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Examining Inertia in Cross-Border Cooperation among European Mobile P2P Payment Services: A Game Theoretic Approach

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Abstract. In a time where technological development and globalization are concurrently expanding, markets must learn to adapt. Mobile P2P payment services in Europe have achieved high national adoption rates but have not been able to cooperate to meet the growing demand for cross-border payments, despite efforts made by both the EU and private payment service providers. The aim of this paper is to understand and explain the current situation of inertia in international cooperation between mobile payment services, an area with limited previous research. Accordingly, we construct a game theoretic model in which firms simultaneously decide whether to switch to a new technology that allows for compatibility or to stay with an incompatible technology. The results show that differing preferences for compatibility and weak expectations may prevent coordination on a mutually beneficial cross-border solution. Another finding is that, due to the strong network externalities present in the industry, there is a possibility of overcoming inertia through what we refer to as a "bandwagon effect". Finally, we suggest that the threat of new technological payment solutions, such as cryptocurrencies, may increase the willingness to cooperate among incumbent firms in the mobile P2P payments industry.

Keywords: mobile payments, network externalities, compatibility, coordination problem, game theory

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Table of Contents

1. Introduction

The financial infrastructure is essential for a well-functioning economy, as it enables economic agents to safely and efficiently manage financial assets and trade with each other. The evolution of money dates to around 600 B.C. when metal coins first appeared in Lydia, today's western Turkey, as a means of transferring value (Allan et al. 2019). New payment methods have evolved since, with paper money, checks, and cards, as markets experience technological development and face new demands. During recent decades, digital and mobile payments have emerged as an alternative to physical cash as society has become more digitalized. Especially in Nordic countries such as Norway and Sweden there has been a move towards a cashless society with only 4% (Wolden Bache 2020) respectively 9% (Sveriges Riksbank 2020) of the population still using cash.

A challenge today is the increasing demand for cross-border payments. Regarding mobile payment services, which mainly operate domestically, there is currently no ability to transfer money between individuals using different services. The European Central Bank's SEPA Proxy Lookup Scheme and the private companies' cooperation association EMPSA are initiatives to promote interoperability between such services. Nevertheless, despite the fact that the technology for catering mobile cross-border payments across Europe is viable, the industry faces inertia in cooperation between these services. Meanwhile, there are actors at the forefront of the technological and digital development that are challenging the traditional financial infrastructure. New distributed ledger technology (DLT) has enabled the creation of cryptocurrencies that are independent of the traditional banking system and may cannibalize on the existing digital payment services in the future. All markets are affected by technological development in society and the industry of mobile payments industry is no exception.

The purpose of this paper is to understand and explain the current situation of inertia in cross-border cooperation in the infrastructure of mobile payment services in Europe. In addition, it aims to study how recent technological progress in money transferring may affect incumbent firms' strategies for mobile cross-border payments.

Using a game theoretic approach to study why inertia in cross-border cooperation exists in the industry of mobile Person-to-Person (P2P) payment services and how this inertia can be overcome, we construct a model that draws upon previous research and literature. The model extends our knowledge about the role of network externalities in the relatively new industry of mobile payment services by generating the following findings. First, the model illustrates how the willingness to make one's payment service compatible with the other services in the industry depends not only on a firm's preference for compatibility but also on its expectations of other incumbents' choices of technology. A further finding is that a willing first mover can instigate a bandwagon effect where all mobile P2P payment service firms cooperate as a result of increasing network externalities of a shared user base. Unwilling first mover incumbents can in turn cause a lack of cooperation. Finally, we suggest that the threat of new payment technologies could create willing first movers in a situation where there initially are none.

Henceforth, the paper is structured as follows. Section 2 provides a background of the mobile payments industry. Relevant literature and theories are outlined in Section 3, while Section 4 proceeds by formulating the research question and briefly discusses the choice of method. In Section 5, we introduce a model of the mobile payments industry, first illustrating a two-player game before moving on to a multiplayer game. Section 6 provides a discussion while Section 7 concludes the thesis. References are listed in Section 8.

2. Background

The mobile payments industry is relatively young, starting in the late 1990's when Finnish banks began to offer their customers the option to perform basic banking services through their mobile phones (van der Boor & Braguinsky 2012). A mobile payment can be defined as a payment transaction where "the payer employs mobile communication techniques in conjunction with mobile devices for initiation, authorization or realization of payment" (Vilmos & Karnouskos 2004, p. 1). As with other industries of methods of payment, the mobile payments industry is characterized by large network externalities. The value of using a mobile payment service is heavily dependent on how many others accept transactions through the same service. This implies that an oligopoly-like market structure, with few and large service providers and rather high barriers to entry, is likely to arise.

Mobile payments, as they are called, can be split up into three categories (Rings & Groth 2017), namely, mobile Near-Field Communication (NFC) services, mobile commerce services, and mobile Person-to-Person (P2P) payment services. NFC is a short-range wireless technology that is used in applications such as Google Wallet and Apple Pay. Mobile commerce is the collective name for purchases made through marketplace apps and mobile banking services that are used to enable online purchases. Lastly, mobile P2P are services that allow for users to send each other money through their mobile devices, where the telephone number is used as a proxy for an International Bank Account Number (IBAN) (European Payments Council 2019).

Even though research has been done on the mobile payments industry since 2006, the research is limited to certain topics such as consumer adoption (Dahlberg, Guo, & Ondrus 2015). For example, Lara-Rubio, Villarejo-Ramos, and Liébana-Cabanillas (2020) present a predictive model for user adoption of mobile P2P payment systems. Other studies investigating the adoption of mobile payments include Crowe, Rysman, and Stavins (2010), Tobbin (2010), and Liébana-Cabanillas et al. (2020).

This paper focuses on the market for mobile P2P payment services in Europe, where many firms offer mobile commerce services to their users as well. In this way, they constitute two-sided platforms where consumers and retailers are connected in addition to the P2P function. Many of the mobile P2P payment service firms set up their business strategies in this way, as retailers generally are less price sensitive than consumers. The additional mobile commerce service could be regarded as a complementary service, since it increases the transaction possibilities of the P2P service with Consumer-to-Business (C2B) payments (Rings & Groth 2017).

There is limited research regarding the supply-side of the mobile P2P payments industry. As for mobile payments in general, Bourreau and Verdier (2010) analyze markets that could be targeted by mobile payment service providers, while Liébana-Cabanillas and Lara-Rubio (2017) explore the adoption of mobile payment systems from the perspective of the merchants. While these studies take the perspective of the supply-side, their focus is on the early stages of adoption. They do not put emphasis on the impact of network externalities in determining competition and strategic firm behavior in a more saturated market. However, such research has been made on more established payment methods, such as payment cards (see e.g., Rochet & Tirole 2002; Chakravorti 2010; Bounie, François, & Van Hove 2017).

The mobile payment industry is currently facing several challenges, one of which is to obtain a significant consumer base because of privacy issues or inability to cater international payments (Bezhovski 2016). In general, solutions reported are limited to a domestic, local, or even intra-bank level (European Central Bank 2015), which means that consumers are limited from making cross-border mobile P2P transactions and retail purchases through these services. One difficulty in cooperation across borders is caused by the regulatory differences between countries. Cross-border payments involve more players, time zones, jurisdictions, and regulations. For instance, there are contracts, laws, and regulations in place for establishing a framework for processing, clearing, and settling cross-border payments (Committee on Payments and Market Infrastructures 2018).

Furthermore, European mobile P2P payment services and mobile commerce services are currently threatened by actors such as American PayPal, which is a well-established, globally available, online payment service that can be used through smartphones with access to internet. Blockchain solutions have also been promising in the area of cross-border payments, with regards to correspondent banking, Business-to-Business (B2B) payments, as well as Person-to-Person (P2P) transactions (Quibria 2015). This technology has given rise to new cryptocurrencies such as Diem (Browne 2021), initiated by Facebook, which will possess the same stability as general currencies. If the current mobile P2P service providers fail to cooperate across borders, they may lose their users to other solutions that meet the demand for international transactions.

There are some examples of current initiatives aimed at encouraging cross-border cooperation between the European services. The European Central Bank has introduced the SEPA Proxy Lookup (SPL) Scheme to facilitate interoperability between participating payment solutions. Since July 2018, the SPL Scheme has been managed by the European Payments Council (European Payments Council 2019). However, there are no willing participants, indicating that they have not yet made the solution attractive enough to private service providers. Many of the large existing mobile P2P payment services such as Bluecode (Austria and Germany), Swish (Sweden), Vipps (Norway), and Paym (UK) joined forces and created the European Mobile Payment Systems Association (EMPSA) in 2019. Their primary goal is to foster collaboration and international payments, and they are currently working on ways to create interoperability between the services (EMPSA 2019). Nonetheless, there are no current examples of successful interoperability or compatibility between existing mobile P2P payment services. This will further be referred to as the inertia in cooperation for cross-border solutions.

3. Literature

This section presents the relevant literature and theoretical concepts that are referenced when constructing the game theoretic model.

3.1 Network Externalities

For goods related to communication technologies, such as payment systems, network effects and network externalities play a significant role in shaping the market. The importance of these network effects and network externalities has been highlighted by the work of Michael L. Katz and Carl Shapiro. In their 1985 paper, they put forward the example of a given telephone purchaser whose utility derived from using the telephone depends upon the number of other people who have joined the telephone network. More generally, there are positive consumption externalities (henceforth: 'network externalities') when "the utility that a user derives from consumption of the good increases with the number of other agents consuming the good" (Katz & Shapiro 1985, p. 424). These externalities are derived from the scope of the network, which in turn is determined by product compatibility, that is, whether the users of a firm's product can contact the users of another firm's product. These users are in the same network if the two firms' systems are compatible (Katz & Shapiro 1985). Moreover, Katz and Shapiro (1985) note that substantive network externalities in an industry generally give rise to a market structure of an oligopoly with many buyers and few sellers. This is because buyers find more value in established networks which, in turn, creates a barrier to entry for new firms.

3.2 Compatibility, Standardization, and Technology Adoption

The benefits of having compatible products are considerable in markets where network externalities are of importance (Katz & Shapiro 1986). Due to the market structure, firms' incentives for making their product compatible may vary depending on, for example, prevailing market shares. For instance, Katz and Shapiro (1985) find that firms with a large existing network or good reputation tend to oppose compatibility, and conversely, that firms with a small existing network or weak reputation tend to be in favor of compatibility. They also note that the former case may hold even when choosing compatibility would increase social welfare and that the latter case may hold even in circumstances where compatibility would reduce social welfare. Moreover, Katz and Shapiro (1985; 1986) find that the social incentives for product compatibility often are higher than the firms' incentives as a collective.

Accordingly, compatibility and standardization tend to be undersupplied in the market, although, what Katz and Shapiro (1986) refer to as, "excessive standardization" can occur. Importantly, if standardization occurs, the socially optimal technology does not necessarily have to be the one that is being chosen. Several factors determine the technology that will be adopted. With regards to this, Katz and Shapiro (1986) present the following findings. First, if there is no support for any technology over another, the technology that is superior *today* has a strategic advantage and is thus more likely to be the chosen standard. Secondly, if there are two competing technologies and one is being favorably promoted over the other, then the promoted technology has a strategic advantage and may dominate the market even if it might be the inferior one. Thirdly, if both competing technologies are equally sponsored, the technology that will be superior *tomorrow* has a strategic advantage. This also relates to the importance of expectations. In their 1985 paper, Katz and Shapiro find that consumers' expectations of the future size of the competing networks are significant in the presence of network externalities in a market, especially in one of a durable good such as a mobile payment service, as they will govern the consumers' purchase decision (Katz & Shapiro 1985).

Keser, Suleymanova, and Wey (2012) examine a technology-adoption game with network effects in which coordination on technologies constitutes Nash equilibria. Because of the network effects, firms will be more willing to choose a technology if other firms do the same. They define a technology's critical mass as "the minimal share of users necessary to make the choice of this technology the best response for any remaining user" (Keser, Suleymanova, & Wey 2012, p. 263).

3.3 Coordination Problem

Farrell and Saloner (1985) examine whether an industry can be locked-in or trapped in an obsolete or inferior common standard or technology when there is a new superior standard or technology available that all firms in the industry can collectively switch to. They show that with complete information and identical preferences among firms, all firms will switch to the new technology if they all would benefit from the change. Moreover, in the case of incomplete information, Farrell and Saloner (1985) show that excess inertia will always occur and that there are two types of this excess inertia. Symmetric inertia is a pure coordination problem and occurs when firms have unanimous preferences for the new technology but do not switch. Asymmetric inertia occurs when firms have different preferences and the total benefits from changing technology would exceed the total costs.

Referring to it as the "bandwagon effect", Farrell and Saloner (1985) describe that firms with the strongest preferences for the switch will do so first and that firms with more moderate preferences will wait to switch and only do so when they see that the bandwagon has started rolling. As more and more firms jump on the bandwagon, even firms who have quite weak preferences for the change to the new technology may in fact also switch when they see that all other firms have adopted the new technology. Both types of inertia arise because no firm is sufficiently in favor of the change to start the bandwagon themselves, although they are willing to jump on the bandwagon if it starts to roll. Each firm might, for example, prefer that the other firms switch first, as there are risks associated with being the first mover (*inter alia*, that other firms do not follow, making the switch more costly for the first mover). Farrell and Saloner (1986) refer to this as the "penguin effect", stating that "Penguins who must enter the water to find food often delay doing so because they fear the presence of predators. Each would prefer some other penguin to test the waters first." (Farrell & Saloner 1986, p. 943). Consequently, the switch could be delayed, as implied by the term excess inertia, or the firms could maintain the *status quo* by not switching to the new Pareto-superior technology (Farrell & Saloner 1985).

Farrell and Saloner (1988) also discuss common mechanisms for achieving coordination with reference to the choice of compatibility standards. Committees are presented as a solution, but with the negative consequence of slow change, which can be referenced back to inertia.

4. Research Question

With regards to the previous sections describing the industry of mobile payment services, it is evident that (1) the technology exists to facilitate cross-border transactions between mobile P2P payment services through, for example, the SEPA Proxy Lookup Scheme. As there is a current need for fast and easy cross-border transactions, this would benefit society at large. However, (2) the industry exhibits inertia for cross-border mobile P2P payments, which could be attributed to the fact that many incumbents possess domestic and local monopolies that would be exposed to competition in the case of increased compatibility among services.

Although general previous research has been done on coordination and technological compatibility in industries characterized by network externalities (see e.g., Farrell & Saloner 1985; 1986; 1988; Katz & Shapiro 1985; 1986), it has not been applied thoroughly to the industry of mobile P2P payment services.

Therefore, this paper aims to investigate the mechanisms of the mobile payments industry. More specifically, the research question is the following.

> *Why does inertia in cross-border cooperation exist in the industry of mobile P2P payment services?*
> *How can this inertia be overcome?*

To investigate these questions, we take a game theoretic approach to illustrate and capture the strategic interaction and behavior among the firms (i.e., decision makers) in the industry. Furthermore, as the succeeding sections will demonstrate, we draw upon the observations of the mobile P2P payments industry and the existing literature and previous research on the topic, as presented in the previous sections, when constructing our game theoretic model. Hence, an abductive method is carried out in this paper where our model tries to find an explanation to the current situation of inertia through the adoption and adaptations of existing theories.

5. Model

In this section, a game theoretic model is presented as a possible tool to investigate the dynamics in the mobile payment service industry. The literature outlined above serves as a foundation in explaining how cooperation can be difficult to achieve in the presence of network externalities. Subsection 5.1 considers the model setup with an application of existing literature to industry observations, while Subsection 5.2 presents the notations that are adopted in the model. Thereafter a simple two-player game is introduced in which the players pose a coordination problem with two Nash equilibria, one of which is Pareto efficient (Subsection 5.3). Subsequently, in Subsection 5.4, the model is extended to a multiplayer game in which the bandwagon and penguin mechanisms come into effect. Subsection 5.5 exposes the multiplayer penguin game to an external shock that alters the equilibrium, consequently transforming the Penguin Game into a Bandwagon Game. Subsection 5.6 summarizes the model results.

5.1 Model Setup

In this section, the previously presented theories are applied and adapted to the context of the mobile P2P payment service industry in order to construct a game theoretic model. Farrell and Saloner (1985) study the problem in which firms must coordinate on a change of technology standard in an industry where product compatibility is favorable. They introduce a model of complete information and incomplete information, respectively, and illustrate the outcome of a sequential game both with and without communication. Among the several models and games explaining similar dynamics and mechanisms in other markets, the model of Farrell and Saloner (1985) especially serves as an inspiration for the following game theoretic model.

5.1.1 Game Basics

Incumbent mobile P2P payment service firms are presented with the option of switching to a new technology that can share transaction infrastructure with other incumbents to connect their users. This is further referred to as the decision of whether to become compatible or not. Thus, in accordance with industry observations, an assumption in our model is that all firms start off with incompatible technologies. For the simplicity of the model, potential new firms will not have the option to join this shared infrastructure that is limited to incumbents with existing networks. Hence, there is no risk that the shared network becomes a "free for all" for new entrants. This ensures that the barriers to entry of the industry remain intact.

We choose to construct a simultaneous game with imperfect information and no communication to represent the situation of firms choosing to become compatible with each other or not. To get a strategic advantage, firms tend to hide their true incentives, meaning that they will be hesitant to share information that could be to the benefit of their competitors. This model simplifies the process to simultaneous, non-reversable commitments to compatibility. In reality, firms rarely commit without a bargaining process or some form of informational exchange between the parties. However, in this model setup and in this early stage of research on the topic, the simultaneous game will suffice to illustrate some of the mechanisms that help to answer the research question.

To reflect the industry there are three overlapping main features, as described by the literature in Section 3, that the model has to capture: the significant presence of network externalities, the incentives for compatibility, and the coordination problem. The model must also consider how these features interact in the industry.

5.1.2 Industry Network Externalities

With regards to network architecture, mobile P2P networks are closed, meaning that both parties need to have the same application to transfer money. Network externalities will determine the value of the mobile payment services to both users and retailers. Therefore, the providers could be expected to want to become compatible under the condition that many firms join in. Modifying Keser, Suleymanova, and Wey's definition (2012) slightly for the purpose of using the term analogously in our model, we introduce a technology's critical mass for any individual firm, which is defined as the minimal number of firms in the industry that is necessary to make the choice of this technology the best response for the individual firm (i.e., a sufficiently large number of firms must adopt a compatible technology for the benefits to outweigh the costs for each individual firm).

Even if mobile P2P payment service firms have different critical masses for coordination on a compatible technology, compatibility could still be achieved through a bandwagon effect, which is presented by Farrell and Saloner (1985). The expectation that other firms want to become compatible could be enough for coordination on the same technology. Likewise, an expectation that no or few other firms want to become compatible could impede coordination on the same technology, hence creating a penguin effect and a lack of a willing first mover (Farrell & Saloner 1985). Thus, due to network externalities, the benefit to any firm of making its payment service compatible with other firms' payment services is larger the more other firms that are expected to become compatible, *ceteris paribus*.

5.1.3 Preferences

The market of mobile P2P payment services consists of firms with varying sizes of market shares and, as expressed by the ECB (European Central Bank 2015), current solutions are mainly operating locally and domestically. Some firms have achieved a very high level of adoption (e.g., Swish in Sweden), while others compete with other firms at a domestic level (e.g., Bancomat Pay and Plick in Italy). As presented by Katz and Shapiro (1985), firms with large existing networks and good reputations tend to oppose compatibility while smaller firms are more likely to be in favor of compatibility. In terms of the mobile P2P payments industry, becoming compatible means a shift from closed to more open networks, enabling more P2P and C2B transactions to be made. This also implies that the monopoly-like position that many of the services possess at their local level would be lost if they would become compatible with other services. If all services were compatible, switching costs for both users and businesses would decrease significantly, rendering the service providers exposed to both price and product competition from the compatible services. However, for smaller service providers, the access to larger markets could be seen as an opportunity to gain more customers, further testifying the differences in preferences of compatibility between firms in the mobile P2P payment service industry.

Thus, in the industry of mobile P2P payment services, in which firms have different user adoption levels and market shares, firms have different incentives to become compatible with other firms. To capture this, we define three types of preferences for compatibility, which are high, medium, and low. Moreover, because firms are reluctant to share their own preferences and therefore lack the corresponding information about other firms in the industry, the players will make common prior assumptions. For simplicity, we define a probability distribution as a discrete uniform distribution, according to which Nature randomly chooses each player's type. Hence, the probability that Nature chooses any of the three types of preferences for each player is 1/3. These Bayesian game features put forward by Harsanyi (1967; 1968a; 1968b) only regards the multiplayer game (Subsection 5.4 onwards), which is the main part of our model, and not the two-player game (Subsection 5.3), in which players are assumed to have symmetric preferences and know each other's payoff.

5.1.4 Threat of Substitutes

As observed and described in Section 2, the industry of digital and mobile payments has seen and is increasingly facing new innovations and technologies that threaten existing solutions as the industry matures, despite its barriers to entry. One such example is the Diem project initiated by the global technology company Facebook, who is currently not in the payments industry but has access to a global network of people due to its large user base on various platforms. Furthermore, American PayPal is a mobile P2P payments service that operates globally and on multiple platforms. Similarly, blockchain technology and cryptocurrencies allow for cross-border transactions and could cannibalize on the established mobile payment services if more widely adopted. This implies that there is an increasing threat to mobile payment services of being left behind if they fail to maintain their established consumer base. Hence, even though they may lose their local monopolies, it could be beneficial for incumbent firms to cooperate across borders to stop their industry from being heavily disrupted such that their existing services become outcompeted. In other words, these circumstances may affect the preferences for compatibility, *ceteris paribus*, making a compatible technology more favorable for all incumbent firms in the industry. In accordance with the work of Katz and Shapiro (1986), compatible technology may therefore become relatively more "sponsored" than incompatible technology, and subsequently more likely to be adopted by the industry, as it not only affects firm preferences but also firm expectations which are important for choice of technology.

5.2 Notations

With regards to the model setup, we now present some notations used in our model.

Firms = mobile P2P payment service providers.

$N = \{1, 2, ..., n\}$ denotes the set of firms in the mobile P2P payments industry.

Each firm j in the industry chooses to either keep its service incompatible (X) with the other services offered by the other firms in the industry, or to switch to a technology that allows for compatibility between the services (Y). Hence, the actions available are given by $A = [X, Y]$.

c: individual fixed cost of choosing Y.

S: number of firms in the industry who choose to become compatible (Y).

For any $j \in N$ and any $S \subseteq N$ containing j, we define the following:

$B_j(S, Y)$: benefit to firm j from being compatible together with the other firms in S (i.e., together with $S - 1$ other firms). This implies that expected $B_j(S, Y)$ is based on the expected S.

Further, it follows that:

$B_j(N \setminus S, X)$: benefit to firm j from being incompatible together with the other firms in $N \setminus S$ (i.e., together with $(N \setminus S) - 1$ other firms).

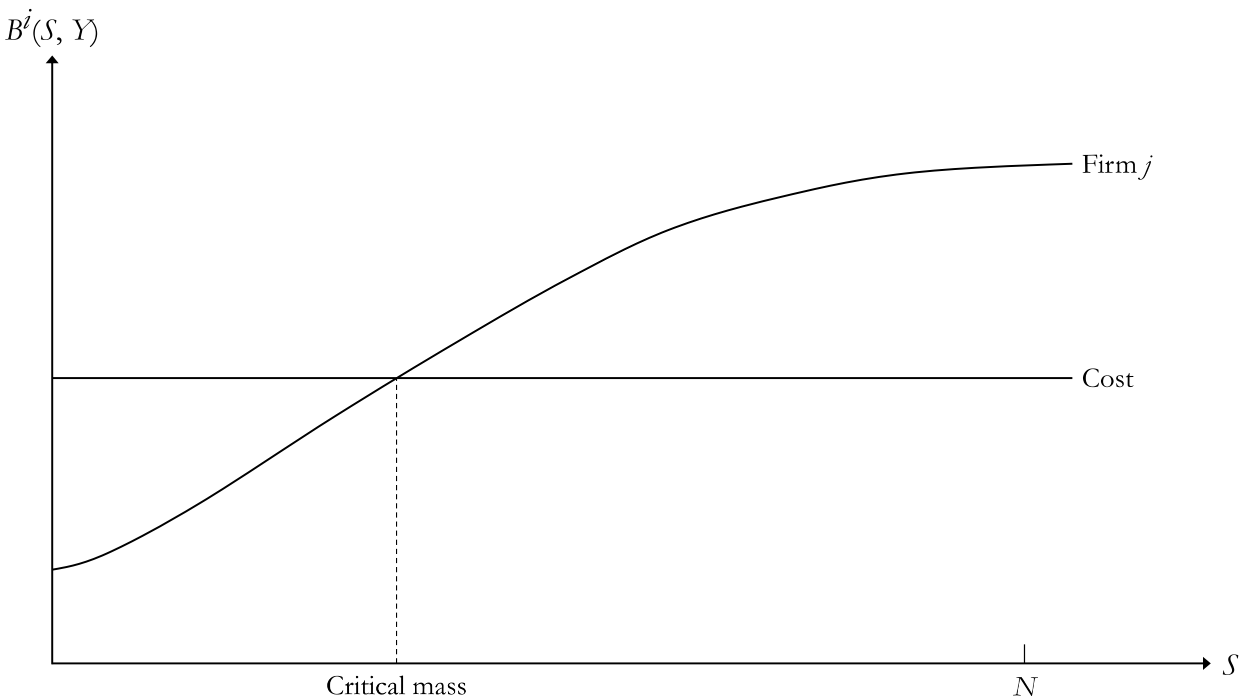
We assume that the benefit of staying incompatible is independent of how many other firms choose compatibility. Therefore, the benefit can be normalized to zero in order to decide whether becoming compatible brings a net benefit or not. In other words, $B_j(N \setminus S, X) = 0$ for any j and any S.

As a result of mobile payment services' network externalities, the function $B_j(S, Y)$ is monotonically increasing in S. Thus, if $S' > S^*$ then $B_j\left(S', Y\right) > B_j\left(S^*, Y\right)$ for any j. If sufficiently many firms choose to be compatible, the individual net benefit is positive. However, we do not assume that all benefits of the new compatible technology (Y) come from positive network externalities. Some firms may prefer the technology based on other merits as well.

As mentioned in the previous subsection, the minimal number of firms in S that is necessary for the benefit of switching technology (Y) to exceed the costs, c, is referred to as firm j's critical mass. There is also a general critical mass for the compatible technology which is defined as the number of firms in S that is necessary to make the switch to the compatible technology (Y) the best response for any remaining user.

Figure 1 illustrates how the firm benefit of being compatible increases with the number of total compatible firms S. Considering that there is a cost of switching to a compatible technology, there is a critical mass of compatible firms where the benefit is equal to the cost for firm j.

Figure 1. Critical Mass.

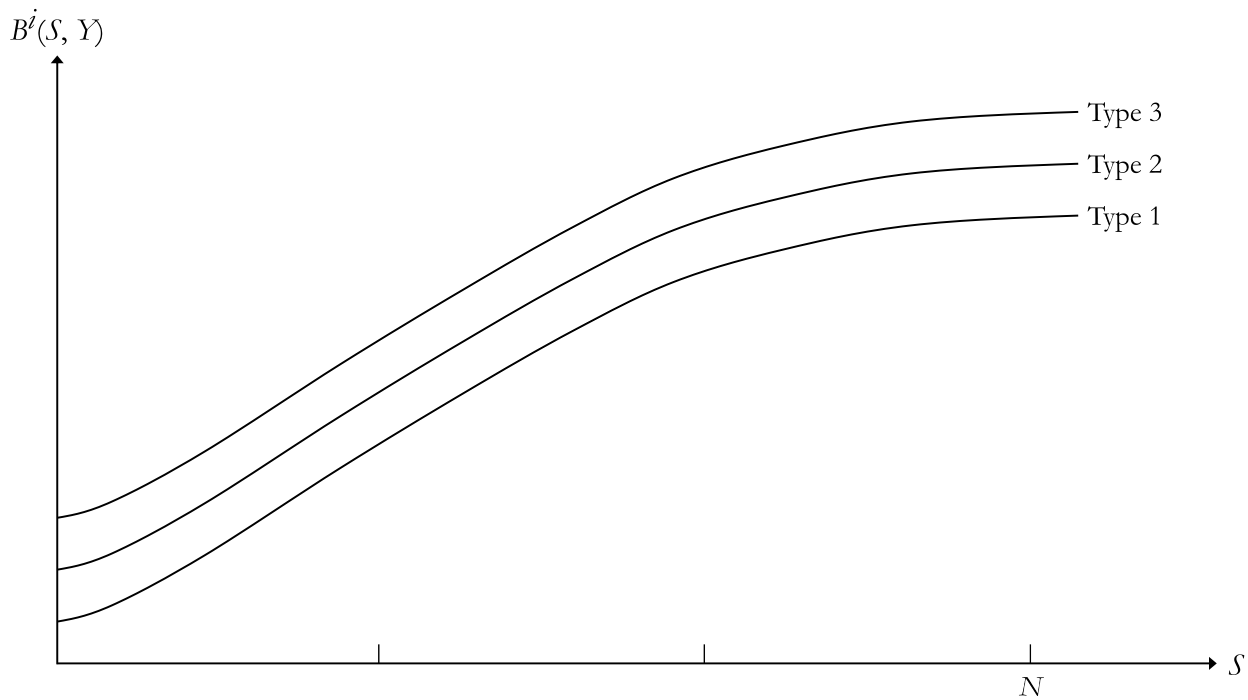


Source: Authors' own elaboration.

Preferences for compatibility differ among firms and are defined by $i = \{1, 2, 3\}$, where the benefit of compatibility is strictly increasing in i. The common prior assumption is that preferences are uniformly distributed. Hence, the benefit function is given by $B^i(S, Y)$, where $B^3(S, Y) > B^2(S, Y) > B^1(S, Y)$ and $p^i = 1/3$.

Figure 2 illustrates an example of benefit functions for preferences $i = \{1, 2, 3\}$ where the above assumptions hold.

Figure 2. Preferences.



Source: Authors' own elaboration.

As mentioned in the model setup (Subsection 5.1), the different preferences are meant to illustrate some common differences between firms that determine their benefit of switching to a compatible technology (Y). Larger firms will get relatively less benefit from switching to a shared network than smaller firms, as they contribute with more users. Also, firms with established local monopolies may fear future competition in terms of price and quality, as consumer switching costs are decreased. Hence, a large firm or a firm with a local monopoly is more likely to be classified as type 1.

5.3 Simultaneous Two-Player Game

In this subsection, a simultaneous two-player game is introduced to illustrate the coordination problem of switching to a compatible technology. For the purpose of isolating the coordination problem, we assume that the players have symmetric preferences and know each other's payoffs. The game has 2 players, Firm A and Firm B, who belong to the industry, i.e., $\{\text{Firm A, Firm B}\} \subseteq N$. The actions are to stick with their current incompatible technology (X) or to switch to a compatible technology (Y). Furthermore, the players have symmetric preferences and choose their action simultaneously such that they "lock in" their choice of technology before observing the decision made by the other player. The game is therefore one of complete but imperfect information, because the players know all the possible payoffs but cannot observe the other player's action before taking their own action.

Assumption: The main benefits of switching to the compatible technology (Y) come from positive network externalities. Therefore, we assume that $B_j(2, Y) > c > B_j(1, Y) \geq 0$ in this two-player game. There are not sufficiently large benefits to cover the investment cost unless you get access to the network benefits, meaning that the critical mass of firm j in this game is $S = 2$. As brought up in the previous section, $B_j(N \setminus S, X) = 0$ for any j and any S. Thus, for this game, it implies that $B_j(1, X)$ and $B_j(2, X)$ are normalized to zero.

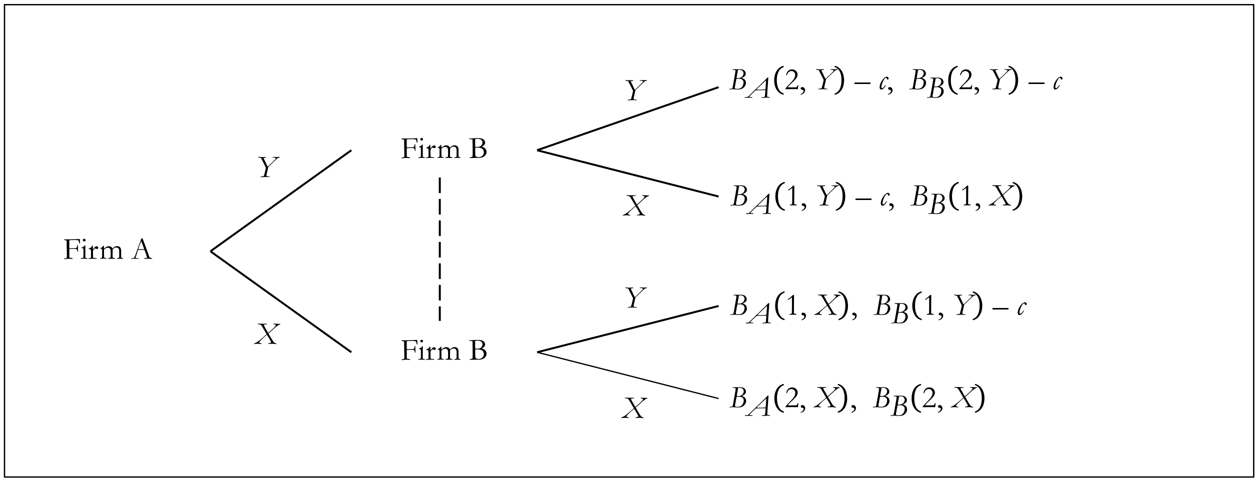
The two-player game is illustrated by the following matrix (*Figure 3a*) in normal-form and the game tree below in its extensive-form (*Figure 3b*).

Figure 3a. Two-Player Matrix.

	Firm B choosing compatible technology (Y)	Firm B retaining incompatible technology (X)
Firm A choosing compatible technology (Y)	$B_A(2, Y) - c,\ B_B(2, Y) - c$	$B_A(1, Y) - c,\ B_B(1, X)$
Firm A retaining incompatible technology (X)	$B_A(1, X),\ B_B(1, Y) - c$	$B_A(2, X),\ B_B(2, X)$

Source: Authors' own elaboration.

Figure 3b. Two-Player Tree.



Source: Authors' own elaboration.

This coordination game resembles a stag hunt game (see *Figure 3a* and *Figure 3b*). Both players would like to coordinate on the compatible technology (Y), receiving the highest possible payoff each. However, there is a risk of receiving a negative payoff instead, if the other player chooses X (because $B_j(1, Y) < c$), so no player wants to be left alone playing Y. If Firm A believes that Firm B will play Y, its best response is to play Y (because $B_A(2, Y) - c > B_A(1, X) = 0$). If Firm A believes that Firm B will play X, its best response is to play X (because $B_A(2, X) = 0 > B_A(1, Y) - c$). Since the game is symmetric, the identical reasoning goes for Firm B's decision. Hence, the game has two Nash equilibria. The Pareto efficient equilibrium is (Y, Y), i.e., that both firms choose compatible technology. The second equilibrium is (X, X), i.e., that both firms choose to stay with their incompatible technologies. Because both firms are assumed to have incompatible technologies from the start, there is a risk that the players will end up playing the suboptimal equilibrium. This relates to the importance of expectations in choosing technology, as noted by Katz and Shapiro (1986). If the players cannot make credible commitments in this simultaneous game or the payoffs associated with the different outcomes do not change, there is a risk of the players being "trapped" or "locked-in" in the suboptimal equilibrium.

5.4 Simultaneous Multiplayer Game

Having illustrated the coordination problem in the previous subsection, we now extend our model by introducing the following simultaneous multiplayer game. This is a Bayesian game with N firms ($n > 3$) who have incomplete information about the payoffs of the other firms. As in the previous two-player game, the actions available are to stick with their current technology (X) or to switch to a compatible technology (Y). The common prior assumption is that there are three different preference types among firms that are equally probable. As described by Harsanyi (1967), this technically transforms the game of incomplete information into a game of complete but imperfect information. Each firm knows their own type.

Because $S \subseteq N$ and $n > 3$, there are now larger positive network externalities to gain compared to in the two-player game (Subsection 5.3).

The type of firm j is given by the function τ_j: $\Omega \rightarrow i = \{1, 2, 3\}$ where Nature (Ω) assigns the firm to a type (i). The common prior belief of all the firms is that $p^i = 1/3$, which they will take into consideration when choosing their strategy.

The pure strategy for firm j is given by s_j: $i \rightarrow A$ where A represents the actions available $[X, Y]$. The pure strategy for each player is dependent on how the benefit functions of different firm types are defined and what the expected number of compatible firms (S) is.

5.4.1 The Bandwagon Game

Is there a situation in which the Pareto efficient equilibrium is the only Nash equilibrium? The following example is a game in which there is incentive for at least one type of player to diverge from the suboptimal equilibrium presented in the two-player game. The following common prior assumptions are beliefs held by all N firms in the Bandwagon Game.

Common prior assumptions:

$p^i = 1/3$

$B^i(N, Y) > c$

$B^3(1, Y) > c$

$B^2((1/3) \times N, Y) > c$

$B^1((2/3) \times N, Y) > c$

s_j: $i = 3 \rightarrow A$

A firm of type 3 has a benefit of the compatible technology that exceeds the cost of switching to it even if $S = 1$. Because the firm itself represents one unit of S, the dominant strategy for a firm of type 3 is to switch technology (Y) even if it is unilateral. Hence, firms of this type do not require the positive network externalities of compatibility in order to find the new compatible technology more attractive. For example, the firm could prefer the technology based on that it is better than their current one.

s_j: $i = 2 \rightarrow A$

A firm of type 2 has a benefit of the compatible technology that exceeds the cost of switching to it when $S = (1/3) \times N$. There is common knowledge among the players that type 3 firms' dominant strategy is to switch technology (Y). Additionally, there is a common prior assumption about the distribution of firm types, $p^i = 1/3$. Therefore, expected $S \geq (1/3) \times N$ and the dominant strategy for firms of type 2 is also to switch to the compatible technology (Y).

s_j: $i = 1 \rightarrow A$

A firm of type 1 has a benefit of the compatible technology that exceeds the cost of switching to it when $S = (2/3) \times N$. There is common knowledge among the players that type 2 and type 3 firms' dominant strategies are to switch technology (Y). There is also a common prior assumption about the distribution of firm types, $p^i = 1/3$. Therefore, expected $S \geq (2/3) \times N$ and the dominant strategy for firms of type 1 is also to switch to the compatible technology (Y).

With regards to the above reasoning, the strategy profile for this Bandwagon Game is the following:

s_j: $i = 3 \rightarrow Y$

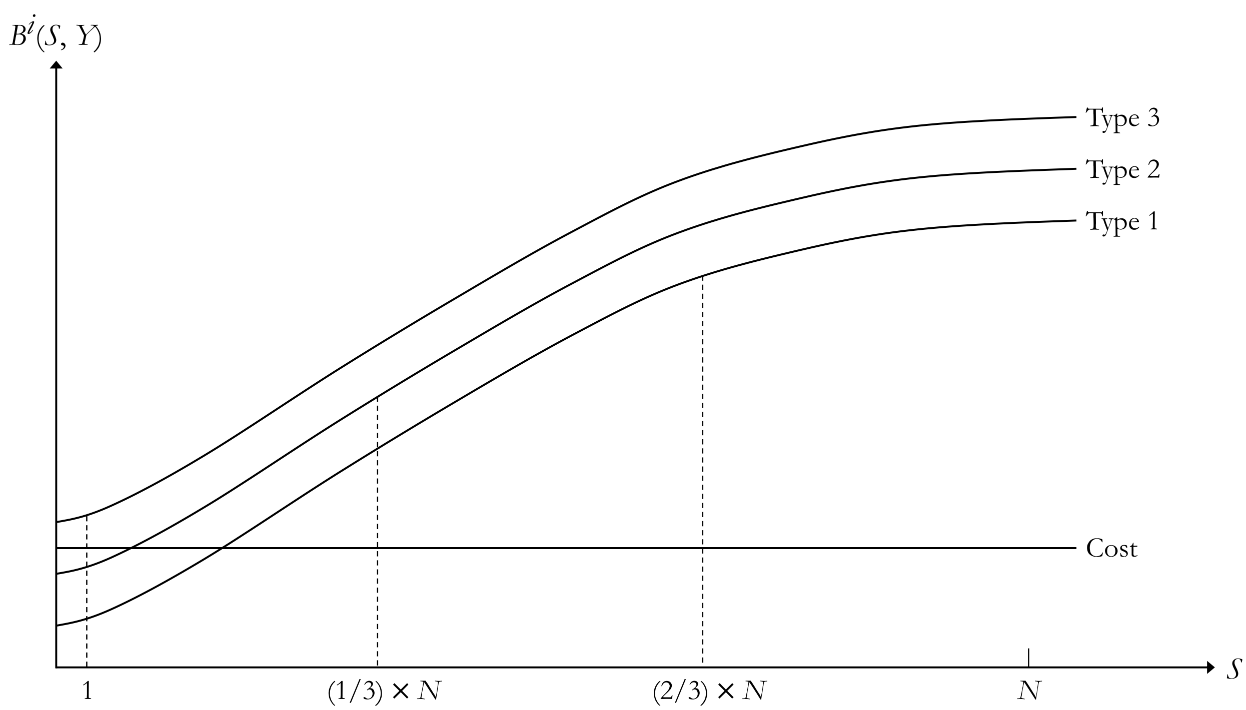
s_j: $i = 2 \rightarrow Y$

s_j: $i = 1 \rightarrow Y$

Accordingly, the only Nash equilibrium in this multiplayer game is that all firms switch to a compatible technology, i.e., play Y. The mechanism in this game can be compared to the bandwagon effect that Farrell and Saloner (1985) refer to in their model with sequential decisions, hence the name Bandwagon Game in this paper. The game demonstrates that the choice of technology will not solely depend on firm preferences but also on the expected actions of other firms. For example, even a firm of type 1, who is relatively more satisfied with retaining its current technology (X), may choose to switch technology (Y) based on the expectations that other firms will do the same. Therefore, due to the importance and impact of firm expectations, the bandwagon effect can also be achieved in this model with simultaneous decisions.

Figure 4 illustrates a set of benefit functions and a cost for switching technology (Y) that follow the assumptions of this game and allow for a bandwagon effect to take place.

Figure 4. Bandwagon Game.



Source: Authors' own elaboration.

5.4.2 The Penguin Game

By having observed the mobile payment service industry, it is evident that there are no successful attempts at making the services compatible thus far. It is therefore reasonable to assume that the firms are stuck in the suboptimal equilibrium of the two-player game (Subsection 5.3). The following multiplayer game aims to illustrate such a situation, in which the bandwagon effect, which is presented above, is possible but not necessarily achieved.

Common prior assumptions:

$p^i = 1/3$

$B^i(N, Y) > c$

$B^3\big((1/3) \times N, Y\big) > c > B^3(1, Y)$

$B^2\big((1/3) \times N, Y\big) > c$

$B^1\big((2/3) \times N, Y\big) > c$

Compared to the previous example of the Bandwagon Game (Subsection 5.4.1), there is no obvious pure strategy for firms of type 3 in this game, as their choice of action will no longer be based solely on their own individual preferences. Instead, they will have to construct their strategies based on their expectations of other firms' decisions. Ultimately, this means that all the firm types will have less knowledge about what moves the other firms will make and they will therefore pursue mixed strategies with assigned probabilities of choosing each action.

$\sigma_j: i = 3 \rightarrow \Delta A$

A firm of type 3 has a benefit of the compatible technology that exceeds the cost of switching to it when $S = (1/3) \times N$. As opposed to the Bandwagon Game, it is no longer beneficial for a type 3 firm to unilaterally switch to the new technology (Y) because it would fail to outweigh the cost of switching. Then, the choice of strategy will depend on the firm's expectations of what other firms will do. Thus, the dominant strategy for a firm of type 3 would rather be represented by a mixed strategy of switching technology (Y) and staying incompatible (X).

$\sigma_j: i = 2 \rightarrow \Delta A$

A firm of type 2 has a benefit of the compatible technology that exceeds the cost of switching to it when $S = (1/3) \times N$. Thus, the strategy of type 2 firms will be like that of type 3 firms, namely, a mixed strategy.

$\sigma_j : i = 1 \rightarrow \Delta A$

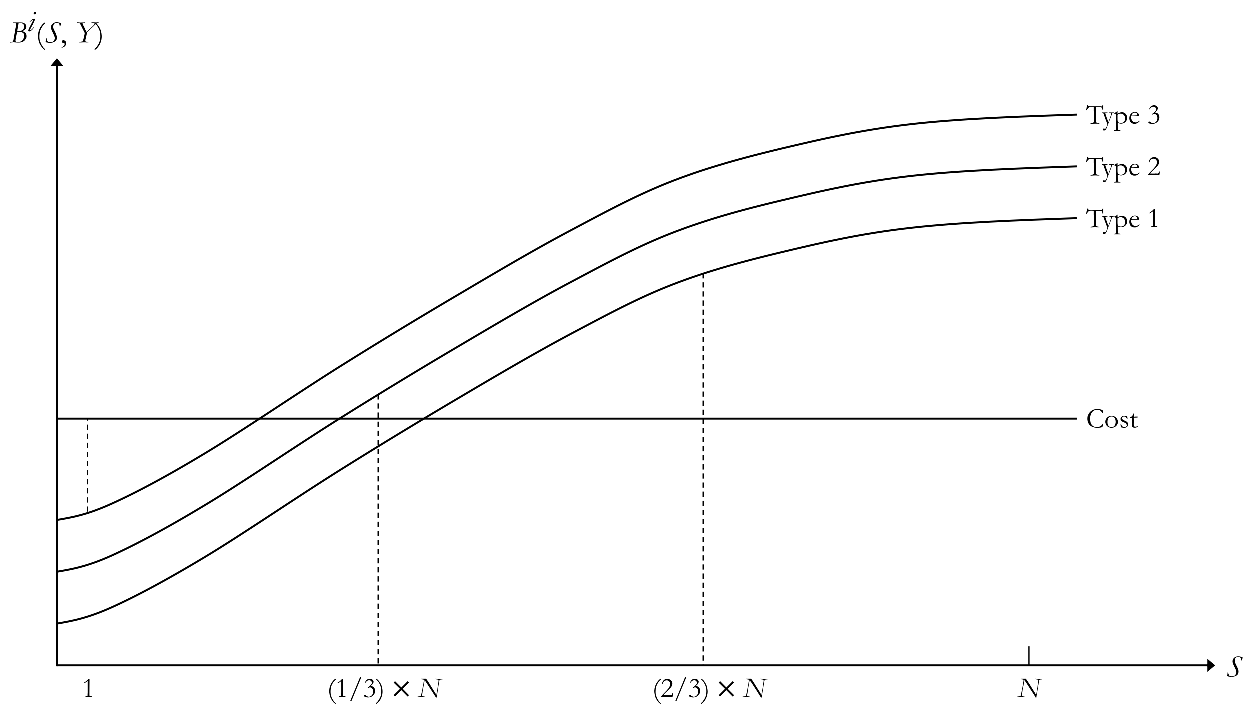
A firm of type 1 has a benefit of the compatible technology that exceeds the cost of switching to it when $S = (2/3) \times N$. This means that the other firm types (type 3 and type 2) must switch technology (Y) for a firm of type 1 to find the same action beneficial. Ultimately, the lack of communication will cause firms of type 1 to also go for a mixed strategy of switching technology (Y) and staying incompatible (X). Because type 1 firms have lower incentives to switch technology (Y), compared to the other firm types, they are likely to assign more of its mixed strategy towards remaining incompatible (X), *ceteris paribus*.

With regards to the above reasoning, the two Nash equilibria are that all firms switch technology (Y) and that no firms switch technology (X), respectively, as no firm has any incentive to diverge from these two states. The conclusion of this game is that all firms will adopt mixed strategies, where it is reasonable to assume that they might assign higher probability on the action of staying incompatible (X) than on the action of switching to a compatible technology (Y). This because of the importance of expectations in assigning these probabilities. Firm j will choose a technology depending on the moves of the other firms, while the other firms will do the same, thus creating an ambiguous situation. The main aspect that the firms take into consideration is the fear of playing Y when their critical mass happens to be unachieved, *ex post*. The compatible technology is still preferred (optimal) if all firms would switch $(N = S)$ but because of the lack of communication between the firms, there is a coordination problem (similar to the two-player game in Subsection 5.3), and they fear ending up with a negative payoff if other firms diverge.

Rather than solving for the exact strategies of the firm types, this game aims to illustrate how multiple firms, not just two firms as in the two-player game (Subsection 5.3), can end up in a suboptimal equilibrium. What is lacking here, in comparison to the Bandwagon Game, is the lack of an obvious willing first mover. This game is instead named the Penguin Game, inspired by the findings of Farrell and Saloner (1986) who used the psychological term penguin effect, which is based on the behavior of penguins diving into the water only after one of them takes the lead.

Figure 5 illustrates an example of benefit functions according to which all firms would like to coordinate on compatible technology (Y), which is the Pareto efficient equilibrium, but do not necessarily do so due to the penguin effect.

Figure 5. Penguin Game.



Source: Authors' own elaboration.

5.5 Simultaneous Multiplayer Game with an External Shock

Returning to the mobile payment service industry and its current incompatibility, one could compare it to a Penguin Game in which there is no pure dominant strategy to switch to the compatible technology (Y), even though all firms would benefit from a sufficiently large fraction of them switching. As demonstrated by the previous section, this is mainly due to the lack of coordination and the fact that no firm type is willing to switch technology unilaterally.

What if the market is exposed to a shock in the form of competition from new types of payment solutions? There is a need for cross-border payment solutions and other mediums like PayPal and cryptocurrencies are entering the market and meeting a consumer demand that might cannibalize on incumbent mobile payment services if adopted by end users. As a result of the shock, there is not necessarily a larger benefit for firms to become compatible, but rather a negative benefit of remaining incompatible.

Even though preferences will still differ among firms, an external shock partly exposes a threat of remaining incompatible. Hence, there is a non-communicative signal that more firms might be willing to follow if one firm starts the bandwagon.

5.5.1 The Penguin Game with a Shock

Earlier it was assumed that the benefit of remaining incompatible, $B^i(N \setminus S, X)$ was constant and normalized to zero. Now there is a negative common shift, $-\delta$, in the benefit of remaining incompatible for all the firms. When firm j faces the choice of whether to become compatible or not, $B^i(S, Y) - c$ does not have to be larger than zero, but larger than $-\delta$, for the compatible technology to become the more attractive choice. Moreover, we assume that if a firm successfully becomes compatible with another, the consumer base is pleased and will not be attracted to other payment solutions. Hence, $\delta = 0$ for S firms that choose to become compatible with each other. To illustrate the effect of the threat, we also assume that a firm unilaterally switching to the new compatible technology (Y) will signal, to its consumer base, a commitment to meeting the consumer demand. It will therefore keep its consumers as well. Hence, $\delta = 0$ for a firm that unilaterally chooses the compatible technology (Y).

The new strategy is therefore the following: Switch to compatible technology if $B^i(S, Y) - c > B^i(N \setminus S, X) - \delta$ which can be rewritten as $B^i(S, Y) + \delta > c$.

Common prior assumptions:

$p^i = 1/3$

$B^i(N, Y) > c$

$B^3(1, Y) + \delta > c > B^3(1, Y)$

$B^2\big((1/3) \times N, Y\big) + \delta > B^2\big((1/3) \times N, Y\big) > c$

$B^1\big((2/3) \times N, Y\big) + \delta > B^1\big((1/3) \times N, Y\big) > c$

s_j: $i = 3 \rightarrow A$

A firm of type 3 has a benefit of the compatible technology that exceeds the net cost $(c - \delta)$ of switching to it even if $S = 1$. Note that this only holds after, and not before, the external shock (see e.g., *Figure 6*). Thus, for type 3 firms, the potential customer loss in the case of retaining the incompatible technology $(-\delta)$ makes the choice of switching to the new compatible technology more beneficial than staying with their current technology (X). A firm of type 3 can escape the threat $(-\delta)$ even if it only switches unilaterally because of the assumption made that consumers would perceive the firm's effort to become compatible as a signal that it strives to enable cross-border payments. Hence, existing users will not be tempted to pursue new payment means such as cryptocurrencies. The dominant strategy for a firm of type 3 is therefore the pure strategy of switching technology (Y), even if it is unilateral.

s_j: $i = 2 \rightarrow A$

A firm of type 2 has a benefit of the compatible technology that exceeds the net cost $(c - \delta)$ of switching to it when $S = (1/3) \times N$. This was also the case before the shock, but then type 2 firms could not rely on that $(1/3) \times N$ firms of type 3 would switch. Because the shock affects all firms the same $(-\delta)$, firms of type 2 now know that type 3 firms' dominant strategy after the shock is to switch technology (Y). There is still the common prior assumption about the distribution of firm types, $p^i = 1/3$. Therefore, expected $S \geq (1/3) \times N$ and the dominant strategy for firms of type 2 is also to switch to the compatible technology (Y).

s_j: $i = 1 \rightarrow A$

A firm of type 1 has a benefit of the compatible technology that exceeds the net cost $(c - \delta)$ of switching to it when $S = (2/3) \times N$. This was also the case before the shock, but then type 1 firms could not rely on that $(2/3) \times N$ firms of type 2 and type 3 would switch. There is common knowledge among the players that type 2 and type 3 firms' dominant strategies are to switch technology (Y) after the shock. There is also the common prior assumption about the distribution of firm types, $p^i = 1/3$.

Therefore, expected $S \geq (2/3) \times N$ and the dominant strategy for firms of type 1 is also to switch to the compatible technology (Y).

With regards to the above reasoning, the strategy profile for this game is the following:

s_j: $i = 3 \rightarrow Y$

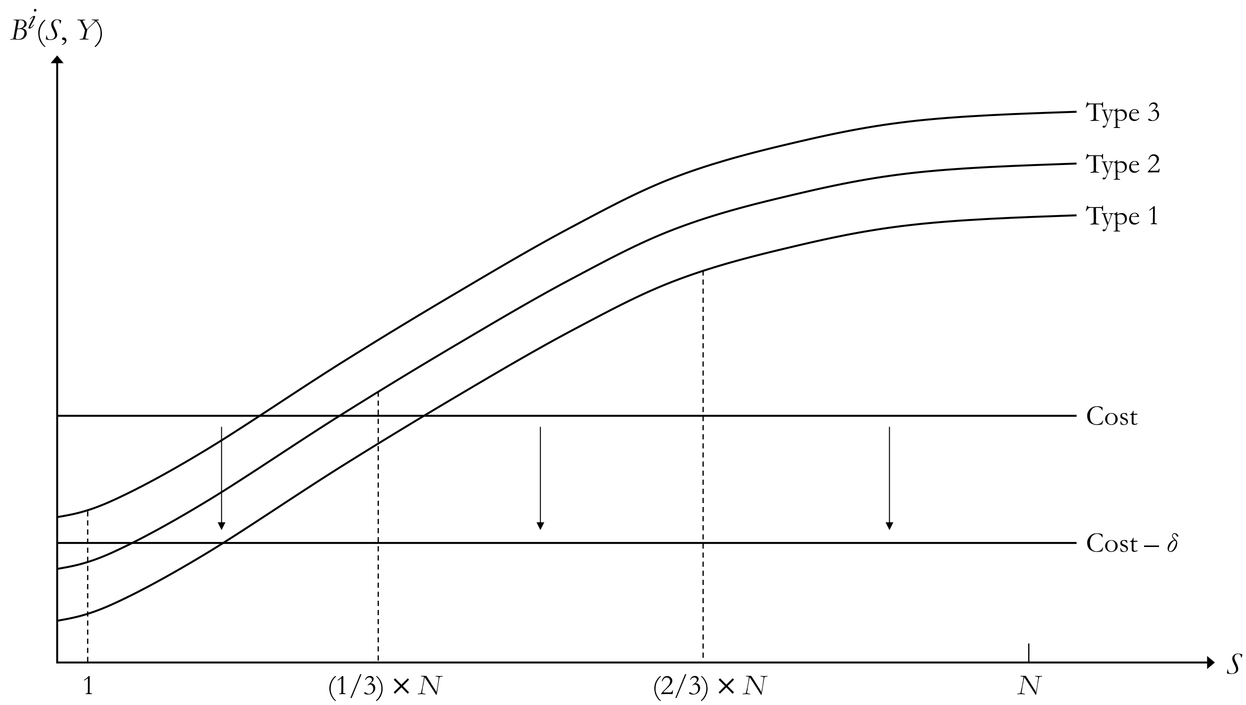
s_j: $i = 2 \rightarrow Y$

s_j: $i = 1 \rightarrow Y$

Accordingly, the only Nash equilibrium is that all firms switch technology (Y) and get the expected net benefit $B^i(N, Y) - c$. This game shows how mobile P2P payment services stuck in a suboptimal equilibrium may escape it through the creation of a willing first mover. We suggest that the threat of payment substitutes could do this.

Figure 6 illustrates how an external shock affects the strategy choice of the different firm types. It resembles a move from the previous Penguin Game (F*igure 5*) to the Bandwagon Game (F*igure 4*). There is now a type of firm (type 3) that is willing to unilaterally switch to the compatible technology.

Figure 6. Penguin Game with a Shock.



Source: Authors' own elaboration.

5.6 Model Results

The result of our model shows that inertia in cooperation between mobile P2P payment services could be explained by the lack of willing first movers. The existence of different preferences does allow for, but not necessarily mean that some firms prefer the compatible technology independent of network externalities. However, because these firms are so heavily value dependent on network externalities, it is realistic to assume that no incumbent firm wants to switch to a compatible technology without the knowledge or expectation that other firms will do the same. If all firms are exposed to a simultaneous common change in benefit, such as a threat from new substitutes, this could result in willing first movers. In turn, these willing first movers can set off the bandwagon such that all firms in the industry eventually coordinate on the compatible technology.

6. Discussion

This model provides one possible explanation to why there is currently no compatibility between European mobile P2P payment services. However, a model is only as good as its assumptions. Many of the assumptions of this model are formed from industry observations of the mobile P2P payment services and economic theory on technological compatibility. Because the mobile P2P payment industry consists of rather powerful domestic monopolies or oligopolies, there are motives and strategies that these incumbents are very reluctant to share with the public and their competitors. This entails that our model has limited industry information, particularly when it comes to firm incentives.

Additionally, the model can only try to simplify a very complex situation which requires some strong assumptions. For example, in the case that the threat of new extra-industry payment solutions does not have the capability to create a willing first mover, it is plausible to believe that it would still increase the general willingness to cooperate among incumbents. Then, in a penguin game, firms would increase the probability of switching to a compatible technology in their mixed strategy. To investigate this would require a more detailed examination of the mixed strategies than this bachelor thesis allows for, but it would make a promising subject for further research. Nonetheless, we believe that a threat of this character and scope is a viable means of escaping inertia in the industry. The extent of this will hopefully be observable in the future as these new payment solutions possibly gain higher user adoption levels.

Despite the above limitations, the model is useful in illustrating some market mechanisms in the relatively new industry of mobile P2P payment services. It uses economic theories and game theory to extend our understanding of markets with substantive network externalities, through the application on the mobile P2P payment industry.

In reality, private firms have formed associations such as the EMPSA in order to foster cooperation between private services but with no success thus far. This process of communication in choice of compatibility standards is further discussed by Farrell and Saloner (1988). Using communication is more efficient but slower than using unilateral irrevocable choices, such as in our model. This slowness in coordination through communication is especially worrying for the mobile P2P payments industry, as the industry is threatened by new solutions and technologies. Farrell and Saloner present a mix between communication and unilateral preemptive actions as a viable option that may speed up the process of cooperation. We argue that our model proposed in this paper could further be used to illustrate such a situation that Farrell and Saloner propose. By combining communication with repeated unilateral irrevocable choices, mobile P2P payment services could increase their chances of overcoming inertia. However, because our model is only inspired by, rather than based on, the model of Farrell and Saloner (1985), this suggests that the application of Farrell and Saloner (1988) would require some alterations and is thus a possible subject for further research.

Why is this inertia something to overcome? As expressed by Katz and Shapiro (1986), the social incentives for compatibility are often higher than those of the firms. Hence, in the industry under investigation, it is plausible that the benefit of compatibility of services all over Europe is larger for the users than for the service providers themselves, who would have to conduct the change of technology, adapt their business strategies, and encounter increased competition. This discrepancy in private and public benefit is apparent when observing that the SEPA Proxy Lookup Scheme, provided by the European Union, has failed to incentivize private services to become compatible with each other. In terms of the model presented in this paper, such technological government policy could lower the cost for incumbent firms to make their services compatible each other. Consequently, it would suggest that government intervention could help to overcome inertia in the mobile P2P payments industry. However, this does not seem to be the case with the SEPA Proxy Lookup Scheme. Nonetheless, our model shows that the possible threat from new technological solutions is one example of a natural market mechanism that eventually may overcome inertia in the mobile payments industry. This sheds light on the general discussion about the optimal extent of government intervention in markets in order to achieve economic efficiency; whether this inertia could and should be overcome by non-market forces, or whether pure market mechanisms should prevail. In this regard, the model and market mechanisms presented in this paper have the potential to spur and support further investigation of the subject matter, as well as to contribute to the corresponding policy discussion.

7. Conclusion

This paper has examined the current situation of inertia in cross-border cooperation in the infrastructure of mobile payment services in Europe. Using a game theoretic approach, it finds that inertia in cross-border cooperation exists in the industry of mobile P2P payment services, likely in part due to the significant network externalities in the industry that subsequently make incumbent firms reluctant to unilaterally make their services compatible with others. The lack of a willing first mover in initiating the bandwagon process may stem from weak preferences for compatibility *per se* or weak expectations, or a combination of both, thus making the expected net benefit of switching to compatible technology lower than the expected net benefit of retaining an incompatible service. The inertia can only be overcome if preferences and/or expectations are altered, which the recent and future technological progress in money transferring could do. The threat from substitutes may inevitably intensify the need for compatibility and thereby result in coordination on compatible technology, as opposed to the prevailing circumstances with incompatible services and the industry's inability to cater cross-border mobile P2P payments.

Our work is an application of existing theory on an empirical phenomenon and provides one explanation as to why and in what way inertia in the mobile P2P payments industry exists. While this paper thus improves on the current state of knowledge, by explaining how substantial network externalities play out in the relatively new, digitalized mobile P2P payments industry, it also provides scope for further research and possible policy implications. Although our model is not by any means normative—it does not prescribe what ought to be, nor does it suggest any policy measures—it provides a basis for further positive and normative economic discussion, regarding topics such as network externalities in technological environments and their impact on market structure and competition. As a final remark, we therefore conclude that broader and further research is desirable in order to increase the understanding of inertia in cross-border cooperation in the mobile P2P payment service industry in Europe, as well as to extend these findings to similar industries in which network externalities are significant.

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