

Dematerialization and the as-a-service (XaaS) business model are a strong business trend. They are key to reducing the carbon footprint of the economy.

Everything as a service

By KOEN DE BOSSCHERE and MARC DURANTON

Over the last thirty years, almost everything that can be represented by bits and bytes, has been digitized: music, movies, photos, books, news... the list goes on. This digitization has led to full dematerialization of production, transmission and consumption. Thanks to increased compute power, large and affordable digital storage capacity, and fast networks, the digital solution has not only replaced the physical one but is, in many cases, better. This trend has led to disruption in several economic sectors, which have had to reinvent their business models so as to transition from selling physical goods to selling a service. COVID-19 is leading to an accelerated digital transformation, which will lead to further disruption and more as-a-service business models.

Key insights

- Digitization has transformed the entire media industry. Consumers and distribution platforms became content creators too.
- The as-a-service business model changed users' world view. Ownership is being gradually replaced by "24/7 access" and renting. This leads to a rapid dematerialization of the economy, and might have impact on the long-term existence of creations.
- The impact of dematerialized services like streaming, videoconferencing and cloud gaming on the environment is moderate, which possibly makes them ecologically less damaging than travelling to a movie theatre, a meeting or a gaming event.

Key recommendations

- Keep investing in ultra-low power computing technology (data centres, networks, devices) so as to reduce the carbon footprint of digital services, and offset the environmental impact of their exponential growth.
- If the above recommendation is executed, keep investing in further dematerialization of services by improving existing solutions and creating new services.
- Create digital libraries and archives, in order to preserve digital-only creations.
- Ensure that European ethics are thoroughly taken into account by content providers.

Very few people in 1982 realized that the introduction of the compact disc (CD) was the start of a new trend (digitization of analog information) that was going to disrupt whole industries. For the customers of 1982, it was just a convenient and higher quality carrier of music.

In 1988, Fujifilm introduced the first fully digital camera, able to store up to ten photographs on a memory card. This represented another major analog-to-digital transition. The first camera phone was the Kyocera Visual Phone VP-210 in 1999. By 2010 all smartphones could record and play media, and resolution and storage capacity were no longer a serious constraint for most users. In the end, it took almost thirty years to evolve from the first digital music player to a powerful multimedia device in pocket format that people are ready to spend a couple of hundred Euros per year on, and that they carry with them at all times. Today, for millions of people it is the last device they see at night, and the first they see in the morning.

Digitization and the as-a-service business model leads to disruption

In the process of digitization, the business model of the content providers has also changed. Instead of selling physical content (like they did in the times of the CD), they started selling digital content that could be downloaded. When the networks became better, they moved to a subscription model for a streaming service where the user has full access to millions of songs for a flat monthly rate of less than €10, or less than the cost of one CD per month. Subscriptions to video streaming services are of the same ilk. Per streaming service, there are several plans, and access to premium content requires a higher monthly subscription rate. Some also have a free plan where content is regularly interrupted by adverts, which is called the freemium business model (from free to premium). This model has the advantage for the provider to lock-in the subscribers and to provide more stable revenues. As, most of the time, the digital contents have DRM which can be revoked at any time, the owners don't own the content, and their subscription is only a rental licence. For the first time in history, intellectual content can be erased with one

click (it happened in 2009, when Amazon remotely deleted some digital editions of the books of George Orwell – including “1984” – from the Kindle devices of readers who had bought them) [7].

Streaming services have put music shops and video rental services out of business in a very short time (Figure 1). Users now have all the content they can dream of available without having to invest in a collection, and music is available on every platform at an affordable price. The choice of what is available now depends on the choices of the provider; for example, some classic movies can't be found at all on platforms that keep only what is fashionable and immediately profitable. The distributors no longer have to invest in the production and distribution of physical media and – very importantly – have full access to the behaviour of their customers. In the last decade, some (especially in the video streaming sector) have started producing their own content and have become very successful. In 2019, Netflix spent \$15 billion on content creation and will become the second largest entertainment producer of 2020 (Figure 2). It earned no less than 24 Oscar nominations in 2020. One of Netflix's key assets is that it has access to the behaviour of its viewers and can tailor its offering to their interests and preferences. It is a dominant market leader, making it more difficult for smaller players to survive. The “recommender systems” use artificial intelligence to best profile the users. The side-effect is that they can easily lock the users in their preferences, and might be, in malevolent hands, a way to manipulate people, based on their individual behaviour – customized manipulation; and victims may well be unaware that this is happening.

More generally, the digitization of media (audio, video, photos, newspapers, books, games, ...) has profoundly changed society. The impact of this technology may be compared to the introduction of the printing press in Europe by Johannes Gutenberg. Today everything from books to audio recordings and movies can be duplicated forever without loss of quality, in no time, and at an extremely low cost. Thanks to the internet and the cloud, available content can be accessed from nearly

anywhere in the world – if not blocked by regional licences and DRMs. This was made possible thanks to the giant leaps made in performance in processing, storage and digital communications, fuelled by Moore's law. Modern streaming media companies are made possible by reliable broadband access and huge data centres distributed across the globe.

But there is more. The printing press enabled more people to print and distribute their ideas in printed format. Digital media enables everyone with a smart phone to produce and distribute audio, video, photos, text, games, ... We are all now prosumers who produce and consume at the same time. YouTube is the market leader for video sharing, Instagram for

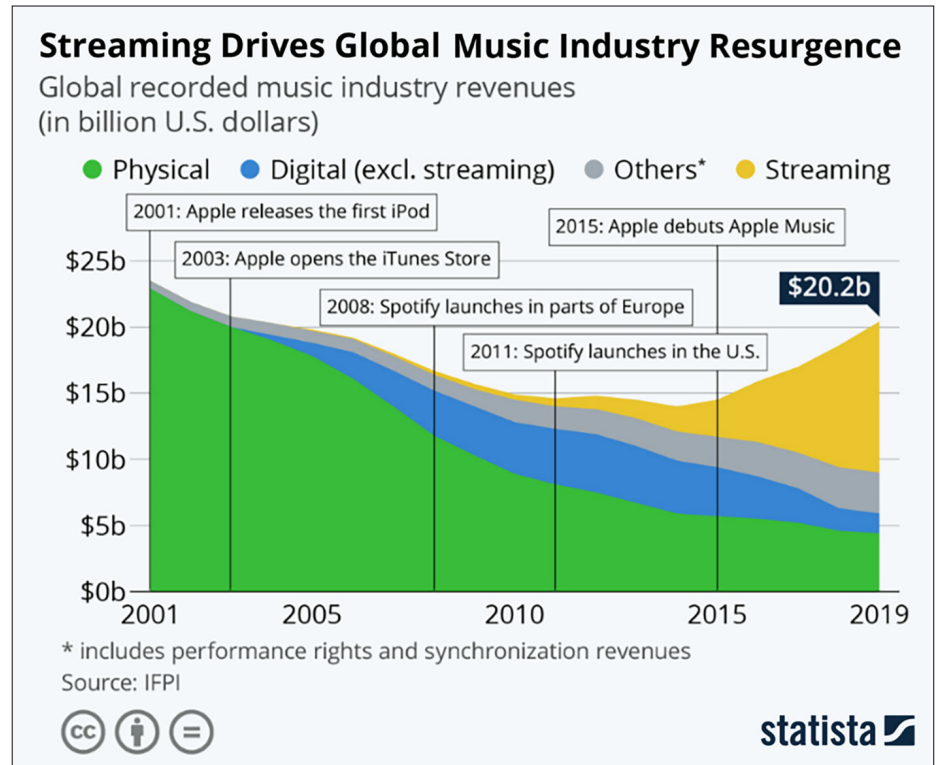


Figure 1: The fast growing music streaming industry brings music industry the revenue back to levels seen in the 2000s [1]

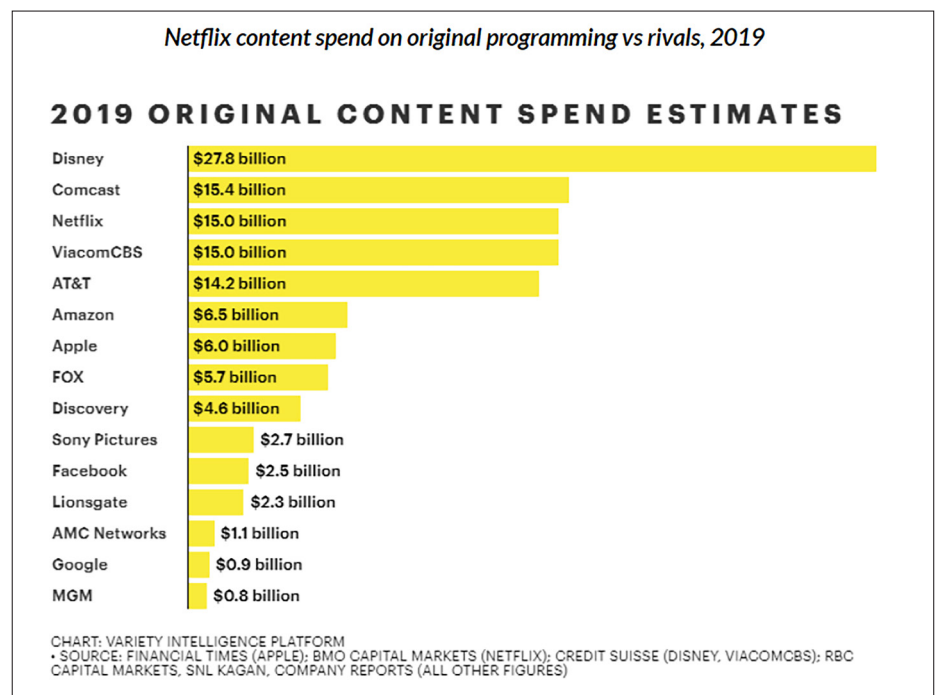


Figure 2: Content creation spending [2]

photo sharing. But this time there is no editorial board to control the quality or the veracity of the content. Facebook and YouTube use algorithms based on artificial intelligence to check the most obvious characteristics of the content and identify pornography or violence for example, but recent history has shown that this is not a perfect system and that it can also incur problems. These social media applications and their massive data sets are a key driver for the development of modern AI.

The consumer market has reacted to this evolution by offering a wide range of devices to improve the media experience (headsets, headphones, loudspeakers, large screens, ...). The computing part is almost invisible: a smartphone, tablet or smartphone suffices to carry out the necessary processing.

Traditional printed media like newspapers and magazines have followed the trend. They cannot survive without a digital channel. In the beginning, the content was merely a digital copy of the printed version, but that no longer suffices. Today, media outlets start from the digital content that feed into a news website, offering video, audio, blogs, vlogs, digital puzzles, etc. They are processing information as fast as the television networks: in real time with breaking news and updates. The printed

version follows the next day. The benefits for the consumer are clear: digital delivery is more convenient, faster, available 24/7 on the platform of choice, cheaper and takes up less space. Since it is dematerialized, it is available worldwide, and converts the use of physical resources (paper, ink, fuel for transportation) into the use of energy. However, it is much harder to come up with a profitable business model: many users do not want to pay for premium content they can find for free elsewhere on the internet, and the income from ads is also shrinking because many advertisers prefer the larger platforms like Google or Facebook. Printed newspapers are struggling to survive and are primarily bought by those over fifty. The younger generation gets 53% of its news from news websites and social media; their smartphone, rather than a television, radio or printed newspaper, is their window to the world (Figure 3). The availability of large amounts of content also entails that users spend less time on each one, switching from one to another, at the expense of paying close attention. This drives content to be short, superficial and very appealing, if not sensational, rather than to offer any in-depth analysis.

The as-a-service economy changes people's world view

This technology is also having an impact on how people view the world. With things increasingly becoming non-physical, younger generations have developed a different view of possession. Having 24/7 access to information in the cloud is perceived as being as good as possessing it, even for emotional assets like family pictures and movies; many people no longer care to keep such treasures safe at home. In fact, there is no point in seeking permanent possession of a physical good that has a digital equivalent (a video, a picture, a book, etc.) or whose availability can be summoned instantly (a shared car, look-up in a dictionary or knowledge base, etc.). The physical good occupies physical space, which is a scarce resource for many, and implies an upfront investment to acquire it and, in some cases, cost of maintenance and care. Owned goods tend to become rapidly obsolete, rarely acquiring value in the process. The digital equivalent has none of those limitations but has

one single, vital, prerequisite: connectivity for the users, and storage for the providers.

This observation is at the heart of the *as-a-service economy* [4], which is sure to expand far beyond the cloud as we know it and enter our everyday lives through the simple appendix of a connected device. The as-a-service economy materializes in apps that, once installed in the user's device, form a gateway to a gigantic and ever-growing wealth of potentially cooperating services. Access to an almost unlimited amount of information also alters the value that is attributed to that information. When people had to go to the effort of visiting a shop or library, for example, to access a song, a movie, a newspaper article or a book, information had value. Today, with near-free access to almost limitless content and information, their perceived value is less and people discard them more easily. When buying a newspaper, people will normally read at least part of it. With a subscription, more articles will go unread, and people are not per se listening to more music than they did in the past because they find it tiring to discover it. Most websites therefore have recommender systems that suggest a small range of selected items to the user, hoping he or she will click on them, like them... and keep paying the subscription.

COVID-19 is currently the digital transformation officer of the world

In 2020, COVID-19 has spurred the transition to the as-a-service economy. At record pace, yet more physical objects and activities have been digitized.

- Money: most people have now learned how to pay cashless (and sometimes even contactless) in shops. It is easy, more hygienic and more convenient. There is little chance that cash payments will make a great comeback in the future.
- Physical meetings: everybody has learned in 2020 that in order to meet, there is no need to move a brain in a body with a car to another location. A meeting can happen in the dematerialized cyberspace instead of in a physical meeting room. Although most of us are well aware of the limitations, we also appreciate the advantages (no need to move to another location, switching between meetings takes

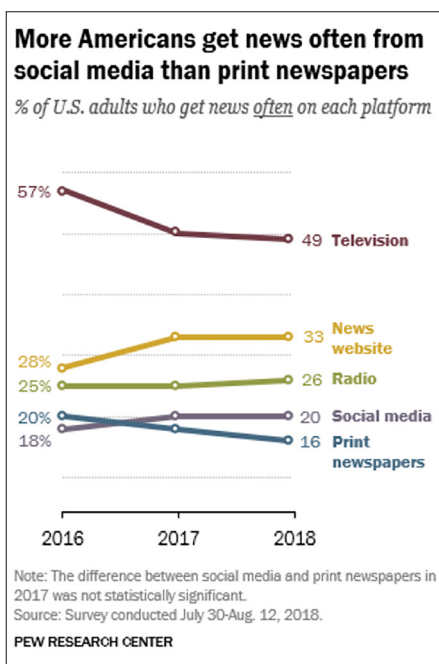


Figure 3: Platform usage by US adults [3]



less than one minute, it is very convenient to share documents, virtual meetings are easier to schedule, everybody is more equal – there are no reserved seats at the table, it is easier to do some other work if an item on the agenda does not require one's attention, some people even manage to be in two meetings simultaneously,...). There are also clear disadvantages: most people find virtual meetings more exhausting than physical meetings, it is less effective for meetings in which the participants do not know each other, scheduling a meeting between distant timezones is a challenge. It is however clear that a number of physical meetings will stay permanently substituted by virtual meetings in the future.

- Schools: although not ideal for compulsory education (from preschool to the end of high school), tele-teaching is suitable for knowledge transfer in higher education and lifelong learning. This is an example of the dematerialization of a classroom. It is however not a good way to teach skills or attitudes and it is defi-

nately not good on a social level, to make friends or build a network, which is also an important goal of higher education. The fact that it is not good for compulsory education has to do with the fact that schools do more than teaching. They are also very important for children's social and emotional development, in some cases playing a role in protecting them (by bringing them in a safe environment, offering them a healthy meal, ...).

Users are also discovering the impact of this new economy: if they have an internet outage, or the provider of a service is down, they are stuck without any options until the service starts again. Some people are discovering that physical books are more reliable than services that can be disrupted.

Maybe surprisingly, dematerialization does not only happen with goods and services that can be digitized: it also happens for material goods that are getting smaller and lighter, and hence require less (and lighter) physical material to manufacture [5].

The impact of streaming on the environment

Some people are worried about the climate impact of the use of digital technologies, fuelled for example by a report by the *Shift Project* indicating that watching one hour of Netflix generated 3.2 kg CO₂. Although clearly too high because this number was based on old assumptions and on an error in which bit rate was confused with byte rate, there is a lot of controversy about this kind of study because of the huge economic interests involved (big tech + entertainment). This study generated a worldwide discussion on the climate impact of streaming. A follow-up study by George Kamiya from the International Energy Agency led to much lower numbers, but was also based on assumptions (only the operational costs were taken into account, not the investments in devices and data centres) and best estimates. The conclusions of this study are [6]:

- The energy efficiency of computing doubles every 2.7 years, and it doubles every two years for transmission networks.



It is important to base an analysis on recent data. Using five year old data will lead to an error of 400%;

- The energy consumption of hyperscale data centres has remained flat at 1% of global electricity use, while the traffic has tripled, and the workload has doubled. The increased demand has apparently been offset by efficiency improvements;
- The biggest energy cost of viewing streamed content is the viewing device itself. A smartphone is five times more efficient than a laptop, and 100 times more efficient than a 50-inch TV screen;
- According to George Kamiya, one hour of Netflix streaming consumes the amount of energy (in Wh) as shown in Figure 4. The total energy consumption is, in the first place, determined by the energy consumption of the device (smaller is better), and the resolution (smaller is better too). Depending on the mix of

devices for Netflix, this leads to an average of 76.9 Wh, of which 70% is used in the device, 25% in the transmission, and 5% in the data centre;

- Expressed in terms of emissions, one hour of streaming is equivalent to 35.6 g CO₂ (based on the global average CO₂ intensity of 463 g/kWh in 2019). This is the equivalent of driving 250m (and eight times less on a smartphone). Only 30% is due to the streaming itself; the remaining 70% would still be used whatever the device was used

for (like watching a broadcasted movie, or playing a game). These numbers are confirmed by other recent studies [8,9];

- The numbers also depend heavily on the origin of the electricity, and on the time of the day the streaming happens. In France, it would only be 4g CO₂ or driving 28m;
- These numbers will keep falling in the coming years due to efficiency gains in data centres, transmission networks and devices, and the decarbonization of electricity generation.

Energy consumption (Wh)	TV	Laptop	Smartphone	Average
	(Wifi, 4K)	(Wifi, HD)	(4G, Auto)	-
Data centre	13.9	6	0.5	3.7
Transmission	18.8	18.3	8.5	17.7
Device	120	22	1.2	55.5
Total	152.7	46.3	10.2	76.9

Figure 4: Energy consumption of 1h streaming on different platforms

The conclusion is that it is very difficult to draw a definitive conclusion on such studies, in part because there are a range of financial and commercial implications of their results. But, if we follow George Kamiya's study, the carbon footprint of streaming a movie is moderate, and definitely much lower than taking a car to go to a movie theatre, and the gap between the two will continue to widen in the future. Given the similarity between streaming video content and videoconferencing systems, meeting virtually will always consume less energy than attending a physical meeting. The same holds for cloud gaming and streaming content including gaming.

However, there is also Jevon's paradox that states that more efficient use of a resource can lead to lower cost and therefore increased demand, undoing the effects of the efficiency gains. The streaming market seems to grow faster than the efficiency gains in computing.

Conclusion

Dematerialization has been ongoing for the last forty years, and there is no reason why it would or should stop now. Dematerialized services might consume fewer resources than physical ones, they are cheaper and are available 24/7, yet there are many concrete challenges to work on. The environmental footprint (also in terms of energy) should be further reduced and existing solutions should be improved; for example, the tools for virtual meetings,

lectures and conferences that do not yet offer the immersive experience that physical events offer.

On top of that, there are still huge opportunities for big virtual events, for tourism, and for museum visits. How cool would it be to 'visit' a city or a museum with an interactive video guide who shows you all the interesting places or objects, and where you can determine how the tour will evolve? This could happen at home, but perhaps also in a virtual tourism facility with a fully immersive experience including the sounds, the smells, the burning sun, and maybe a meal with local food afterwards.

Finally, we should also take into account the possible negative impact of digital-only information, such as the loss of ownership of content, which comes as a result of the content providers deciding what to offer.

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Koen De Bosschere is Professor in the Electronics department of Ghent University, Ghent, Belgium.

Marc Duranton is Researcher at the Research and Technology Department of CEA (Alternative energies and Atomic Energy Commission), France and the coordinator of the HiPEAC Vision 2021.

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