Impacts of Apple's M1 SoC on the Technology Industry

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ABSTRACT

The Apple's M1 System-on-a-Chip, a highly integrated processing unit that has all the essential components to a fully-functional computer, has brought lower power consumption in general to buyers in the laptop and desktop markets without sacrificing much performance. This study was aimed to investigate and discuss the influence of the M1 chip on the competitive companies and the consumers. Almost all consumers would be likely to gain from the M1 indirectly through the healthy competition it sparked in the market segment for laptops and thin-and-light notebooks, in particular. After Apple's public appearance, Google, Nvidia, and other tech giants quickly followed up, announcing their plans and roadmaps for their respective custom ARM solutions. This research concludes that M1 chip has played an important role in the development of chips and its industry; the consumer also benefits with lower prices and more options. Thus, the technology innovations in this field have promising future and grants more investigation and research toward the development of the chips.

Keywords: SoC, Apple, M1, Technological Innovation

1. INTRODUCTION

The technological sector of our economy has remained mostly stagnant over the past decade or so in terms of architectural breakthrough--Intel, which enjoyed its market power in the processing segment, had been rocking the same x86 platform with the same 64-bit instruction set that they've adopted since the Pentium D back in 2004, Advanced Micro Devices, being stripped of the privilege to rip off its competitor, was slowly going downhill with what their former partnership with Intel had taught them, Nvidia, having settled down with manufacturing graphic solutions for other companies as well as regular consumers, made little improvements to their graphics cores year by year on the same underlying chip design, International Business Machines (IBM), previously being a powerhouse in enterprise computing, came to a halt with regards to development except for a few minor acquisitions, and Apple, which had already launched the iPhone and iPad line-ups, kept refreshing their products with nothing more than some feature improvements and minor hardware tweaks.

This trend of sluggishness all ended in November of 2020, with the launch of Apple's M1 System-on-a-Chip, a chip designed with efficiency in mind for the laptop segment of the market for electronic computing. An SoC, short for System-on-a-Chip (SoC), is a highly integrated processing unit that has all the essential components to a fully functional computer. Typically, an SoC consists of the graphics engine, or graphics processing unit (GPU), the central processor, more commonly referred to as the central processing unit (CPU), in combination with its high-bandwidth dynamic random access memory (DRAM)-cache, the input/output (I/O) controller, which handles all the different kinds of incoming and outgoing data, a security module of some sort, and, finally, some low-bandwidth, high-capacity dynamic random access memory (DRAM) as its primary memory pool. Compared to the traditional laptop and desktop chips manufactured by Advanced Micro Devices (AMD) and Intel-based on their x86 platform, SoC's are more energy-efficient, albeit less powerful, thanks largely to their use of Advanced reduced instruction set computer Machines (ARM) core architectures. The ARM processing architecture, which utilizes a combination of

high-performance and power-saving cores in a unified design named the BIG-little processor layout, is especially useful on the mobile side, where battery life is a crucial part of the whole user experience. Historically, this type of core design has only been used in mobile devices such as cell phones and low-powered home smart devices like air conditioning modules and smart door locks. Glancing over the past few decades since the establishment of ARM, the implication of its architectures in the laptop and desktop sectors have been few and far apart, not to mention the lack of popularity for the notorious performance that such designs have led to.

Apple's M1 changed all of that. It served as a hybrid between the traditional x86-based power-hungry beasts and the energy-efficient ARM-Cortex chips—bringing lower power consumption in general to buyers in the laptop and desktop markets without sacrificing much performance. Thanks largely to its invaluable expertise and experience designing chips for iOS devices, Apple was able to pull off this unprecedented feat that will act to their advantage for quite some time to come. As alluded to before, other companies have been trying to adopt the technology for years, such as Microsoft and Qualcomm with their combined effort in making the SQ1 processor for the Surface Pro X, without much success, and this gave Apple the perfect incentive to step in and make the industry proud.

Moving onto the consumer side, the launch of the M1 was and still, to this day, is an utter delight, too. Not only do Mac users benefit from having laptops and desktops that are eco-friendlier, not to mention more performant than their previous Intel counterparts, but all consumers alike will likely also gain from the M1 indirectly through the healthy competition it sparked in the market segment for laptops and thin-and-light notebooks, in particular. After Apple's public appearance, Google, Nvidia, and other tech giants quickly followed up, announcing their plans and roadmaps for their respective custom ARM solutions. For one, this builds a certain level of confidence in the mind of the regular laptop buyer with regards to the expected success of ARM technologies, and, for two, creates an urge for investment in research and development (R&D) of the implementation of such technologies.

Thus, it is safe to say that the future of the laptop and desktop markets looks promising. With all the major companies all alerted of the imminent danger of being left in the dust, ARM on laptops can soon be anticipated to show up in more and more devices outside of the handheld. However, if the other tech companies fail to catch up to Apple in the long run, which is extremely unlikely, given that no wall in the industry is sealed tight and completely sound-proof, the latter may have just gifted us with the downfall of the industry and the market for computing in general, for that no consumers, under no circumstances whatsoever, will benefit from monopolistic control.

2. MAIN BODY

2.1. M1 on Apple Silicon MacBook

A large and growing body of literature has investigated on the development of chips, the silicon processor of computers, comparing the market of it and furtherly displaying its technology innovation, the factors of it and demonstrating the relationship between the technology innovation and consumers.

In an article published on April 29, 2021 by Henry T. Casey for Tom's Guide, and internet technology review website, Mr. Casey reviews the performance of the M1 Chip, compares it with the Intel Chip previously used by Apple, and discusses the cost effectiveness and benefits of the chip in relation to the consumer [1]. Mr. Casey suggests the performance of M1 chip as "massive" by supporting the effects of it running twice as fast as using intel chips, with longer battery life provided, gaining the control of production, and lowering the production cost to soar the benefit [1]. He concludes with noting that Mac Book using M1 chips will be the most powerful innovations in Apple [1].

In Juli clover's article, he also analyses the characteristics of M1 chip and stands out that it integrates several different components enables to power the different functions in the Mac, but, different from Henry T. Casey's Tom's Guide, he demonstrates in the way of CPU, GPU , and neural engine [2]. He also stands that Apple has put a great effort into it, and it also benefits apple with benefits compared to the performance previously used with Intel chip in the way of speed, battery life, security features and translation layers [2].

By contrast, In the article published by Consumer News and Business Channel (CNBC) , it demonstrates the benefits that M1 chips bring in the way of analysing the reasons why apple is breaking a 15-year-partnership with Intel .For one thing is its ARM technology, different from Intel, previously designed for mobile devices, being able to provide the applications with longer battery life. For another, Tim Cood, Apple chief executive officer (CEO), claimed that it is invented for "long-term strategy of owning and controlling the primary technologies behind the products we make". It's pointed that the silicon processor technology is crucial to the company. Thirdly, M1 chip allows all Apple computers to run on the same framework overall, which, in the way of integrating all its products together. Fourthly, it uses shorter transistors providing higher efficiency. it identifies apples can wake up from sleep instantly. However, it hints at the end that there are some performance advantages of Intel chips compared to M1

chips as Apple had not stop selling Intel laptops, and its highest brand of laptops are still Intel-based.

With M1's chip development, there are also some articles displaying the pressure that M1 chip has brought to its rivals in the market, including Intel and AMD. In a way, it gives them instructions on how to innovate, affecting their choices and pushing them to innovate more, to get rid of being driven out of the market.

For Intel's reaction, Haim Gartenberg has introduced how it innovates to increase its competitiveness against m1 chip in its 12th version [3]. It carries out an approach closed to ARM's BIG. Little technology [3]. It will provide a service on the foundation for future desktop and mobile processors [3]. He suggests that intel is trying to imitate Apple's ARM success with its own technology going forward [3].

Other than that, for AMD reaction, John Loeffler introduces the latest innovation of AMD processors and its future planned development as well as its competition with Intel chip technology, foresees its future powerful development and may be neck and neck to Intel technology in the future [4]. It also focuses on increase its efficiency with shortening its CPU, applying Little architecture as intel, increasing the cores and available threads [4].

Another company, Qualcomm, is planned to invent their own chip as well, believing Qualcomm can design the best chip on the market, and planning to take on both Intel and Apple's M1 laptops intriguingly hinges on the acquisition of a company started by some of Apple's own chip building alumni [5]. This is concluded by Martin Alan [5].

M1 chip's development is part of the development, and it may indicate the technology innovation in the whole world. Ojo-Emmanuel, G., et al has suggested that Innovation is a root in a larger system, enabling and drawing on the innovation process instead of a study behaviour of a company [6]. In the research, four industrial estates in Nigeria were sampled for this study. it analyses the factors influencing technology innovation outputs of small and medium enterprises. It suggests that firm size, turnover, age, ownership, and expenditure on innovation activities are not the factors promoting innovation levels, while quality of human resources and interactions with suppliers both played an important role in innovation. Innovative development is determined by demand or market pull factors instead of technology push sources. The study recommends increasing interaction and dynamism substantial investment as well as adequate supply of infrastructure and funds.

There is another research posted on 37th Annual Hawaii International Conference on System Sciences, 2004., which reviews studies using the technology acceptance model (TAM), creating a modified model and instrument to analyse the acceptance of Internet technology by consumers. With applying precious empirical researching results, using the technology assessment model, an improved TAM was developed to analyse the acceptance of Internet-based technologies by consumers [7]. The original constructs (beliefs, attitudes, behavior, and use) were remained whereas the literature suggests gender, experience, complexity, and voluntariness as additional useful factors analyzing the degree of consumer's acceptance. Analyzing this article enables readers to learn the degree of acceptance from consumers towards the newest internet technology, which is, criticizing whether the technology innovation suits and fits the consumers, and the real factors affecting the degree of acceptance [7].

And this can furtherly analyses on the relationship between consumers and technology innovation, in the way of the benefits, changes and problems it may bring. In the essay published by Ben Lowe, Yogesh Dwivedi, Steve D'Alessandro, it claims that technology innovation can bring predominant benefits to consumers and society with benefits [7]. These benefits can be broken down into time savings, lower cost, and enhanced benefits. In the article, it's claimed that innovation may change consumers' behaviour and affects their opinions towards industries [7]. By contrast, it also brings some challenge such as transferring the power from the suppliers to consumers. Other than this, some problems the technology innovation brings to the consumer is also mentioned in this article [7].

Together, these studies outline the benefits M1 chips has brought to Apple, compared to Intel, the previous partner who invented the chip for Apple. It then furtherly demonstrates on the technology innovation in the whole world, its factors and how it affects consumers.

2.2. Chip

"Chip" is known as the microchip in electronic devices; a chip is an inter grated circuit, or a set of electronic circuits in one flat ground of semiconductor material of silicon, according to Namrata [1]. The use of microchips in telecommunication, high-performance computing, and consumer electronics is growing at a very high pace, said Namrata [8]. They can be applied to communication devices, all electronic home appliances, aeronautical appliances, defense, computers, speech processing, video-on-demand, data-communication, multi-media application, etc.

Around 1958, Jack Killby was hired at Texas Instruments to work on electronic component miniaturization; to solve the current problem, he was working on, he manufactured all circuit components in a single piece semiconductor substrate, which is an integrated circuit, and known as the first silicon chip. The invention and development have a huge impact and enormous influences on digital devices and other

computing technologies. In 1960, IBM developed the first automatic mass-production facility for transistors in New York; in 1971, Intel with the help of Ted Hoff introduced the first microprocessor, it also later introduced the 8008 processor and improved microprocessor chips [10]. Other companies like AMD, together with Intel continued to improve and introduce processors and chips until now.

In November 2020, Apple released the first Macs with an Arm-based M1 chip, this received rave reviews for its incredible performance and efficiency according to Clover [10]. The M1 chip integrates several different components including CPU, GPU, RAM (unified memory architecture), image signal processor, encode/decode engines, which form what is known as "system on a chip". Different from the other chips, Apple's M1 uses an Arm-based architecture which is similar to the chips Apple has been designing for iPhones and iPads; the M1 chip has a built-in Neural Engine, it brings up to 3,5x faster CPU performance, up to 6x faster GPU performance, and up to 15x faster machine learning capabilities compared to the Intel chips used in prior-generation machines [10]. As the M1 chips use significantly less power consumption, two times longer battery life, all these great advantages undoubtedly attracted the consumers' attention. When the M1 chip is released, great revenues and sales are expected.

Meanwhile, the M1 chip does not only attract the attention of the consumers, the other companies also view M1 as a huge step and successful competitor.

A large and growing body of literature has investigated the effects of Apple's new M1 System-on-a-chip. In 2020, Johnsa and Nvidia confirm that their move to ARM is a top priority, especially when it comes to servers, and that it will not make any modifications to ARM's business model and licensing agreements. Meanwhile, Paul Alcorn claimed Nvidia believes that ARM will be the key to the future of data centers and is planning on revolutionizing the product lineup with ARM technology [11]. Ewan Spence also suggests that Microsoft also sees a lot of potential in ARM processor technologies and is working their processors based on ARM's technologies [12]. In 2021, Nvidia will start developing CPUs based on the same ARM core architecture as Apple M1 and it, codenamed "Grace", is said to arrive in 2023 according to Kristin Bryson; Kevin Krewell also reported Nvidia buys ARM and will incorporate ARM-based designs into their chips [13,14].

John Loeffler reported the new APU, which would tentatively be part of AMD's Ryzen 8000-series, could land as soon as 2024, according to KitGuru [15]. AMD also has the Next-Gen Ryzen 8000 'Granite Ridge' CPUs With Zen 5 & 'Strix Point' APUs With Zen 5 + Zen 4D Cores Spotted in Leaked Roadmap according to Hassan Mujtaba [16]. In Alan Martin's press release, Qualcomm is planning for its upcoming revision to their 8CX SoC

for laptop computers [5]. The upcoming Alder Lake chips will feature a combination of performant, high-power cores and efficient, energy-saving cores for a truly scalable performance according to News9 [17]. As time passed, more and more competitors appeared; according to Chaim Gartenberg, Intel's Alder Lake CPUs could pose a threat to Apple's M1 chips, taking on a similar design on the x86 platform [3]. The Ryzen 8000 series, which is rumored to arrive in 2024, looks to rival both Intel's Alder Lake and Apple's M1 by taking on a similar architectural design according to Tsing Mui [18]. In Giuliano J. de Leon's press release, it is said that Intel's Alder Lake Chip takes on a similar BIG-little design and will target the M1 as its primary competitor. According to Argam Artashyan [19,20], Samsung announces its upcoming Exynos chip in response to all the major competitors moving to ARM designs; it is also collaborating with AMD on their upcoming Exynos SoC to rival the M1 from Apple according to Daniel R. Deakin [21].

2.3. Technology Innovation

Technology innovations typically include or make reference to invention, realization, and implementation, which fall in the total disciplines of innovations, but they specifically focus on the technology and how to embody it into the products, services, and processes [22]. Thus, the proposed working definition of technological innovation according to the University of Pretoria is to convince and produce a new solution from scientific and technological knowledge to a real or perceived need; to develop this situation into a viable and producible entity; to successfully introduce and supply this entity to the real or perceived need [23]. The quality of human resources and interactions with suppliers is an external factor within the national innovation system, both made a significant impact on innovation; innovation is mainly influenced by demand or market pull factors [6]. On the other hand, different consumers are likely to show different attitudes toward technological innovations. Some consumers may consider technological innovation as risky and unpromising due to the too-advanced ideas or products that they could not currently understand or appreciate. However, technology innovation indeed provides abundant advantages and is accepted by many consumers. Technology innovation can bring huge convenience and highly improved efficiency; this can also boost the other innovation and competition in the market, which provides more benefits to the consumers since there would be better services or products, more efficient technologies, and lower prices. As most consumers are willing to adopt technology innovations, more innovations are spurred and thus benefit the development of the technology and the market.

3. RESULT & DISCUSSION

After referencing the sources and having read the contents of other's opinions and studies on this topic, we are confident to say that, in general, that the M1 chip has had a positive impact on the technological sector of the economy and possibly the entire economy. Most importantly, it gave other companies the incentive to innovate and eventually bring similar products to the market for consumers to enjoy. In the process of this, consumers inadvertently benefit, whether they want to or not, from more competitors that enter the market, put money forward in an effort to innovate, and better their new-born or existing technologies. As also mentioned in the above analysis, this forward push initiated by an initial innovator eventually will lead to further innovation from the initial investor. This theory is simply justified by the profit motive, where any and every producer aims to make a profit and gain more from market transactions as compared to everyone else. Also, on a less optimistic note, firms that cannot keep up with the trend of innovation that the economy segment is heading towards will, in the long run, be eliminated. However, judging by how fast the technology is advancing in the more recent years, failure of response within a theoretical maximum of 3 to 4 years to a competing firm's actions will mean devastating consequences for a certain company. This, in addition to the profit motive mentioned above, lays the foundation on which firms rely for the push to innovate. In the end, then, every representative body participating in the economic sector, be it the consumer or producer side, wins from this initiative.

4. CONCLUSION

In conclusion, the introduction of the M1 chip has become a marvel stone and played an important role in the development of chips and their industry. What had been a time of sluggishness in chip advances, has turned into a race against the innovations of the M1 Chip. Technological giants such as Intel and Android find themselves engaged in a competition unimagined in recent years. The advance of the M1 chip has brought incredible speed and economy to chip performance. Just as companies rush to catch up, Apple is developing the next step, the M1X chip.

The M1 chip has attracted immense publicity, with accolades from reviewers and consumers. Substantial revenues and sales are expected. Intel, Qualcomm, Microsoft, and numerous other competitors in the industry are setting dates for their rival chips to be on the market. Intel sites 2024, for its similar architecturally designed chip to be a primary competitor. Without a doubt, the M1 Chip has rocked the technological world. What was a technology only used on small devices such as cell phones and tablets, a built-in neural engine,

known as a "system on a chip" allows for less power consumption, and higher speed in applications on all computing devices and a more integrated system which makes Apple less dependent on outside resources.

Historically, Apple has taken on the role of the innovator, the company that thinks "outside of the box" and once again it assumes that role. This is undoubtedly good for the consumer and the market. It demands huge creativity and investment on the part of the tech companies to stay alive and it provides the consumer with a better product. As the competitors catch up with Apple, the consumer benefits from lower prices and more options. Not only are jobs and opportunities created for development, but sales and marketing also flourish. Advertisers, reviewers, and consumers are engaged in the creative advancement of a new idea and monetary investment occurs at all levels. Historically, innovation benefits all sectors of the market, and hopefully, Apple's M1 Chip facilitates access to technology worldwide especially in those countries struggling economically. Most certainly, it has caused a great wave of new technology. What was a stagnant market, has become a firestorm of activity and new ways of thinking.

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