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## Technological Innovation at PC Sector During Covid-Crisis

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### **Abstract:**

**Purpose:** The article's primary goal is to assess the current impact of the coronavirus pandemic on the innovative activity of computer hardware manufacturers. It is imperative to assess whether the impact of a pandemic is negative.

**Design/Approach/Methodology:** For the set goals, the authors analyzed the literature on innovation. The analysis of the case study referred to the segment of graphics card manufacturers. Graphics cards were assessed based on selected criteria. These criteria are the technological process of producing graphics processors (photolithography), and the second element in the evaluation of graphics cards were the results of selected card models in a representative program for computer graphics performance tests.

**Findings:** Thanks to this approach, it was possible to identify trends in graphics card performance in the pre-pandemic and pandemic period. The increase in graphics card performance is the result of the implementation of technological innovations. So far, the coronavirus pandemic has not significantly affected the development of the graphics card segment.

**Practical Implications:** The presented approach and results of analyses may constitute the basis for creating an advanced methodology for determining trends in the development of graphics processor performance.

**Originality/Value:** Research results confirmed the adopted assumptions that so far, the pandemic has not a negative impact on innovation in the computer hardware industry.

**Keywords:** Technology, innovation, technological innovation, Coronavirus (Covid-19), graphic cards.

**JEL Classification:** L63, O31.

**Paper type:** Research paper/ case study.

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## **1. Introduction**

Since the 1970s, the personal computer (PC) industry has developed significantly, as the computer became an essential tool both at work and at home and started playing an important role in communication and home entertainment (Dedrick and Kraemer, 2005). The PC industry involved a global network of independent suppliers of systems, components, peripherals, software, and technology, impacting this sector (Grove, 1996).

Technology as an immaterial asset of the company is essential of a company routine and complex to transfer due to the gradual learning process (Rodasevic, 1999). Practical technological knowledge, which is considered intangible assets, can never be easily transferred from one sector to another because the technological learning process needs to adapt and assign the transferred technology (Lin, 2003). Technology can also be considered as firm-specific information regarding the characteristics and performance of production processes or ways of process info in digital computers (Rosenberg and Frischtak, 1985). Technology can be mentioned as the theoretical and practical knowledge and skills that can be used to progress and grow products, services, or delivery systems (Burgelman *et al.*, 1996). It refers to the integration of physical objects or artifacts (MacKenzie and Wajcman, 1985).

On the other hand, the PC has undergone considerable innovation and change since its first introduction. Innovation is "a new idea, creative thoughts and new conceptions in the form of a device or a method." It is also about the new and better solution that needs new requirements (Thompson, 1965). Technological innovation is part of the overall innovation discipline. It specifically focuses on technology and how it can be successfully implemented in products, services, and processes (OECD, 1997). This paper will show how COVID-19 affects the PC industry. A case study is a research approach of this paper used to generate a multi-faceted understanding of the influence of the Coronavirus on the PC industry.

## **2. Literature Review**

There are various definitions on innovation that are already in the literature review. The purpose of this part is to mention major definitions on innovation. Joseph Schumpeter is the first economist that paid attention to the importance of innovation and divide innovation in five types: 1) producing a new product, 2) opening of a new market, 3) application of new methods of production or sales of a product, 4) acquiring of new source of supply of raw material or semi-finished goods, 5) acquiring of new source of supply of raw material or semi-finished goods. Kimberly (1981) defines innovation as a different perspective, encompassing different forms of innovation. "There are three levels of innovation, innovation as a process, innovation as a discrete object, including products, programs or services, and innovation as an attribute of organizations." Van de Ven *et al.* (1986) described innovation as a new idea for the people even if it appears to others to be an "imitation" of something that leads to a

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definition that exists elsewhere. Innovation involves generating new ideas and implementing a new product or service (Urabe, 1988). New knowledge incorporated in products, processes, and services will be considered innovation and can be classified into the technological market and administrative/organizational characteristics (Afuah, 1998). According to Molchan innovation, scientific work improves social activities and is intended to implement social production (Siauliai, 1979).

Technological innovation is part of the complete innovation discipline. There is an opportunity to relate to technology and protect, entertain, and move around. Technology as a component of knowledge also becomes a building block for technological innovation. In general, technological innovation includes three areas as followed (University of Pretoria, 2013):

- Invention: is a new product, service, or process for solving a technical problem (Christopher, 2012).
- Realization is the phase in the innovation cycle after ideation that products can be workable. Engineers, designers, and developers are realistic, practical, goal-oriented, hardworking, and confident.
- Implementation is the phase that people are convinced to use and buy the new product or service. An essential concern believes customers in the new innovated product (University of Pretoria, 2013).

The personal computer industry pioneered the development of the global production network model of industrial organization. This industry has continued to develop new management practices and organizational structures with new approaches to manufacturing, logistics, sales, and marketing in a dynamic technological and market environment. More recently, PC makers like Dell Computer have been leaders in linking critical members of the manufacturing network (Dedrick and Kraemer, 2002).

The PC industry has introduced many innovations like the creation of new product categories such as notebook PCs, PDAs, and wireless "mobility" notebooks in its 25-years history (Dedrick and Kraemer, 2002). In the PC industry, there is a tendency to focus on operational efficiency, marketing, and sales instead of product differentiation (Porter, 1996). To understand innovation in the PC industry, it is essential to consider the structure of the innovation network, the innovation processes, products, and innovations activities:

- The innovation networks are people, institutions, and active companies inside or outside the firm. In the PC industry, innovation networks consist of component makers, contract manufacturers (CMs) and Original Design Manufacturers (ODMs), branded PC firms, distributors, and resellers (Curry and Kenny, 1999).
- Innovation processes: Research and development (R&D) and new product development are two major phases in product innovation in PC industries. An

initial look at the significant features of the computer industry identifies some aspects like the variety of hardware categories that are relevant regarding the innovation process (Bresnahan and Greenstein,1995).

- Products and innovation activities: In the PC industry, product innovation for desktop includes conventional systems integration, if new parts and software into a system are working together and for notebook involves high-level system integration with complex mechanical, electrical, and software challenges (Dedrick and Kraemer,2002).

One of the problems in technological innovation and innovation management is how new technologies originate and evolve in the presence of environmental threats. In fact, in the presence of uncertain, unstable, and harmful environments, such as COVID-19, many sectors and industries face problematic situations originating from new events that they do not face daily but require timely responses (Global Electronic Services Inc., 2021). Before the Corona crisis, the PC industry was decreasing because of the development of mobile technology and macro computing. PC demand has been shifting continuously for over a decade smaller, more integrated, and more communication-oriented products. The global demand for PCs is changing in terms of form factor, commercial vs. consumer markets, and regional consumption (Dedrick and Kraemer, 2002).

However, the new situation caused some changes. The demand for electronic providers for PCs is increasing worldwide, and these changes have a positive influence on this industry. Nowadays, people are working, learning, and entertaining primarily from home, which is why the need for at-home computers is rising (Global Electronic Services Inc., 2021).

### **3. Research Methodology**

This research is based on a case study to generate an in-depth, multi-faceted understanding of the PC industry in a specific period. During the pandemic, computer hardware manufacturers perform very responsible tasks. The global pandemic has caused significant changes to the functioning of economies and societies. The most significant changes are national and regional lockdowns. Remote work is possible during the lockdown period. In order to implement it, you need appropriate computer equipment. The most popular type of hardware is still the PC platform.

Therefore, the innovation analysis within the hardware sector will focus on selected components of the PC platform. The essential components of the PC platform include Processors, graphics cards, motherboards, RAMs, and hard drives. Processors and graphics cards are the most responsible for computing and graphics performance. They have the most significant impact on the graphics performance of the computer. This performance level affects the overall comfort of working with a computer and, importantly, allows us to use the computer for entertainment purposes.

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## 4. Results

The presented analysis answers the following question: has the current pandemic negatively affected innovations in the sector of computer hardware manufacturers? In this article, graphic cards will be analyzed in detail. The performance of these components is a result of technological progress. This progress is closely related to innovative activities. The implemented production innovations affect the performance of graphics cards. Both processors and graphics cards are manufactured using semiconductor technology. For their production, silicon in the form of "silicon wafers" is used<sup>3</sup>. Photolithography technologies are used in their production. The technological dimension that determines the level of this technology is the nanometer<sup>4</sup>.

The current manufacturing trends of processors and graphics cards place emphasis on the use of obtaining the lowest possible value of the technological process in nanometers. In other words, a lower technological process (for example: 7nm) allows you to: pack more connections and transistors on a GPU surface unit, the computing power increases and, what is important, the system energy consumption does not increase. To sum up this issue the low level of the photolithography process translates into a reduction in energy consumption by graphics cards and processors, greater computing power and graphic performance of these components.

There are many dedicated applications for measuring the performance of graphics cards. One of the most popular application is 3Dmark Fire strike. This program is produced by the famous Finnish company Future mark Corporation<sup>5</sup>, founded in 1997. The firm creates software for testing computer performance. Dedicated computer performance testing program 3Dmark Fire Strike is a showcase benchmark for modern PCs. Its ambitious real - time graphics are rendered with detail and complexity. 3Dmark Fire Strike includes two graphic tests, a physics and a combined test that stressed the processor and graphic card.

Table 1 shows the characteristics of selected AMD Radeon graphics cards. These cards are the most efficient models of the last three generations. The market premiere of the latest generation of AMD Radeon graphic cards (RX 6900XT) took place during the coronavirus pandemic.

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<sup>3</sup>*Silicon wafer - a thin wafer of monocrystalline silicon, used to make silicon chips (microprocessors, microcontrollers and other integrated circuits). Wafer is the basic starting material in microelectronics. In order to obtain certain semiconductor elements from it, it is subjected to many technological processes, including ion implementation and photolithography.*

<sup>4</sup>*Nanometer (symbol: nm) - submultiple of a meter, the basic SI unit of length. It is one billionth of a meter, or one millionth of a millimeter.*

<sup>5</sup> <https://benchmarks.ul.com/contact>

**Table 1.** Most efficient models AMD Radeon of the last three generations.

Characteristics	AMD Radeon Graphic Card		
	RX 590	RX 5700XT	RX 6900XT
Market introduction	November 2018	July 2019	November 2020
Photolithography [nanometer]	14nm	7nm	7nm
Performance [Points in 3Dmark Fire Strike]	16451 points	25313 points	54109 points
Energy consumption [Wats]	225W	225W	300W

Source: Own study based on: <https://www.benchmark.pl>.

Table 2 shows the characteristics of selected Nvidia. These cards are also the most efficient models of the last three generations. The market premiere of the latest generation of Nvidia graphic cards (RTX 3090) also took place during the coronavirus pandemic.

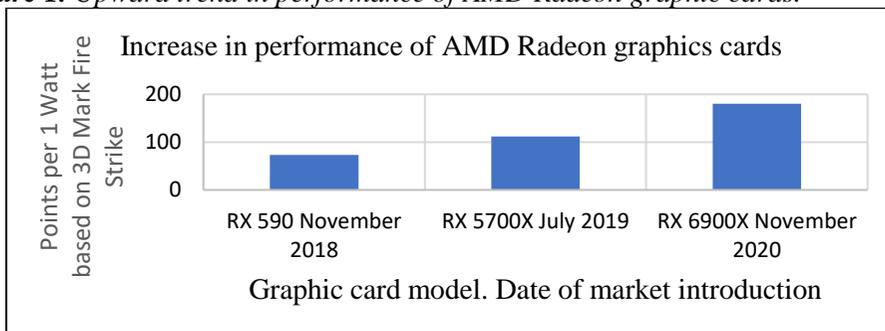
**Table 2.** Most efficient models Nvidia GeForce of the last three generations.

Characteristics	Nvidia GeForce Graphic Card		
	RTX 1080	RTX 2080	RTX 3090
Market introduction	August 2016	September 2018	September 2020
Photolithography [nanometer]	16nm	12nm	8nm
Performance [Points in 3Dmark Fire Strike]	26936 points	35023 points	48002 points
Energy consumption [Wats]	250W	260W	350W

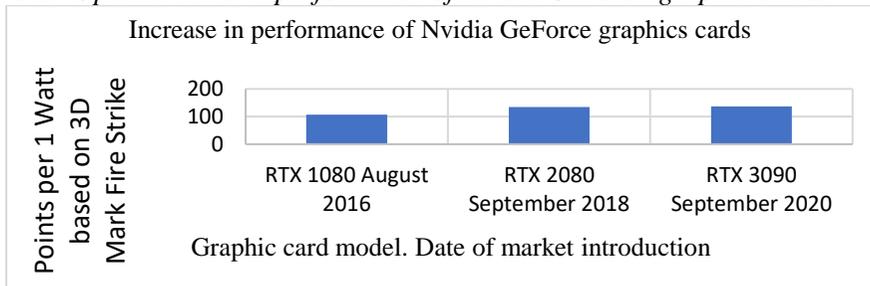
Source: Own study based on: <https://www.benchmark.pl>.

As we can see, the course of the pandemic epidemic so far has not significantly influenced innovation in the graphics card industry. New generations of cards (both Nvidia and AMD Radeon) that had their premiere already during the pandemic are significantly more efficient than previous generations. This performance is the result of advanced innovations in graphics chip design and manufacturing technology. To illustrate the upward trend in the performance of selected graphics cards, we will present two charts- one for AMD Radeon graphics cards, the other for Nvidia graphics cards.

**Figure 1.** Upward trend in performance of AMD Radeon graphic cards.



Source: Own study based on: <https://www.benchmark.pl>.

**Figure 2.** Upward trend in performance of Nvidia GeForce graphic cards.

**Source:** Own study based on: <https://www.benchmark.pl>.

The next generations of cards gain performance without a significant increase in energy consumption. The graphs show the graphics performance of cards measured in the 3Dmark Fire Strike program per 1Watt. AMD Radeon cards make significant progress here. However, it does not mean that they are better than the Nvidia graphic cards. It is just that in this graphical benchmark (3Dmark Fire Strike), they get better results. In other graphics performance testing programs, the Nvidia GeForce card wins another time and program AMD Radeon card. The overall trend is more important, and this is: Computer technology firms Nvidia and AMD Radeon are making progress despite the state of the pandemic. The performance gain of graphics chips is dynamic and precise. The latest generation of Nvidia and AMD Radeon graphics cards provide excellent performance for new personal computers.

## 5. Discussion

The problem may be whether, in the long-term perspective of the pandemic (e.g., several years), it will be possible to maintain this favorable trend? It is difficult to answer this question; we do not know how long the pandemic will last and its consequences in the future. As of today, there are no significant turbulences caused by the pandemic in the computer hardware industry. The more significant problem for customers who want to purchase new Nvidia or AMD Radeon graphics cards is the high course of cryptocurrencies. This fact makes graphics cards unavailable to ordinary customers. High-performance graphics cards are captured by “cryptocurrency miners” outside of the official distribution. However, this issue is beyond the scope of this article.

## 6. Conclusion

The presented considerations and examples show that the impact of the pandemic on the development of the computer hardware sector has not been negative, and the demand for electronic providers for PCs is increasing. However, a more extended period of the pandemic will undoubtedly negatively affect the computer hardware industry. It remains to be hoped that the actions of international organizations and

individual countries' governments will help overcome the coronavirus pandemic. After that, we return to the normal functioning of the economy on a global and national scale.

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