%	8%	10%
Live sports					14%	8%	15%
E-books	6%	7%	7%	6%		8%	9%
E-publishing					12%		
Digital magazines						5%	7%
Audiobooks						5%	6%

Note: The table is sourced from the 2022 Online Copyright Infringement Tracker Report of the UK's IPO. The table shows the percentage of survey respondents who said that they engaged in infringement activities for certain media.

We employ information from the 2021 Online Copyright Infringement Tracker Report of the UK's Intellectual Property Office (IPO). The survey aims to track the consumer behavior of individuals 12 years old and above in relation to online copyright infringement. The survey is conducted annually. The report released in January 2022 is the 11th installment of the survey. For the latest report, the survey employed a sample of 5,000 individuals, representative of the UK's 15+ population.[1]

[1]While we preferred to use the population of individuals 12 for our estimates, this is not available in the ONS data. As such, it is possible that our final estimates would have some downward bias.

Figure 3: Estimated number of individuals engaged in digital piracy



Note: The figure shows the estimated number of individuals engaged in digital piracy. The sources of basic data are the UK's IPO and the ONS.

We plot the estimated number of individuals engaged in digital piracy in Figure 3. Video (TV and film) and live sports make up the majority of the estimates. On average, video and sports accounted for 29.8 percent and 27.7 percent of the total, respectively. We also observe that the estimated number of individuals engaged in piracy is generally declining over time.

To derive the shadow value of products from digital piracy, we use information on both the subscription price of equivalent products and the average expenditures of similar products. For music, we take the weighted average price of the five most popular paid streaming platforms, namely, Spotify, Apple Music, Amazon, YouTube, and Soundcloud Go+. These platforms offer two sets of prices: standard and a student discount price. We take the weighted average of these prices. We used the population of individuals from 16 to 21 to arrive at the weight for the student price. To acquire the prices for previous years, we accessed the price for the previous versions of the website using the portal *Internet Archive* (www.archive.org).

For video streaming, we employ the average price of popular streaming sites from 2016 to 2021. We use price data from Netflix, Amazon Prime Video, Now Entertainment, Apple TV, and Disney Plus. For sports, we use the subscription prices of Now Sports and BT Sports. We generate two types of price estimates for video and sports: the basic price and the price per screen. The basic price reflects the lowest subscription price available on the provider's website. Meanwhile, we derive the price per screen by dividing each

available subscription price by the number of screens users can potentially watch for each subscription. For instance, the basic subscription to Disney Plus allows users to watch on four screens simultaneously.

Table 1: Weighted average prices in GBP, monthly

		2016	**2017**	**2018**	**2019**	**2020**	**2021**
Music		8.7	8.7	8.7	8.7	8.7	8.7
Film and TV	Basic	7.3	7.4	7.4	7.9	7.6	7.9
	Per Screen	3.2	3.2	3.4	3.7	3.3	3.4
Sports	Basic	6.0	7.2	7.7	8.0	18.7	26.3
	Per Screen	3.7	4.9	5.1	6.0	8.5	11.0
Computer software	Household	2.4	2.8	2.8	3.2	2.8	3.6
(including games)	Individual	1.0	1.2	1.2	1.4	1.2	1.5
Books	Household	4.8	4.8	5.2	4.8	4.8	5.6
	Individual	2.0	2.0	2.2	2.0	2.0	2.4

Note: The table shows the average prices of popular streaming platforms from 2016 to 2021, as well as the estimated monthly expenditures of households for computer software and books. Basic data on household expenditures were sourced from the Household Finances survey of the UK's ONS. Estimates of individual-level expenditures are derived by dividing the household expenditures by the average household size for each year. Prices of streaming services are found in appendix A. All figures are in GBP.

For both computer games and books, we use user data on the monthly expenditures of households from the Personal and Household Finances survey of the ONS. We have two options for this approach. The survey tracks weekly expenditures of *households*. However, the volume measure we derived from the IPO report is based on the number of *individuals* involved in digital piracy. Because of this, we estimate the expenditures for each individual by dividing the household expenditures by the average household size in the UK[2].

We show the average prices over time in Table 1. The average price of music is flat from 2016 to 2021. Moreover, we find no cross-sectional variation in the price. The subscription price of music is the same for all providers. The mean subscription price for video and sports is more variable. The average subscription prices for the two categories are both increasing over time. The average subscription price for live sports increased the fastest for the period 2016 to 2021 from £6.0 per month to £26 per month.

[2]Data on the average household size is sourced from the ONS. The data varies each year.

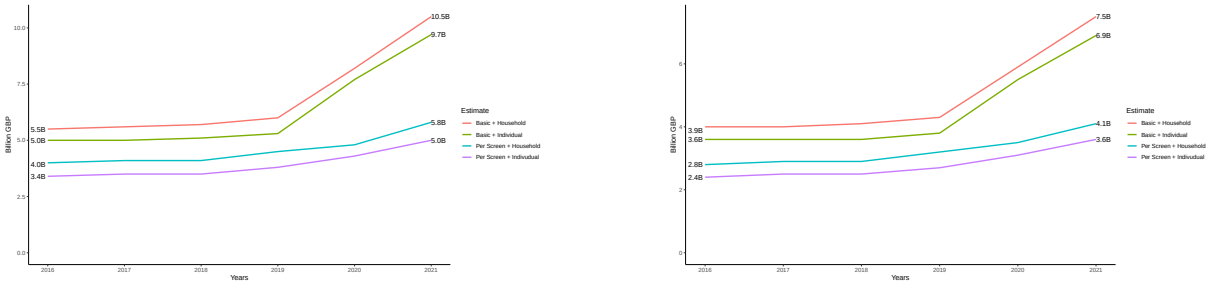
The average expenditures for computer software (including games) and books are likewise increasing. At the household level, the expenditures for software increased from £2.4 per month in 2016 to £3.6 in 2021. Meanwhile, the average expenditure for books increased from £4.8 per month to £5.6 per month.

6 The gross value of digital piracy

In this section, we report our estimates for the gross value of Digital Piracy. We use the formula in equation 1 to generate our estimates.

We show the baseline estimates in Figure 4a. We report the four iterations of the estimates. In the first iteration, we employed the basic price of streaming services and the household-level average expenditures for books, computer software, and games. For the second set of estimates, we used the basic price of streaming services and the estimated individual-level expenditures for books, software, and games. The third iteration employs the average price per screen that we calculate for streaming services and household-level expenditure values for books, software, and games. In the last set of estimates, we use the price per screen and the estimated individual-level expenditures for books, software, and games. The fourth set is our preferred set of estimates because it provides us with conservative values. As such, we can interpret them as the lowest possible estimates for the aggregate value of digital piracy. For discussion purposes, we interpret the first set of estimates as the *upper bound* figures and the fourth set of estimates as the *lower bound*.

Figure 4: Gross value of digital piracy, at current prices



(a) Baseline

(b) Adjusted

Note: The figure shows the estimates for the gross value digital piracy. Left figure shows the baseline estimates from equation 2. Right figure shows the estimates adjusting for the disutility of advertising, where the prices are derived using equation 3.

The estimates show that in 2016, the gross value of digital piracy is between £3.4 billion and £5.5 billion. The data shows that the nominal value of piracy is generally increasing over time. The lower bound estimate grew to £5.0 billion in 2021. Meanwhile, the upper bound estimate jumped to £10.5 billion for the same period. The sharp increase in the upper bound estimates is driven by the increase in the average basic price of live sports subscription.

Our estimates show that live sports accounts for the largest share of the gross value of digital piracy (35 percent). Music and video accounts for the second and third largest share at 28.3 percent and 23.9 percent, respectively. With the exception of 2021, the percentage distribution across products appears to be stable over time. We hypothesize that the increase in the value of live sports that year was a result of the Euro 2020 football tournament.

One can argue that these figures overestimate the value of digital piracy. Because we employ the price of paid market goods as a proxy for the illegally downloaded products, there is an argument to be made that these valuations are not equivalent. One clear distinction is the presence of advertising in illegal streaming sites. Most paid streaming services are ad-free while illegal streaming sites often subject their users to excessive advertising. This is also often the case for websites that allow for the illegal download of software, computer games, and ebooks. We control for this difference by introducing an adjustment term:

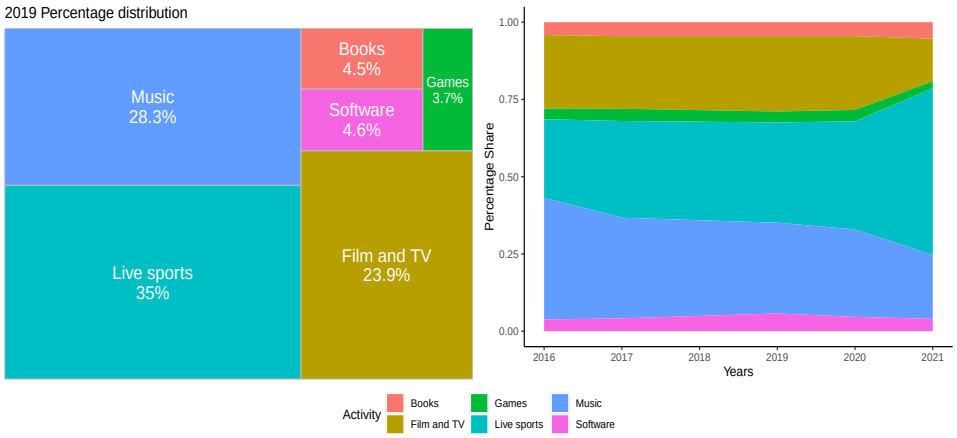
$$\hat{p}i^{aj} = \hat{p}i^{d}\gamma, \tag{3}$$

where $\hat{p}_i^{aj}$ is the adjusted shadow value of digital piracy. In equation 3, we introduce a disutility parameter γ which takes the value $0 < \gamma < 1$. There are many possible reasons why the experience of consuming content from paid sources is better than consuming content from illegal avenues. Among these is the ease of access, security, and assurance that accessing media will not result in accidental download of malware. Ideally, γ should be able to capture the disutility from all the reasons mentioned. Because of the lack of data, we are only able to adjust for the disutility from advertising. Recently, the streaming company Netflix offered an advertising-supported tier. This allows users from selected markets to gain access to a cheaper (30 percent cheaper than the standard subscription) version of Netflix, but with intermittent advertising while viewing. We use the ratio of the price for the ad-supported tier over the standard subscription as our basis for γ. While

this ratio is not perfect in capturing all factors contributing to the difference between the value of illegally accessed digital products and their paid counterpart, this is the best empirical proxy we are able to employ thus far.

We show the results of the adjusted gross value of digital piracy in Figure 6. The upper bound estimate for 2021 is at £7.5 billion and the lower bound is at £3.6 billion.

Figure 5: Percent distribution of digital piracy products



Note: The figure shows the percent distribution of the gross value of each illegally accessed digital service. The left figure shows the share of each product in 2019. The right figure shows the percent distribution over time.

We also generate constant price estimates for the gross value of digital piracy. We first construct a Laspeyres index by extrapolating the base year prices with the growth rates of the shadow price of each product (see equation 4). We chose 2019 as our base year to be consistent with the National Accounts estimates of the ONS. We then deflate our nominal value estimates using the price index (see equation 5) to arrive at the constant price estimates:

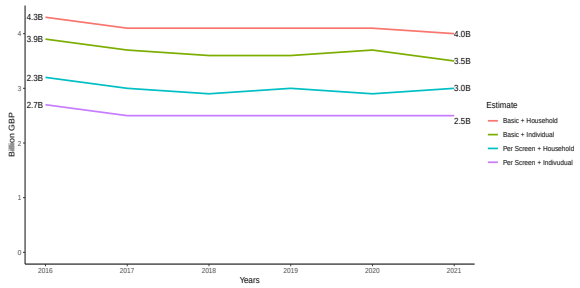
$$Index_i^t = Index_i^{t-1} \times (\hat{p}_i^t / \hat{p}_i^{t-1}) \tag{4}$$

$$\hat{V}i^{R,t} = \frac{\hat{V}i^{N,t}}{(Index_i^t/100)} \tag{5}$$

Here, $Index_i^t$ denotes the price index at time t, $\hat{V}i^{N,t}$ represents the estimates for the gross value of digital piracy in nominal terms, and $\hat{V}i^{R,t}$ represents the gross value in real

terms.

Figure 6: Gross value of digital piracy at constant (100 = 2018) prices



Note: The figure shows the constant price estimates of gross value of digital piracy derived using equation 5.

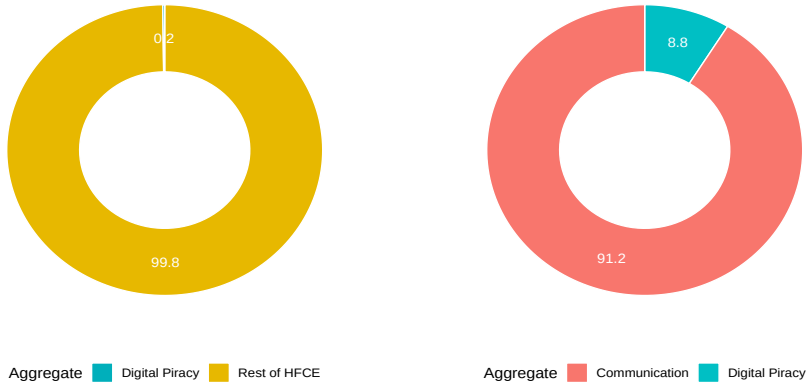
Our estimates suggest that the constant price estimates of the gross value of digital piracy, with 2019 as the base year, have generally declined from 2016 to 2020. This decline reflects the downward trend in the number of individuals engaged in digital piracy.

7 Discussions and applications

estimates. The value of a certain set of statistics depends on its usefulness. The advantage of generating estimates consistent with the accounting principles is that it allows for the estimates to be linked with the core National Accounts data, providing a benchmark for interpretation.

In Figure 7, we present the share of digital piracy (at current prices) in certain household consumption items in 2019. We find that digital piracy accounts for a small share (0.2 percent) of total household final consumption expenditures. Relative to total communication expenditures—which includes paid counterparts to video and music streaming, computer software, and computer games—digital piracy makes up 8.8 percent. This implies that in aggregate terms, households derive a relatively small share of their total consumer welfare from digital piracy.

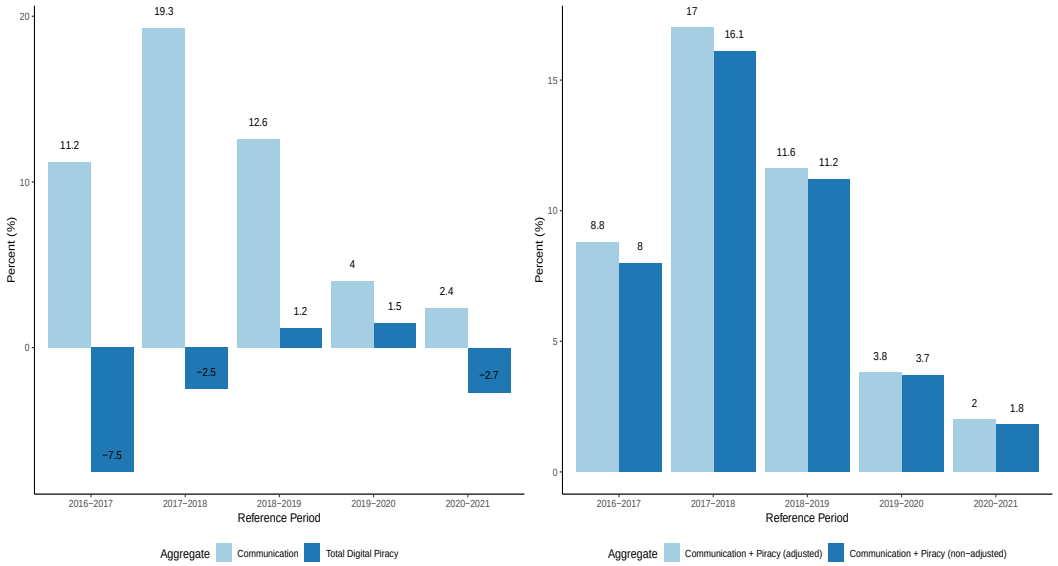
Figure 7: Share of the value of piracy in household consumption



Note: The figure shows the share of the gross value of digital piracy (at current prices) in Household Final Consumption Expenditures (left figure) and the gross value of Household Consumption Expenditures in Communication (right figure). Source of basic data on HFCE is the UK's National Accounts from the ONS.

We can also analyze the pace at which the consumption of digital piracy is growing relative to other goods and services consumed by households. We show the growth rates in Figure 8. The gross value of communication expenditures is consistently growing from the period 2016 to 2021. Meanwhile, the gross value of piracy has declined in three of the five years in the reference period. Summing the value of digital piracy to the expenditures in communications, we find that this aggregate is growing at a slower rate compared with the gross value of communications as reflected in the National Accounts (see right figure). One interpretation that we can give to this is that the National Accounts tends to overestimate the value from the consumption of services such as video and music streaming, sports, software purchases, among others. Households were already consuming a high level of these services through piracy. The welfare derived from this consumption, however, is not reflected in the National Accounts estimates. Perhaps with the advent of cheaper streaming services combined with better enforcement of intellectual property laws, households are switching to the consumption of paid services, artificially increasing the consumption of communication products as reflected in the National Accounts.

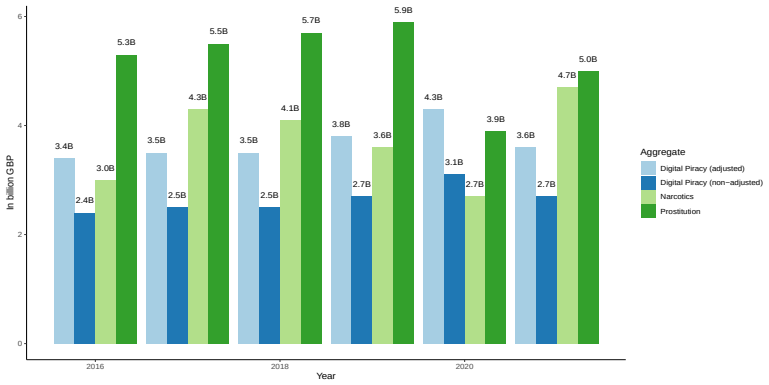
Figure 8: Growth rates of digital piracy consumption of communication services



Note: The figure shows the growth rates of the gross value of digital piracy and the value consumption of communication services. All figures are at constant prices. The source of basic data for communication expenditures is the UK's ONS.

It would also be interesting to compare the value of digital piracy to the value of consumption of other illegal services in the UK. We compare the gross value of digital piracy with the gross value of narcotics and prostitution, the only illegal products recorded in the UK's National Accounts (see Figure 9). We find that the value of digital piracy is comparable with the value of narcotics but below the value of prostitution. It must be noted that not all narcotics and prostitution are illegal in the UK (the ONS does not provide a breakdown between legal consumption and illegal consumption). As such, it is possible that the value of consumption of illegal narcotics and illegal prostitution is comparable or lower than the value of digital piracy. If so, this suggests piracy is more rampant than the two.

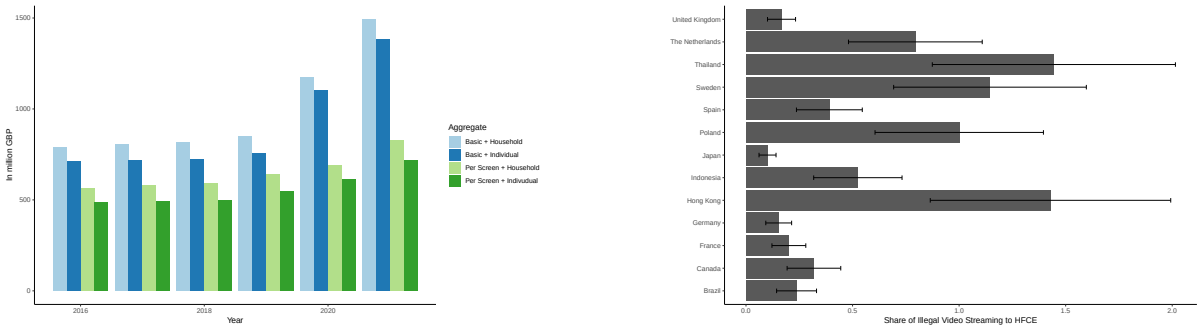
Figure 9: Gross value of illegal goods and digital piracy in the UK



Note: The figure shows the gross value of narcotics, prostitution, and digital piracy (at constant prices) in the UK. Source of basic data is the UK's National Accounts from the ONS.

Estimates on the gross value of digital piracy can have various policy applications. For instance, we can generate estimates of "forgone" government revenues as a result of piracy. We can interpret this as the revenues that the government could have raised from taxes had these services been paid and subject to levies. This is different from displacement, which requires information on the elasticity of paid services to their illegal counterpart. We show the estimates in figure 10a. Assuming that a 20 percent VAT could be levied on these products had they been legal, our estimate is that in 2021, the government could have raised £700 million. To put it in perspective, this is the estimated budget shortfall for the City of London in 2023 (see Chantler-Hicks (2022)).

Figure 10: Other applications



(a) Estimated VAT revenues

(b) Cross-country comparison

Note: The figures show estimates on the foregone VAT revenues from piracy (left figure) and estimates of the gross value of video streaming piracy in selected countries (right figure).

Multilateral institutions and academics may also be interested in comparing the value of piracy across countries. We estimate the gross value of illegal video streaming for other countries using data from Quintais and Poort (2018). The results are shown in Figure 10b. We find that the value of piracy in the UK is actually lower compared to other countries. Based on our estimates, Thailand received the largest value. One can argue piracy is perhaps one avenue that households in developing countries use to "equalize" welfare to some degree. While many individuals from developing countries are not able to subscribe to streaming services such as Netflix and Spotify, they are still able to access the same content through piracy, and these estimates can aid in analyzing this phenomenon.

8 Conclusion and recommendations

In this exercise, we show that the value derived by households from the illegal consumption of media and other digital products can be estimated using existing data. It is interesting to see that the value of digital piracy is declining over time. We offer two likely explanations for this. First, it is possible that the government's crackdown on copyright infringement is causing a decline in digital piracy. While this is a positive development for content producers, we can see from the estimates that this also has an effect on the level of welfare derived by households from the consumption of content. Second, the popularity of low-cost streaming could also be a factor. While the price of Netflix has increased over the years, it is still relatively low. As such, it is possible that more and more households are opting for paid subscriptions as opposed to incurring the cost of piracy.

There are three caveats to our findings. First, we acknowledge that estimates employing the price of paid media as a proxy for illegally accessed media would provide an overestimate of the value of the latter. The logical way forward is to adjust the estimates to address this bias. Ideally, we need to adjust for all sources of disutility from the consumption of pirated media and other products. So far, we are only able to partially adjust for the presence of advertising. It can be argued that there are other reasons why the experience of consuming pirated content is different from the consumption of its paid version. Future research can focus on addressing the challenge of accounting for these other sources of disutility.

Second, we estimate the number of individuals engaged in digital piracy using the population projections for those above 15 years old. The proportion of digital piracy users

in the IPO survey, however, is a representative sample for individuals 12 years old and above. As such, this might cause a downward bias in the estimates. We hope to address this by employing the appropriate population levels for the estimation of individuals engaged in digital piracy.

Lastly, the volume metric that we use in the measurement strategy is the estimated number of individuals engaged in digital piracy. As such, an individual who streams pirated content from two websites would only be counted once. This would likely result in an underestimate of the value of digital piracy since individuals should derive separate utility from the two sites. In the National Accounts, if an individual is subscribed to both Netflix and Disney Plus, the value they derived from the two streaming services would be counted separately.

While the methodology we employed is not perfect, we believe that our estimates are still able to provide useful insights on the size and evolution of the value derived by households from the consumption of pirated digital goods. Future research in this area could attempt to address the caveats mentioned above.

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Appendix

A Prices of Online Streaming

Table A.1: Music streaming prices

	Headline Prices		Average Prices	
	Basic	Student	Simple Ave	Weighted Ave
2016	9.99	4.99	7.49	8.69
2017	9.99	4.99	7.49	8.69
2018	9.99	4.99	7.49	8.69
2019	9.99	4.99	7.49	8.69
2020	9.99	4.99	7.49	8.69
2021	9.99	4.99	7.49	8.69

Note: The table shows the monthly standard prices and monthly student prices of music streaming platforms. Prices are in GBP.

Table A.2: Live sports streaming prices

	Headline Prices		Average Prices	
	Basic	Per Screen	Ave	Per Screen
2016	6.99	2.33	5	5
2017	6.99	2.33	7.5	7.5
2018	7.99	2.66	7.5	7.5
2019	5.99	2	10	10
2020	9.99	3.33	27.5	13.75
2021	25	8.33	27.5	13.75

Note: The table shows the monthly standard prices and monthly prices per screen of live sports streaming platforms. Prices are in GBP.

Table A.3: Video streaming prices

	Netflix			Now Entertainment		Amazon Video		Apple TV		Disney Plus	
	Basic	Per Screen	Implied Price	Basic	Per Screen	Basic	Per Screen	Basic	Per Screen	Basic	Per Screen
2016	7.99	3.93	6.09	6.99	2.33	5.99	2				
2017	7.99	3.93	5.69	7.99	2.66	5.99	2				
2018	7.99	4.2	5.09	7.99	2.66	5.99	2				
2019	8.99	4.83	4.74	7.99	2.66	5.99	2	4.99	0.83		
2020	8.99	4.83	4.51	8.99	3	5.99	2	4.99	0.83	5.99	1.5
2021	8.99	4.83	4.17	9.99	3.33	5.99	2	4.99	0.83	7.99	2