November 2023

The Economic Impacts of Video Game Technology Spillover

Evaluation of how video game technology adoption has benefited the broader UK economy and the economies of Denmark, Finland, Norway and Sweden

FTI CONSULTING™

ukie

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Executive Summary

Ukie engaged FTI Consulting ("FTI") to assess the impact of video game technologies' contribution to non-game sectors in the UK and select Nordic economies. Sectors such as healthcare, audiovisual media, manufacturing, and real estate have adopted and applied innovations from game developers to enhance their products and improve their business operations. These technologies include game engines, virtual reality ("VR"), augmented reality ("AR"), rendering software, controllers and input devices, and haptic feedback. This game technology is developed globally, but "spills over" into non-game sectors of local economies, which benefit through higher productivity and output.

To determine the scope of the impact, FTI isolated the growing linkages between video game-related software publishing and development and other economic sectors. These linkages showed the gradual dissemination of video game technology throughout the broader economy.

The United Kingdom

Table 1 presents the impact of video game technology "spillover" on the UK economy for 2021. Highlights include nearly 10,000 jobs supported, 1.3 billion GBP in output,[1] 760 million GBP in Gross Domestic Product ("GDP"), and 380 million GBP in labour income[2]. This amount of activity also supports 250 million GBP in government revenues. Sectors that saw the highest spillover from game technology in the UK included Information Technology, Energy Extraction and Business Services.

Table 1 includes the ancillary jobs supported from video game technology's supply chain and consumer expenditures. All impacts summarised in Table 1 are in addition to the activities of the video game sector itself.

Table 1 – 2021 economic and fiscal impacts of video game technology spillovers in other sectors on the UK economy

	Metric	Unit	Total
	Employment	Jobs (Units)	9,900
	Output	2021 GBP (millions)	£1,330
	GDP	2021 GBP (millions)	£760
	Labour Income	2021 GBP (millions)	£380
	Government Revenues	2021 GBP (millions)	£250

[1]"Output" is the value of all transactions occurring throughout an economy.
[2]Labor income is defined as the sum of all wages and salaries, the cash-equivalent value of other compensation for employees, and earnings.

This game technology is developed globally, but "spills over" into non-game sectors of local economies, which benefit **through higher productivity and output.**

For example, the almost 10,000 jobs supported by game technology spillover in the UK are on top of the 71,400 jobs supported by the video game sector itself in 2019 according to the BFI Screen Business Report.[3]

As the design of game technology and tools has evolved to consider users of broader technical skill levels and more diverse creative processes, these technologies have expanded their application beyond just the video games industry. Alongside providing an additional source of economic contribution from the UK games industry, which generated over 5.1 billion GBP in Gross Value Added ("GVA")[4] in 2019 to the UK economy,[5] video game technology has lent a hand in many ground-breaking innovations outside of games, such as:

- Game engine technology is instrumental in creating state-of-the-art visual effects ("VFX"). The cinematographer of Disney+'s The Mandalorian—a top 50 ranked television show of 2023—praised game engines for their ability to not only speed up the production process but also improve the final product by providing a real-time view of the finished VFX. In addition to the time and visual benefits, the technology also reduces the need for physical props and locations, enabling studios to produce smaller-scale productions with smaller environmental footprints than previously.
- Healthcare professionals and surgeons can enhance their skills through virtual reality simulations. These simulations replicate real-world scenarios and surgical procedures with accurate representations of human anatomy.
- AppliedVR, a virtual reality ("VR") developer, helps individuals reduce chronic lower back pain. RelieVRx, a VR technology and treatment programme, supports and assists patients' long-term pain management needs using principles of cognitive behavioural therapy. It has been shown to reduce pain for users in an independent clinical trial.[6]
- Video rendering technology originating in game engines is now being used by real estate developers to produce interactive digital designs that assist in guiding the physical development and construction of their projects. The process is currently being employed in developing Co-op Live, the largest indoor arena in the UK. Digital renderings allowed the architect and design teams to visualise the final 23,000-seat arena.

Denmark, Finland, Norway and Sweden

Table 2 shows the impact of video game technology spillover on Denmark, Finland, Norway and Sweden for 2021. Highlights include supporting approximately 1,700 jobs in Norway and Sweden, over 1,000 jobs in Denmark, and 890 jobs in Finland. Additionally, the technology spillover generated 700 million GBP in output for Norway, 270 million GBP for Sweden, 190 million GBP for Denmark, and 130 million GBP in Finland. This amount of activity also generated 570, 140, 120, and 60 million GBP in GDP in Norway, Sweden, Denmark, and Finland, respectively. Labour income for workers in Norway, Sweden, Denmark and Finland was 100, 80, 50 and 30 million GBP and their respective governments gained 180, 70, 40, and 30 million GBP in tax revenues. Across these regions, Energy Extraction, Information Technology and Machinery Manufacturing were the sectors that saw the greatest total impact from game technology spillover. The Energy Extraction sector in the Norwegian economy is very large compared to other economies of similar size and the value of game technology spillover in Norway scales alongside this. The high output from game technology spillover in Norway is sustained by a comparatively

[3]https://www.bfi.org.uk/industry-data-insights/reports/uk-screen-sector-economy
[4]GVA is generally used when talking about specific industries or sectors, while GDP is often more appropriate when looking at an entire economy, as is the case with the impact of game technology spillover. Most sector specific reporting in the UK (incl. the BFI Screen Business Report) uses GVA. Figures throughout this report are given in GVA or GDP as they were originally calculated or published. GVA is a major component of the calculation of GDP and quarterly growth figures for both metrics are generally within 0.2% of each other, so comparisons between the two are reasonable. For more detailed information, please see the ONS website: https://www.ons.gov.uk/economy/grossdomesticproductgdp/methodologies/aguidetointerpretingmonthlygrossdomesticproduct
[5]https://www.bfi.org.uk/industry-data-insights/reports/uk-screen-sector-economy
[6]https://www.fda.gov/news-events/press-announcements/fda-authorizes-marketing-virtual-reality-system-chronic-pain-reduction

Table 2 – 2021 economic and fiscal impacts of video game technology spillovers in other sectors on select Nordic economies

	Metric	Unit	Norway	Sweden	Denmark	Finland
	Employment	Jobs (Units)	1,670	1,710	1,100	890
	Output	2021 GBP (millions)	£700	£270	£190	£130
	GDP	2021 GBP (millions)	£570	£140	£120	£60
	Labour Income	2021 GBP (millions)	£100	£80	£50	£30
	Government Revenues	2021 GBP (millions)	£180	£70	£40	£30

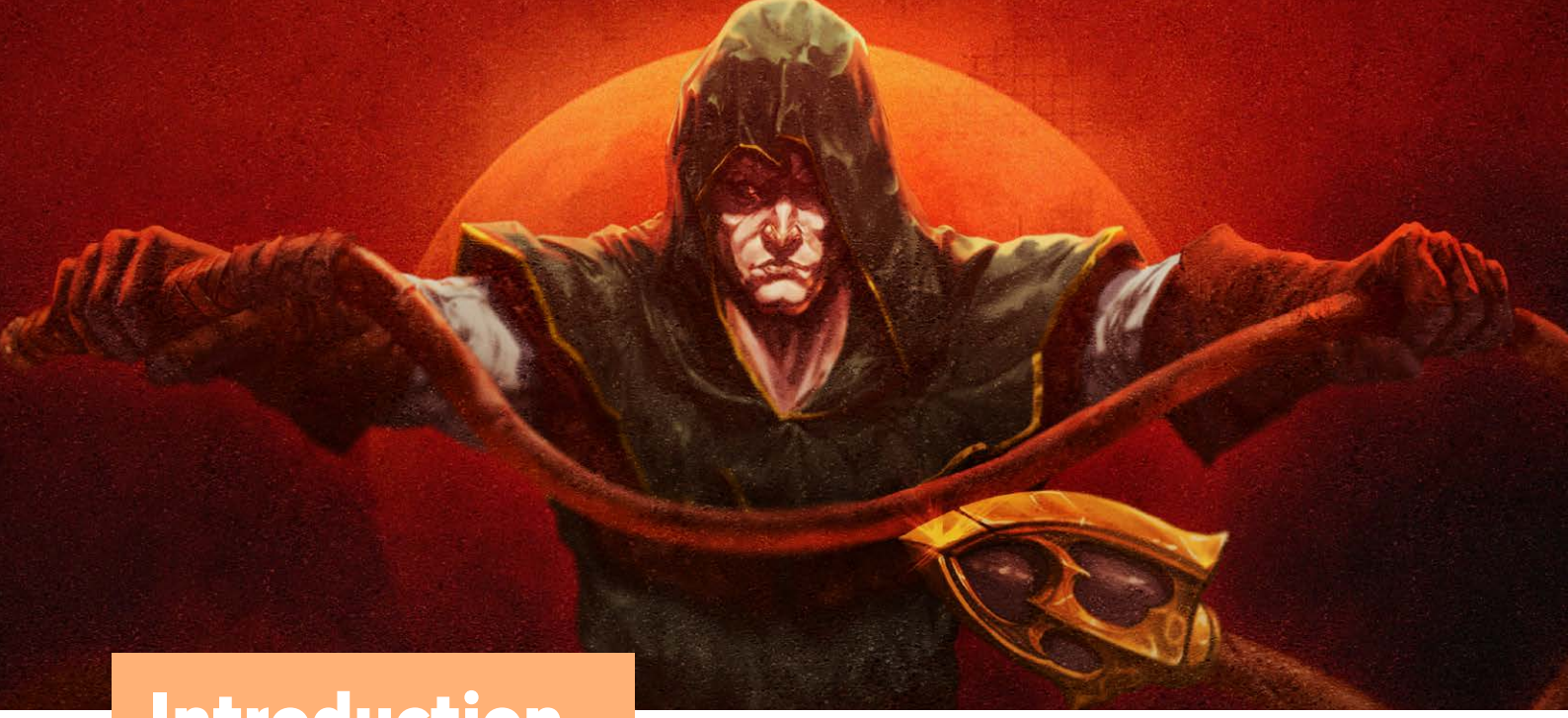
modest workforce and so the spillover output per worker in Norway's Energy Extraction sector is the highest of any sector analysed across all regions, including the UK.
As with the UK, all impacts summarised in Table 2 are in addition to the those of the video game sector itself, which supported over 12,000 jobs and generated over 5.5 billion GDP in revenue across the selected Nordic economies.[7]
Video game technology has been used in the following contexts across Denmark, Finland Norway and Sweden.

- Advanced game engine technology is being integrated into digital interfaces for passenger vehicles, providing drivers and passengers with unobstructed views from all angles. These digital renderings offer high-resolution graphics in real-time, which contribute to the overall safety of the vehicles.
- Game engine technologies also allow for the advancement of hyper realistic driving simulations to support testing and training capabilities in the commercial transportation sector.
- The manufacturing industry uses detailed digital renderings to produce furniture designs. This technology generates lifelike 3D designs that help manufacturers design, adjust, and develop new products. These renderings also enhance the online customer experience by allowing users to customise products and view the changes instantly.
- The oil and gas industry is leveraging VR and AR technology to enhance safety, training, maintenance, and construction by employing detailed virtual representations of facilities and equipment. Through the use of VR and AR headsets, workers can engage with a realistic 3D model of offshore platforms. This technology reduced travel time, costs, and emissions associated with offshore transportation, while also promoting the secure operation of the platform by allowing users on the rig to find and repair damaged equipment more efficiently.

[7]https://www.egdf.eu/2021-european-video-games-industry-insight-report/

The UK is home to almost 2,600 games companies...

with over 55% of game development roles outside of London and the South East



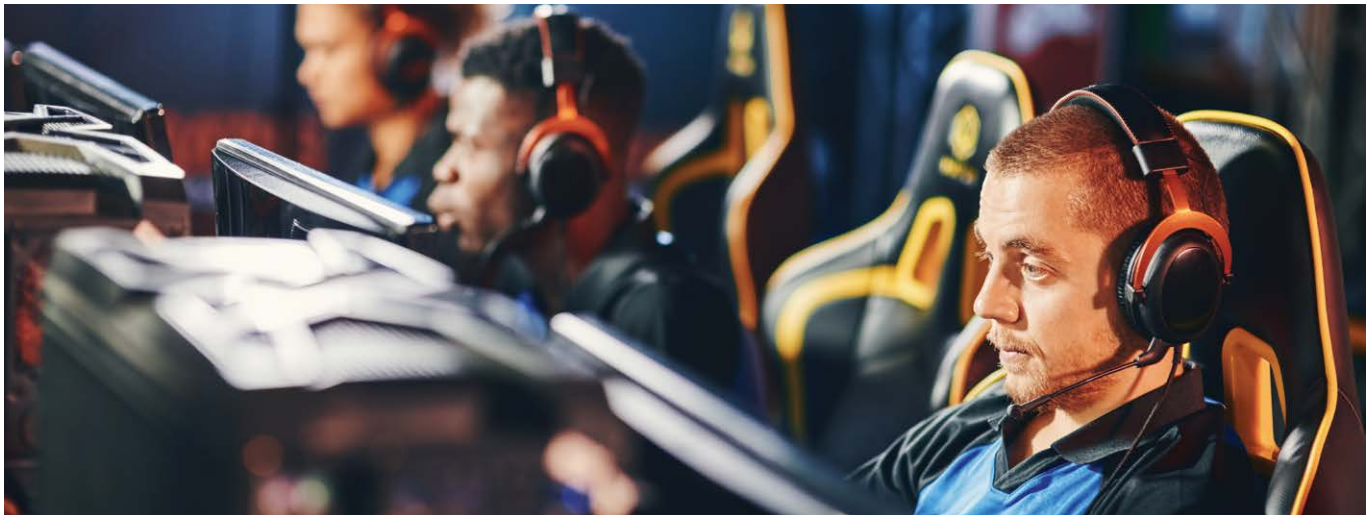
Introduction

The UK is home to almost 2,600 video game companies, with around 2,340 located in England, 122 in Scotland, 68 in Wales, and 35 in Northern Ireland. The London region is the primary hub for video game companies, with almost 900 operating in the city.[8] Although the UK's registered companies are concentrated in London, the games industry's workforce is more distributed, with over 55% of game development roles being outside of London and the South East. Over 1,100 video game companies operated in Denmark, Finland, Norway and Sweden combined in 2021. Sweden had the largest number of companies and employees, with 785 companies, and the video game industry was centred primarily in Stockholm. Finland had 216 video game companies, while Denmark had 168 companies. Norway had a smaller presence in the industry, with fewer than 20 video game companies.[9,10]

The UK video game sector is oriented towards exports, with 95% of UK game development studios exporting some of their games. Some notable UK video game production highlights are:

- *Grand Theft Auto* ("*GTA*") is one of the most successful video game series ever produced. Developed by Rockstar North, located in Edinburgh, the GTA franchise has sold over 400 million copies since 1997.[11] *Grand Theft Auto V* was released in 2013, has sold over 180 million copies, continues to appear in the UK's top-selling games charts a decade after its release and is considered to be the "most financially successful media title of all time".[12]
- The *Tomb Raider* franchise is another success story for the UK video game sector. Originally created by Core Design in Derby, England, the franchise has generated 19 games and three feature films with upcoming plans for a streaming series.[13]
- Released on Steam in early access in December 2021, *Vampire Survivors* is an indie game success story. Originally the work of solo developer Luca Galante, following an explosion in popularity, it is now made by a 15-person UK studio named poncle, headed by its original creator. It saw an all-time peak of over 77,000 concurrent players[14] on Steam, putting it alongside games like *Call of Duty: Modern Warfare II Warzone*. Its success was capped by winning both Best Design and Best Game at the 2023 BAFTA Games Awards.[15]

[8]https://map.gamesmap.uk
[9]https://dataspelsbranschen.se/game-developer-index
[10]https://www.egdf.eu/2021-european-video-games-industry-insight-report/
[11]https://ir.take2games.com/static-files/f04c0f81-91d9-4792-a05f-c11d244c96c3
[12]https://www.gamesindustry.biz/gta-v-is-the-most-profitable-entertainment-product-of-all-time
[13]https://www.hollywoodreporter.com/tv/tv-news/tomb-raider-tv-show-amazon-phoebe-waller-bridge-1235311582/
[14]https://steamcharts.com/app/1794680
[15]https://www.bafta.org/games/awards/2023-nominations-winners



Developers in Nordic countries have created some of the largest and most popular video games in the world, including those listed below.

- *Minecraft*, the number one best-selling game of all time,[16] is developed by Stockholm-based Mojang Studios. Originally launched in 2009, Minecraft would go on to sell over 240 million copies and attract 93 million active players every month.[17] Minecraft is available on over 20 platforms with Dundee-based 4J Studios handling several console ports. The Minecraft brand has recently expanded to other genres with *Minecraft Dungeons* and *Minecraft Legends*.
- Rovio Entertainment, established and based in Finland, is the creator of the world-famous *Angry Birds* franchise. What began as a video game in 2009 quickly became a global sensation and an immensely popular brand. The franchise has since grown to now include around 30 video games and two movies.[18]
- The first entry in the *Hitman* franchise, *Hitman: Codename 47* was released by Copenhagen-based IO Interactive in 2000. Over 21 years and 8 games, the franchise has established itself as a staple of the stealth game genre, with *Hitman 3* (2021) being named the best stealth game of 2021 by PC Gamer[19] and the *World of Assassination* trilogy attracting over 50 million players[20]. IO Interactive, who became independent in 2017, employs over 150 people[21] and operates subsidiary studios in Malmö, Barcelona, Istanbul and Brighton. The franchise has also seen two film adaptations and several mobile spin-offs.

According to the 2021 Screen Business report, in 2019, the UK video games industry directly employed 24,000 full-time equivalents, supported 24,200 indirect supply-chain jobs, and induced another 18,200 jobs through consumer expenditures.[22] These 71,400 jobs represent 2.4 billion GBP in employment-related compensation and altogether support 5.1 billion GBP in GVA for the UK economy. In the Nordic region, according to the 2022 Game Developer Index and the 2021 European Games Developer Federation Industry Insight Report, the video games industry provided employment to over 12,000 workers in 2021. Sweden supported just under 8,000 jobs in the video game industry, Finland employed 3,550 workers, and Denmark and Norway employed 911 and 433 workers, respectively.[23,24]

The video game industry's economic impacts go beyond just these figures and extend into other sectors where the industry's technology has been adopted, such as film and television production, healthcare, and real estate. This increasing "technology spillover" has enabled other sectors to increase innovation and total output, improve product designs, enhance product safety and training efforts, enrich customer experiences, and preserve culture,[25] making now a worthwhile time to gauge the extent to which video games can be a source of economic value beyond its core sector.

This report documents how the growth of the video game industry and game technology has resulted in spillovers in multiple economies. It showcases specific examples of how software and hardware technology developed by video game developers has been applied in other economic sectors.

[16]https://www.forbes.com/profile/markus-persson/?sh=4565d5f969aa
[17]https://dataspelsbranschen.se/game-developer-index
[18]https://gamerant.com/every-angry-birds-game-chronological-order/#angry-birds-seasons
[19]https://www.pcgamer.com/best-stealth-game-hitman-3/
[20]https://youtu.be/r6Y3Bqjz_AY
[21]https://regnskaber.cvrapi.dk/90261242/amNsb3VkczovLzAzLzAxLzkyLzZmLzIxL2U2NTktNGM0Zi05MmU4LWEzMDEwNjI4ZGM3MA.pdf
[22]https://www.bfi.org.uk/industry-data-insights/reports/uk-screen-sector-economy
[23]https://gamedevreports.ru/wp-content/uploads/2022/10/gamedeveloperindex2022webb.pdf
[24]https://www.egdf.eu/2021-european-video-games-industry-insight-report/
[25]https://www.cbsnews.com/news/notre-dame-cathedral-fire-video-game-assassins-creed-could-help-in-its-restoration/

Spillover Technologies

Overview of Spillover Technologies

This section describes several significant technologies developed by the video game industry that have benefited other economic sectors. Important technologies include, but are not limited to, game engines like Unreal Engine[26] and Unity,[27] virtual reality ("VR"), augmented reality ("AR"), 3D rendering software, input devices, and haptic feedback. These technologies are not all mutually exclusive, as they could benefit each other in various ways. For example, game engines often incorporate 3D rendering software, and input devices may include haptic feedback to immerse users in a VR world.

In the past decade, video game technology has matured greatly, and its uses have expanded beyond video game development alone. For example, use of game engines as visualisation tools has spread to various industries such as healthcare, real estate, and preservation efforts, as illustrated further in the case studies. As a result, it is a crucial time to evaluate the economic impact of game technology.

> **"As more immersive and engaging communication mediums** that are predominantly driven by games technology and games design practices, **AR and VR content has a broad spectrum of appeal and interest beyond the gaming sector.** From training and L&D, through to marketing and retail, **the appetite and investment for solutions using these new technologies is vast and rapidly increasing."**

Matt Vernon-Clinch, Business Development Director, PRELOADED[28]

[26] https://www.unrealengine.com/en-US
[27] https://unity.com/
[28] Expert interview conducted by Ukie

Virtual and Augmented Reality

Virtual Reality is an immersive experience that isolates the user from the physical world. VR headsets, such as the Meta Quest, allow users to explore fully interactive environments while providing visuals and audio that demand the full capacity of the user's eyes and ears.[29] Combined with intuitive controls, this creates the illusion of being fully transported to a different world, allowing users to engage in video games with a deeper sense of immersion or a more complete replication of real-life experiences like tourism or driving.

In contrast, Augmented Reality ("AR") superimposes real-world environments with sensory elements. These include visual or audio elements to overlay digital content on real-world objects. An early example of mass-consumed AR is the popular *Pokémon Go* app, originally released in 2016. *Pokémon Go* players use the camera on their mobile device to search for Pokémon hiding in the "real world."[30] Users could find Pokémon hiding in their houses, behind a tree at a local park, or at mass social gatherings.

AR has contributed to the medical field as well. The technology allows healthcare workers to search for veins more easily within patients' arms. It also allows mechanics to locate and troubleshoot damaged equipment in the oil and gas industry.[31,32]

Controllers and Input Devices

Controllers and input devices establish the link between users and electronics. The obvious examples include a mouse, keyboard, and video game controller.

Video game controllers have several advantages: low-cost, abundant, easy to connect, easy to replace if failure occurs, and user familiarity across a wide range of demographics. Looking at the issue from the perspective of an engineer, video game controllers are a commercial off-the-shelf ("COTS") part of a system that can be folded into existing designs and are easily adaptable.[33]

Controllers are no longer limited to video games. They have found their way into many other contexts, such as military applications. In 2018, the *USS Colorado*, a nuclear submarine, was equipped with Xbox controllers to operate photonic masts in lieu of pricier periscope controllers that required bespoke equipment.[34]

[29]https://www.meta.com/quest/products/quest-2/
[30]https://pokemongolive.com/?hl=en
[31]https://www.accuvein.com/
[32]https://www.equinor.com/energy/digital-twin
[33]https://csrc.nist.gov/glossary/term/commercial_off_the_shelf
[34]https://www.usatoday.com/story/news/nation/2018/03/16/attack-submarine-colorado-xbox-controllers-included-join-fleet/431719002/

Game Engines

Game engines represent perhaps the most significant spillover technology. A game engine is a software product with settings and configurations to simplify the development of video games. They include a two- or three-dimensional graphics rendering engine, a physics engine that simulates the physical behaviour of objects and individuals, artificial intelligence ("AI") that automatically responds to the players' actions, a sound engine to control sound and music, and more. These components help produce new games and can ease the porting of existing games to additional platforms.[35]

Many of today's game engines are used for "in-house" development only, meaning the engine's owner (often a publisher) and other studios within their group have exclusive access to the engine for creating games published by that same owner (e.g. EA's Frostbite Engine[36] and Capcom's RE Engine[37]). Other engines were developed as licensable products, such as Unreal Engine from Epic Games and Unity by Unity Technologies. Historically, these tools were licensed to game development studios, many of whom would not have the resources to build their own game engine. They were often best suited to a particular style of game. For example, Unreal Engine began with a focus on PC first-person shooters. Both Unreal Engine and Unity are now robust engines capable of handling many styles of games. A significant shift in recent times has seen these engines licensed to companies outside of the games industry and used for purposes other than game design, becoming increasingly ubiquitous as state-of-the-art visualisation tools across many industries due partly to their ease-of-use, broad knowledge base, and frequent updates.

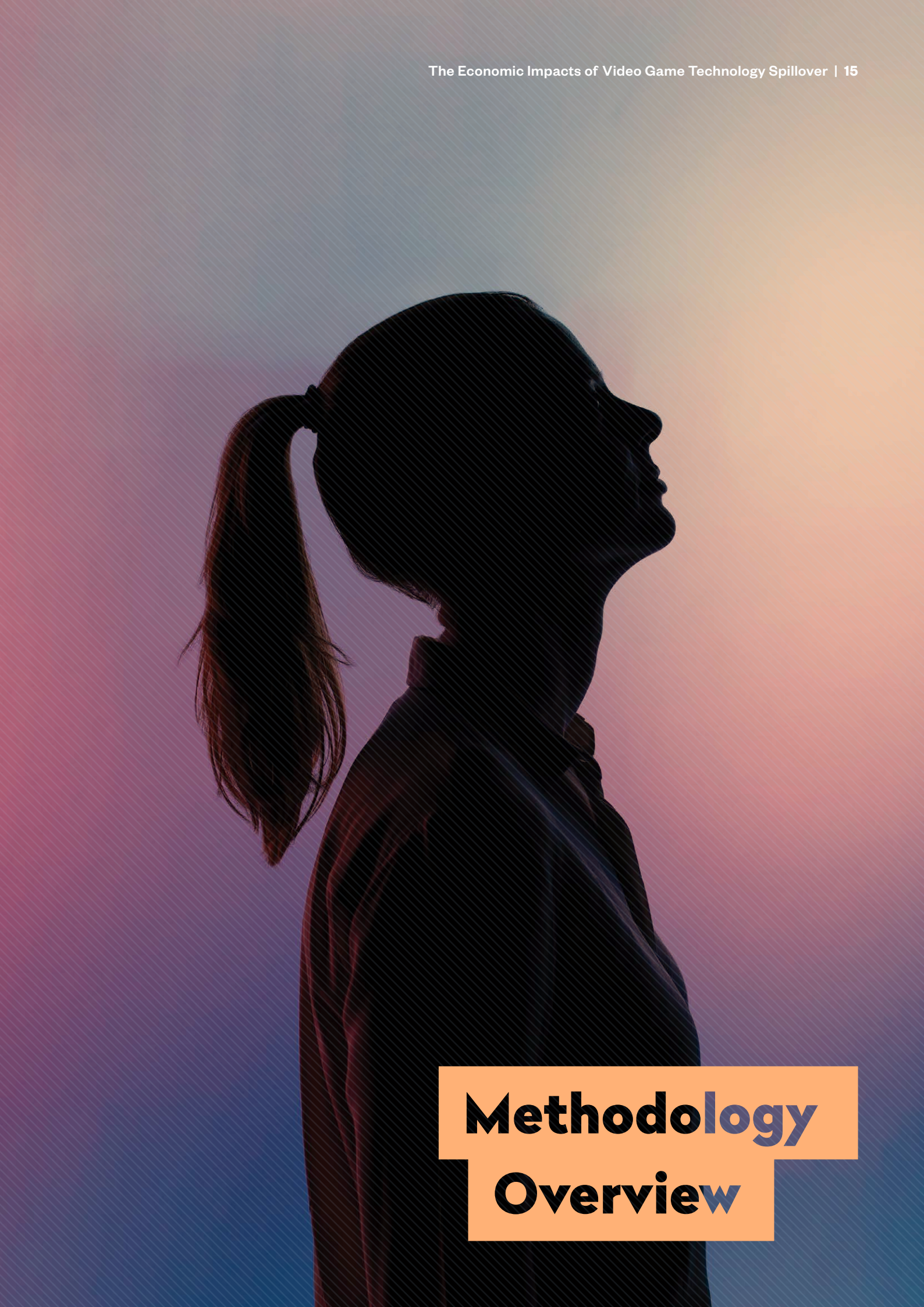
Haptics

Haptic technology, also known as haptic feedback, allows users to experience physical sensations which imitate their virtual environment.[38] For instance, a video game controller or VR headset may shake, vibrate, or rumble in response to in-game events, which provides real-time feedback to the player. Such feedback increases the level of interactivity and offers the users a more immersive experience.

In the automotive sector, haptic technology is being employed to enhance both driver and passenger experience. Using adaptive haptic gloves, users can operate automobile functions such as audio through hand-tracking movements, without ever touching the screen.[39]

Advancements in haptic technology are also bringing substantial improvements in robotics and healthcare. Based in London, Fundamental Surgery is a medical technology company incorporating haptic technology into VR applications. These tools offer surgeons the ability to merge VR surgery techniques with haptic feedback, which allows them to feel aspects of anatomy. This approach has resulted in a 44% increase in surgical accuracy over traditional VR training.[40]

[35]https://www.arm.com/glossary/gaming-engines
[36]https://www.ea.com/frostbite/engine
[37]https://www.gameinformer.com/2023/07/03/how-is-capcoms-re-engine-so-versatile
[38]https://masschallenge.org/articles/haptic-technology/
[39]https://www.businesswire.com/news/home/20170216005123/en/HARMAN-Partners-with-Ultrahaptics-to-Bring-Custom-Haptic-Sensations-to-the-Connected-Car
[40]https://fundamentalsurgery.com/platform/hapticvr/



Methodology Overview

Methodology Overview

This section provides an overview of the underlying approach and specific analyses carried out by FTI Consulting to determine the economic spillover impacts of video game technology on the UK and Nordic economies. For more detailed information, please see the appendices of this report.

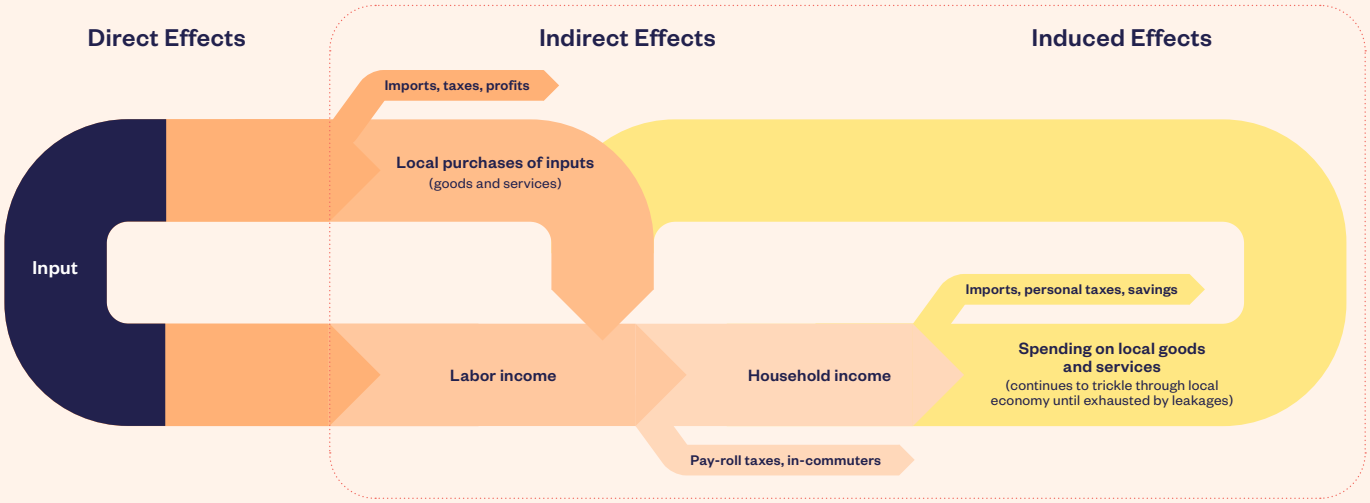
IMPLAN Model and Definitions

FTI used the IMPLAN model, which is an input-output ("IO") model of regional and national economies.[41] IMPLAN produces five main metrics for the UK, Denmark, Finland, Norway and Sweden:

1. *Employment* – the number of jobs supported
2. *Output* – the revenues of businesses associated with video game technology
3. *GDP* – the sum of all income related to production
4. *Labour Income* – the household income supported by video game technology
5. *Government Revenues* – incremental tax revenues for all levels of government because of higher levels of economic activity, such as higher income tax payments

IMPLAN illustrates how a direct change in employment or expenditures, the "direct impact", will then influence the rest of the economy. IMPLAN describes these "ancillary" or "ripple" effects through its "indirect" and "induced" multiplier effects as shown in Figure 1.

Figure 1 – IMPLAN flowchart



Source: IMPLAN, Ukie

[41] https://support.implan.com/hc/en-us/articles/12150245873435-2015-International-Product-Release-Notes

The types of IMPLAN effects are defined as the following:

- *Direct Effect* – The direct effect is the direct employment or output associated with video game technology. Examples might include construction workers or audiovisual artists.
- *Indirect Effect* – The indirect effect is the impact on the regional or national supply chain. For instance, equipment and material inputs might be used in another sector after first being produced by an initial sector from the raw materials produced by the agriculture or resource sectors. Other sectors, such as utilities or the many professional services and business services needed to operate an enterprise, can also be indirect impacts.
- *Induced Effect* – The induced effect is the consumer expenditures supported by the wages paid to the employees of the direct and indirect economic sectors.
- *Total Effect* – The total effect is the sum of the direct, indirect, and induced effects.

Analysing the US Economy and Mapping Results to European Territories

IO models represent all transactions occurring between sectors throughout an economy. The IMPLAN IO model for the US economy is significantly more detailed both in terms of sectoral breakdown and timeseries than European models. Acknowledging that the changing technological relationships among economic sectors in the US are likely to manifest themselves similarly in other high-income countries, the US data was used as a proxy for the five European economies, with results mapped onto each individual European country using the European IMPLAN models, informed by MIT's Global Cloud Ecosystem Index 2022 (see Appendix #2: Mapping the US IMPLAN results to the UK and Nordic economies).[42]

The video game industry is found within two software publishing and software development sectors in the IMPLAN model. FTI analysed the millions of connections between these sectors and the broader economy across the two decades of data available. Transactions from 2009 onwards were identified as the most appropriate to focus on, with demand for software-related products and services growing rapidly during the economic recovery that followed the Great Recession in 2008.

FTI Consulting isolated growth in economic output due to video game technology by analysing comparative job growth between the video game sector and the broader software publishing sector using independent data,[43] with video game jobs found to grow at a significantly higher rate. In total, from 2009 to 2021, video game technology spillover contributed an economic output of 7.1 billion USD to the US economy. The results chapter that follows presents the overall economic value of game technology spillover in the UK and Nordic regions in 2021 and considers which sectors of each unique economy are most impacted.

[42]https://wp.technologyreview.com/wp-content/uploads/2022/04/MITTR-INFOSYS-Cloud_Reort_FNL.pdf?fbclid=IwAR1LgGMak430HwmgV6C0qmXM_J6iTe3tg2eO9EZpa8rdlGhL7LuBXTu19sE
[43]https://www.ibisworld.com/industry-statistics/employment/video-games-united-states/

Results

UK

Economic Impact Results in the United Kingdom

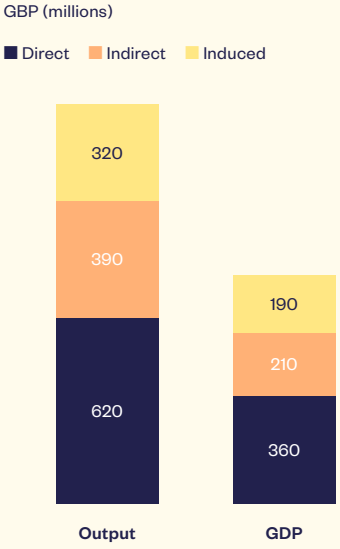
The UK games industry was estimated to contribute over 5.1 billion GBP in GVA to the UK economy in 2019, with this figure expected to increase in the following years. It supported 71,400 jobs across the entire value chain and is considered a cornerstone of the UK's creative industries.[44] The results below show how technology developed in the global games industry has spilled over into the rest of the UK economy, outside of games. It is important to note that the figures below do not represent spillover from the UK's domestic games sector itself, but from global video game technology, to which the UK is undoubtedly a contributor. All currency conversions between USD and GBP use the average exchange rate in 2021.[45]

Analysing the US Economy

In total, the technology spillover contributed more than 1.3 billion GBP of output to the UK economy in 2021 as shown in Figure 2. Direct, indirect, and induced output contributions amounted to 620 million GBP, 390 million GBP, and 320 million GBP, respectively. In terms of output, game technology spillover roughly aligns with the UK timber and forestry industry,[46] the aluminium production industry[47] and the cycling industry.[48]

The technology spillover contributed 760 million GBP in total to the UK's GDP as shown in Figure 2. Direct, indirect, and induced output contributions amounted to 360 million GBP, 210 million GBP, and 190 million GBP, respectively. This is also roughly three times the size of the GVA generated by animation series produced in the UK in 2019,[49] although note that this does not include animated film.

Figure 2 – UK's output and GDP impacts



[44]https://www.bfi.org.uk/industry-data-insights/reports/uk-screen-sector-economy
[45]https://www.exchangerates.org.uk/USD-GBP-spot-exchange-rates-history-2021.html
[46]https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/adhocs/15105turnoverinsicclasses
[47]https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/adhocs/15105turnoverinsicclasses
[48]https://store.mintel.com/report/uk-cycling-market-report#:~:text=Bicycle%20market%20value%3A%20Bike%20sales,%25%2C%20reaching%20around%20170%2C000%20units.
[49]https://www.bfi.org.uk/industry-data-insights/reports/uk-screen-sector-economy

Figure 3 – UK's top 10 most impacted sectors by output

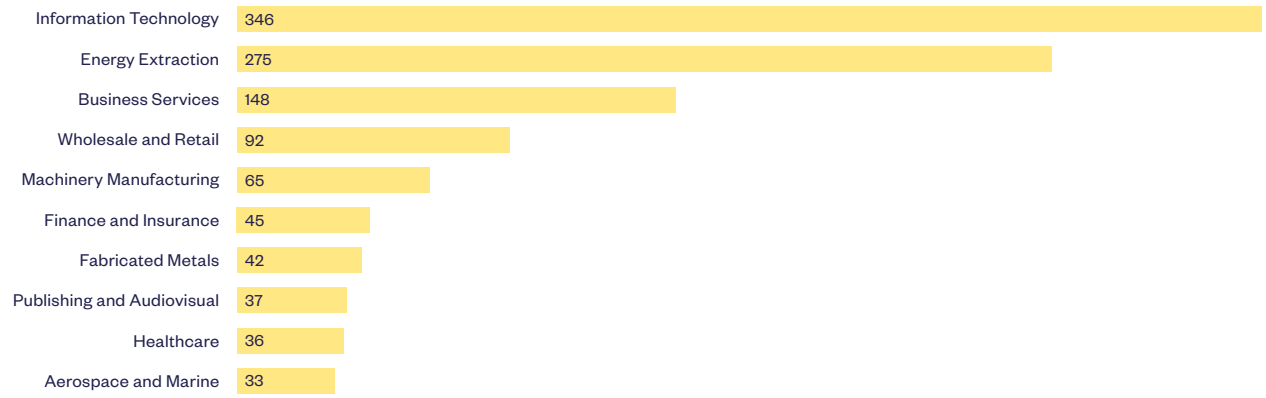


Figure 3 above summarises the top 10 sectors most impacted by video game technology in terms of economic output. These figures are in dollars as they are taken from an earlier stage in the analysis. These sector impacts are compared to employment impacts below in Figure 5.

Employment

Video game technology spillover supported 9,900 UK jobs in total in 2021 as shown in Figure 4 opposite. Direct, indirect, and induced output contributions amounted to 4,420 jobs, 3,140 jobs, and 2,340 jobs, respectively.

Figure 5 opposite summarises the distribution of the top 10 sectors impacted by video game technology spillover in terms of employment. Of the 9,990 total jobs supported, 3,000 of these were in the IT and Other Information Services sector. This sector includes subsectors such as data processing, internet publishing, and all other information services. Other Business Sector Services supported 1,560 jobs, which includes subsectors such as legal, accounting, and consulting services. The third largest sector supported is the Mining and Extraction of Energy Producing Products sector which supported 990 jobs. This sector includes oil and gas extraction and coal mining.

Figure 4 – UK's employment impacts

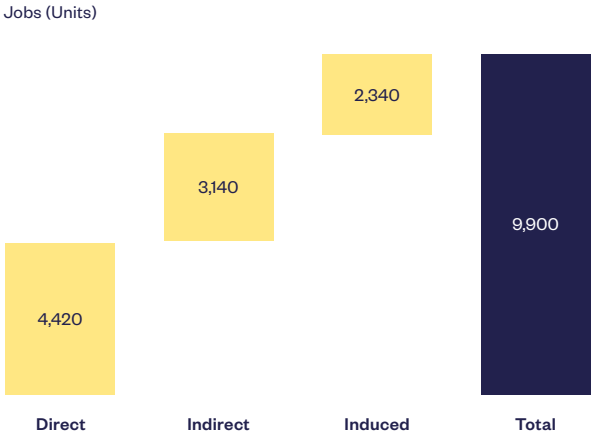
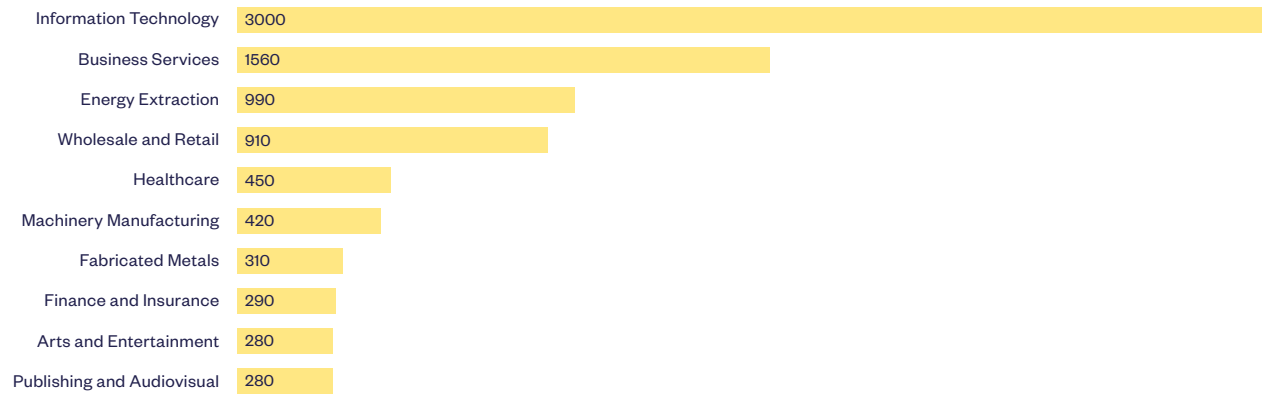


Figure 5 – UK's top 10 most impacted sectors by employment



These results indicate that job and output impacts generally follow the same trends. However, different sectors have varying levels of labour productivity in terms of output, which results in a difference in the rankings of sectors between these results.

Both Figure 3 and Figure 5 show that Energy Extraction, Information Technology, and Business Services are among the top three sectors impacted. In the Energy Extraction sector, AR and VR technology is used for virtual training and to enable engineers to review faults on oil rigs remotely.[50] The Information Technology sector includes firms like popular social media platform Snapchat, which uses AR technology to power some of the app's most popular features such as facial filters and "try-before-you-buy" experiences for fashion.[51] Within the broader Business Services sector, architecture and engineering services are using game engines in architectural visualisation. This technology enables architects to create realistic and stylish 3D renderings to be used in project planning.[52]

[50]https://pale.blue/2021/06/10/paleblue-delivers-vr-for-oil-rig-to-neptune-energy/
[51]https://www.forbes.com/sites/forbestechcouncil/2020/01/08/how-augmented-reality-can-boost-social-media-marketing/?sh=749907ae3604
[52]https://parametric-architecture.com/architectural-visualization-by-using-game-engines/

Labour Income

The direct impacts of 190 million GBP received as direct labour income is equivalent to an average yearly salary of 42,990 GBP for the 4,400 directly employed workers. Summarised in Figure 7, this salary is 25% higher than the average yearly salary of a UK worker, which is 34,280 GBP.[53]

Government Revenues

Increased economic activity often leads to higher government revenues because of additional opportunities for taxes to be collected. This relationship is formalised in the economics literature as Hauser's Law.[54] While empirically formalised in the US, the relationship between GDP growth and growth in government revenues has been generalised to all world economies.

Video game technology spillover generated 250 million GBP in government revenues in 2021 as shown in Figure 8 below. Direct, indirect, and induced output contributions amounted to 100 million, 80 million, and 70 million GBP respectively.

Figure 6 – UK's labour income impacts

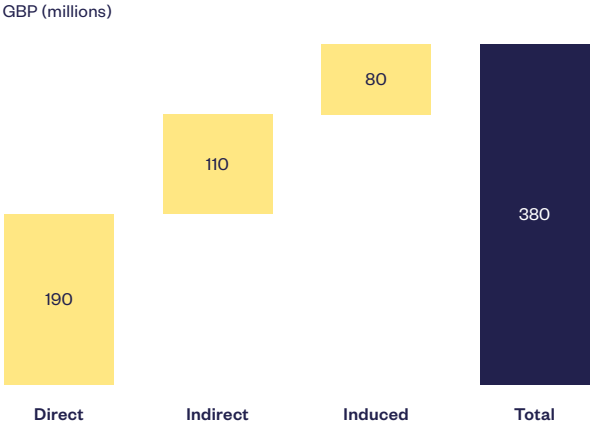


Figure 7 – UK's average employee annual salary comparison

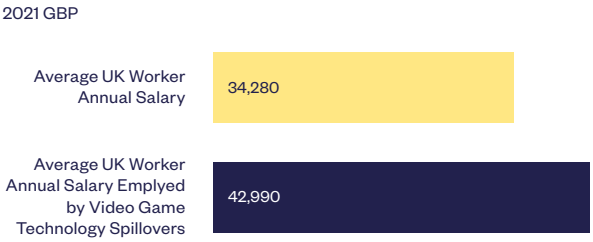
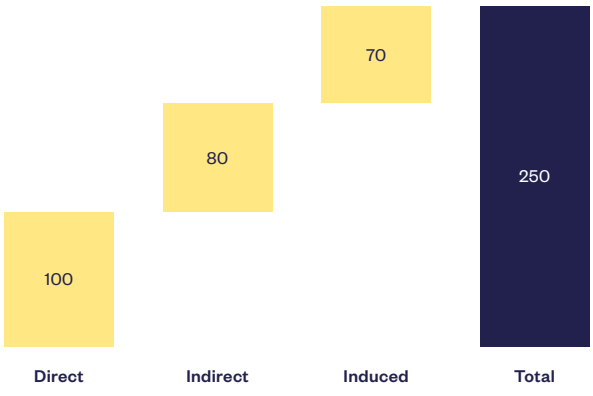


Figure 8 – UK's government revenue impacts



[53]https://www.oecdbetterlifeindex.org/countries/united-kingdom/
[54]https://www.hoover.org/research/hausers-law

Summary Impacts

The 2021 Screen Business Study estimated the video game sector in the UK at 5.1 billion GBP in GVA.[55] Table 3 below summarises the additional spillover economic and fiscal impacts of video game technologies on other sectors in the UK economy.

Table 3 – Economic and fiscal impact results (2021)

Metric	Unit	Direct	Indirect	Induced	Total
Employment	Jobs (Units)	4,420	3,140	2,340	9,890
Output	2021 GBP (millions)	£620	£390	£320	£1,320
GDP	2021 GBP (millions)	£360	£210	£190	£750
Labour Income	2021 GBP (millions)	£190	£110	£80	£370
Government Revenues	2021 GBP (millions)	£100	£80	£70	£260

[55]Gross Value Added ("GVA") is a more appropriate measure for sector-specific economic totals but is closely related to GDP and the two can be compared.

Results of the Economic Analysis in Select Nordic Countries

Introduction

The latest data[56,57] for Denmark, Finland, Norway and Sweden shows that, combined, the video game industry itself directly supported over 12,000 jobs in 2021 through over 1,100 companies across those regions. Company revenues exceeded 5.5 billion GBP, driven primarily by Finland and Sweden's contributions.

The results in this section describe the economic impact of video game technology spillover on each economy, specifically for 2021. The analysis considers the spillover impacts on non-game sectors given advancements in video game technology globally, not how video game technology produced explicitly in a given region impacts the broader economy in that region. For example, seen later in this chapter, Norway sees a significant impact from game technology spillover despite the smaller size of its domestic games industry, due to the spillover of game technology produced globally into Norway's large energy extraction sector. The relationship between GDP growth and government revenues was formalised in the US as Hauser's Law[58] but has been generalised to all world economies and is used in the calculation of government revenues as it was for the UK. Results in this chapter are presented in GBP but note that the average conversion rate of pounds to euros in 2021 was 1.159233,[59] if results in euros are preferred.

[56]https://www.egdf.eu/2021-european-video-games-industry-insight-report/
[57]https://dataspelsbranschen.se/game-developer-index
[58]https://www.hoover.org/research/hausers-law
[59]https://www.gov.uk/government/publications/exchange-rates-for-customs-and-vat-yearly

Results

Denmark

Table 4 – Economic and fiscal impact results – Denmark (2021)

Denmark	Units	Direct	Indirect	Induced	Total
Employment	Jobs (units)	500	330	270	1,100
Output	2021 GBP (millions)	£100	£50	£40	£190
GDP	2021 GBP (millions)	£70	£30	£20	£120
Labour Income	2021 GBP (millions)	£30	£10	£10	£50
Government Revenues	2021 GBP (millions)	£20	£10	£10	£40

Overall economic impact in Denmark

In total, video game technology spillover contributed 190 million GBP of output to the Danish economy in 2021. Direct, indirect, and induced output contributions amounted to 100 million GBP, 50 million GBP, and 40 million GBP, respectively. Total output impacts are approximately half the size of the railroad construction industry in Denmark.[60] For comparison, in 2020 (the latest figures available) the Danish video game industry generated 380 million GBP in direct revenue.

Additionally, technology spillover contributed 120 million GBP in total to Denmark's GDP while Direct, indirect, and induced output contributions amounted to 70 million GBP, 30 million GBP, and 20 million GBP, respectively.

Video game technology spillover supported 1,100 Danish jobs in total in 2021. Direct, indirect, and induced output contributions amounted to 500 jobs, 330 jobs, and 270 jobs, respectively. The Danish games industry itself supported 911 employees directly in 2020. Video game technology spillover contributed 50 million GBP of labour income to Denmark's economy in 2021. Direct, indirect, and induced output contributions amounted to 30 million GBP, 10 million GBP, and 10 million GBP, respectively. The direct labour income distributed across the 500 directly employed workers gives an effective salary for a game technology spillover worker as 60,000 USD.[61] This salary is slightly higher than the average yearly salary of a Danish worker, which is 58,430 USD.[62]

Video game technology spillover generated 40 million GBP in government revenues in 2021. Direct, indirect, and induced output contributions amounted to 20 million, 10 million, and 10 million GBP respectively.

[60]https://www.ibisworld.com/denmark/industry-statistics/railway-underground-construction/14664/
[61]The OECD reports global average annual salaries in USD.
[62]https://www.oecdbetterlifeindex.org/countries/denmark/

Sectors most impacted by game technology spillover in Denmark

Figure 9 – Denmark's top 10 most impacted sectors by output

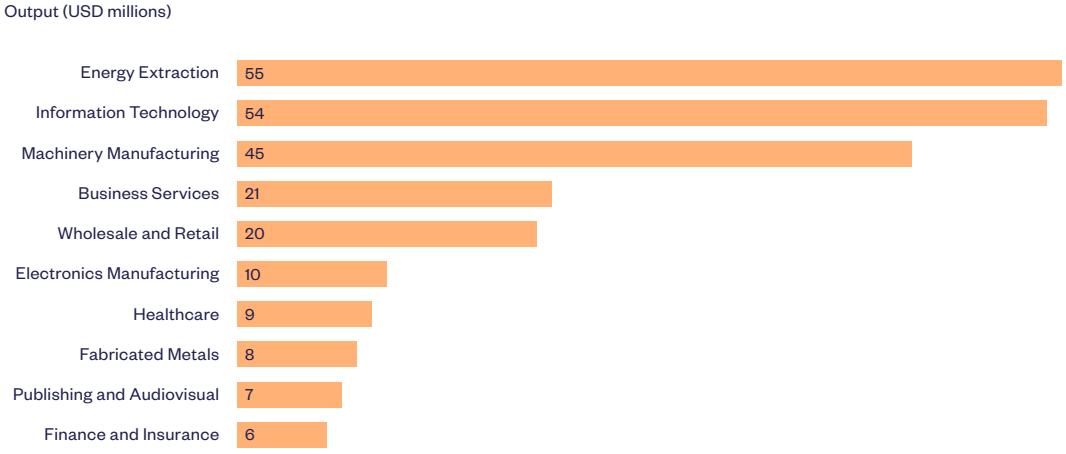


Figure 9 above summarises the individual sectors most impacted by video game technology in terms of economic output; values are presented in dollars as they are extracted at an earlier stage of the analysis. Energy Extraction, Information Technology and Machinery Manufacturing appear as a clear top 3. Firms within the Energy Extraction sector use VR and AR technology in training contexts where they recreate the layout of complex sections of rigs in virtual reality, while the Information Technology sector includes social apps with AR features and other firms providing interactive experiences to clients.[63] Video game technology is being used in construction, a subsection of the Machinery Manufacturing sector.

[63]https://www.forbes.com/sites/forbestechcouncil/2020/01/08/how-augmented-reality-can-boost-social-media-marketing/?sh=749907ae3604

Results

Finland

Table 5 – Economic and fiscal impact results – Finland (2021)

Finland	Units	Direct	Indirect	Induced	Total
Employment	Jobs (units)	430	290	170	890
Output	2021 GBP (millions)	£60	£40	£20	£130*
GDP	2021 GBP (millions)	£30	£20	£10	£60
Labour Income	2021 GBP (millions)	£20	£10	£10	£30*
Government Revenues	2021 GBP (millions)	£10	£10	£10	£30

*Numbers do not sum due to rounding

Overall economic impact in Finland

In total, the technology spillover contributed 130 million GBP of output to the Finnish economy in 2021. Direct, indirect, and induced output contributions amounted to 60 million GBP, 40 million GBP, and 20 million GBP, respectively. Total output impacts are approximately half the size of the landscaping services industry in Finland.[64] For comparison, in 2021 Finland saw a direct total revenue from its games industry of 2.8 billion GBP, the highest of the countries considered.

Additionally, the technology spillover contributed 60 million GBP in total to Finland's GDP. Direct, indirect, and induced output contributions amounted to 30 million GBP, 20 million GBP, and 10 million GBP, respectively.

Video game technology spillover supported 890 Finnish jobs in total in 2021. Direct, indirect, and induced output contributions amounted to 430 jobs, 290 jobs, and 170 jobs, respectively. The Finnish games industry itself supported a direct employee count of 3,550. Technology spillover contributed 40 million GBP of labour income to Finland's economy in 2021. Direct, indirect, and induced output contributions amounted to 20 million GBP, 10 million GBP, and 10 million GBP, respectively. The direct labour income distributed across the 430 directly employed workers gives an effective salary for a game technology spillover worker as 69,767 USD.[65] This salary is 51% higher than the average worker's salary of 46,230 USD.[66]

Video game technology spillover generated 30 million GBP in government revenues in 2021. Direct, indirect, and induced output contributions amounted to 10 million GBP each.

[64]https://www.ibisworld.com/finland/industry-statistics/landscaping-services/14745/
[65]The OECD reports global average annual salaries in USD.
[66]https://www.oecdbetterlifeindex.org/countries/finland/

Sectors most impacted by game technology spillover in Finland

Figure 10 – Finland's top 10 most impacted sectors by output

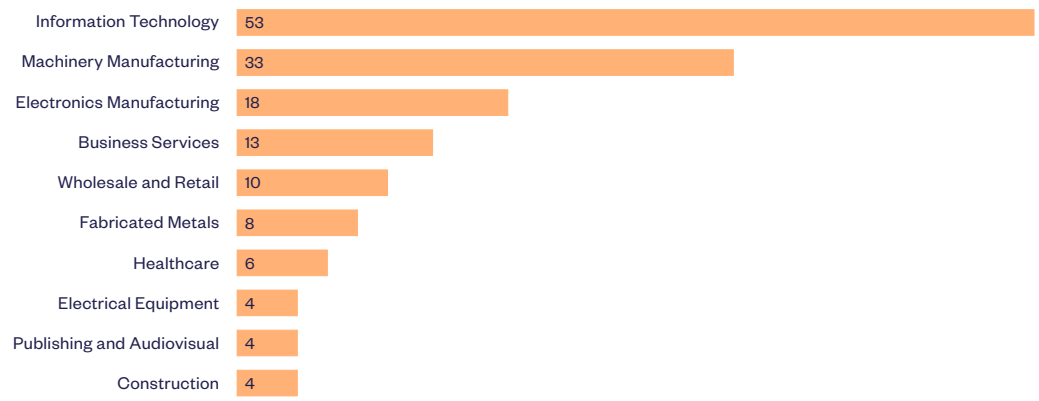


Figure 10 above summarises the sectors most impacted by video game technology in terms of economic output; values are presented in dollars as they are extracted at an earlier stage of the analysis. Figure 10 shows that Information Technology and Machinery Manufacturing benefited the most from video game technology spillover in Finland; they were ranked 2nd and 3rd for impact in Denmark. The Information Technology sector includes technology-driven firms like popular social media platform Snapchat. Meanwhile, video game technology is being used in the construction industry, a subsection of the Machinery Manufacturing sector. Here, haptic feedback and controllers can be utilised to operate large-scale industrial equipment, such as cranes. With handheld controllers, users can operate these instruments and receive haptic warning notifications if the machines are close to obstacles.[67]

[67] https://www.precisionmicrodrives.com/haptic-feedback-applications

Results

Norway

Table 6 – Economic and fiscal impact results – Norway (2021)

Norway	Units	Direct	Indirect	Induced	Total
Employment	Jobs (units)	730	520	420	1,670
Output	2021 GBP (millions)	£500	£130	£70	£700
GDP	2021 GBP (millions)	£470	£60	£40	£570
Labour Income	2021 GBP (millions)	£50	£30	£20	£100
Government Revenues	2021 GBP (millions)	£130	£30	£20	£180

Overall economic impact in Norway

In total, the technology spillover contributed 700 million GBP of output to the Norwegian economy in 2021. Direct, indirect, and induced output contributions amounted to 500 million GBP, 130 million GBP, and 70 million GBP, respectively. Total output impacts are approximately the size of the cheese industry in Norway.[68] For comparison, in 2021 Norway's games industry produced a direct revenue of 44 million GBP, so owing to the global impact of game technology, the spillover effect in Norway contributed more to the economy than the Norwegian games industry itself.

Additionally, the technology spillover contributed 570 million GBP in total to Norway's GDP. Direct, indirect, and induced output contributions amounted to 470 million GBP, 60 million GBP, and 40 million GBP, respectively.

Video game technology spillover supported 1,670 Norwegian jobs in total in 2021. Direct, indirect, and induced output contributions amounted to 730 jobs, 520 jobs, and 420 jobs, respectively. The games industry in Norway directly supported 433 jobs in 2021, so, as with output, the video game technology spillovers in Norway supported more jobs than the video game industry itself. Technology spillover contributed 100 million GBP of labour income to Norway's economy in 2021. Direct, indirect, and induced output contributions amounted to 50 million GBP, 30 million GBP, and 20 million GBP, respectively. The direct labour income distributed across the 730 directly employed workers gives an effective salary for a game technology spillover worker as 95,890 USD.[69] This salary is over 70% higher than the average yearly salary of a Norwegian worker, which is 55,780 USD.[70]

Video game technology spillover generated 180 million GBP in government revenues in 2021. Direct, indirect, and induced output contributions amounted to 130 million, 30 million, and 20 million GBP respectively.

[68]https://www.statista.com/outlook/cmo/food/dairy-products-eggs/cheese/norway
[69]The OECD reports global average annual salaries in USD.
[70]https://www.oecdbetterlifeindex.org/countries/norway/

Sectors most impacted by game technology spillover in Norway

Figure 11 – Norway's top 10 most impacted sectors by output

The sectors that are most impacted in terms of economic output are shown in Figure 11 above; values are presented in dollars as they are extracted at an earlier stage of the analysis. The impact on the Energy Extraction sector significantly outstrips all other parts of the economy and the game technology spillover output per worker in Norway's Energy Extraction sector is the highest of any sector analysed across all regions, including the UK. Neptune Energy represents an example of game technology spillover to the Energy Extraction sector as the company uses VR technology to virtually maintain offshore oil platforms.[71] More information on the adoption of video game technology in Norway's Energy Extraction sector can be found in Case Study #3: Oil & Gas.

[71] https://pale.blue/2021/06/10/paleblue-delivers-vr-for-oil-rig-to-neptune-energy/

Results

Sweden

Table 7 – Economic and fiscal impact results – Sweden (2021)

Sweden	Units	Direct	Indirect	Induced	Total
Employment	Jobs (units)	860	560	290	1,710
Output	2021 GBP (millions)	£140	£90	£40	£270
GDP	2021 GBP (millions)	£70	£50	£20	£140
Labour Income	2021 GBP (millions)	£40	£20	£10	£80*
Government Revenues	2021 GBP (millions)	£40	£30	£10	£70*

*Numbers do not sum due to rounding

Overall economic impact in Sweden

In total, the technology spillover contributed 270 million GBP of output to the Swedish economy in 2021. Direct, indirect, and induced output contributions amounted to 140 million GBP, 90 million GBP, and 40 million GBP, respectively. Total output impacts are approximately half the size of the car rental and leasing industry in Sweden.[72] For comparison, Sweden's domestic games industry contributed 2.3 billion GBP in direct revenue in 2021.

Additionally, the technology spillover contributed 140 million GBP in total to Sweden's GDP. Direct, indirect, and induced output contributions amounted to 70 million GBP, 50 million GBP, and 20 million GBP, respectively.

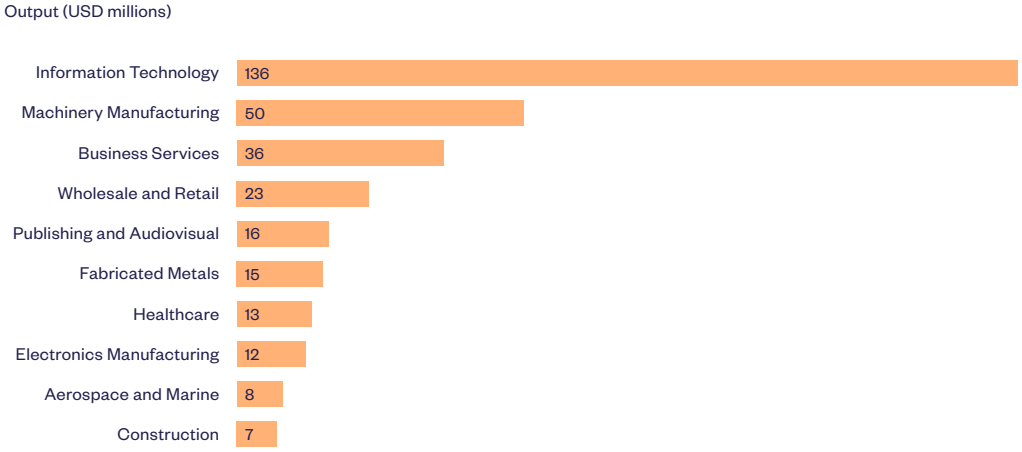
Video game technology spillover supported 1,710 Swedish jobs in total in 2021. Direct, indirect, and induced output contributions amounted to 860 jobs, 560 jobs, and 290 jobs, respectively. Sweden's games industry directly supported 7,944 jobs, the highest total of the Nordic regions analysed. Technology spillover contributed 80 million GBP of labour income to the Swedish economy in 2021. Direct, indirect, and induced output contributions amounted to 40 million GBP, 20 million GBP, and 10 million GBP, respectively. The direct labour income distributed across the 860 directly employed workers gives an effective salary for a game technology spillover worker as 71,430 USD.[73] This salary is 52% higher than the average worker's salary of 47,020 USD.

Video game technology spillover generated 70 million GBP in tax revenues in 2021. Direct, indirect, and induced output contributions amounted to 40 million, 30 million, and 10 million USD respectively.[74]

[72]https://www.ibisworld.com/sweden/industry-statistics/car-rental-leasing/4080/
[73]The OECD reports global average annual salaries in USD.
[74]https://www.oecdbetterlifeindex.org/countries/sweden/

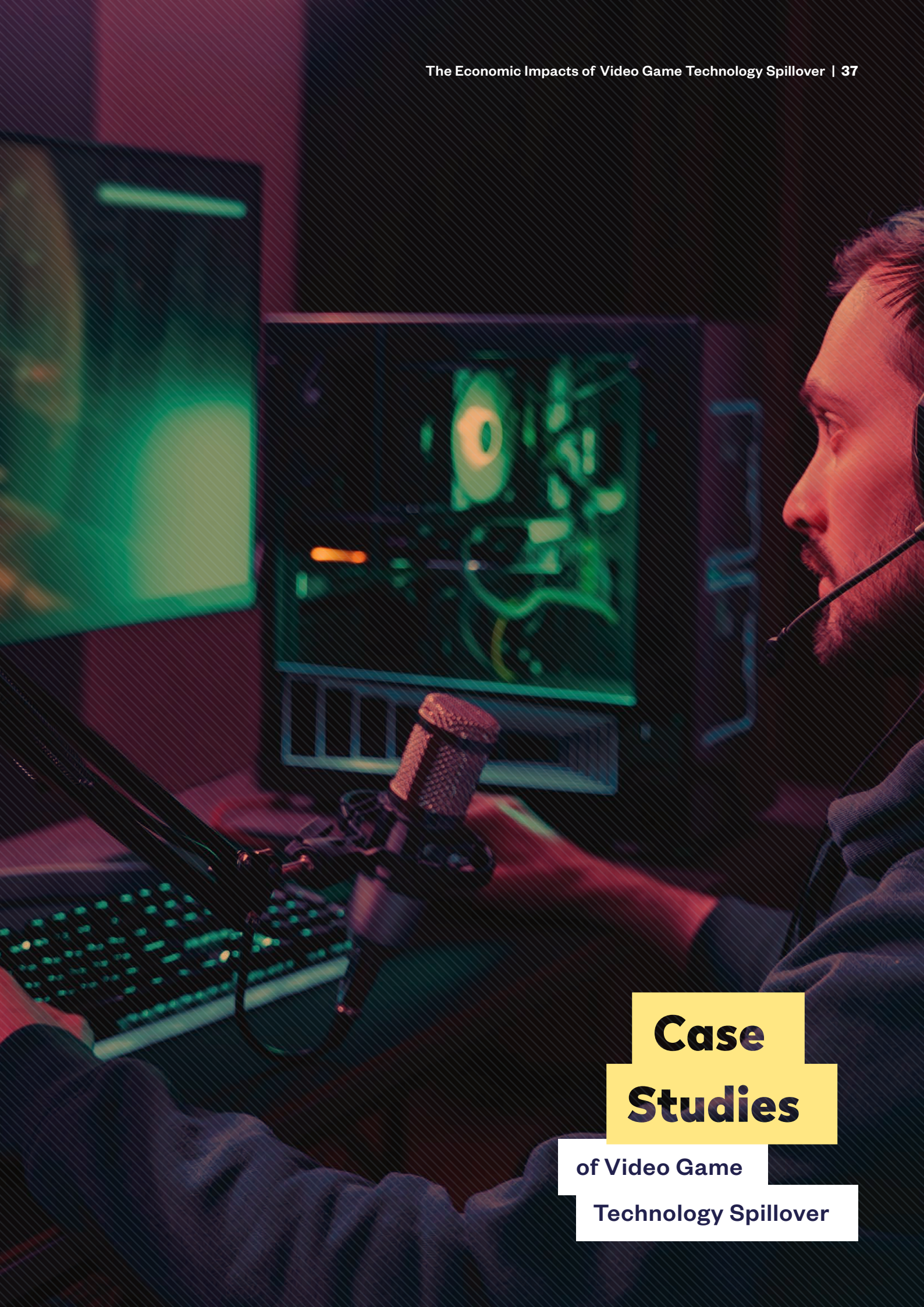
Sectors most impacted by game technology spillover in Sweden

Figure 12 – Sweden's top 10 most impacted sectors by output



The sectors that are most impacted in terms of economic output are shown in Figure 12 above; values are presented in dollars as they are extracted at an earlier stage of the analysis. The Information Technology sector is the most significant beneficiary of game technology spillover, appearing in the top 3 most impacted sectors across all five countries considered, including the UK. The Information Technology sector includes technology-driven firms like social media platform Snapchat and other firms providing interactive experiences to clients. Sweden also sees the largest impact on the Business Services sector among the Nordic regions. An example of video game technology used in the business service sector is in architecture and engineering services. Game engines are being used for architectural visualisation, allowing architects to create realistic and stylish 3D renderings to be used in project planning.[75]

[75]https://parametric-architecture.com/architectural-visualization-by-using-game-engines/



Case Studies of Video Game Technology Spillover

Case Study #1: Film & TV

Films and TV shows such as *The Batman*, BBC's *Match of the Day* and *Rogue One: A Star Wars Story*, all made in the UK,[76] or globally successful shows like *The Mandalorian* are increasingly leveraging innovative visual effects ("VFX") capabilities such as virtual production.

Game engine technology is a key component to the successful operation of a virtual production stage for film and TV. Virtual production tools and services enable producers to use dynamic, photo-real digital landscapes on LED walls to set a scene in any location, using "in-camera" techniques rather than greenscreen and post-production. Principal photography can combine VFX elements with actors' performances in real time, enabling creatives to see and interact with both physical and digital worlds simultaneously. The game engine technology underlying virtual production allows for tweaks to the scene to be made on-set, almost effortlessly, but virtual environments and objects must be built earlier in production to accommodate this. Examples include adding or removing objects from a scene (with the objects lit correctly by the game engine) and swapping day for night. A production's creatives can review a more complete image on-set and make changes while all the key staff are together on the film, as opposed to traditional post-production approaches, which happen after principal photography when many of those involved may have moved on from the project. This technique can help actors better adapt to their on-screen characters' lives. *Star Wars* franchise actor Ewan McGregor stated his frustrations over acting with greenscreens, "There's not something to dig into in the dialogue that can satisfy you when there's no environment there. It was quite hard to do."[77] Virtual production technology is also adaptive; production studios can continue to utilise traditional camera technologies while increasing the use of CGI and on-set LED screens with display riggings.

[76] https://www.bfi.org.uk/apply-british-certification-tax-relief/cultural-test-film
[77] https://www.hollywoodreporter.com/movies/movie-news/ewan-mcgregor-obi-wan-star-wars-halston-4174111/

> **"...**On the practical side, **we're able to move faster** [using virtual production]. **But even more importantly,** on an emotional side, **we're able to build the world that we're wanting to in advance,** knowing that we're going to have an **extended period of that particular controlled light..."**

Cinematographer, The Mandalorian[78]

Despite being used for decades, virtual production emerged as one of the best technologies to support TV and filmmaking during the COVID-19 pandemic because it reduced the physical limitations of on-location filming and allowed studios and filmmakers to continue production amid the COVID-19 lockdowns. This ability to reduce the need for on-location filming plays into arguably the greatest benefit of virtual production, which is its ability to increase innovation and filming possibilities while reducing costs across many below-the-line production layers, including:

- Cast, crew, "on-location" filming, filming timelines and associated travel, insurance, permits, and housing
- Constructing full sets
- Post-production VFX compositing fees

Virtual production technology greatly benefits TV and film studios. Utilising virtual production technologies can result in significant cost savings relative to "traditional" CGI-heavy production. Studios can increase their overall efficiency through smaller productions and leaner crews, while enabling a safer, faster, and more efficient production. These qualities alleviate VFX capacity constraints resulting from the post-COVID production boom and allow providers to absorb more demand.

[78]https://deadline.com/2021/07/stagecraft-ilm-disney-plus-mandalorian-vfx-cannes-magazine-disruptor-1234787530/

The virtual production facilities market is forecasted to reach 190 million GBP by 2025 across film, broadcast, and digital formats.[79] Growth in virtual production has made big VFX-driven productions more accessible for episodic content, which is expected to see significant growth over the next five years. The technology presents a massive opportunity for expanded use across genres and formats and is the primary alternative for tentpole Action or Sci-Fi. Industrial Light & Magic ("ILM"), for example, recently expanded its global operations by setting up virtual production stages at Manhattan Beach Studios in Los Angeles, Pinewood Studios in London, and Fox Studios in Australia. These studios supported popular features such as *Thor: Love and Thunder*, *Avengers: Endgame*, *Rogue One: A Star Wars Story*, and more.

To meet this growing demand for content, the UK is investing heavily in virtual production infrastructure with state-of-the-art studios opening in Manchester and London. Film Soho, the talent-led film and TV group, recently launched the first permanent virtual production studio in London in 2022. More recently, the company partnered with Cannes Next, Marché du Film's innovation-driven platform, to act as principal partner and presenter at the Marché du Film in May 2023, where Film Soho presented at the Global Virtual Production Summit.[81]

In addition, ScreenSkills, a UK-based body dedicated to identifying skills gaps across film, television, VFX, animation and games industries, is designing training programs specifically tailored to teach crews how to operate virtual production spaces. The company is working in partnership with the Department for Business and Trade ("DBT"), formerly the Department of International Trade ("DIT"), and the Department for Culture, Media, and Sport ("DCMS") to ensure that the UK is a global centre of excellence for virtual production innovation[82]. Industry representatives include UK Research and Innovation, Epic Games, Ntropic, Sky Studios and UK Screen Alliance, who have committed to the initiative along with leading educators such as Bournemouth, Edinburgh Napier, Portsmouth and more.

"...There's already a huge base of talent in the UK, whether it's onstage support or from visual effects, who understand these new tools. **I am struggling to think of the last time** we worked on a project that started in LA **that didn't end up going to the UK..."**

President, Halon Entertainment[80]

"...The Department for International Trade **continues to work closely** with international industry partners and businesses to **support significant investments into the UK's thriving creative industries,** with over **£100m of planned investments** by international studios into virtual production technology **in the UK already identified for 2021..."**

UK Minister of Investment[83]

[79]FTI Expert Interviews & Analysis
[80]https://www.screendaily.com/features/how-virtual-production-technology-is-transforming-the-uk-film-and-tv-sector/5169397.article
[81]https://variety.com/2023/digital/news/cannes-film-market-cannes-next-film-soho-global-virtual-production-summit-1235568750/
[82]https://www.screenskills.com/news/new-national-standards-to-ensure-the-uk-is-a-global-centre-for-virtual-production
[83]https://www.screenskills.com/news/new-national-standards-to-ensure-the-uk-is-a-global-centre-for-virtual-production/

The UK government has committed significant funds to developing the UK's virtual production capabilities. The Arts and Humanities Research Council ("AHRC") is providing 75.6 million GBP over six years to the CoSTAR project ("Convergent Screen Technologies And performance in Realtime")[84]. This ambitious undertaking will provide a new national infrastructure to drive the next generation of R&D for building creative and digital economies. The winning bidder will build and develop a state-of-the-art national R&D lab including a virtual production stage. They will also run knowledge exchange and demonstrator programs within the new lab. Of the total, 12.6 million GBP is earmarked to deliver up to 3 CoSTAR network labs, to facilitate access to the state-of-the-art facilities across the UK's nations and regions. A further 9 million GBP is intended for a data insight and foresight unit.

"We urgently need new facilities, technologies and skills to keep pace with a rapidly evolving creative landscape and to **maintain the UK's position in the global digital and creative economies.** CoSTAR will respond to this need by **bringing together leading figures in research and industry** as well as audiences to develop and converge technologies in the creative industries. In doing this, we will **reimagine how we interact with entertainment, and support entirely new experiences that will enrich our economy and our culture."**

Professor Christopher Smith, AHRC Executive Chair[85]

[84]https://www.ukri.org/opportunity/national-capability-for-rd-in-screen-and-performance/
[85]https://www.ukri.org/news/enter-the-metaverse-investment-into-uk-creative-industries/

Case Study #2: Healthcare

Healthcare is among the top three industries expected to lead VR adoption through 2025, as providers quickly adopt VR and AR technologies as a means of advancing patient care. Game engine technology is at the forefront of enabling this advancement.

The global Healthcare VR market is growing by 41% annually, and video game technology has been used for many different applications.[86] For example, medical professionals and surgeons can use game engine-enabled products such as Precision OS to learn and practice on realistic VR simulations. Patients can use therapy products like chronic lower back pain management programme RelieVRx to help aid their recovery and improve everyday quality of life. RelieVRx has been shown to reduce pain for users in an independent clinical trial.[87] Experts estimate that VR in healthcare could reach 25 billion GBP globally by 2027, indicating the scale of the untapped potential for game technologies in the industry.[88]

> "... [In a 2019 study,] virtual reality for surgical training **significantly increased procedural accuracy and completion rate,** which more than **tripled the odds of completing a procedure successfully** and demonstrated a **300% improvement in accuracy...**"
>
> ***Orthopaedic Surgeon, Bone and Joint Institute***[89]

[86]https://medium.com/ivey-business-review/epic-games-an-unreal-healthcare-opportunity-30c5492c88d3
[87]https://www.fda.gov/news-events/press-announcements/fda-authorizes-marketing-virtual-reality-system-chronic-pain-reduction
[88]https://medium.com/ivey-business-review/epic-games-an-unreal-healthcare-opportunity-30c5492c88d3
[89]https://www.healthcareitnews.com/news/how-virtual-reality-turning-surgical-training-upside-down#:~:text=%22Subsequent%20findings%20by%20researchers%20at,completion%20rate%2C%20which%20more%20than

"...The [games] industry has been a pioneer in the burgeoning VR and AR space and **Epic is at the forefront.** Using [Epic's] engine allows us to **stay at the cutting edge of technology and quickly implement new features** as they are released to the market, priming us to be able **to take advantage of improvements in the VR, AR and mixed reality development..."**

Software and Technology Development Strategist, C4X[90]

Video game technology has also been adopted in the pharmaceutical industry. Companies use game engines to facilitate drug discovery and development across multiple disease areas through enhanced DNA-based target identification and candidate generation capabilities. These techniques have applications in developing drugs to treat inflammation, cancer, neurodegeneration, and addictive disorders. For example, C4X Discovery develops medicines in the digital world with a tool called 4Sight that uses the Unreal Engine developed by Epic Games. 4Sight visualises molecules in a VR space and allows C4X scientists to view molecular data in new and innovative ways. The company cites the benefits of using Unreal Engine for its innovative rendering and code foundation flexibility. Epic Games provides continuous support to keep the technology current and to design bespoke features for 4Sight users.

VR has been part of the drug-discovery process for years, with scientists having used it in synthesising a vaccine for COVID-19, for example.[91] C4X has also demonstrated how these tools can lead to successful product deployment, with AstraZeneca acquiring the exclusive rights to develop and commercialise the company's oral NRF2 activator for treating chronic obstructive pulmonary disease and other inflammatory and respiratory diseases for roughly 290 million GBP as of November 2022.

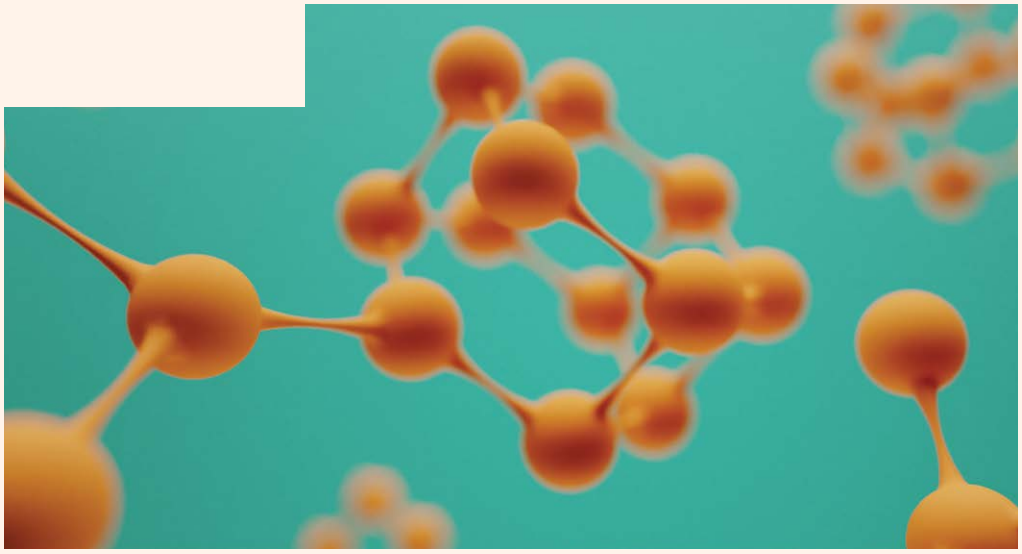
"...Scientists are constantly working with very complex data, but the tools previously didn't exist for 4D visualisation, **so it is an ongoing challenge to realise these molecules.** By bringing them alive in a virtual 3D environment, **brain space is freed up to focus on other issues..."**

Software and Technology Development Strategist, C4X[92]

[90]https://www.immerseuk.org/case-study/c4x-discovery/
[91]https://www.immerseuk.org/case-study/c4x-discovery/
[92]https://www.immerseuk.org/case-study/c4x-discovery/

Game engines are not the only game technology being leveraged in the healthcare industry. Companies use haptic technology, a staple in the video game world, to enable medical professionals to access training for specific procedures using haptic gloves and purpose-built controllers. For example, London-based FundamentalVR provides training in areas such as orthopaedic joint/spine procedures, and anterior/posterior total hip replacement, among others, that use haptic technologies. The company's Fundamental Surgery platform uses these technologies to make virtual procedures more life-like through sensory feedback. The company designed the platform to work with a broad range of hardware such as VR headsets (e.g., Oculus Quest and HTC Vive), mixed reality platforms (e.g., Magic Leap and Holo Lens) or laptops provided to employees. FundamentalVR raised 15 million GBP in 2022, showing promise for further investments in the Healthcare VR space.[93]

FundamentalVR's HapticVR technology has been deployed by hospitals and pharmaceutical companies alike, with clients such as St. George's Hospital, Novartis, and Orbis International. The company has also partnered with the Houston Methodist Institute for Technology, Innovation, and Education (MITIE) to launch the MITIEverse and use the FundamentalVR platform to support healthcare learning. The MITIEverse app is devoted to healthcare education, training, and innovation. Users can create customisable showcase rooms and surgical simulations. The app also enables users to virtually attend lectures from Houston Methodist faculty and collaborate with other users around the world.[94]



"...[VR] essentially democratises access to healthcare educators and innovators by **breaking down physical barriers.** There's no need to travel **thousands of miles to attend a conference when you can patch into the MITIEverse..."**

Vascular Surgeon, Houston Methodist Institute for Technology[95]

[93]https://techcrunch.com/2022/08/11/medical-simulation-platform-fundamentalvr-raises-20m-to-help-surgeons-learn-through-vr/
[94]https://www.xrtoday.com/virtual-reality/xr-healthcare-case-study-fundamentalvr-and-mitie/
[95]https://www.xrtoday.com/virtual-reality/xr-healthcare-case-study-fundamentalvr-and-mitie/

Case Study #3: Oil & Gas

Video game technology has similarly crossed over into the oil and gas industry. Companies use game engines and other technologies to support safety, training, maintenance and construction through the visualisation of facilities and equipment. One example is Neptune Energy's VR training application developed by PaleBlue and used on its Gjøa platform in the Norwegian North Sea.

The technology uses VR headsets that allow offshore workers to interact with a realistic 3D model of the Gjøa platform from onshore, shown below in Figure 13. The company also shared their intentions to expand the use of the technology for other complex activities such as simulations related to Health, Safety & Environmental events or to better understand how platform modifications will appear before being carried out.

Figure 13 – 3D model of the Gjøa platform

"...The restrictions and all the consequences of COVID-19 have introduced **challenges to operations for many companies. By doing the familiarisation training in a virtual world,** even from home, **companies can overcome travelling restrictions, save time, costs and emissions,** and will be 100% prepared with **crucial knowledge of the facility when they physically arrive offshore..."**

Account Director, PaleBlue[96]

"...Transportation is one of the main safety hazards in the oil & gas industry, so anything which **reduces the need to travel** can improve **safety, reduce costs and reduce your carbon footprint.** Broadening your people's skillsets means that, **when you do need someone onsite, you're more likely to have a qualified specialist in the region** – ensuring they get there quickly, to **reduce equipment downtime..."**

Information Solutions Sales Executive, Rockwell Automation[97]

[96]https://drillingcontractor.org/neptune-energy-pilots-virtual-reality-technology-on-gjoa-platform-60455
[97]https://emag.directindustry.com/2023/01/11/oil-gas-trends-for-2023-cybersecurity-ar-vr-inspection-and-3d-printing/

The technology enables teams to virtually visit the facility significantly reducing the need for offshore travel, lowering costs and emissions, while also supporting the safe operation of the platform. Specifically, Neptune disclosed that the initiative will reduce the need for 30 offshore trips each year, with expectations that this number could grow as the technology advances.

Equinor, Norway's largest oil and gas operator, has developed a digital twin solution called Echo to help field employees navigate over 50 installations, locate specific equipment, and collaborate in real-time across locations. This tool enhances safety and efficiency of project development and operations throughout the company by providing visualisations of each plant, augmented pictures of modifications, and by allowing repair crews to quickly identify specific equipment.

Echo enables users to access and visualise data from Omnia, Equinor's data platform, which is now being used as a digital tool in subsea operations for the first time ever on the Northern Lights project in Norway. The tool offers several key benefits, including but not limited to analysing production rates, identifying system bottlenecks, conducting root cause analysis of equipment failures, optimising new designs based on historical data, and utilising new collaboration and communication tools to work more efficiently in the field.

To complete platforms under construction, Equinor also employs augmented reality ("AR") tools, such as the Mariner A installation. The technology has been reported to help identify errors much earlier in the construction process and reduce the costs and potentially significant delays associated with flying in experts to make onsite changes on offshore rigs.

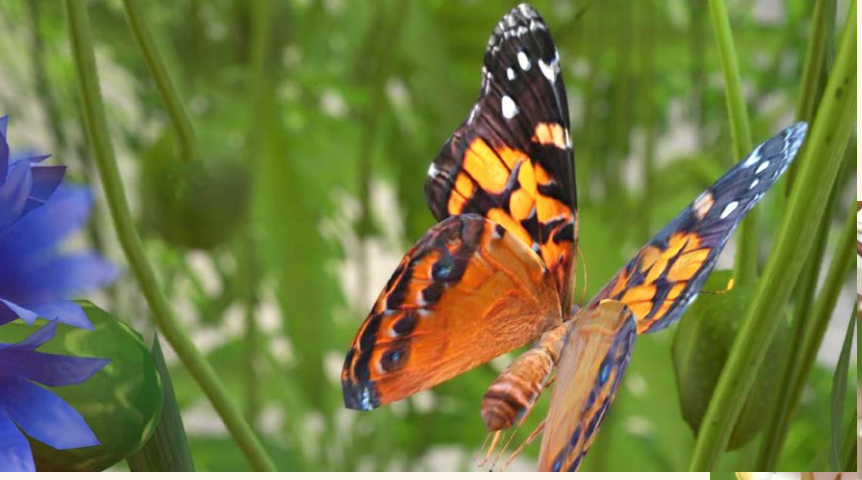


Figure 14 – Tower Superbloom AR

Case Study #4: Cultural Heritage

Twinmotion,[98] an architectural visualisation software tool powered by Unreal Engine serves as a powerful tool for preserving or rehabilitating historical and culturally significant buildings.

The Ferguslie Thread Works, located in the Scottish town of Paisley, is considered an industrial heritage site, but the building was demolished in the 1990s. A local artist named Cameron Swanson was able to bring the structure back to life using the Unreal Engine with the help of funding through the National Lottery Heritage Fund.[99] Cameron developed a virtual reality version that would eventually be used as an educational tool in schools, and to rekindle memories for those that worked at the mills. He spent approximately two hundred hours building historically accurate terrain and architecture using the unique Twinmotion design software. Cameron used Twinmotion to combine separate models using a common coordinate system. The Twinmotion tool significantly sped up the process by allowing Cameron to render the models in real time and adjust light levels and other settings to make the virtual Ferguslie Thread Works as realistic as possible.

In February 2022, to mark Queen Elizabeth II's Platinum Jubilee, over 20 million seeds were planted to create a "superbloom" at the Tower of London's Moat.[100] Preloaded, a London-based, BAFTA-winning immersive games studio, collaborated with Historic Royal Palaces to mirror the event in a digital space to allow anyone across the nation or around the world to participate. Built in Unity using Niantic's Lightship plugin for AR experiences,[101] Tower Superbloom AR[102] was the result. With the help of the event's lead horticulturalist, Preloaded collected high resolution photographs and lithographical prints to allow them to build detailed digital plants, which grow and bloom in a realistic, though accelerated manner. This digital bloom is projected onto surfaces in the real world through a phone or device screen while its makeup changes with the real-world bloom, which progressed through different waves of colours across the summer. The market-leading meshing capability of Lightship allows the app to quickly understand the topology of the world and place the digital bloom convincingly in the device's frame.

[98] https://www.twinmotion.com/en-US
[99] https://www.twinmotion.com/en-US/spotlights/discover-how-cameron-swanson-breathed-life-back-into-the-ferguslie-thread-works-with-his-digital-visualization
[100] https://www.hrp.org.uk/tower-of-london/whats-on/the-tower-moat/
[101] https://lightship.dev/
[102] https://preloaded.com/work/tower-superbloom-ar/

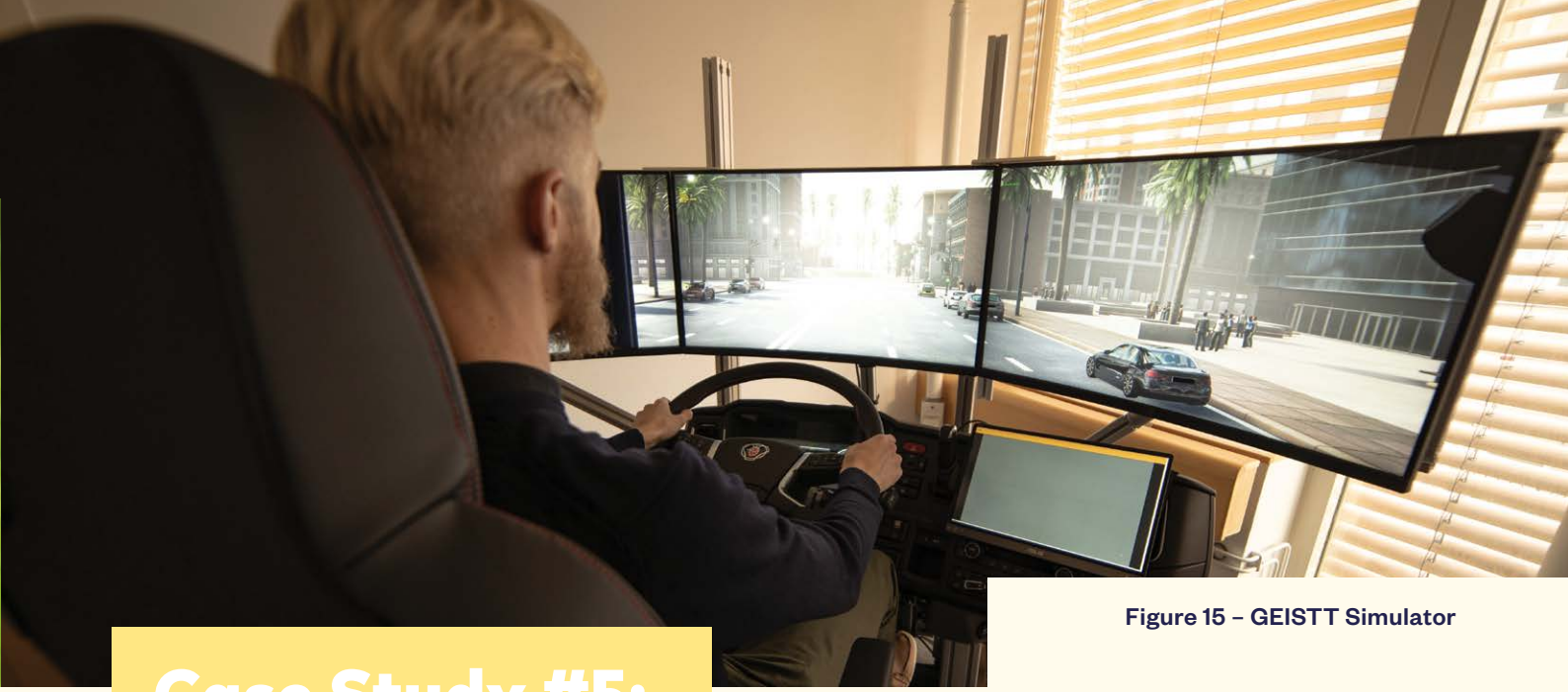


Figure 15 – GEISTT Simulator

Case Study #5: Automotive

Game engine technology has become a prevalent tool in the automotive industry, specifically in the areas of vehicle interface and research and development. The automotive industry has demonstrated a growing interest in game engine technology, particularly as vehicles start to rely more heavily on software and technology. The visualisation capabilities offered by commercial game engines such as Unreal and Unity make these products compelling solutions for automotive applications. Game engine technology has also contributed to R&D by expanding simulation and testing capabilities.

Sweden-based heavy-vehicle manufacturer, Scania, has engaged technology consultancy GEISTT AB to provide R&D services, concept development and simulation-based testing.[103] GEISTT developed and tested human-machine interface (HMI) concepts, such as new UI features and best-practice procedures for interactions between humans and autonomous vehicles. GEISTT delivered the first complete driving simulator platform to Scania in 2022 to help the company further develop its vision for a virtual transportation experience, shown in Figure 15. GEISTT used Unreal Engine for hardware integration, multiplayer co-simulation capability, configuration management, and automated code testing.

Volvo, a Swedish automaker, recently announced it will partner with Epic to create visualisations for its upcoming electric vehicle's digital interface. Volvo intends to employ Unreal Engine to present drivers with a clear view of what the car's external sensors, including cameras, radar and lidar, are detecting outside the vehicle.

> **"...This technology gives us the capability to create responsive,** really high-quality visuals that we can play with and layer in information, **create realistic representations when needed, all of those kinds of things..."**
>
> ***Head of User Experience, Volvo***[104]

[103] https://geistt.com/2020/11/07/geistt-in-unreal-engine-spotlight/
[104] https://www.theverge.com/2022/6/1/23144461/volvo-epic-unreal-engine-hmi-human-machine-interface-partnership

"...The speed with which it is possible to put a scene together in Twinmotion and the simplicity of its drag-and-drop system for assets gives **creative developers and artists more time to work on content creation, scene dressing, and composition..."**

Vascular Surgeon, Houston Methodist Institute for Technology

Case Study #6: Real Estate

The real estate industry has adopted game engines and related technologies to optimise design planning, construction, and marketing of properties. Co-op Live is a UK arena being built to rival New York's Madison Square Garden. The project uses a smart 'bowl' design and innovative technology to elevate the artist and fan experience.

The arena is due to open in April 2024 on the Etihad Campus, home of Manchester City football club, and will house 28 suites, twelve lounges and club spaces, thirty-two bars and restaurants and over 2,000 premium seats and VIP experiences. Soluis, the UK-based visualisation studio, built a fully interactive virtual representation of Co-op Live's main area and surrounding hospitality areas, shown in Figure 16, inside Unreal Engine to bring the unfinished project to life. These digital renderings were utilised to illustrate the layout of the arena and to expedite content creation for promotional videos.

Game engine technology also has applications outside of supporting new construction. For example, the University of Salford's THINKlab used Twinmotion to create an immersive VR experience of the Royal Horticultural Society's ("RHS") £30 million Bridgewater Garden project - Europe's largest gardening project. The centrepiece of RHS Bridgewater Garden is the 11-acre Weston Walled Garden, one of the UK's biggest, measuring the size of six soccer pitches and comprising eleven individual gardens. THINKlab visualised the buildings within the VR environment using a combination of photogrammetry, 3D sculpting, and standard 3D modelling techniques. Twinmotion then added plants and trees to the model to complete the VR experience. The VR tool allowed the THINKlab team to forgo the typical process of creating physical level-of-detail models, which drive up project complexity and costs. Twinmotion was able to manage all of that in a virtual space, enabling the RHS to virtually experience the space and the new garden designs from any angle at any time of day across different seasons of the year.

Figure 16 – VR representation of Co-op Live interior

Case Study #7: Manufacturing

Game technology also has practical applications in the realms of design and manufacturing. Flokk, a renowned Norwegian workplace furniture manufacturer, engaged Forte Digital, a Norwegian design and digital consulting company, to revamp their customer experience.

Flokk products are known to be highly customisable, but the company identified that the static content on their website did not allow customers to explore this feature.
Together, Forte Digital and Flokk determined Unity's ArtEngine[105] software would allow them to render Flokk's products in a digital space. The team used ArtEngine to render accurate digital representations of the company's chair components that were captured using images of the parts taken from multiple angles. From there, they were able to generate 3D digital twins of each separate component. The digital twins were seamlessly integrated into Flokk's online platform, allowing customers to select any desired component in their preferred colour and get a realistic visualisation of the final product, as seen in Figure 17. Using the interface, customers could now make live changes to the product configuration, see then results in real time, then view finished products from multiple angles[106]. This revamp resulted in an increase in website visitors, average session length, and page views, as well as a decrease in bounce rate, drastically improving the customer experience.

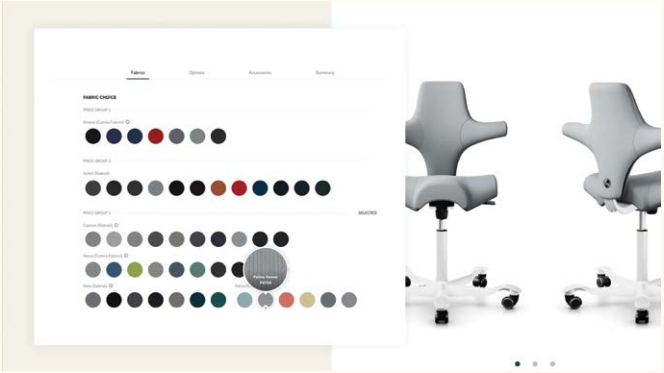
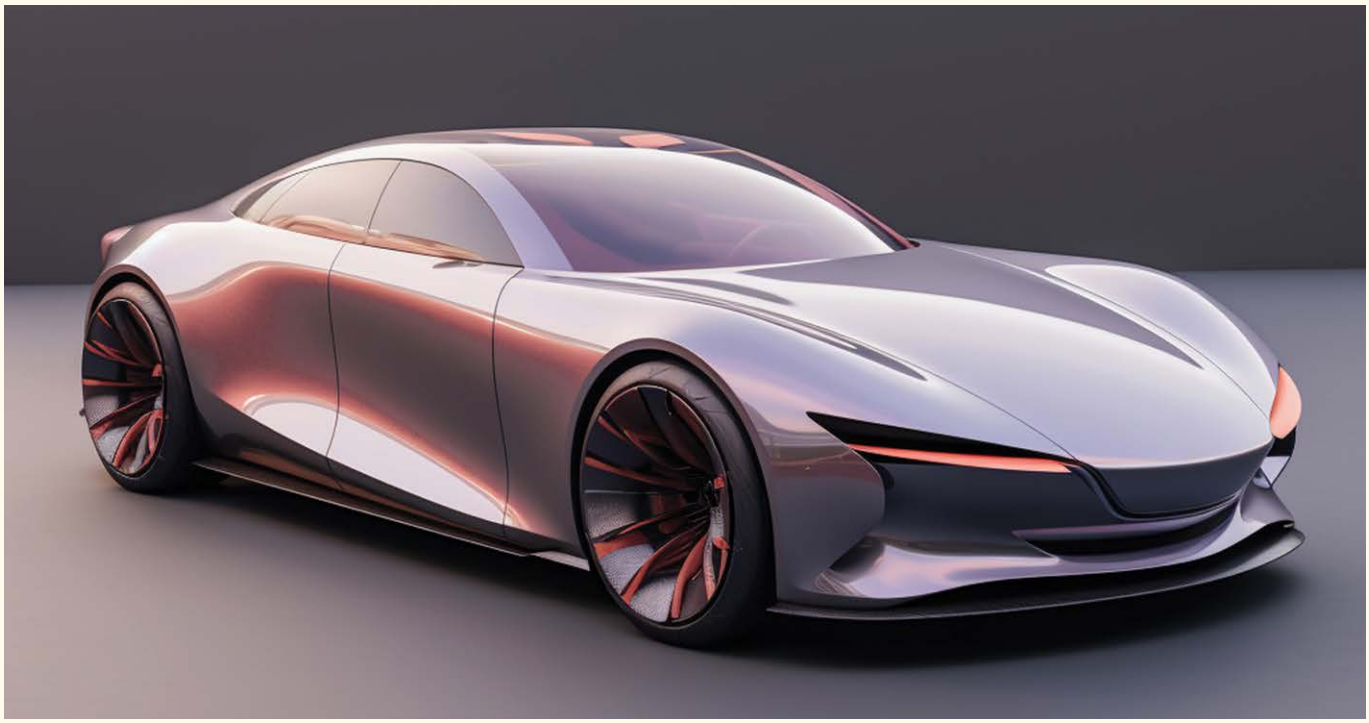


Figure 17 – Flokk digital platform

[105]https://unity.com/products/unity-artengine
[106]https://store.flokk.com/uk/en-gb/products



Autoliv, a supplier of automotive safety parts based in Sweden, collaborated with Cybercom, an IT solutions provider, to develop a product visualisation app that leverages Unity's capabilities. The app generates a digital twin of over fifteen of Autoliv's products and allows users to project them onto vehicles, providing a realistic and interactive 3D view. The tool provides a 360-degree view inside the car, and the option to toggle between normal and x-ray views of the vehicle.

The use of commercial game engines allowed Autoliv to deliver a heightened brand experience. Autoliv sales personnel use the app during trade shows and meetings, replacing tools such as PowerPoint and reducing the need for costly physical demonstrations. The company also uses the app to conduct virtual demonstrations of safety products and enhance the visualisation of safety features. Moreover, the app offers the manufacturing operators an in-depth understanding of how the products they produce are used within the vehicle, which in turn, improves the manufacturing process.

> **"...The capabilities of the Unity engine,** combined with the different assets we used from Unity Asset Store, **transformed the creative pipeline completely. With Unity, we can make things look photorealistic, with a high degree of detail.** Plus, Unity really helped us to experiment, iterate quickly, and **execute new ideas quickly..."**
>
> ***XR Advisor, Cybercom***[107]

[107] https://unity.com/case-study/autoliv

Conclusion

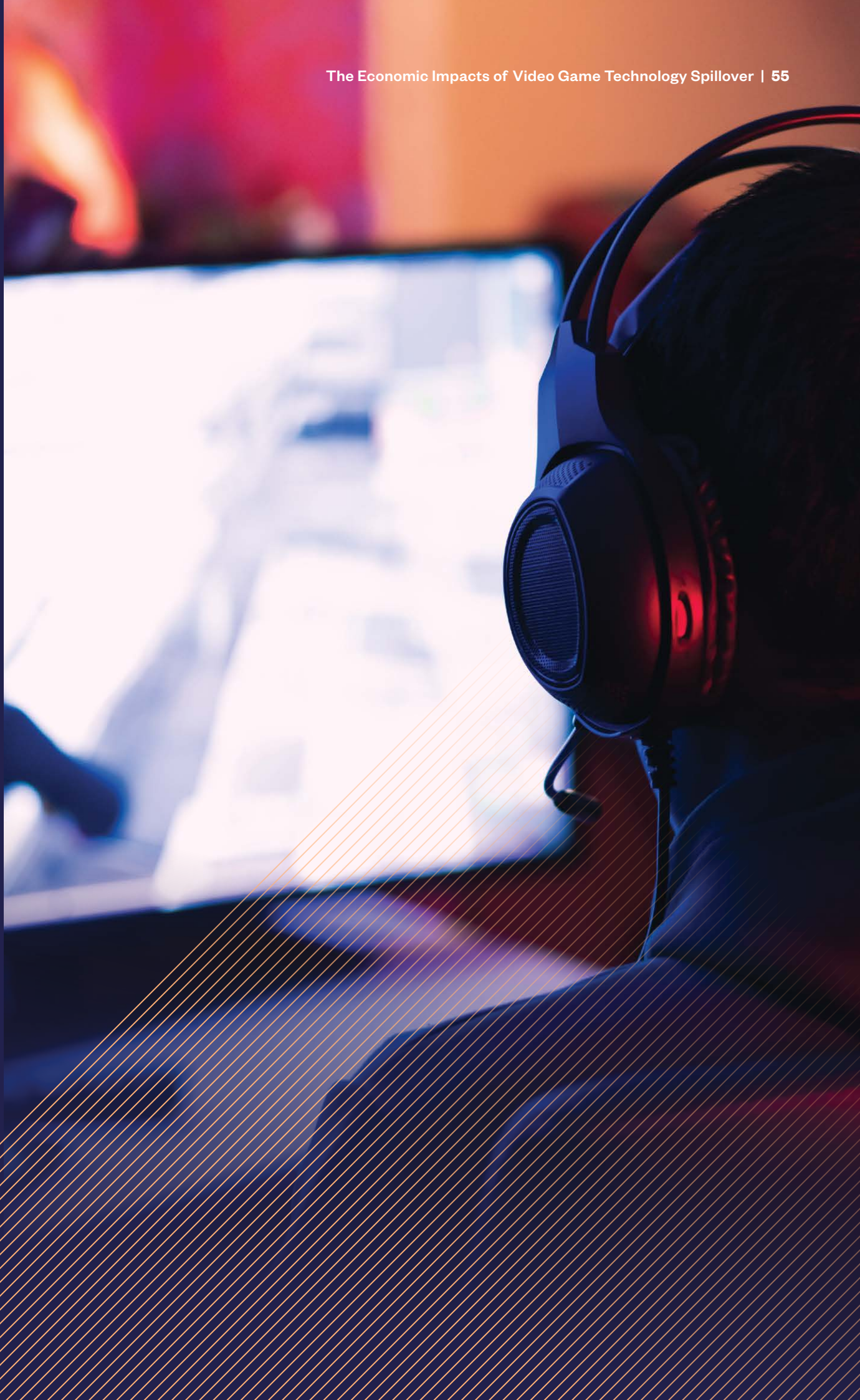
Over the past decade we have seen the cultural significance of games explode beyond the bounds of dedicated enthusiasts – bringing people together during the pandemic, finding a place in classrooms, video game language entering our common lexicon, critically and commercially successful adaptations of games, and concerts performed entirely within *Fortnite*. Game technology has similarly expanded beyond the applications of making and playing video games.

The key technologies of game engines, virtual and augmented reality, controllers and input devices, and haptics have all seen significant adoption outside of video games in such diverse places as high-end film and television production, highly technical training programmes, digital heritage, and research tools in the pharmaceutical industry. Video games are a cultural, technological and innovation leader worldwide and each of these strands brings with it a significant and vital economic contribution.

In the UK in 2021, video game technology spillover created an **output of 1.3 billion GBP**, with a corresponding contribution to **GDP of 760 million GBP**. This is an addition of approximately 13% on top of the UK games industry's total GVA for 2021, which we anticipate approaching 6 billion GBP. A total of **9,900 jobs** were supported by video game technology spillover in the UK; 4,420 of them were workers directly employed in industries utilising this innovative technology such as Information Technology and Business Services. This is a similar addition of approximately 19% on top of the 23,000 jobs we expect the UK games industry supported in 2021 in the development and publishing subsectors. UK households saw the benefit of game technology spillover in **380 million GBP paid as salaries** across the value chain. Treasury was calculated to have collected **250 million GBP in tax revenue**.

The analysis also showed how the economies of the UK's neighbours of Denmark, Finland, Norway and Sweden benefitted from contributions from video game technology spillover, with a combined total output of 1.3 billion GBP and corresponding GDP contribution of 910 million GBP. Together, technology spillover supported 5,370 jobs across these four regions. Norway saw the most striking spillover impact due to its highly developed Energy Extraction sector.

This report has quantified a hidden economic value of video games and highlighted the diverse ways in which game technology is influencing art, science and industry beyond the playing of games. With continued support from Innovate UK for game technology and the Video Games Expenditure Credit and UK Games Fund for game production, combined with a healthy investment ecosystem in the UK, video game technology can continue to create value throughout the entire economy and grow alongside the games sector itself.



Methodological Appendices

Appendix #1: Data Analysis

Historical Software Purchases

IO models generally represent one year of transactions throughout an economy. Examining multiple IO models for an economy across years can produce interesting insights into how an economy and its sectors have changed over time. These include the changing dynamics in the labour market because of an aging population, the impacts of changes in fiscal policy triggered by a new government, or the reworking of relationships among sectors due to technology advancement.

To estimate the magnitude and direction of changes in linkages between video game technology and other economic sectors in the UK and Nordic regions, FTI used the US IMPLAN model as a proxy because of its more highly disaggregated sectoral representation. The US version of IMPLAN has a detailed timeseries for each year from 2001 through 2021 of 546 economic sectors[108] while IMPLAN models of European economies only include 37 economic sectors and lack the time series needed to provide the sufficient insights required for this analysis.[109]

Using the US model as a proxy assumes that the changing technological relationships among economic sectors in the US would manifest themselves similarly in a high-income countries such as those investigated.

FTI analysed the millions of sector-to-sector connections contained in the US dataset to show the linkages between software publishers and software developers and other US economic sectors.

[108] https://support.implan.com/hc/en-us/articles/115009674428-IMPLAN-Industries-NAICS-Correspondences
[109] https://support.implan.com/hc/en-us/articles/12150245873435-2015-International-Product-Release-Notes

Figure 18 – Intermediate purchases of software-related goods and services

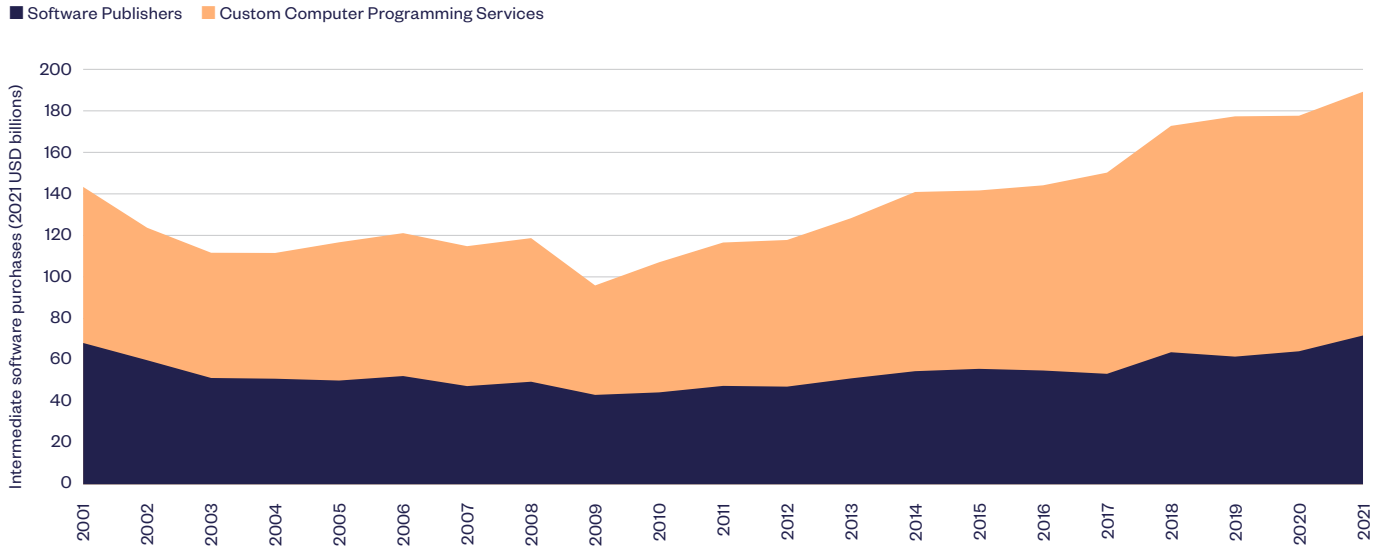


Figure 18 shows the intermediate purchases for software-related goods and services in the US economy from 2001 through 2021, defined as two sectors in IMPLAN – software publishers and custom computer programming services. The video game industry, and particularly video game technology, represents a subset of these two sectors. The purchases' values have been adjusted to 2021 dollars to make dollars comparable across years.

In 2001, at the peak of the "Dotcom" economy, the US economy purchased 143 billion USD of intermediate software-related goods and services. This number decreased to 112 billion USD in 2003 before dipping again in 2009 in response to the financial crisis and the ensuing "Great Recession" in the labour market. The trend reversed starting in 2010, and purchases grew to 190 billion USD by 2021, which is approximately the GDP of Hungary.[110]

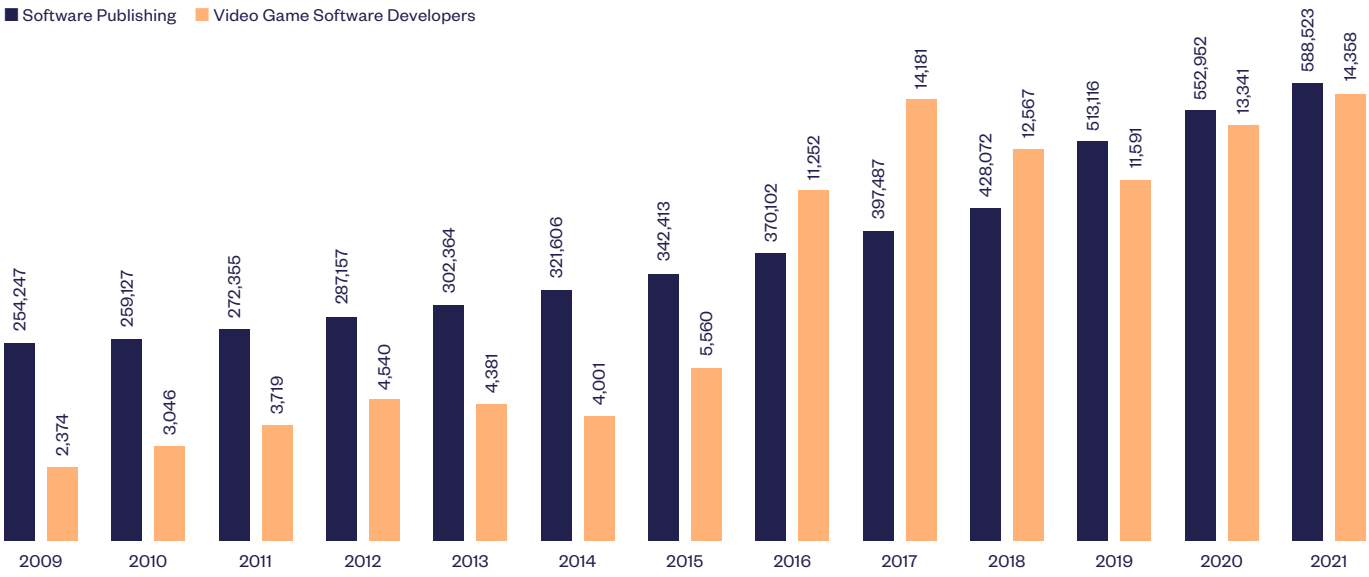
[110]https://tinyurl.com/3spwc64d

Isolating growth due to video game technology

To determine the growth directly attributable to video game technology, FTI conducted a series of analyses. First, FTI mapped the historical relationship between video game development jobs and software publishing jobs. This analysis examined the long-term, weighted average relationship between video game development and software publishing in the US and applied that relationship to the target economies for a single year – 2021. By using a long-term relationship, the analysis ignores any single-year economic volatility, such as the impact of COVID-19 on the global economy in 2020. Figure 19 shows total US employment in software publishing grew from approximately 250,000 jobs in 2009 to 590,000 jobs in 2021, or 131%. Meanwhile, US video game development jobs grew at a significantly faster pace from approximately 2,400 jobs in 2009 to almost 14,400 jobs in 2021, or 505%.[111,112,113]

Second, FTI calculated the share of US video game development job growth as part of the broader US software publishing industry employment growth in each year. For example, in 2016, US software jobs grew by 27,689 from 342,413 in 2015 to 370,102 while US video game developer jobs grew by 5,692 from 5,560 in 2015 to 11,252. This implies US video game development jobs represented 20.6% of the US software publishing job growth in 2016 (5,692 divided by 27,689).

Figure 19 – US Software publishing and video game developer jobs



[111]https://www.ibisworld.com/industry-statistics/employment/video-games-united-states/

[112]Because the historical data series on extends only from 2013 to 2021, we extrapolated backwards using data on total employment in the US video game sector from IBIS World. IBIS World reported total US video game employment in 2009 and 2013 as 96,931 and 178,910, respectively. Dividing 96,931 by 178,910 equals 54.2%. Statista reported 4,381 developer jobs in 2013. Multiplying 54.2% by 4,381 implies 2,374 developer jobs in 2009.

[113]Video game software developer employment figures were triangulated with [ESA's 2020 Economic Impact report; hyperlink: https://www.theesa.com/video-game-impact-map/wp-content/uploads/sites/2/2020/12/Video-Games-in-the-21st-Century-2020-Economic-Impact-Report-Final.pdf], which indicates ~143K direct jobs for the total US Video Game sector, of which ~57K in developers and developer/publishers. Video game software developer employment figures were estimated by assuming ~20-30% of employees of these types of organizations are coders, which validated IBIS World's figures.

Third, FTI used this job growth relationship to estimate economic output attributable to video game technology development. In 2016 US intermediate demand for software grew by 2.5 billion USD. Multiplying that figure by 20.6% implies 0.5 billion USD in US economic output from new video game technology.

This step was repeated for all years from 2009 through 2021. The cumulative amount of US output attributable to new video game technology growth across these years sums to 7.1 billion USD. Figure 21 below shows the disaggregation of the 7.1 billion USD by major economic sector.

Figure 20 – Example calculations to separate video games from software generally (2016 example)

Software jobs grew by 27,689

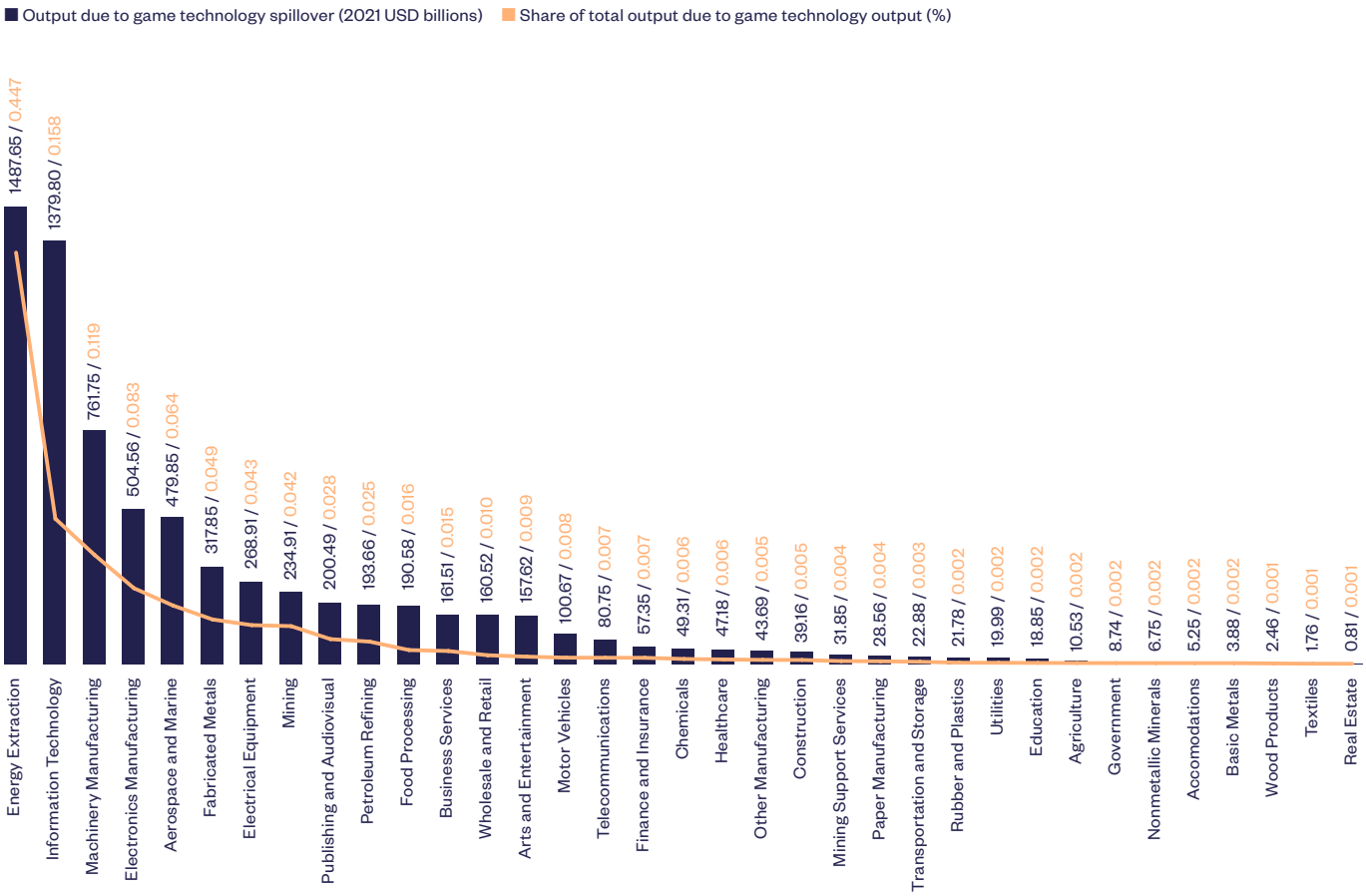
Video game developer jobs grew by 5,692

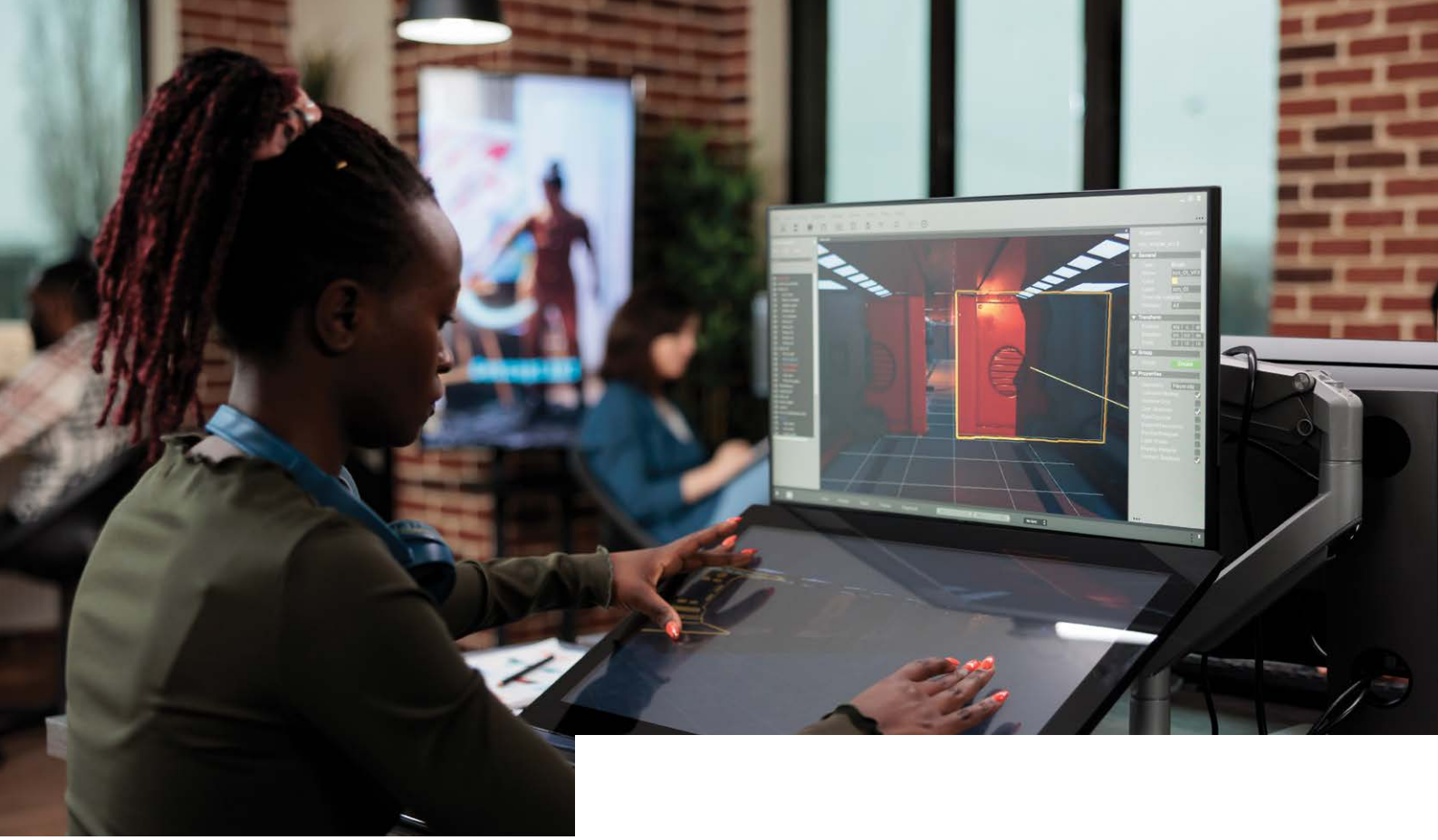
5,692 / 27,689 = 20.6% of total software jobs growth attributable to video game developers

Intermediate demand for software grew by $2.5 billion

$2.5 billion multiplied by 20.6% = $0.5 billion in direct output attributable to video game technology

Figure 21 – US sector output and share of sector output attributable to game technology (2021)





Sectors most impacted by video game technology

Sectors with the largest share of their output attributable to video game technology include extraction of energy-related resources, such as petroleum and natural gas, information technology, other business sector services, wholesale and retail trade, computers and electronics fabrication, finance and insurance, and publishing and audiovisual activities. Most of these are areas where video game technology, such as game engines and 3D rendering software, are useful, such as in visualising the Earth's geology or in CGI-related production of film, television, and other media content.

The oil and natural gas sector relies heavily on technology to find resources before significant and expensive exploration and drilling activities commence. As such, any technology that increases "success rates," even marginally, can have a sizable impact on the sector's output, which is why video game technology through its visualisation capabilities is influential.

Sectors with the smallest share of their output attributable to video game technology include "primary" natural resource and manufacturing sectors, such as agriculture, textiles, and wood products, and low value-added services, such as personal and household services.

Appendix #2: Mapping the US IMPLAN results to the UK and Nordic economies

The share of US sector output attributable to video game technology shown in Figure 21 was applied to the sector output represented in the European IMPLAN models, which formed the "direct" impact or activity from video game technology. This approach considers the varying sizes of economic sectors across each territory. For example, a country with a larger natural resource sector, like Norway, would be more affected by the impact of video game technology due to its preexisting industry mixture.

This methodology assumes all impacts from video game technology on the economy occur after 2009 because of (1.) the finite time series on the number of video game developers and (2.) the rapid growth in intermediate demand for software-related products after 2009.

A further adjustment was made to account for the rate of digital technology adoption in each territory relative to the US economy. The inputs for these adjustments are summarised in Table 8 and Table 9, which compare various metrics of a country's ability to incorporate digital infrastructure nationally. The indices listed for each category compare the different European economies to the US. The data source for this analysis was the Global Cloud Ecosystem Index 2022 produced by the Massachusetts Institute of Technology.[114] The UK scores slightly lower than the US on several measures of the physical scope of digital infrastructure (e.g., number of data centres, number of secure servers, total number of IP addresses, high-speed internet access, etc.). Thus, after weighing different factors in the index, the UK results were adjusted down by 4.5%.

[114]https://wp.technologyreview.com/wp-content/uploads/2022/04/MITTR-INFOSYS-Cloud_Reort_FNL.pdf?fbclid=IwAR1LgGMak430HwmgV6C0qmXM_J6iTe3tg2eO9EZpa8rdIGhL7LuBXTu19sE

Table 8 – Digital technology adoption indices, UK and US

Category	Relative Weight	UK Indices	US Indices
Telecommunication infrastructure	100%	9.2	9.2
Data centres	100%	7.7	8.1
Secure servers	100%	8.3	9.4
IP addresses	100%	9.2	10.0
Internet speed	100%	7.2	8.1
Digital adoption	25%	4.9	1.9
Government AI readiness	25%	9.2	9.8
Broadband prices	25%	7.2	8.8
Innovation	100%	9.0	9.3
E-participation	25%	9.7	10.0
SaaS companies	25%	3.3	2.8
Human Capital Index	10%	9.0	9.0
Internet users	10%	9.9	9.7
Engineering graduates	10%	6.1	3.8
Math scores	10%	8.0	7.4

Table 9 – Digital technology adoption indices

Category	Relative Weight	Norway Indices	Finland Indices	Denmark Indices	Sweden Indices	US Indices
Telecommunication infrastructure	100%	9.0	9.1	10.0	9.6	9.2
Data centres	100%	8.3	7.7	8.2	8.2	8.1
Secure servers	100%	8.4	9.0	10.0	8.2	9.4
IP addresses	100%	9.6	9.4	9.3	9.6	10.0
Internet speed	100%	8.9	8.8	9.7	9.7	8.1
Digital adoption	25%	5.8	5.9	4.6	5.5	1.9
Government AI readiness	25%	8.2	8.9	8.5	8.9	9.8
Broadband prices	25%	8.6	8.4	7.7	9.1	8.8
Innovation	100%	7.3	8.7	8.5	9.6	9.3
E-participation	25%	9.0	9.5	9.6	8.1	10.0
SaaS companies	25%	3.1	4.8	4.8	4.2	2.8
Human Capital Index	10%	9.2	9.4	9.4	9.3	9.0
Internet users	10%	9.8	8.9	9.6	9.8	9.7
Engineering graduates	10%	4.6	6.5	4.7	6.0	3.8
Math scores	10%	7.9	8.1	8.1	8.0	7.4

Norway and Finland score slightly lower than the US on several measures of the physical scope of digital infrastructure (e.g., number of secure servers, total number of IP addresses, etc.), while Denmark and Sweden score higher than the US. Thus, after weighing different factors in the index, Norway's and Finland's results were adjusted down by 3.2% and 0.1%, respectively, to account for this.

Denmark and Sweden's results were increased by 3.5% and 2.7%, respectively.

After making these adjustments, the respective local IMPLAN models were then used to model the indirect, induced, and total economic impacts from the direct output or activity calculated.

ukie

Ukie is a not-for-profit trade body that represents the UK games and interactive entertainment industry. Its mission is to make the UK into the best place to make, sell and play games in the world.

Ukie represents over 600 businesses working across the UK, including game developers, publishers, platforms and service providers. It supports companies through business support programmes, political engagement, speaking with the media on behalf of the sector and running education initiatives to boost the industry talent pipeline.

Ukie also supports and manage key industry campaigns such as the parental outreach work through Ask About Games and the #RaiseTheGame pledge.

www.ukie.org.uk

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