The Dynamics of Platform Ecosystem: An Agent-Based Simulation of a Semi-conductor Company

Yujia Hu

The Faculty of Environment, Science and Economy, University of Exeter, Exeter, UK

Abstract. In recent years, the platform ecosystem has emerged as a pivotal construct influencing the strategic decision-making processes of modern businesses, particularly in high-tech sectors. Leveraging the case of a leading semiconductor company, this study delves into the intricate dynamics governing platform ecosystems. Through an agent-based simulation, the study showcases how individual agents (customers) interact with the platform based on the quality of products and the frequency of service upgrades. The simulation results elucidate the significance of maintaining high product quality and ensuring regular service upgrades in bolstering the company's position within the semiconductor platform ecosystem. Further, the study offers insights into how network effects, catalyzed by these two critical factors, lead to a sustainable competitive advantage in a rapidly evolving market landscape. These findings not only present a nuanced understanding of platform ecosystem dynamics for semiconductor companies but also offer strategic imperatives for businesses operating in similar high-tech environments.

Keywords: Platform Ecosystem, Semiconductor Company, Agent-Based Simulation.

1. Introduction

1.1 Background

The significance of platform ecosystems in influencing the landscape of many businesses has become increasingly apparent in recent years. These ecosystems are intricate networks of interconnected customers, suppliers and producers who communicate with each other through a shared medium. Given the strategic role of the semi-conductor industry in the global digital economy and its intricate network of interdependencies, it is an ideal environment to explore these dynamics. Due to their enormous complexity, platform ecosystems have the potential to display emergent phenomena that are difficult to predict from the knowledge of their parts. They are dynamic systems, responding to many internal and external inputs throughout time through evolution and adaptation. This raises the question of how to assess the strategic impact of these interactions on a given ecosystem actor [1]. To answer this question, dynamics and interactions at the individual level must be studied, as they collectively shape the behaviour of the ecosystem as a whole. Past research has focused on using descriptive models or qualitative methods to investigate platform ecosystems. These methods are helpful, but they need more understanding of these ecosystems' dynamic interactions and emergent behaviour. This constraint is particularly evident in the semi-conductor sector, where more comprehensive and dynamic knowledge is required due to the complexity of platform ecosystems.

1.2 Semiconductor Market

The sector is a good case study given the significant contribution of semi-conductor companies to technological progress and the digital economy. The case study for this research is ARM Ltd, also known as Acorn RISC Machine, a global semi-conductor and software design company based in Cambridge, U.K. ARM is known for its very energy-efficient computer chip designs, which makes it perfect for portable electronics such as smartphones and tablets [1]. A significant ecosystem has formed around ARM's technology as the company's ideas are licensed to other companies using them in their products. ARM's designs are utilised in a broad variety of applications, including servers, network infrastructure, consumer electronics, and automotive systems. Surprisingly, the company's technology powers the majority of smartphones sold worldwide, demonstrating its influence throughout the globe. The Internet of Things (IoT), artificial intelligence, machine learning, and other emerging technologies are just a few examples of how ARM is still at the forefront of technological innovation today.

2. Literature Review

2.1 Platform Economy

The global economy is currently moving towards a megatrend: a digital-first world. According to [2] and Walter (2015), global economic activity will be based on or influenced by digitisation, as most products and services use digital delivery models or require digital enhancements to remain competitive. In order to compete in a digital-first world, companies need to prioritise investments in digital tools to expand their physical space and assets. IT technology is becoming increasingly important in the business field.

The platform economy is one of the most influential business models of the early twenty-first century, typified by companies such as Google, YouTube, Alibaba and Amazon. By connecting supply and demand through their platforms, these companies have further facilitated the efficient allocation of resources, the widespread dissemination of innovations, and the creation of new jobs [3]. This review will systematically examine the opportunities, challenges and prospects of the platform economy.

2.1.1 Opportunity

The platform economy opens up diverse opportunities. Most obviously, the platform economy enhances the efficient use of resources. For example, through Uber and Airbnb, individuals can make full use of unused vehicles and houses, thus solving urban transport and housing problems to a certain extent [4]. Also, the platform economy provides a broad venue for innovation [5]. Google Play and Apple App Store allow developers to spread innovative software applications globally faster. In the case of Taobao, for example, many merchants who do not have physical shops can conduct business through this platform, thus creating a large number of jobs [6]. In addition, the platform economy has demonstrated a significant impact in changing consumer behaviour. For example, the rise of online video platforms such as YouTube and Netflix has not only changed people's viewing habits, but has also given more independent producers a platform to showcase their work, further fuelling innovation [7].

Similarly, e-commerce platforms such as Amazon have made it possible for consumers to access goods from all over the world at home, greatly facilitating people's lives [8]. Moreover, in the context of globalisation, the platform economy has made it possible to allocate resources across geographical boundaries. For example, through social platforms such as LinkedIn, employers and job seekers worldwide can easily find each other, breaking geographical constraints and realising the effective allocation of global talents [9]. Education platforms such as Coursera and edX make it possible for students all over the world to enjoy the high-quality educational resources of prestigious schools, enhancing the fairness and efficiency of education [10].

2.1.2 Challenge

While the platform economy presents great opportunities, it also faces several challenges. The first is the issue of data security and privacy [11]. Taking Facebook as an example, the company, one of the world's major digital labour platforms, was exposed to a large-scale scandal of misuse of user data in 2018, which triggered global concern [12]. Second, the development of the platform economy has also raised concerns about labour rights. For example, many online taxi drivers and takeaway delivery workers need more adequate protection at work [13]. Finally, the platform economy may raise the issue of market monopoly. As the platform economy has significant network effects, once a platform dominates the market, it is difficult for competitors to get a market share, as exemplified by Amazon's dominance in e-commerce [14].

Furthermore, the rapid development of the platform economy has also brought pressure and impact on traditional industries. For those traditional enterprises that are unable to adapt to the development of the platform economy promptly, they are faced with the loss of market share and challenges to their survival [15]. For example, many traditional retailers are facing the risk of declining turnover or even bankruptcy because they cannot compete with e-commerce platforms such as Amazon. At the same time, the development of the platform economy has also exacerbated social inequality to a certain extent. On the one hand, the development of the platform economy has enabled some people to acquire great wealth through the platform, but some people have also been marginalised in the process [16]. Taking the sharing economy as an example, while some people have gained income by sharing their homes or vehicles, others have lost traditional job opportunities as a result. Finally, the rapid development of the platform economy has also posed an enormous challenge to government regulation. This is because the platform economy is global, virtual and dynamic, which makes it difficult for the traditional regulatory model to effectively control it [17]. For example, for multinational e-commerce platforms, how to carry out effective tax management and how to protect the rights and interests of consumers are all problems that regulators must face.

2.1.3 Prospect

The impact of the platform economy is pervasive, reshaping the way how we work, the way we consume and the way we organise our societies. For example, the emergence of Amazon has changed our shopping habits, allowing us to buy goods from all over the world at home; the rise of YouTube has made it possible for anyone to become a film producer, changing the traditional production and consumption patterns of the film and television industry. The success of Alibaba has driven the rapid development of e-commerce in China and around the world. Despite the challenges, the outlook for the platform economy remains promising. New technologies and regulatory models may help to address these issues. For example, blockchain technology may improve data security issues, while new labour law rules could safeguard the rights of online workers [18]. In addition, in response to the problem of market monopoly, policymakers could ensure fair competition in the market by strengthening the enforcement of antitrust laws. The platform economy of the future will be more intelligent. With the technology of AI and big data, platforms can more accurately understand users' needs and provide more personalised services. For example, Netflix and YouTube both use AI algorithms to recommend videos that users may be interested in, improving their viewing experience [19]. Next, as consumer needs become increasingly diverse, platforms will place greater emphasis on providing personalised services. For example, Amazon analyses a user's shopping history to recommend items they may be interested in [20]. While platforms used to be mainly a place to provide goods for trading, they will be more likely to provide various services in the future, including finance, education, healthcare, and a variety of other services. For example, Alibaba already provides various financial services through its Alipay platform, including payment, wealth management and loans [21].

As an emerging business model, the platform economy raises both opportunities and challenges. On the one hand, the rise of the platform economy has had far-reaching impacts on resource allocation, innovation promotion, employment and entrepreneurship, consumer behaviour and globalisation and has demonstrated great potential; on the other hand, issues such as data security and privacy protection, protection of labour rights and interests, monopoly in the market, the impact on traditional industries, the increase in social inequality, and the difficulty of regulation have also come to the fore, posing challenges to its healthy development [1]. For the future, scientific research and policy innovation are the keys to solving these problems, and they will help the platform economy better serve the development of society and the economy [22]. The trends of intelligence, personalisation, serviceability and internationalisation will continue to drive the evolution of the platform economy, but this will also require research into new management and regulatory mechanisms to address new challenges [23].

2.2 Influencing Elements of Platform Ecosystem

2.2.1 Product Quality

In the platform economy, product quality is a central competitive factor. Studies have revealed that customer preference and platform market position are highly influenced by product quality [24]. High-quality products can increase consumer satisfaction and loyalty, which can increase consumer evaluations of platforms' strengths and weaknesses [25]. One such illustration is Amazon. Through its stringent supplier management and product audit system, it ensures the quality of the items sold on its platform, earning the trust and support of customers. A closer examination of how product quality affects the platform economy demonstrates that its effects go beyond a simple rise in market share and profit margins. Furthermore, high-quality goods have a significant influence on customer behaviour, which affects the platform's viability [26]. A platform's brand image may be shaped and improved by high-quality items. High-quality goods may increase customers' faith in the platform, luring additional customers in and creating a positive feedback loop [27]. Moreover, high-quality products play a key role in promoting word-of-mouth communication among users [28]. In the platform economy, consumers' purchasing decisions are often influenced by other users' evaluations [29]. Positive ratings are more likely to be given to high-quality items, which promotes platform user growth. High-quality products are a powerful tool for lowering transaction risk. In the platform economy, there is an information gap between buyers and sellers during transactions. High-quality products can reduce the risk perception of buyers and increase the success rate of transactions [30].

2.2.2 Service Upgrade

Another key development in the platform economy is the improvement of services. To fulfil the more sophisticated expectations of customers, they are also compelled to offer a variety of value-added services [31]. In the case of Alibaba, by using the Alipay platform provides not only payment services but also a series of value-added services such as finance, wealth management, insurance, and consumer credit, which significantly improves the attractiveness of the platform and the stickiness of users [32]. At the same time, service upgrades can also increase the profit level of the platform, as these value-added services tend to have higher profit margins [33]. The impact of service upgrades on the platform economy, in addition to significantly improving user stickiness and platform profits, also has a more far-reaching effect. Service upgrades can help platforms expand new revenue channels [34]. It enriches the user experience and broadens the company's profit model. Service upgrades also help raise the platform's competitive barriers [35]. Platforms providing value-added services are more likely to attract and retain users, so competitors need to invest more resources to capture market share. Also, since value-added services often involve expertise and technology, platforms can improve their competitive position in the industry by offering these services [36].

High-quality products and upgraded services can increase consumer satisfaction and loyalty and enhance the platform's market position and profit. In the future, the competition in the platform economy will be more reflected in product quality and service upgrading [37]. Therefore, platform enterprises must continuously improve product quality and innovate service models to adapt to market changes and consumer demands. At the same time, they also need to pay attention to the impact of product quality and service upgrading on consumers' rights and interests so as to protect the legitimate rights and interests of consumers [38].

2.3 Platform Economy in the Semiconductor Industry

The platform economy model has been used in information technology in various forms. However, its application in the semi-conductor industry is still in its infancy, mainly in intellectual property licensing and collaborative R&D between companies. In the semi-conductor sector, the platform economy is characterised by the fact that some companies open up their technological intellectual property rights to attract other companies to use them and carry out secondary development [39], to achieve the purpose of sharing resources, reducing R&D costs and improving market competitiveness. The most typical case is the UK company ARM. With US companies leading the IT industry, ARM has emerged as a UK company among the leading companies. The intellectual property of its technology is licenced by ARM to many of the top semi-conductor companies in the world rather than producing its chips [40]. ARM has succeeded in becoming a significant business by providing design solutions that are not manufactured in-house but can facilitate transactions between two or more parties. This is a typical example of the platform economy [41].

The market for microprocessors is growing as a result of digitalisation. Recording to Sen [42], the central processing unit (CPU) for all computers and other electronic devices is sometimes referred to as the microprocessor. Nevertheless, a famous ARM company is absent from the list of CPU manufacturers. This is due to the fact that ARM does not manufacture its chips; instead, it designs and licences semi-conductor firms to utilise its architecture [43]. Its architecture's worth may be assessed because eight of the top ten microprocessor producers used it as the foundation for their processor chip designs. Its main line of business is the creation and licencing of processors as intellectual property (IP), primarily for tablet computers and mobile phones (smartphones or other) [1].

The importance of CPU quality in the semi-conductor industry cannot be ignored, and its performance is directly related to the experience and satisfaction of product users, which in turn affects the market share and reputation of the manufacturer [44]. In the same process, the size of a CPU's cache is directly proportional to its processing power [45], which not only affects the processor's operating speed but also has an impact on the ability to handle complex tasks. A larger cache provides higher data access speeds, allowing the CPU to run programs more efficiently and improving overall system performance [46]. However, increasing the size of the CPU's cache brings about an increase in production costs, requiring manufacturers to find a balance between product performance and cost.

CPUs with high performance can support more innovative applications, such as the development of artificial intelligence, virtual reality and other high-tech fields, which will bring more possibilities and opportunities for the platform economy [47]. Therefore, improving CPU quality and the sustainable development of the platform economy go hand in hand. It is worth noting that the improvement of CPU quality should not ignore environmental and social sustainability. High-performance CPUs may lead to higher energy consumption and carbon emissions, which have a negative impact on the environment [48]. Therefore, how to improve CPU quality while considering environmental sustainability and social justice is a challenge that the platform economy needs to face in the development of the semi-conductor industry.

The platform economy is greatly aided by service upgrading, which is a vital component of the semi-conductor sector. In addition to the technological advancement of products, service upgrading also include the improvement of after-sales support and the investigation and use of emerging technologies [49]. Improvements in technology in the semi-conductor sector can assist businesses in enhancing product performance to adjust to the ongoing changes in the market. Nevertheless, technology advancements may also assist businesses in entering new markets and creating fresh company strategies [50].

The optimisation of after-sales service plays an essential role in enhancing consumer satisfaction and building consumer loyalty. In the semi-conductor industry, high-quality after-sales service can solve consumer problems in a timely manner, improve consumer satisfaction, and thus enhance the competitiveness of enterprises [51]. In addition, high-quality after-sales service can also help enterprises establish a good brand image, attract more partners, and further promote the development of the platform economy [52]. In terms of the exploration and application of new technologies, such as the application of cloud computing, big data, artificial intelligence and other technologies, it can help enterprises to improve their service level and achieve the personalisation and intelligence of their services [53].

Currently, the research about the dynamics of the platform ecosystem is rare. This study seeks to understand the dynamics by simulating the platform ecosystem of a semi-conductor company – ARM. ARM's entry into the mobile device market in the 1990s illustrates this quadrant despite having little initial negotiating power in the semi-conductor ecosystem [54]. The chip architectural layer of the technological stack for the mobile sector is where ARM is most active, licencing processor designs to its clients (licensees), who then use them to produce their central processing units (CPUs). Based on the above reviews of past research, the study aimed to understand the platform ecosystem model for semi-conductor companies and analyse the dynamics of the platform ecosystem of the semi-conductor industry.

3. Research Methods

3.1 Agent-Based Model

Agent-based modelling is one of the most cutting-edge practical advances in modelling [55]. Using computer simulations to develop testable, falsifiable hypotheses is the goal of the agent-based method. It is possible to create theories that anticipate future occurrences and explain current events and their causes.

The word "agent" was developed from the word "object," which is an abstraction of a collection of tangible items with similar traits and tendencies [56]. Several techniques for building multi-agent systems are conceptual description, preliminary design, and complete design. As they lay the groundwork for the following levels, the organisational structure, goals, operational processes, and information support should all be specified at the first level of the ontology. The multi-agent system assigns tasks to the agents, each of whom is considered a group or organisation member. The delegation of tasks implies that each group member has a specified set of obligations and expected behaviours [57]. The conceptual description level establishes the framework for the other levels of the process. Critical elements, including the organisational structure, goals, operational procedures, and supporting data, are all carefully determined in this context [58]. This rendering is a virtual world where agents work by specified ontologies, each aiming to accomplish their predetermined objectives and carrying out a range of duties [59].

Each agent in the elaborately constructed multi-agent system is viewed as an integral part of a bigger group or organisation. Delegating duties is one of this system's distinguishing characteristics [60]. Each group member has been given a set of particular duties and a set of required behaviours. This suggests that each agent has a specific job to perform within the organisation. Additionally, the multi-agent system offers a distinctive perspective for analysing the dynamics of a more prominent organisation [61]. The system may mimic a broad range of circumstances by giving roles and responsibilities to individual actors, enabling researchers to investigate and comprehend the probable outcomes and repercussions of various scenarios. The prediction of complicated dynamics, which would be practically challenging to forecast using conventional approaches, is made feasible by this simulation-based methodology [62].

ABM offers a powerful tool for modelling, comprehending, and forecasting complex systems and processes in each domain [63]. For instance, it may be used to mimic the effects of climate change on ecosystems in environmental research and to model market dynamics in economics [64]. The flexibility and adaptability of agent-based modelling serve to emphasise its usefulness further. In the hands of academics, practitioners, and decision-makers across sectors, the technology may be customised to suit particular situations and use cases [65].

3.2 NetLogo

NetLogo is a multi-agent programming language and modelling environment. It is used to simulate social and ecological events [66]. It works exceptionally well for simulating complicated systems that change over time. Modellers have the ability to provide commands to hundreds or thousands of autonomous "agents" that are all active at once. It is now feasible to investigate relationships between the micro-level activities of specific people and the macro-level patterns that result from their interactions. Since NetLogo is a Java standalone application, it can be run on all of the significant computing systems.

The capacity of the modeller to concurrently send orders to hundreds or even thousands of autonomous agents lies at the core of the NetLogo environment. These autonomous "agents" can interact with one another, follow predefined instructions, and take actions in response to particular circumstances. The result is an incredibly intricate model that behaves like real-world systems, such as ant colonies and stock markets [67].

Additionally, NetLogo's adaptability as a Java-based standalone programme frees it from the limitations of specific operating systems. Due to this, it is usable by a wide range of users, regardless of whether they use Windows, macOS, or Linux [66]. This broad availability reinforces NetLogo's status as the go-to tool for researchers and professionals who need to simulate complicated systems. Furthermore, the robust support for customization in NetLogo allows users to tailor their models to suit their specific needs. To better capture the erratic character of real-world systems, they can alter the settings, add fresh behaviours, and even inject randomization. Because of its adaptability, NetLogo is a potent modelling tool and a valuable instructional tool for those researching complex systems [67].

3.3 Quantitative Study

Quantitative research is an empirical research method that emphasises numerical data and statistical analysis and plays a vital role in many fields of science and social science [68]. The design, execution, and analysis of quantitative research are all covered in the methodology, which is a detailed, step-by-step manual. The goal of the study is first specified, along with a specific and unambiguous research topic or hypothesis. To make sure that the sample is representative of the wider population, the scope of the research must then be determined, and a sampling strategy must then be chosen. Typical strategies include systematic, stratified, and random sampling. The following phase is data collecting, where the researcher must choose the right resources and techniques based on the study topic. These resources might include everything from tests and surveys to secondary data analysis. In order to find trends, patterns, and linkages, the data are statistically evaluated once gathered [69]. The methodology section's last portion is the explanation of how to keep study findings reliable and valid, making sure they are repeatable and appropriately represent the phenomena they are supposed to evaluate. In order to achieve this, investigations may need to be pilot tested. Validated measuring instruments and robust statistical analysis may also be needed. Because of this, the quantitative research approach serves as both a crucial framework for the research process and a model for future researchers to follow, so advancing our understanding of the topic as a whole.

4. Empirical Research

4.1 Arm Company Data Collection

Based on product information provided by Arm Ltd [70]. The study chose to use the Cortex series of CPUs as experimental subjects for simulation.

The ARM Cortex-A55 and Cortex-A520 are two high-performance processors from ARM [71]. Both processors are designed on the ARMv8-A architecture and support 64-bit processing power, providing them with a good balance between performance and efficiency. They both include ARM's Dynamic Sharing technology, allowing the processor cores to share critical resources when needed. In addition, they both support the full range of ARM instruction sets, including AArch64 and AArch32, which means they can both run software written for the ARM platform.

However, despite their many similarities, there are significant differences between the Cortex-A55 and Cortex-A520 in some key technical aspects. Firstly, the Cortex-A55 is designed to be a more general-purpose processor that can be used in various scenarios. The Cortex-A520, the other hand, is more focused on high-performance computing scenarios for highly compute-intensive applications.

Regarding major extensions, the Cortex-A520 has some significant improvements over the Cortex-A55. The Cortex-A520 uses the new Armv9.2 architecture set, providing more powerful vector processing capabilities to handle high-performance computing tasks such as AI and machine learning more effectively. In contrast, the Cortex-A55, while also supporting the Armv8.2-A architecture set, may not be as good as the Cortex-A520 at handling these tasks. The Cortex-A55 and Cortex-A520 support extensions to Armv8.1, including more powerful vector processing and improved virtualisation support. However, the Cortex-A520 extends this further with support to Armv8.7, making it better to support more complex computing tasks. Similarly, the Cortex-A520 includes QARMA3 extensions, a mechanism that provides more robust data protection and integrity verification to prevent data tampering effectively. In addition, the Cortex-A520 also supports SVE2 extensions, a technology for complex vector arithmetic tasks that significantly improve the processor's performance for machine learning and artificial intelligence tasks. The Cortex-A520 also supports Memory Tagging Extensions (MTE) (Including Asymmetric MTE), a mechanism that provides a higher level of memory protection against malware attacks. As for Cryptography extensions, both Cortex-A520 and Cortex-A55 have support. This is a technology that provides hardware-level encryption capabilities to improve data security and prevent unauthorised access.RAS extensions are also common to both and provide a mechanism to improve system reliability, availability and serviceability, which is essential when building critical systems that need to run continuously. Notably, Cortex-A520 has significantly more major extensions than the Cortex-A55, making it more potent in handling higher-level and more complex computing tasks. This also gives the Cortex-A520 an edge in handling scenarios with more complex requirements, such as machine learning, artificial intelligence and high-performance computing. However, the Cortex-A55 is still a practical choice for handling general-purpose computing tasks, especially in scenarios with stringent power and cost requirements.

On the other hand, in terms of cache performance, the Cortex-A520 also outperforms the Cortex-A55 in several key areas. The Cortex-A520 has larger L1 and L2 caches that can store more data and instructions, which helps to reduce the number of accesses to the main memory, thus improving overall performance. In addition, the Cortex-A520 also has a superior cache coherency mechanism than the Cortex-A55, which can more effectively maintain data consistency in a multi-core environment. For the L1 cache, the Cortex-A520 has a choice of 32KB or 64KB, while the Cortex-A55 has a broader range of choices from 8KB to 64KB. In general, a larger L1 cache can store more data and instructions inside the processor core, which can reduce the number of accesses to the main memory and thus improve overall performance. However, an oversized L1 cache may increase power consumption and chip area, so trade-offs must be made based on specific application requirements and power budgets. For the L2 cache, the Cortex-A520 offers more options from 128KB to 512KB, while the Cortex-A55's options range from 64KB to 256KB. Since the L2 cache sits between the L1 cache and the main memory, it plays a crucial role in reducing the latency of the main memory accesses and increasing the efficiency of data accesses. Therefore, a larger L2 cache may be more advantageous for high-performance computing applications. In terms of L3 cache, the Cortex-A520 also offers a more extensive range from 256KB options to 32MB, while the Cortex-A55 ranges from 256KB to 4MB. The L3 cache is mainly used for sharing data in a multi-core environment to reduce access to the main memory. Therefore, a larger L3 cache is essential for parallel computing and multi-core tasks. While both the Cortex-A55 and Cortex-A520 have flexible cache configuration options, the Cortex-A520 offers a more excellent range at each cache level, making it better suited for high-performance and large-data-volume computing tasks. However, this does not mean that the Cortex-A55 is inferior to the Cortex-A520 in all cases, as it may offer a better price/performance ratio in application scenarios with stringent power and cost requirements.

4.2 Simulation Program

In the NetLogo environment, the model is designed to simulate how ARM's product gains customers as well as loses customers in the potential customer base (per unit); in other words, to simulate the customer dynamics of the product. The model's core components include global variable declarations, unique patch variable declarations, a model setup procedure, a dissemination process, an understanding of the product process, and a colour change process.

First, the global variable "colour-mode" is declared, which represents the model's visual mode. This mode has three choices: 0 for the normal mode, 1 for the mode when becoming a customer, and 2 for the number of times becoming a customer.

Next, unique attributes are defined for each patch (customer). This includes recording the number of times each individual became a customer ("times-heard"), the point in time when they first became a customer ("first-heard"), and the rate of forgetting the product ("forget-rate").

In the setup procedure, model initialisation consists of clearing all content, setting the colour pattern, initialising the variables for each customer unit, and seeding the initial customer with one or more products, depending on the user's choice. In addition, the "get-rate" is set to simulate the extension of product service updates, meaning that the better the update service, the less likely it is that the product will be forgotten.

The leading runner of the model is the "go" process. The model stops when all individuals have become customers. A propagation operation is performed on the non-customer group, and a forgetting operation is performed on the red customers (current customers). Each forgetting operation reduces the forgetting rate by 1 until the rate reaches 0, and the customer returns to a state of no impression of the product at all. The effect of product quality is also considered; the better the product quality in this procedure, the larger the number. When a random number exceeds the product quality, the customer will forget the message.

In the "spread-rumor" procedure, the product spread from one customer to his neighbours is simulated. Select a neighbour and call the "hear-rumor" procedure.

The "hear-rumor" process describes the reaction of an individual who becomes a customer. The time of becoming a customer is set to the current time, the number of times the product is used increases by one and the colour changes.

The colour change procedure changes the colour of each customer according to a different colour pattern. Normal mode is red for customers who use the product and blue for those who do not. The colour is changed according to the time of hearing the product message.

5. Results and Discussion

Based on the performance of the 3-tier cache, we can get 50% less L1 cache compatibility for the Cortex-A520 than the Cortex-A55. In the L2 cache area, the Cortex-A520 has 20% more compatibility than the Cortex-A55, while the L3 cache compatibility is also 75% more than the A55 model CPU. We consider the product quality of Cortex-A520 as 1, and by calculating the compatibility of each cache level, we can conclude that the product quality of Cortex-A55 is $((1+0.5)+(1-0.2)+(1-0.75))/3=0.85$. Regarding the service upgrade, it can be directly set to the corresponding number of expansion packs. UpdateExtensions-ProductService (forget rate) is set to 12. A55 has 5 update packages, and its corresponding parameter is 5. After completing the above parameter settings, the simulation can be started.

5.1 Cortex-A520

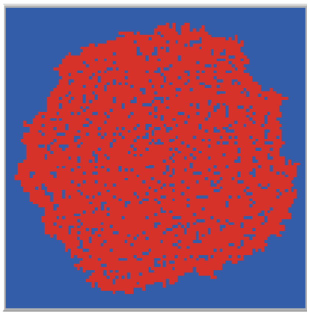

Figure 1. “View area of Cortex-A520 after 100 ticks”

In one run of the model, we set the following parameters: UpdateExtensions-ProductService (forget-rate) to 12 and product-quality (product quality) to 1. After 100 ticks, we found that the red individuals in the graph exceeded 50%, which means that the percentage of clients reached 50% .

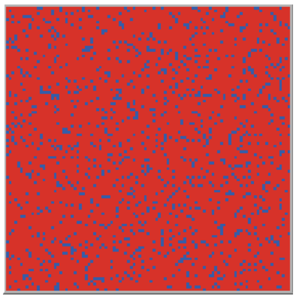

Figure 2. "View area of Cortex-A520 after 250 ticks"

We continue to run the programme, and after the programme has run for 250 ticks, we can see that most of the individuals have changed to red, with a small percentage of blue individuals still present. Furthermore, the percentage of clients reaches 87%.

5.2 Cortex-A55

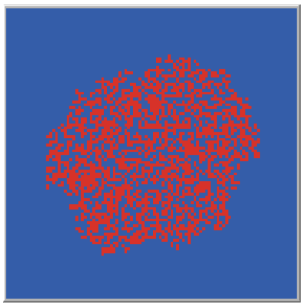

Figure 3. "View area of Cortex-A55 after 100 ticks"

Now we run the simulation for the A55. Set UpdateExtensions-ProductService (forget-rate) to 5, as there are 5 update extension packages for this model of CPU. By comparing the 3 levels of CPU cache, we can calculate that the product quality of the A55 is 0.85 (compared to the A520). After running 100 ticks, it can be noticed that the blue individuals are still in the majority, and the red individuals are in the minority. This represents a smaller percentage of clients, only 19%.

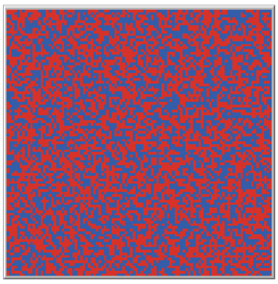

Figure 4. "View area of Cortex-A55 after 250 ticks"

We continue to run the programme until the 250th tick. It can be noticed that the whole viewing area is half blue and half red. The percentage of clients is almost 53%. At the same time, the percentage fluctuates slightly around that percentage, but the difference is not significant.

5.3 Comparison

By observing the above two simulations, we can make a general conclusion that the Cortex-A520 is better at bringing in new customers and retaining existing customers than the Cortex-A55.

To further understand the impact of these two parameters on product propagation, we can keep UpdateExtensions-ProductService (forget-rate) unchanged (keep it at 12) and reduce product quality from 1 to 0.85. With the same run of 100 ticks, the percentage of customers was reduced from 53%

to 24%. This shows that improving product quality can speed up the dissemination of product information and increase its reach.

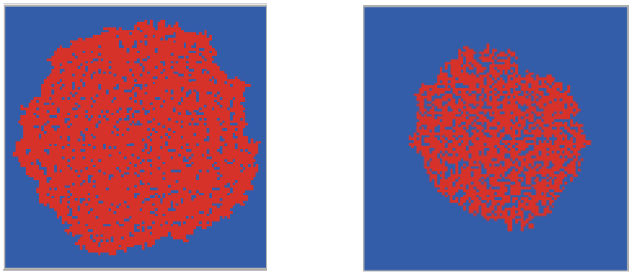

Figure 1 & Figure 5. "View area of Appendix B.9"

Next, we keep the product quality the same (keep it at 1) and reduce UpdateExtensions-ProductService (forget-rate) from 12 to 5. Again, running to the 100th tick and stopping, we can see that the percentage of customers has decreased from 53% to 43%. Although smaller than the drop in product quality, it is still a non-negligible customer reduction for the company.

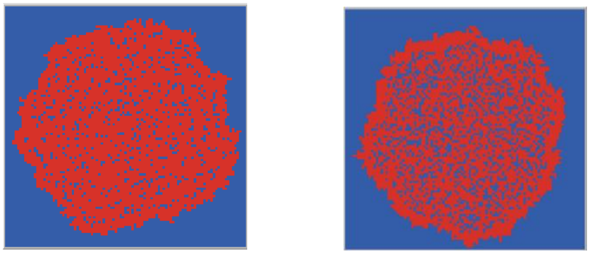

Figure 1 & Figure 6. "View area of Appendix B.10"

According to the simulation results, the observed rate and extent of product adoption by customers is influenced by several factors. Specifically, product quality and service upgrades were crucial in the diffusion process. Higher quality products (i.e., higher "product-quality" values) led to faster and broader product acceptance, as customers were more likely to adopt high-quality products. Similarly, weaker service upgrades (i.e., lower "UpdateExtensions-ProductService" values) may reduce the speed and scope of product diffusion, as customers may forget about the product (i.e., stop using it) after a short period of time. Product quality and service upgrades are two essential factors affecting product information dissemination. This provides ARM with some operational suggestions: By improving product quality and providing continuous product updates, the reach and dissemination of product information can be improved.

6. Conclusion

As the core of the global high-tech industry, the semi-conductor industry plays a crucial role in the development of modern society and economy. In the context of economic globalisation, the semi-conductor industry is experiencing a shift from a traditional competitive model to a platform economy. The platform economy model is based on technology and data through the construction of a digital trading platform, effectively connecting supply and demand to realise the economy's value. In the semi-conductor industry, the British company ARM is a typical representative of this economic model.

In this context, this study adopts an agent-based model to explore the impact of product quality and service update frequency on product information dissemination, using ARM as an example of a simulation experiment via the NetLogo platform. The results of the study show that improving product quality and ensuring the frequency of service upgrades can effectively accelerate the dissemination of product information and improve the coverage of product information, thus enhancing ARM's competitive advantage in the semi-conductor platform economy.

Improving product quality and ensuring the frequency of service upgrades are two important ways for semi-conductor enterprises to enhance their competitiveness in the platform economy environment. In the platform economy, an enterprise's competitive advantage comes from whether it can form a good network effect in the market, and product quality and service upgrading have a decisive impact on the formation of the network effect. Firstly, improving product quality is the key to attracting and retaining users. High-quality products can enhance user satisfaction and loyalty, thus forming a stable user group. At the same time, high-quality products can also enhance the enterprise's reputation and attract more new users to join the platform, thus forming a positive network effect. Specifically, semi-conductor companies can improve the performance and stability of their products by utilising research and development of new technologies, optimisation of the production process and strict quality control to meet the needs of different users. Second, ensuring the frequency of service upgrades is also a key factor in the competitiveness of enterprises in the platform economy. Timely service upgrades can help enterprises adapt to market changes and meet users' new needs, thus retaining customers. At the same time, service upgrading is also an essential manifestation of enterprise innovation, which can enhance the competitiveness of enterprises, attract more users to join the platform, and further form the network effect. Semi-conductor companies can regularly upgrade and improve their services through a deep understanding of users' needs in order to enhance their competitive advantage in the market.

In conclusion, improving product quality and ensuring the frequency of service upgrades are essential ways for semi-conductor companies to enhance their competitiveness in the platform economy. Enterprises need to improve product quality and service upgrades through continuous innovation and improvement to meet users' needs, enhance their competitive advantages in the market, and achieve sustainable development. The future market of the semi-conductor platform economy will pay more attention to the quality of products and timely updates of services. Improving product quality enhances the user experience and increases user satisfaction and loyalty, thus attracting more users to join the platform. At the same time, ensuring the timely update and upgrade of services can maintain the platform's activity, meet users' personalised needs and enhance their stickiness. Therefore, improving product quality and ensuring the frequency of service upgrades will be the key for semi-conductor companies such as ARM to achieve sustainable development in the future platform economy market.

In future studies, we suggest that researchers further delve into other factors affecting the economic competition of platforms, such as the scale effect of platforms and the network effect. Meanwhile, more empirical studies can be conducted to verify and enrich our findings and provide more empirical guidance for the development of the semi-conductor industry.

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