The Economics of Retail Payments Security

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Abstract

Economics provides a useful framework for understanding both drivers of and barriers to retail payments security. This paper documents economic principles that underpin retail payments security and describes how a game theory approach can be used to evaluate and construct security strategies. It then demonstrates in four case studies how economics can help explain why some payment security mechanisms succeed while others fail. Topics investigated include efforts to reduce card-not-present fraud through enhanced authentication, initiatives to better protect payment card data, emerging mobile payment platforms, and alternative payments based on cryptocurrencies. The final section provides a summary and discussion on the role for policymakers to consider payments security from a broad and long-term perspective.

Keywords: Retail payments security, Incentives, Game theory, Security economics

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1. Introduction

In recent years, weaknesses in payment security have become increasingly evident through a constant stream of news reports on data breaches, phishing attacks, spoofed websites, payment card skimming, fraudulent ATM withdrawals and online purchases, computer malware, and infiltration of retail point-of-sale systems. Although these events seem not to significantly affect current end users' payment method choices, they may hinder adoption of new technologies, such as mobile and faster payments (Schuh and Stavins). Were the public to lose confidence in the payments system, however, payment behaviors could drastically change, potentially undermining commerce and overall economic activities.

Motivated by various factors, all involved parties make continuous efforts to improve payment security. Financial institutions, payment networks, processors, businesses, and consumers, take steps to mitigate security threats. Regulators help to ensure compliance with appropriate security practices. Law enforcement puts pressure on attackers to deter bad behavior. However, while these continuous efforts to improve the payments system are underway, attackers are becoming more sophisticated in finding weak links and developing new modes of attack.

To better understand the dynamics of retail payments security, economics provides a useful framework. Economic principles that characterize retail payments security enable us to identify both drivers of and barriers to security investment and coordination in the industry. Applying game theory to payment security decisions reveals sources of conflicts among industry participants, and whether security strategies, technical solutions, and policies employed by industry participants and policymakers can achieve security goals. If the results suggest those strategies, solutions, or policies would be unlikely to achieve the goals, this approach also

enables us to consider which part(s) of the game needs to be modified to achieve the desired level of security, providing insights into public policy and private entities' strategies.

The goal of this paper is to demonstrate how economic analyses can help to better explain coordination challenges facing payments security and strategies that produce socially desirable levels of payment security. Section 2 documents economic principles that underpin retail payments security. Section 3 describes how the game theory approach can be used to evaluate and construct security strategies. Section 4 applies this approach to several case studies to evaluate actual technical solutions, both successfully and unsuccessfully implemented. Section 5 provides a summary and discussion on the role for policymakers to consider payments security from a broad and long-term perspective.

2. Economic principles related to retail payments security

Retail payments markets can be characterized by several economic principles. Basic principles that characterize retail payments markets in general include network externalities, two-sided markets, and economies of scale and scope. Additional economic principles characterize retail payments security more specifically. These key principles include jointly produced goods, competition *for* the market, asymmetric information, moral hazard, and trade-offs between information sharing and privacy. This section first describes basic economic principles that characterize retail payments markets. It then provides definition of each key principle related to payments security, describes how the principle and payments security are related, and discusses the implications on the incentives of various payments users and industry participants to align so as to produce socially desirable payments security.[1]

[1] See Anderson (2001) and Moore (2010) for a more comprehensive treatment of how economics affects information security more broadly.

2.1 Basic economic principles that characterize retail payments markets

2.1.1. Network externalities

An externality exists when an individual agent's taking action affects other parties' benefits or costs that are not reflected in the prices of the goods or services involved. As a result, an individual agent's private benefits or costs do not coincide with the benefits or costs to society as a whole. Network externalities are one type of externality.[2] When this type of externality is present, the value of a product or service for an individual consumer is dependent on the number of other consumers using it. For example, as more people adopt ATMs, more ATMs may be deployed and the number of ATMs available to an individual consumer may increase, and thus the value of ATM service for an individual consumer increases.

Payment innovations typically need to achieve "critical mass," a sufficient number of adopters so that the rate of adoption becomes self-sustaining and creates further growth. If multiple providers in a network market compete for their customers with their new services, the degree to which providers' services are interoperable could be an important determinant of whether the services can achieve critical mass. If those providers are effectively interoperable, then the services may achieve critical mass relatively easily because interoperability allows customers of alternative providers to exchange payments with each other.

To achieve critical mass as quickly as possible, competing providers may prioritize growth over any other goal, such as security (Levitin). For a new payment method, end users' concerns over its security are a barrier to adoption. However, once the method overcomes that concern, end users tend to care about convenience of the method more than its security (Schuh and Stavins). This leads to payment providers' focusing on enhancing convenience rather than

[2] Network externalities are also called network effects of demand-side economies of scale.

improving security of the payment method.

2.1.2. Two-sided markets

In a two-sided market, end users are divided into two distinct groups. In payment markets, one side of users are payees, such as merchants, and the other side are payers, such as consumers. Two types of externalities exist in two-sided markets because decisions of one side of users affect the value of the product or service to the other side of users.

The first type is adoption externalities, or cross-side network effects, which exist when a market is at its infant stage. In order for a new payment method to achieve critical mass, it needs to overcome a chicken-and-egg problem: enough payees must accept the new payment method for payers to use that method, and enough payers must use that method for payees to install the necessary hardware or software to accept that method.

The second type of externalities is usage externalities, which exist even in a mature market where critical mass has been reached or exceeded. For example, a consumer's choice of payment method for a transaction at a merchant will affect the merchant's cost and benefit from that transaction. When the consumer decides which payment method to use, he typically does not take into account the merchant's cost or benefit from the transaction, unless there is a mechanism to incorporate the merchant's cost or benefit, such as surcharges and discounts offered by merchants to their customers based on payment method.

2.1.3. Economies of scale and scope

Production technology that requires significant capital investment often yields increasing returns to scale. As more quantities are produced in a plant, costs per quantity are reduced. In the payment industry a large share of costs is fixed and thus as one provider processes a larger volume of payments, its average cost per payment becomes lower than that of other providers.

Multiple types of payments can be effectively supported by an integrated infrastructure. Compared with entities that specialize in a limited service, entities that play multiple roles, such as network switches and processors for issuers and merchants, likely have lower average cost per payment by exploiting economies of scope. They may have separate physical platforms to play different roles, but other components necessary for payment processing, such as communication protocols, can be used to produce various services, thereby reducing the costs.

The presence of large economies of scale and scope in processing payments may inhibit entry and lead to payment markets in which a small number of large firms operate. This may be cost-effective, but may also give these firms significant market power, which may lead to monopoly or near-monopoly pricing and provide insufficient incentive for innovation.

2.2 Key economic principles related to retail payments security

2.2.1. Jointly produced goods

The strength of payment security is the result of efforts by all participants—not only by entities in the payment supply chain but also end users—and thus is a jointly produced good. The contribution of each participant's efforts to secure payments is a function of the efforts of other participants. This interdependency implies the potential for coordination failure. Thus, without proper coordination of participants, the level of effort and the resulting strength of payments system security are more likely to be inadequate.

Protection of payment card data from breaches is a good example of jointly produced goods. Currently, sensitive payment card data are exchanged among entities in the payment card processing chain, including merchant, merchant processor, acquirer, card network, issuer processor, and issuer. All of these entities' actions are important to protect payment card data

from breaches.[3] To coordinate their actions, the four U.S. credit card networks, along with JCB, established the Payment Card Industry Security Standards Council (PCI SSC).[4] The PCI SSC develops and maintains the PCI Data Security Standards (PCI DSS) as a framework for prevention, detection, and reaction to security incidents. The framework includes an audit function, enforced by each of the card networks, where any entity that stores or transmits sensitive card data must evaluate compliance with the standard.[5]

Many security technologies and protocols require joint adoption by industry participants. For example, both the payer's and payee's payment service providers need to adopt the same encryption standard so that they can read payment instruction and response. Encryption is used to secure sensitive payment data by transforming plain text information into non-readable information. A key (or algorithm) is required to decrypt the information and return it to its original plain text format. Coordination is essential for industry participants to decide which encryption standard to adopt and avoid a chicken-and-egg-problem: both the payers' and payees' service providers may wait to adopt the encryption standard until their counterparts adopt it.

Payment security is designed for defense-in-depth: if one defense is compromised, other defenses may mitigate losses. Although this design is beneficial, it may also cause free-rider problems whereby some industry participants may choose not to leverage useful defenses and instead rely on defenses provided by other industry participants. Thus, without coordination, investments in certain defenses or by certain industry participants may be inadequate.

[3] Consumers also play a role in protecting payment card data, such as keeping PINs or passwords from being exposed to third-parties. Note, however, that consumers' role is limited in that they must accept the technologies that have been offered to them.
[4] The PCI SSC was formed in 2006. For more details, consult *https://www.pcisecuritystandards.org*.
[5] The PCI SSC has also establishes and validates security standards for software payment applications and devices into which a cardholder enters a PIN, as well as maintaining lists of qualified security assessors.

2.2.2. Competition for the market

Profit-oriented firms may compete for the market by employing proprietary security standards rather than participating in open, consensus-based standards development. Although proprietary security standards may support incentives of firms to innovate, they may reduce interoperability. They also may be less secure in that security mechanisms designed in secret do not benefit from an open vetting process to spot bugs prior to deployment. Open, consensus-based standards, on the other hand, are more likely to achieve interoperability by increasing industry participants' willingness to comply with the standards and thus exploit positive network effects (Greenstein and Stango). But they may take longer to develop and may not support innovation incentives. Neither type of standard setting process can avoid coordination problems.

A good example of proprietary security standards is Europay, MasterCard, and Visa (EMV) chip technology. EMV is a set of standards developed and maintained by EMVCo, which is owned by the global card brands. EMV uses the concept of dynamic data to strongly authenticate each and every transaction to mitigate counterfeit fraud in the card present environment.[6] The proprietary nature of the technology standard, coupled with a unique requirement in the U.S debit card industry—specifically, that a debit card carry at least two unaffiliated card networks to process transactions on the card—has provided global brands such as Visa and MasterCard a competitive advantage over U.S. PIN debit networks. Visa and MasterCard, by virtue of their ownership of EMVCo, could have met the requirement by making their chip available only to each other, or to a subset of PIN debit networks they select. After a long debate among card networks, Visa and MasterCard eventually made a series of bilateral agreements with each PIN debit network. While these agreements preserve the interoperability

[6] However, many vulnerabilities have been uncovered in EMV protocols in countries in which EMV chip cards were adopted. See Anderson and Murdoch (2014) for an overview of the technical literature on weaknesses in EMV.

among PIN debit networks, reaching the solutions took a long time.

Another example is "tokenization" developed by EMVCo. A token, which replaces the payment card account number, is used for transactions made at a particular online merchant or mobile wallet provider (for example, Apply Pay). The token and card account number pair is stored on a highly secure server called a "vault."[7] Although this tokenization uses open standards, due to the proprietary environment in which the standards were developed, global card brands may have a competitive advantage at least initially in offering vault services compared with U.S. domestic card networks or processors.

2.2.3. Asymmetric information

Asymmetric information is a situation in which one party has more or superior information than the other. For example, a seller of security products may assert its product is more secure than the other products, but if potential buyers cannot verify it, sellers with better security products are unable to differentiate their product from other, less secure products. As a result, suppliers of security products have little incentive to produce a better product (Anderson).[8]

Asymmetric information may also exist between industry participants and regulators. Industry participants, such as card networks, have more and better information about security technologies, protocols, and standards that are used in their day-to-day operation, while regulators may not have expertise to assess their effectiveness. Thus, regulators' security

[7] With this method of tokenization, the authorization request message for a card payment is initiated with a token, instead of with the actual card number. The message with a token is sent to a vault service provider, which identifies the card number that corresponds to the token and routes the message to the appropriate card issuer through the appropriate card network.

[8] Akerlof (1970) described information asymmetry between sellers and buyers in the market for used cars (the market for lemons). When potential buyers of used cars cannot verify the quality of the cars, sellers of good quality used cars will not place their cars on the used car market. This is summarized as "the bad driving out the good" in the market.

guidelines are often non- or less-prescriptive, allowing industry participants to select the security tools that they perceive as effective.

Information asymmetry can be seen in the reporting of costs of fraud or data security incidents. Many industry participants have an incentive to underreport those incidents. Banks and merchants may not want to reveal fraud losses for fear of frightening away customers using certain payment methods (such as cards) or channels (such as online). They may also not want to reveal data security incidents because of reputational risk. Operators of payment infrastructures may not want to reveal information on outages caused by malicious attack for fear it would draw attention to systemic vulnerability. On the other hand, other industry participants may have an incentive to overstate the aggregate losses in the industry. For example, security vendors may induce their customers to purchase their security services or products by overstating potential losses.

The lack of information about true costs of fraud or data security incidents prevents industry participants from accurately understanding threats and defenses. As a result, security investments may not be properly distributed across appropriate defenses.

2.2.4. Moral hazard

Moral hazard occurs when one person or party takes more risks because someone else bears the burden of those risks. Improper allocation of liability for fraud losses or data breaches discourages security investments made by parties that are best positioned to control the security. An example is a current lack of adoption of strong authentication methods for card-not-present (CNP) transactions, such as for online transactions, which impose a heavier fraud liability to merchants than to card issuers. Although card issuers could play more active roles in authenticating cardholders for online transactions, many U.S. card issuers currently do not do so,

partly because the issuers do not bear most of the CNP fraud losses.

Data breach cost allocation may be another example of potential moral hazard or incentive misalignment. When a data breach occurs at a merchant, costs to compensate damages of the data breach to cardholders and card issuers are generally borne by the merchant and are not shared with its acquirer, who is responsible for ensuring their merchants are PCI compliant. But if some data breach costs are shared with acquirers, they may be more thorough in ensuring their merchants consistently comply with PCI DSS.

2.2.5. Trade-offs between information sharing and privacy

Managing payments security is information intensive. As industry participants share more detailed information, the information becomes more actionable and helps mitigate payment security risks more effectively. But at the same time, the detailed information may raise privacy concerns.

An aggregate, accurate view of payment security incidents, losses, and causes over time would be valuable to better understand threats and defenses, enabling industry participants and policymakers to make informed decisions on security investment or policy. Other types of data sharing activities address data security, cyber-attack, or fraud more directly. For example, Financial Services – Information Sharing & Analysis Center (FS-ISAC) was formed to identify threats, coordinate protections against those threats, and share information pertaining to both actual and potential physical and cyber security threats. Card networks and other payment service vendors use "big data" for neural network intelligence to detect suspicious transactions.

Some data sharing activities are successful, while others have struggled to overcome barriers to cooperation. Cyber-threat sharing may be viewed as one of the most successful examples of information sharing in the payment industry. Besides financial institutions, payment

processors formed their own ISAC as a subgroup of FS-ISAC. Trade associations representing the merchant and financial service industries formed a cyber-security partnership to share threat information, disseminate best practices for cyber risk mitigation, and promote innovation to enhance security. More detailed and particular information than that currently shared may make cyber-threat information more effective and actionable; however, sharing such information may require a safe harbor agreement. For example, a regulation or a rule on privacy protections can specify conditions under which specific data sharing activities will be deemed not to violate a given regulation or rule.

Data on payment fraud are collected and analyzed within large organizations, such as large financial institutions and global card networks, but such data are not shared broadly. Although the Federal Reserve has started collecting some fraud data in its triennial payment study, they are very high level and may not be detailed enough or available in a timely manner to be actionable. Organizations may hesitate to share fraud data because doing so may expose the organizations to reputational risk and have privacy implications.

To detect suspicious transactions, neural network intelligence is used along with, or as a substitute for, stronger payer authentication. The neural network intelligence leverages "big data," such as payers' spending patterns and geographical areas, to flag payments outside of a specific payer's "norm." The data may be effective to mitigate payment fraud, but they raise privacy concerns because the data include detailed behavioral information about individual consumers.

3. Strategies to achieve desired payments security – game theory approach

In considering payments security strategies, a game theory approach would be useful. To examine whether the current market structure will be able to develop, implement, and adopt a

specific security technology, method, or protocol, the game theory approach defines actual players, their preferences, rules of the game including actions available to each player, and outcomes of the game. If the results suggest the current market would be unlikely to achieve the goal, this approach also enables us to consider which part(s) of the game needs to be modified to achieve the desired level of security, providing insights into public policy and private entities' strategies.

3.1 Game theory

Game theory is the formal study of conflict and cooperation. Game theory can be applied whenever the actions of two or more entities—individuals, organizations, governments—are interdependent. These entities make choices among actions in situations where the outcomes depend on the choices made by both or all of them and each has his, her, or its own preferences among the possible outcomes. The concepts of game theory are useful to understand, analyze, structure, and formulate strategic scenarios. Readers familiar with game theory can skip this subsection and resume in Subsection 3.2 where applications to payments security are presented.

A game is a formal model of an interactive strategic situation. It typically involves two (or more) players, their preferences, their information, their available actions, and outcomes represented by a separate payoff for each player. In a game, the outcomes and the actions available to the players are assumed to be common knowledge. In other words, each player knows not only his own payoffs and actions but also the other players' payoffs and actions. Typically, each player is assumed to be rational and always chooses an action which gives the outcome he most prefers (or the highest payoffs), given what he expects his counterparts to do.[9]

To describe a 2-player, 2-action game, the *strategic form* (also called *normal form*) is

[9] This rationality assumption can be relaxed and more recently the resulting models have been applied to the analysis of observed behavior, including laboratory experiments.

typically used (Figure 1). In this game, Player 1 has two actions to choose from—Up or Down—and Player 2 also has two actions—Left or Right. When Player 1 chooses Up and Player 2 chooses Left, the strategy profile is denoted as (Up, Left), and the payoff of that strategy for Player 1 is A and that for Player 2 is a.

Figure 1: 2-player 2-action game

		Player 2	
		Left	Right
Player 1	Up	A, a	C, c
	Down	B, b	D, d

In a game theory, an equilibrium (often called Nash equilibrium) is the set of choices of each player that provides the maximum payoff to the players given what they believe about the other players' beliefs, and all players beliefs are rational.[10] The equilibrium depends on both *actions* and *beliefs*, and is stable because all players have the same information and the actual choices coincide with the beliefs of the players.

Consider a numerical example in Figure 2. Player 1 chooses his action based on his beliefs about Player 2's behavior. Suppose Player 1 believes Player 2 chooses Left, then he chooses Up, because his payoff is higher by choosing Up than by choosing Down (10 vs. 0). And his belief about Player 2 is reasonable: if Player 2 believes Player 1 chooses Up, then she chooses Left because her payoff is higher by choosing Left than by choosing Right (5 vs. 0). Since each player's belief about the other player's choices coincides with the actual choices the

[10] A more formal definition is the following: A pair of strategies (s_1^*, s_2^*) satisfies two conditions. First, given Player 2's strategy s_2^*, Player 1 earns the higher payoff by choosing s_1^* than by choosing any other strategy available to Player 1. Second, given Player 1's strategy s_1^*, Player 2 earns the higher payoff by choosing s_2^* than by choosing any other strategy available to Player 2. In other words, each player's belief about the other player's choices coincides with the actual choices the other player intends to make.

other player intends to make, (Up, Left) is an equilibrium of this game. Another equilibrium exists in this game. Suppose, Player 1 believes Player 2 chooses Right, instead. In this case, Player 1 chooses Down, because his payoff is higher by doing so than otherwise (5 vs. 0). His belief about Player 2's action is also reasonable because if Player 2 believes Player 1 chooses Down, then her choice is Right, rather than Left. Again, each player's belief about the other player's choices coincides with the actual choices the other player intends to make, and therefore, (Down, Right) is an equilibrium as well.

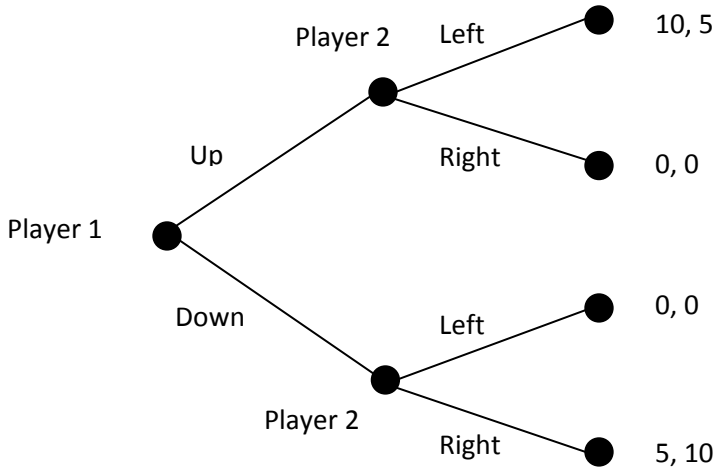
Figure 2: Numerical example of 2-player 2-action game

		Player 2	
		Left	Right
Player 1	Up	10, 5	0, 0
	Down	0, 0	5, 10

The above example describes a case where both players make their choices simultaneously. But what if Player 1 chooses his action before Player 2 and Player 2 chooses action after knowing Player 1's action? To describe a sequential game, a *game tree* (also called *extensive form*) is used (Figure 3). A choice in the game corresponds to the choice of a branch of the tree and once a choice has been made, the players are in a *subgame* consisting of the strategies and payoffs available to them from then on. If Player 1 chooses Up, it will be optimal for Player 2 to choose Left, which gives a payoff of 10 to Player 1. If Player 1 chooses Down, it will be optimal for Player 2 to choose Right, which gives a payoff of 5 to Player 1. Player 1 is better off by choosing Up than Down, and thus, (Up, Left) is the equilibrium for this sequential game. Unlike the simultaneous-move game above, Player 1 does not have to consider the

possibility that Player 2 chooses Right because once Player 1 chooses Up, the optimal choice in the resulting subgame is for Player 2 to choose Left.

Figure 3: Sequential game (extensive form)



3.2 Applications to payment security

Both the strategic form and a game tree can be used to conceptualize coordination problems the payment industry faces to achieve high level of security. Some coordination problems are relatively easy to solve, while others are more complicated.

As an easy coordination problem, consider a game shown in Figure 4. In this game, two players choose to adopt either one of two security technologies: Technology 1 or Technology 2. Both technologies require joint adoption by both players to be effective. Technology 1 is superior to Technology 2, in terms of its effectiveness of making payments secure or its costs of initial investments and ongoing operation incurred by each of the players. In this game, (Technology 1, Technology 1) and (Technology 2, Technology 2) are equilibria, although the

former provides higher payoffs to both players than the latter. It may be easier to reach the equilibrium which provides higher payoffs to both players than the other equilibrium. Since both players have no incentive to deviate from cooperation, either or both of the players can provide their true preference for technology before the game. Or a regulator's non-prescriptive guidance in encouraging industry participants to adopt "stronger" security may be sufficient to reach the equilibrium of (Technology 1, Technology 1).

Figure 4: Security technologies that require joint adoption

		Player 2	
		Technology 1	Technology 2
Player 1	Technology 1	10, 10	0, 0
	Technology 2	0, 0	5, 5

The second example is the same as above except that both technologies are equally effective (Figure 5). Two equilibria exist for this game, and both equilibria are equally preferred by both of the players. In this case, a regulator's non-prescriptive guidance may not help select one of the two equally effective technologies to adopt in the industry. But the industry can easily select either one of the technologies by negotiating which technology to pick.

Figure 5: Equally effective security technologies that require joint adoption

		Player 2	
		Technology 1	Technology 2
Player 1	Technology 1	10, 10	0, 0
	Technology 2	0, 0	10, 10

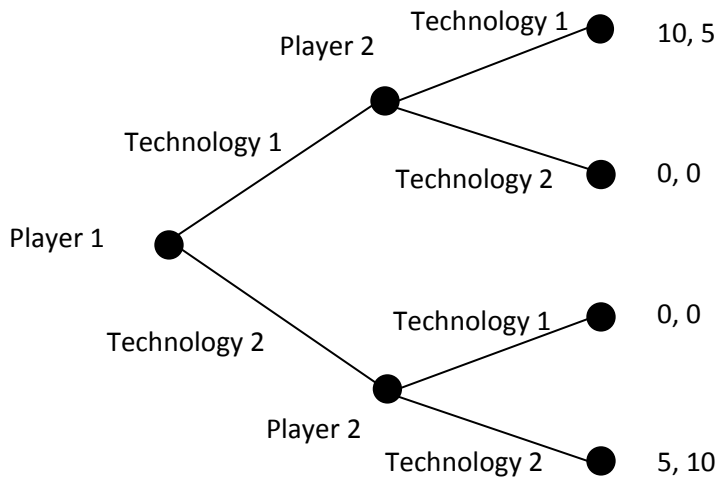
A third example shows the case where reaching one solution is more complicated than the previous two examples (Figure 6).[11] The payoffs of this game are exactly the same as the numerical example shown in Figure 2. Like the previous two examples, the two technologies require joint adoption. But in this game, payoffs are asymmetric. Among the two equilibria, Player 1 prefers both players adopt Technology 1, while Player 2 prefers both players adopt Technology 2. Unlike the example shown in Figure 5, industry negotiation may not be easy unless one player has stronger bargaining power than the other. Or alternatively, if one player can move before the other player, they can reach one equilibrium (Figure 7). In this case, the first mover (say, Player 1) has the advantage and chooses the technology the first mover prefers. Since the second mover is better off by choosing the same technology the first mover chose rather than by choosing the other technology, this sequential game has one equilibrium, in which both players' adopting the technology the first mover prefers.

Figure 6: Asymmetric payoffs with security technologies that require joint adoption: Simultaneous move game

		Player 2	
		Technology 1	Technology 2
Player 1	Technology 1	10, 5	0, 0
	Technology 2	0, 0	5, 10

[11] This example is known as battle of the sexes or conflicting interest coordination.

Figure 7: Asymmetric payoffs with security technologies that require joint adoption: Sequential game



The next example is the case where one technology requires joint adoption, but another technology does not require joint adoption (Figure 8).[12] The technology requiring joint adoption (Technology 1) is more effective in securing the payments system than the technology that does not require joint adoption (Technology 2). Two equilibria exist in this game: both players' adopting Technology 1 or both adopting Technology 2. Similar to the first example, both players prefer both adopting Technology 1 over both adopting Technology 2. Nevertheless, the coordination may be more difficult in this example than the first example. The problem here is the riskiness of adopting Technology 1. While adopting Technology 2 guarantees a payoff of 7 for both parties, adopting Technology 1 provides either 10 or 0. For this reason, both players might choose the less risky Technology 2.

[12] This example is known as the stag hunt game.

Figure 8: Security technology that requires joint adoption vs. one does not

		Player 2	
		Technology 1	Technology 2
Player 1	Technology 1	10, 10	0, 7
	Technology 2	7, 0	7, 7

3.3 Tools to influence the game

The previous two subsections consider the structures of games, such as players, their available actions, sequence, and payoffs, are given. In reality, however, the structures can be changed. Myerson (2009) suggested necessary steps to change the structure of a game so that the players of the game can achieve collective action. The structures of games are influenced by various factors, including pricing, liability distribution, industry requirements, regulatory mandates, subsidies and property rights. By using these factors as tools, regulators and payments system operators can change the structures of games to overcome coordination problems.

Regulatory mandates and industry requirements, for example, may limit actions available to players. They may also change the sequence of a game, so that the game provides a level playing field for every player. Subsidies, liability distribution, and pricing can be used to change payoffs. Subsidies from government or card networks may be provided if players select socially desirable actions, enticing each player to select those actions. Heavier fraud or data breach liability may be imposed on players if they select actions that are not socially desirable. Pricing, such as interchange fees, can be structured so that players who adopt stronger security technology or protocols are more rewarded than those who do not. Property rights or standard setting may affect payoffs as well as sequence of games. Having consensus-based standards,

rather than proprietary standards, may distribute payoffs more evenly across different players and eliminate the first mover advantage to players who have property rights versus players who do not.

To illustrate the value of modeling payments security scenarios using game theory, consider the EMV migration currently underway in the United States. At the time of writing, issuers are generally liable for card-present (CP) fraud.[13] In October, 2015, the fraud liability for a CP transaction will shift to the merchant if the merchant does not adopt EMV but the issuer does.[14] If neither or both parties adopt EMV, then the fraud liability will remain as it is today.[15] How the liability shift incentivizes merchants to adopt EMV and changes equilibrium can be demonstrated in a game theory framework.

Both before and after the liability shift, issuers and merchants have a choice of whether they adopt EMV or not. Figures 9 and 10 represent hypothetical payoff matrices for EMV adoption before and after the liability shift.[16] In both figures, the payoffs are set relative to the status quo of issuers distributing magnetic stripe cards and merchants not deploying EMV terminals. Suppose EMV adoption by both issuers and merchants will reduce CP fraud by 4 in value. Suppose also EMV adoption will require issuers and merchants respectively to spend additional cost of 2. For example, the additional cost for issuers includes the cost of issuing EMV cards relative to that of issuing magnetic stripe cards. Similarly, the additional cost for merchants includes the cost of deploying EMV terminals relative to the cost of deploying terminals that can read magnetic stripe cards only.

[13] Two main sources for CP fraud are counterfeit and lost or stolen cards.
[14] Liability shift for transactions at automated fuel dispensers will be in October, 2017. Visa will shift liability of counterfeit fraud, while MasterCard will shift liability of both counterfeit and lost or stolen fraud.
[15] MasterCard introduced a security hierarchy in which fraud liability will shift to the party with the highest risk environment. In this hierarchy, MasterCard considers an EMV card used with a PIN to be more secure than an EMV card used with a signature.
[16] To simplify the model, all issuers are assumed to be homogeneous and make the same choice, and all merchants are also assumed to be homogeneous and make the same choice.

Before the liability shift, merchants always choose not to adopt EMV regardless of issuers' choice (Figure 9). If merchants adopt EMV, they incur the additional cost of 2. Even if issuers also adopt EMV, merchants do not receive any benefit from the reduced CP fraud because issuers are liable for CP fraud. Thus, merchants' net payoff is -2 when they adopt EMV regardless of issuers' choice. If merchants do not adopt EMV, then they do not incur additional cost at all and thus their net payoff is zero. Given merchants always choose not to adopt EMV, issuers also choose not to adopt EMV. By adopting EMV, issuers incur the additional cost but they cannot reduce CP fraud because merchants do not adopt EMV. Hence, their net payoff is negative. On the other hand, if issuers do not adopt EMV, they incur no additional cost and thus their net payoff is zero. In this game, the only equilibrium is both issuers' and merchants' not adopting EMV.

Figure 9: Hypothetical payoff matrix for EMV adoption before liability shift

		Issuer Adopt EMV?	
		No	Yes
Merchant Adopt EMV?	No	0, 0	0, -2
	Yes	-2, 0	-2, 2

After the liability shift, merchants are liable for CP fraud if they do not adopt EMV but issuers do. The only outcome where payoffs change from Figure 9 to Figure 10 is (No, Yes) strategy profile, that is where merchants choose not to adopt EMV and issuers choose to adopt EMV. In this case, merchants' net payoff is -4: although merchants incur no additional cost for terminal deployment, they incur CP fraud losses of 4, the liability shifted from the issuers. Under the modified payoff matrix, the only equilibrium is now (Yes, Yes). Hence, in a situation where

payment card networks can alter liability distribution, they can influence payoffs in a way that encourages the adoption of secure technologies.

Figure 10: Hypothetical payoff matrix for EMV adoption after liability shift

		Issuer Adopt EMV?	
		No	Yes
Merchant Adopt EMV?	No	0, 0	-4, 2
	Yes	-2, 0	-2, 2

It is worth noting that while the payment card networks' liability shift will likely generate the more secure outcome, it may not distribute the net benefit equally to the involved parties. Indeed, the equilibrium payoff for merchants in the game after the liability shift is less than that in the game before the shift. However, it is difficult to infer the fairness of this liability shift from these payoffs for a few reasons. First, since the payoffs in these games are set relative to the status quo, the actual payoffs in absolute term are unknown. Thus, this unequal net benefit distribution could worsen, or improve, the distribution of initial payoffs in absolute term between merchants and issuers. Second, potential indirect benefits of EMV migration are disregarded in these games. For example, if EMV migration will increase the share of transactions made with PIN, merchants will reduce interchange fee payments to issuers. The EMV migration may also facilitate mobile payment adoption, which may benefit merchants and issuers. Third, as these games indicate, even if merchants incur the heavier burden than issuers for EMV migration, merchants may incur the lighter burden than issuers for other complementary security improvements, such as stronger authentication for CNP transactions. It is important for entities that can influence the structure of coordination games, such as regulators and payments system

operators, to have security strategies with a broad scope so that the costs and benefits of security improvements as a whole—rather than those of a single security improvement— can be distributed fairly among the involved parties.

4. Case studies

Fraud, data breaches, and other security incidents should be minimized in a cost-effective manner in order to maximize the social benefit of payments. In principle, this could be achieved if the payment participant in the best position to prevent these incidents took steps to detect and deter them. In the ideal world, the best positioned payment participant has enough incentive to balance the incremental costs of security against the incremental reduction in fraud, data breaches and other security incidents. Public and private entities ensure payment security by increasing incentives among industry participants to secure data and deter fraud. They enforce laws and contractual rules (sometimes embedded in operational procedures) through mechanisms such as regulations, supervision, and audits (Sullivan). In reality, however, it is not easy to coordinate industry participants and align their private incentives so that private benefits and costs correspond to social benefits and costs. When private benefits or costs are not aligned with social benefits or costs, the level of security is typically not at the socially desirable level.

Four case studies illustrate situations where incentives appear insufficient to adequately secure payments. In some markets, however, incentive misalignment has been reduced due to coordinated efforts led by public authorities or among industry participants voluntarily, while in other markets incentive misalignment remains unaddressed. Each case study identifies economic principles that explain incentive misalignment or sources of conflict to make coordinated efforts among industry participants for payment security difficult. It also describes whether and how the coordinated efforts have reduced conflict or incentive misalignment.

The first concerns fraud in CNP payments, such as online payments where the card is not physically presented to a merchant. Because access to the card is eliminated, the merchant cannot authenticate the card or the buyer's signature, leading to high rates of fraud losses. Systems to improve CNP payment authentication have been available for many years but have not been widely adopted in the United States.

The second case study illustrates inadequate protection of sensitive payment data that is useful for committing payment fraud. Despite card brands creating institutions to encourage strong security over sensitive data, card accepting merchants and card payment processors have been victims of successful attacks that penetrate computer system defenses and allow unauthorized access to sensitive data. The expectations for card payment security has been ratcheted up over time yet data breaches appear to be more frequent and expose more data. There is some evidence showing higher rates of compliance with security standards recently yet data breaches continue to grow.

Mobile payments are the third case study. This emerging payment method, or form factor, offers the promise of improved security through the use of tokenization. However, adoption remains low. One explanation for the slow uptake is that the new stakeholders are involved (device manufacturers and carriers), and they are fiercely competing for the market even when it comes at the expense of network effects needed to achieve widespread adoption. Unresolved tussles over who gets to control payment metadata also threaten adoption. Moreover, early evidence suggests fraud rates exceed existing methods.

The fourth case study, cryptocurrencies, demonstrates security that is, in some respect, more secure than existing payment methods in that no sensitive account information is transmitted with payments. They may also be the most "disruptive" challenger to existing

payment networks. Payment processing services make it easy for merchants to accept payments in bitcoin, and do so at very attractive terms to merchants: zero transaction fees and non-revocability. Nonetheless, significant barriers remain. Consumer incentives to adopt cryptocurrencies for payments are weak, with the exception of international payments in the remittance market. Operational risks due to widespread fraud (both payment fraud and broader financial fraud) could inhibit adoption, particularly when compared to the consumer protections available in traditional payments.

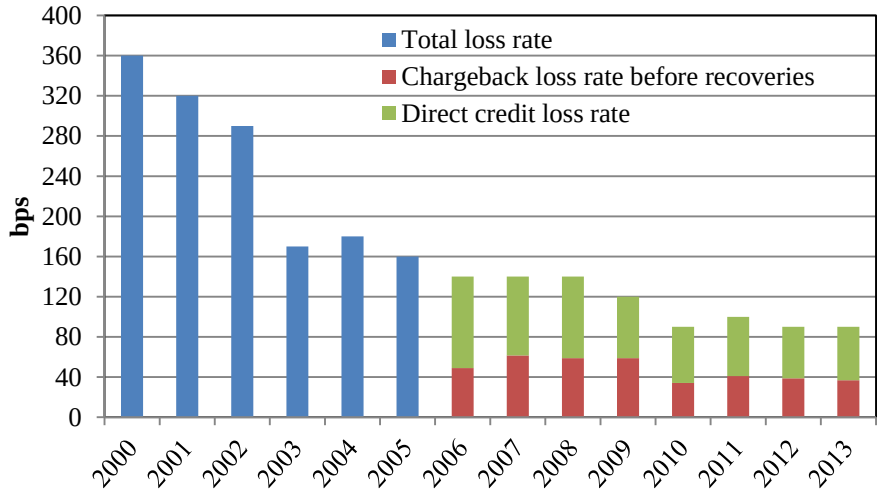
4.1 Reducing fraud in CNP payments

CNP payments, where the merchant sees neither the payment card nor the cardholder, have high fraud loss rates. A recent survey of U.S. and Canadian internet merchants suggests a loss rate of 38.7 basis points (0.387 percent) on the value of sales in 2013 for chargebacks, which are transactions reversed by the card issuer, as fraudulent (Cybersource 2015).[17] The survey also reports an average 51.3 basis point (0.513 percent) loss of the value of sales for refunds provided to customers who contact the merchant, instead of their issuers, to report unauthorized transactions (Chart 1).[18] In this case, merchants credit directly to the customer's payment card account.

[17] The rate is the gross loss of funds charged back to the merchant for fraudulent transactions. The merchant can the recover funds if it successfully challenges the fraudulent status of the transaction. In 2013, merchants reported successfully challenging 41 percent of fraud chargebacks, which implies a net fraud loss rate of 22 basis points on card transactions. The loss rate is roughly twice that found on all CNP debit and credit card transactions for 2012 (Federal Reserve System). In the Federal Reserve's study, CNP transactions include telephone, mail order, and pay-at-the-pump gasoline purchases in addition to e-commerce transactions.

[18] An unknown portion of these refunds is fraud by someone other than the cardholder (third-party fraud).

Chart 1: Fraud loss rate on the value of Internet transactions
United States



Source: Cybersource (various years).

To combat fraud, internet merchants review a range of information to evaluate whether a transaction is trustworthy. Merchants commonly verify payment card numbers, customer addresses, and phone numbers, as well as consult their own records for a history of serving customers. These measures have helped to bring the fraud loss rate down since 2000 but it still remains high (Chart 1).

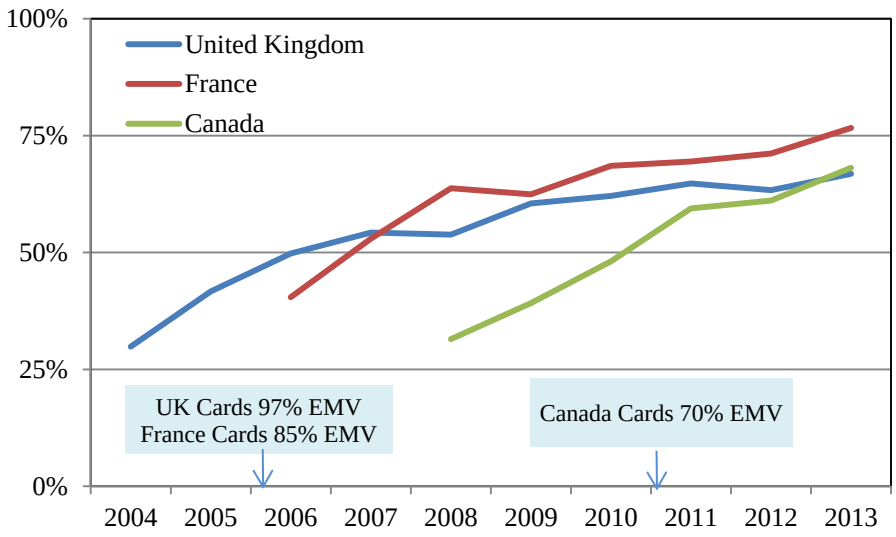
The fight against fraud in CNP payments is an urgent matter in the United States for two reasons. First, CNP payments, especially in internet commerce, will continue to expand and thus transfer transactions from relatively safe brick-and-mortar locations to the more fraud-prone online marketplace. Second, and more important, in 2015 the United States will begin to deploy new payment cards that contain an EMV chip. These chip cards will cut off counterfeit payment cards in the United States, a leading cause of fraud transactions on card payments.[19] When the cardholder also enters a PIN to initiate a payment at brick-and-mortar locations, the chip card

[19] Financial institutions report that over half of fraud transactions on both PIN and signature debit cards were on counterfeit cards in 2012 (American Bankers Association). The share has risen steadily since 2006.

also prevents fraud on lost or stolen cards.[20]

The rest of the world has moved to chip cards, and in many countries fraud shifted to channels with relatively weak security. Fraud increased dramatically in CNP transactions such as internet, mail order, and telephone order purchases, where cardholder authentication is weak because the payment card is not physically presented to the merchant. The United Kingdom, France, and Canada each experienced substantial increases in fraud on CNP transactions, which became the leading source of fraud on card payments soon after introduction of chip cards (Chart 2). It is likely the United States will have a similar experience.[21]

Chart 2: CNP fraud share in card payment fraud losses
United Kingdom, France, and Canada



Sources: Financial Fraud Action; Canadian Bankers Association, Credit Card Fraud Statistics; OPCS; Lucas (2011).

[20] Including cards stolen in intercepted mail.
[21] Many issuers of chip cards in the United States will not require a PIN to initiate a payment, and instead may require a signature or other method of authorization. As a consequence, fraud via theft of payment cards (in person, intercepting mail, or other means) will be relatively more attractive to fraudsters and may increase after chip cards are introduced.

The difficulties of authenticating payment cards and cardholders in CNP payments contribute significantly to these losses. Because an internet merchant has little reliable evidence of who initiated the purchase, it cannot easily dispute a fraud chargeback or counter the claim of a customer who denies making an online purchase.[22]

Authenticating a cardholder in CNP transactions can be improved by adding a step to payment initiation. To initiate a transaction, the cardholder enters a password, which is previously shared with his card issuer, or a special code received from his card issuer. Because only the cardholder would know the password or code, it adds assurance that the cardholder truly initiated the transaction.

Two common methods of enhanced authentication are 3D Secure (3DS) passwords, offered by the major payment card brands, and single-use codes sent to the cardholder via text messages, available from a variety of processors. The 3DS system requires a cardholder to register with the program and create a password that is used solely for CNP transactions. A cardholder must also register for single-use code authentication systems and have a mobile device to receive the code.[23]

Available in the United States since 2003, 3DS has gained little traction. In 2013, only 21 percent of merchants responding to a survey reported using 3DS for internet transactions. Survey estimates of adoption rates among merchants in 2013 range from 3 percent to 21 percent (TSYS; Cybersource 2015).[24] Adoption has lagged despite evidence that enhanced authentication has proven effective at reducing payment fraud in internet transactions in France (OPCS 2013a). The puzzle is why it is not more widely adopted in the United States.

[22] If false, the claim of a customer who denies making an online purchase is an example of "friendly fraud," which occurs in both online and in person transactions.
[23] Single-use tokens for CNP payment appear to be more common outside of the United States. They are used in the United States primarily for authentication when a password is changed.
[24] Card companies have not reported how many card issuers have deployed 3DS.

An important reason is that incentives to adopt are misaligned.[25] Card issuers absorb fraud losses in CP transactions and thus take advantage of physical authentication (signature or PIN) to deter fraud. But card issuers do not absorb the loss on fraudulent CNP transactions and thus do not have much incentive to enhance authentication. Merchants, on the other hand, in the absence of wide-scale adoption, fear that the extra steps in the checkout process required by enhanced authentication will cause customers to abandon an online shopping cart and make their purchases elsewhere. Indeed, a recent study reports cart abandonment in 3DS transactions is over 40 percent in the United States (Adyen), a substantial disincentive for merchants to adopt the system.[26] Because everyone would be better off if everyone is collectively switching to a stronger authentication process, the current misalignment of incentives—no parties have a strong incentive to be the first party to make changes—is an example of a chicken-and-egg barrier.

This chicken-and-egg barrier can be illustrated in a game theory framework. Consider a game in which two merchants compete in the circumstance where issuers' 3DS adoption rate is quite low and a merchant's adoption of 3DS does not shift fraud liability to issuers (Figure 11). Suppose that a merchant can reduce CNP fraud by 2 by adopting 3DS but it may lose sales by 3 to its rival merchant if the rival merchant does not adopt 3DS.[27] The payoffs for both merchants are higher when both adopt 3DS than when neither adopts it; nevertheless, they cannot reach that outcome because a merchant is better off by not adopting 3DS when its rival accepts it.

[25] See Appendix A for the detailed discussion about costs and benefits of 3DS adoption for issuers and merchants.
[26] The cart abandonment rate for France is about 14 percent (OPCS 2013a).
[27] In this game, the payoffs are set relative to the status quo of merchants not adopting 3DS.

Figure 11: Hypothetical payoff matrix for 3DS adoption:
Low issuer adoption rate and no liability shift

		Merchant 2 Adopt 3DS? No	Merchant 2 Adopt 3DS? Yes
Merchant 1 Adopt 3DS?	No	0, 0	3, -1
	Yes	-1, 3	2, 2

Consider another 2-merchant game when the benefit of 3DS exceeds the cost of forgone business. This could be achieved by either a higher 3DS adoption by issuers or by shifting liability to issuers for potential 3DS transactions, or both (Figure 12). Merchants can now reduce CNP fraud by 4 by adopting 3DS, but it may still lose sales by 3 to its rival merchant if the rival merchant does not adopt 3DS. In this game, the most secure outcome—both merchants' adopting 3DS—is the single equilibrium.

Figure 12: Hypothetical payoff matrix for 3DS adoption:
High issuer adoption rate or liability shift to issuers

		Merchant 2 Adopt 3DS? No	Merchant 2 Adopt 3DS? Yes
Merchant 1 Adopt 3DS?	No	0, 0	3, 1
	Yes	1, 3	4, 4

These two games suggest that if the benefit from reduced fraud by adopting 3DS exceeds the opportunity cost of lost sales, then the most secure outcome is the likely equilibrium.

Increasing issuers' adoption of 3DS is an important first step. The higher the issuers' adoption rate of 3DS, the greater the reduction in fraud losses incurred by merchants will be.

This, in turn, could increase merchants' adoption of 3DS, and thereby diminish the opportunity cost of offering 3DS in terms of business lost to rivals. Hence the interaction between merchants and issuers exhibit substantial cross-side network effects in the two-sided market. Were issuers to assume liability for CNP transactions at merchants who adopt 3DS, this could make adoption more attractive to merchants. As more merchants adopt 3DS, more issuers are also willing to adopt 3DS.

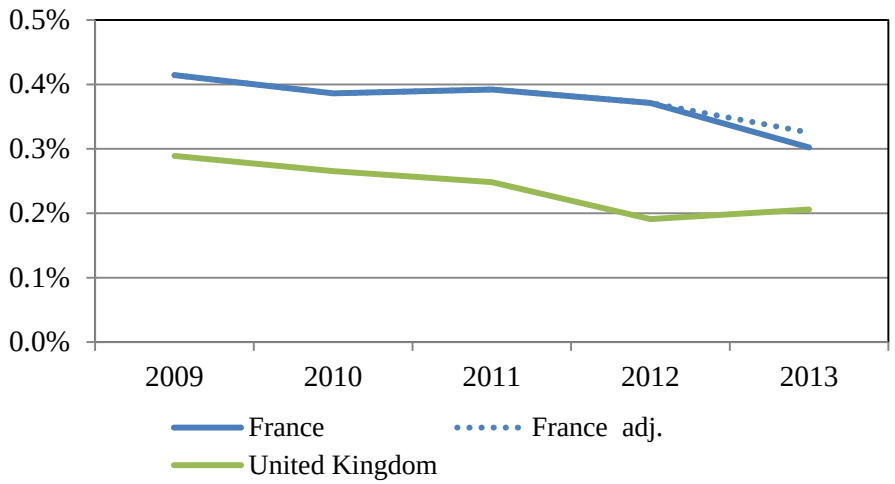
The experiences of some countries can shed light on how greater adoption of enhanced online authentication might be encouraged. France and the United Kingdom have successfully increased adoption of 3DS and reduced their CNP fraud rates; however, approaches taken by these two countries were different. In France, the Bank of France and OPCS played a leadership role, while in the UK, participants in the payment card industry adjusted their behavior to new incentives created by rapidly rising CNP fraud losses with little involvement by public authorities.

In various ways, leadership of the Bank of France helped to promote collective action on CNP fraud. It tracked CNP fraud and revealed a growing problem (OPCS 2008a). It researched options for securing CNP transactions and cited value of 3DS system in enhanced authentication (OPCS 2008b). It examined consumer attitudes towards security in CNP transactions (OPCS 2009). It engaged card issuers and merchants in a working group and partnered with payment participants to find ways to lower cart abandonment among consumers asked to use enhanced authentication in online transactions (OPCS 2010). Instead of being overly prescriptive in specifying the technology, the Bank of France let card schemes and issuers freely evaluate and implement forms of strong online authentication that best fit their needs (OPCS 2013b).

France has shown considerable progress with CNP fraud by adopting 3DS. In 2008, a

significant number of card issuers began to accept fraud losses if the merchant used 3DS authentication for internet transactions. Merchants and cardholders also took actions: in 2013, 95 percent of cardholders had access to enhanced authentication, and 43 percent of internet merchants used it for transactions that account for nearly 30 percent of the value of internet sales (OPCS 2013a). The fraud loss rate in internet transactions fell steadily since 2009, to 0.29 percent of the value of transactions in 2013 (Chart 3).

Chart 3: Fraud loss rate on the value of Internet transactions
France and the United Kingdom



Sources: Financial Fraud Action; UK Office of National Statistics; OPCS.
Notes: For 2013, the OPCS changed its method for calculating fraud on CNP transactions, which lowered the fraud rate on ecommerce transactions. The France adj. series shown makes a rough adjustment to obtain a fraud rate more comparable to previous years, and demonstrates that the continued downward trend in the loss rate is unlikely to be a result of the change in OPCS methods.

In the United Kingdom, in contrast, concerted efforts of card issuers, card networks, merchant acquirers, and merchants were drivers of 3DS adoption. Merchant acquirers provided incentives to merchants for adopting 3DS and for promoting cardholder enrollment in the system. Card networks and issuers developed an enhancement to 3DS so that merchants can

flexibly decide when to use 3DS.[28] Computer analysis of payment at initiation is used to predict the likelihood of fraud. The merchant can choose the threshold for requiring 3DS, and if the risk of fraud on an enrolled card is low, the transaction would not require a password for approval but the merchant is still not liable for fraud (Cybersource 2012). Moreover, the simplified transaction process reduces the rate of cart abandonment. Interestingly, more recent estimates show that internet shoppers in Great Britain are more likely to complete a purchase if the merchant uses 3DS (Adyen). The merchants' adoption of 3DS may have altered consumers' perceptions toward 3DS from negative to positive.

The United Kingdom also made progress in adopting 3DS and reducing CNP fraud. About half of UK payment cards were enrolled in 3DS by 2011 (British Retail Consortium, private communication 2011). Nearly 70 percent of UK merchants used 3DS as one tool to combat card payment fraud in 2013 (British Retail Consortium 2014). Statistics on the UK fraud rate for internet card transactions are less precise than those for France, but available data suggest a decline in the rate since 2009 (Chart 3).

In the United States, similar barriers to enhanced authentication are present and high rates of fraud in CNP transactions will likely persist without increased effort to make changes that properly align incentives. Like in the United Kingdom, Visa and MasterCard have recently taken important steps to reduce the burden of 3DS on merchants (Montangue). First, in 2011, MasterCard joined Visa in shifting the liability of fraud for U.S. merchants to the card issuer for CNP transactions that go through the 3DS system. Second, rather than sending a customer to a card issuer's website to enter a 3DS password, merchants can now choose to present the

[28] Some card issuers, however, have shifted liability onto consumers. For example, the terms and conditions of RBS Secure, its 3DS implementation, state that "You understand that you are financially responsible for all uses of RBS Secure." See https://www.rbssecure.co.uk/rbs/tdsecure/terms_of_use.jsp.

password entry window on their own websites.[29] Third, merchants also have some control over what transactions go through 3DS. For example, a merchant can accept the payment of a customer it has served for a period of time without requiring 3DS. The merchant does not get a payment guarantee, but from its perspective the transaction has low risk and its long-time customer can enjoy a simplified checkout process.

Whether these changes are sufficient to drive U.S. adoption of enhanced online authentication of card payments is yet to be seen. Network effects in a two-sided market can be difficult to overcome when the current equilibrium is low adoption by both sides. Nonetheless, since large numbers of EMV cards will be distributed in 2015, the time is very short to get meaningful numbers of merchants, issuers, and consumers to use enhanced authentication.

4.2 Protecting sensitive data

Data breaches are a common but particularly damaging method of stealing card data.[30] Hackers access large numbers of payment card records from computer systems where the data is stored. The stolen card data can be used to create counterfeit payment cards useful in over the counter purchases. They can also be used to make CNP purchases.

To better protect payment card data, the major card brands joined together in 2006 to establish the Payment Card Industry Security Standards Council (PCI SSC) as part of their risk control structure. The PCI SSC develops and maintains the PCI Data Security Standards (PCI DSS), and each card brand enforces compliance with the PCI DSS for entities that process its payments and for merchants that accept its cards. A tiered compliance system imposes stricter

[29] Academic researchers panned the initial design of 3DS due to poor usability (Murdoch and Anderson). The design ran counter to many of the cues adopted to fight phishing, such as by asking users to input their credentials to unfamiliar websites. The system was also vulnerable to phishing attempts to retrieve user passwords.
[30] Other methods of obtaining card data include social engineering, phishing emails, and installation of skimmers on payment terminals or ATMs.

validation requirements on large, higher risk merchants, which must engage independent validation assessors on at least an annual basis, but allows smaller merchants to perform self-evaluations. Large merchants are more likely to be validated as compliant with the PCI DSS than are smaller merchants. For example, in 2014, 97 percent of Visa's 450 largest merchants (Level 1), whose aggregated transactions accounted for 50 percent of Visa's U.S. transactions, validated as compliant with the PCI DSS (Table 1). The proportions of compliant merchants decline for smaller merchants (Levels 2–4).

Table 1: PCI DSS compliance status for merchants accepting Visa cards in 2014

Merchant Level (Annual Transactions)	Estimated Population Size	Estimated Share of Visa Transactions	PCI DSS Compliance Validation	Validated Not Storing Prohibited Data
Level 1 Merchant (>6M)	450	50%	97%	100%
Level 2 Merchant (1-6M)	972	13%	88%	100%
Level 3 Merchant (e-commerce only 20,000 – 1M)	4,095	< 5%	61%	N/A
Level 4 Merchant (<1M)	~ 5,000,000	32%	Moderate**	TBD

**As of June 30, 2014. Level 4 compliance is moderate among stand-alone terminal merchants, but lower among merchants using integrated payment applications.
Source: *http://usa.visa.com/download/merchants/cisp-pcidss-compliancestats.pdf*.

High compliance validation rates among level 1 and 2 merchants were achieved in the first few years after the card brands started enforcing PCI DSS in 2006 (Table 2). The compliance validation rates were 12 percent for level 1 merchants and 15 percent for level 2 merchants at the end of the first quarter of 2006, which increased to 91 percent and 87 percent, respectively, by the end of year 2008. The compliance validation rate for level 1 merchants has been higher than 95 percent for the past several years, while that for level 2 merchants peaked at 99 percent in 2010 and has declined since then. The rate for level 3 merchants has been lower: it

has been around 60 percent for the last few years.

Table 2: PCI DSS compliance validation rates for merchants accepting Visa cards

	2006	2008	2010	2012	2014
	Q1	Q4	Q2	Q2	Q2
Level 1 Merchant (>6 million annual transactions)	12%	91%	99%	97%	97%
Level 2 Merchant (1-6 million annual transactions)	15%	87%	99%	93%	88%
Level 3 Merchant (e-commerce only, 20,000 – 1 million annual transactions)	n.a.	n.a.	n.a.	60%	61%

Despite the relatively higher compliance validation rates among larger merchants, data breaches that exposed millions of payment card accounts have occurred at several larger merchants in the last few years. Among the largest U.S. breaches that exposed payment card data are the 2009 breach at Heartland Payment Systems (130 million records), the 2013 breach at Target Brands, Inc. (40 million records) and the 2014 breach at Home Depot (56 million records). The total number of U.S. data breach incidents, which includes breaches that exposed non-payment card data, was 1,343 in 2014, as compared to just over 600 in 2009 (Sullivan; Risk Based Security). During the same period, the number of records exposed per year also increased from about 200 million to 512 million.

It is hard to reconcile a long established audit regime for data security and high levels of compliance with an increasing stream of data breach reports. Part of the answer lies in the many economic challenges that the card brands face in developing a secure network, as outlined in Section 2. These challenges suggest that misaligned incentives are playing a significant role in undermining the card brands' security control structures.

Four groups of entities are responsible for the design, implementation, and enforcement of card payment security standards. The card brands, through the PCI Council, specify security

standards and certify validation assessors. Banks that offer merchant acquiring services (that is, card payment processing) monitor their merchant client operations, including tracking records of validation, and enforce fines or other sanctions for compliance violations. Third-party validation services assess large merchants for PCI DSS compliance, while smaller merchants assess themselves. Finally, merchants are responsible for implementing PCI DSS to secure the data used to process card payments.

Conflicts of interest may compromise incentives to protect card payment data among any of the four entities. The card brands and issuers place a high value on security but at the same time may choose convenience of the card payment process ahead of security (Huen). Merchant acquirers often include in their contract provisions that make merchants responsible for any fines that result from a failure to comply with PCI standards, which diminishes their incentive to closely monitor their clients. PCI validation services are relatively new, and assessors may be placing a high value on building their client list at the expense of thorough assessments, while self-assessments have an obvious conflict of interest.[31] Merchants bear significant costs implementing PCI DSS but have seen penalties enforced on validated merchants after security failures, and may not see enough value in compliance to put much effort into protecting data.[32] Finally, any of these four parties that suffer a breach may not have sufficient incentive to secure data if they are not held responsible for the costs of the damage that results from the breach.[33]

By their nature, modern payment systems are large and complex, which makes the effort

[31] The organization that assessed Target's payment software applications prior to their 2013 breach validated compliance in September 2013 yet the hack occurred only two months later. Subsequently, the assessor was required to enter a PCI Council remediation program, which indicates a need to improve their assessment process (Daly).
[32] A recent report found that after validating compliance with the PCI DSS, 81 percent of organizations fall out of compliance within a year (Verizon).
[33] After the 2013 breach at Target many card issuers bore the costs of reissuing cards, added customer services, increased fraud losses, and possibly loss of customers in the wake of the breach. Many issuers expressed concern that compensation being offered to them by Target in a proposed settlement between MasterCard and Target was too low (Cumming). The settlement did not receive sufficient support from card issuers and negotiations are still ongoing (Sidel).

to ensure integrity very difficult. The PCI Council is clearly a step in the right direction. But the continued reports of unauthorized access to sensitive data suggest that incentives to improve data security may not be strong enough to keep up with threats of data breaches. The card industry may be in a situation represented by a game shown in Figure 8 in Section 3, which depicts an equilibrium with inadequate levels of security and little incentive for the parties to jointly adopt options with stronger security.

4.3 Mobile payments

The mobile device form factor offers a promising opportunity to improve the security of electronic payments. Mobile wallet applications typically use methods and technologies that stronger authenticate the payer and payer's payment device and better protect sensitive data than those used by existing payment methods such as payment cards. This opportunity, however, comes at the cost of added institutional complexity to business models of mobile payment platforms. New players, such as mobile carriers and device makers, have joined the market with their own incentives. Carriers may want to be a tollbooth, charging a fee for transactions that take place on their networks. Device makers may want to construct a services platform with themselves in the middle. These competing interests turn out to have broad implications for the security technologies that they propose, and especially their prospects for widespread adoption.

As compared to existing payment methods such as credit and debit cards and automated clearing house (ACH), mobile wallet applications will improve payment security by enhancing both payer authentication and data protection. Mobile payments could reduce the likelihood of unauthorized transactions through password or biometric protection of the mobile device and of the mobile payment application on the device. Such protection provides an extra layer of security that does not exist when consumers make payments with plastic cards. Similar to an EMV chip

card, a chip embedded in a mobile device, such as the one using a near-field-communication (NFC) chip, can enable dynamic authentication, in which data unique to each transaction is used to authenticate the payer and the payment device. Two prominent mobile payment platforms, Google Wallet and Apple Pay, are NFC-based platforms.[34]

Mobile payment platforms also use a token to replace sensitive data such as a payment card number or a bank account number. Both Google Wallet and Apple Pay use a token to replace the card number of the payment card to which the mobile payment application is linked. When merchants receive payment instructions from these mobile payment applications, they do not see the card number. Google Wallet generates its tokens in the "cloud," in other words tokens are generated at Google's servers, requiring the phone to have a working data connection in order to make a transaction at a POS terminal. Apple Pay, in contrast, uses a locally generated token and the token along with other information about the card is stored in a secure element of the mobile device.[35] Locally generated tokens are perceived to be more secure than tokens in the cloud, but both types are huge leaps in terms of security when compared to protocols that transmit actual card numbers. Another mobile payment platform, CurrentC, which is owned by a consortium of many leading merchants, called Merchant Customer Exchange (MCX), is in pilot stage.[36] Instead of using payment cards and NFC, CurrentC will use ACH by linking a customer's bank account to its mobile wallet and use a quick response (QR) code to transmit payment instruction from the mobile device to the POS terminal. A customer's bank account information will be stored in CurrentC's cloud vault and will not be transmitted to the merchant

[34] In May 2015, Google announced that it was splitting its contactless payment platform from its peer-to-peer payment service, branding the former as Android Pay and the latter Google Wallet. This paper refers to the former service under its original Google Wallet name.
[35] Apple Pay uses the tokenization developed by EMVCo. The token and card account number is stored on a highly secure server called a "vault" provided by the major card networks and processors.
[36] See http://mcx.com/.

in the QR code.

To realize security improvements that will be brought by mobile payments, widespread adoption of mobile wallet applications by various types of entities—including consumers, merchants, financial institutions, card networks, mobile carriers, device manufacturers, and technology and payment vendors—is needed. To date, however, mobile payment platforms, even prominent ones, have not gained traction.

When Google Wallet launched in 2011, its business model was murky. Google did not generate fee revenue from merchants and users for participation or for each transaction they received or made.[37] Instead, Google experimented with selling ads on the platform and those ads or "offers" were tailored to Google's existing customer profile. Google collects various data associated with transactions made with Google Wallet.[38] Google can use these data, in accordance with Google's privacy policy, to serve more targeted ads and thereby enhance Google's core business; however, thus far, there is scant evidence that Google has implemented this practice.

Google Wallet's business model did not attract card issuers and mobile carriers until very recently. Card issuing banks were reticent to participate, with only Citibank doing so initially. This may be because Google's weak privacy of transactions did not align well with banks' long-held norms of respecting customer privacy. As of May 2015, however, Google Wallet works with most major U.S. credit card brands, as well as debit cards and bank accounts. The lack of initial support by mobile carriers, except Sprint, may have been partly due to the lack of fees

[37] Merchants were charged a regular payment card fee.

[38] According to the Google Wallet privacy policy, the following transaction information is collected: "Date, time and amount of the transaction, the merchant's location, a description provided by the seller of the goods or services purchased, any photo you choose to associate with the transaction, the names and email addresses of the seller and buyer (or sender and recipient), the type of payment method used, your description of the reason for the transaction, and the offer associated with the transaction, if any." See https://wallet.google.com/legaldocument?family=0.privacynotice.

charged to users or of additional fees charged to merchants for each transaction. This "no-fee" model conflicted with the business model mobile carriers envisioned, in which a small fee was charged for each phone-enabled payment. Recently, however, Google acquired technology from Softcard, the mobile payment platform jointly owned by three major U.S. mobile carriers, and these carriers agreed to install Google Wallet on their devices.

In 2014, Apple introduced Apple Pay, its own proprietary payment service. Apple Pay uses the same fee structure as payment cards to which Apple Pay is linked. A part of the fee the card issuer receives from the merchant of a transaction using Apple Pay is shared with Apple.[39] Other features, including security features, of Apple Pay may reflect Apple's business model, which is to sell more iPhones. Apple Pay only works on the latest-generation phones (iPhone 6). Apple has chosen to implement a proprietary protocol, as it is not interested in network effects beyond its own customers. As mentioned above, credential of payment cards to which Apple Pay is linked is stored in a secure element of iPhone, which is not transferable to another phone. Unlike Google, Apple emphasizes the privacy of transactions—neither Apple nor the merchant can link payments to particular users.

Apple Pay has received much broader initial support than Google Wallet. A large number of issuers offered support from the time of launch. This may be partly due to Apple's customer profile—the large number of high-value customers—and partly due to improved privacy compared to Google Wallet. Apple Pay is also supported by all four major U.S. mobile carriers, because they support any iPhone.

Unlike financial institutions or mobile carriers, merchants are not necessarily enthusiastic about NFC-based mobile payments (Hayashi and Bradford). Merchants who plan to adopt EMV can accept NFC-based mobile payments by installing contactless card readers, but for merchants

[39] Apple receives 0.15 percent of a purchase on Apple Pay when it links to a credit card.

who do not have such a plan, installing NFC-based terminals would be a significant burden. Further, accepting mobile payments that have the same fee structure as payment cards will not help merchants control payment acceptance cost. Merchants also are concerned about ownership and control of customer data captured by third-party mobile payment providers, such as Google. Many merchants expect mobile payments to enhance their ability to collect customer data and engage in highly targeted marketing, but Apple Pay does not enable merchants to do so.

CurrentC's business model is designed to suit the needs of merchants who participate in the MCX. CurrentC uses a QR code to transmit a payment instruction and many merchants may already have QR code scanners in place at their points of sale. CurrentC is linked to customers' bank accounts to use ACH for payments, which are less costly than credit and debit cards for merchants to accept. Using ACH also eliminates the need for financial institutions to participate in the platform. CurrentC can collect information about transactions, which enables merchants to observe multiple transactions by the same customers, as they can currently do with credit and debit cards. Although privacy of transactions for CurrentC may be weaker than that for Apple Pay, consumers who use CurrentC will retain considerable control to limit what information is shared and with whom.

Although CurrentC may have advantage over Google Wallet or Apple Pay in terms of adoption by merchants, it faces the same barrier as the other two platforms: consumers must adopt their mobile payment applications for the platforms to succeed. However, U.S. consumers' incentives to adopt mobile payments seem weak (Crowe et al). Stronger security and more targeted marketing and rewards offered by mobile payments may potentially entice some consumers to switch from incumbent payment methods to mobile payments (Hayashi). These early adopters could facilitate further adoption if there is a large-scale positive network effect but

competition among mobile payment platforms may prevent that.

Mobile payment platforms that compete for market share may not be willing to make their platforms interoperable. While both Google Wallet and Apple Pay rely on similar hardware and have adopted roughly similar technical approaches, they remain mutually incompatible. Competition for the market may undercut the positive network effects and a potential end result could be that no platform gains traction. This, in turn, could inhibit the market for more secure payments from emerging at all.

Consumers' adoption of mobile payments may significantly deteriorate if mobile payments develop a reputation for being unsafe. While the mobile payment technologies do offer features that clearly improve security, similar to other emerging payment methods, mobile payments may face elevated fraud risk during the initial deployment phase (Braun et al). These risks often diminish once the payment method is established, but the responsibility is on the operators of mobile payment platforms to be especially vigilant in rooting out fraud during the rollout and respond rapidly to problems that inevitably arise.

Additional vulnerability in mobile payment platforms are new stakeholders, such as device makers and mobile carriers: they do not have the same experience managing operational risk in payments as other existing stakeholders, such as banks and card networks. Shortly after its launch, Apple Pay experienced a huge spike in fraud, in which groups of criminals enrolled stolen payment cards and then used Apple Pay to make large purchases.[40] Criminals systematically exploited insufficient safeguards in the process some card issuers used to enroll cards into Apple Pay. While one cannot conclude the spike in fraud was due to Apple's inexperience in the payments system, Apple was slow to react to the fraud and did not engage

[40] By one estimate, the incidence of fraud in Apple Pay was $6 for every $100 charged, compared to 10 cents per $100 for CP transaction (Sorkin).

with the issuers to resolve the problem quickly. Apple's reaction may also reflect the fact that card issuers, not Apple, had to absorb the loss on the fraudulent payments. Apple's delayed response may indicate Apple either reacted narrowly to fraud liability incentives or, more plausibly, did not sufficiently understand the elevated risk associated with a new payment product.

Realizing security improvements from the introduction of new payment methods is likely to be more challenging than improving security in the existing payment methods. The former requires additional coordination: adoption of the new payment methods by end users. Adoption by consumers may be especially difficult and security improvement is not often sufficient to compel consumers to shift from incumbent payment methods to new, more secure payment methods.

4.4 Cryptocurrencies as an alternative method of payment

Cryptocurrencies is another emerging payment method that offers some promise of enhanced payment security. They offer stronger authentication of payers and payees as well as strong protection against alteration of payment messages and records. But, operational integrity is still largely uncertain. Cryptocurrencies also have potential to attract end users: a low transaction cost and irrevocability are especially attractive to merchants. However, attracting consumers is more challenging.

Most cryptocurrencies have been designed by those outside of the financial industry, seeking to bypass much of the existing payments infrastructure. Cryptocurrencies have been proposed in various forms since the 1980s, yet none have received widespread interest and adoption until Bitcoin arrived on the scene in 2009 with a mysteriously-authored white paper

(Nakamoto).[41] Bitcoin is an alternative currency to hard currencies backed by governments. Bitcoin is specified by a protocol, adhering to rules that are enforced in a decentralized manner with no state backing.[42] Bitcoin has inspired scores of alternative cryptocurrencies, though none has attracted the participation from users that Bitcoin has.[43] As of May 2015, the total value of bitcoins in circulation is US$3.3 billion.[44]

While many of Bitcoin's backers envision its primary use as an alternative currency operating alongside or even displacing existing currencies, some (especially the venture capitalists who have backed startups) have focused on its potential as alternative payment method. The Bitcoin network offers a decentralized system that facilitates global payments where no single entity controls the network. Its operation is governed by rules set out by the original white paper and updated by open-source developers working on the core software.

In some respects, cryptocurrencies are much more secure than existing payment methods. There is no sensitive account information transmitted with payments. Observing the payment message provides no advantage to a fraudster. Protocols rely on public-key cryptography, ensuring that money can be spent only once, and that only the holder of the cryptocurrency can spend it. To initiate a payment, the holder of cryptocurrency denotes an amount of the currency and encrypts a message using a private key associated with the holder.

However, as with any emerging technology, there can be considerable operational risks using cryptocurrencies outside of the core technology, such as the means by which they are acquired and held. Most users acquire cryptocurrencies via online currency exchanges, typically

[41] Böhme et al. (2015) provides a primer on Bitcoin, especially for economists.
[42] The term Bitcoin is used to denote both the "coins" and the protocol. It is the accepted practice to use Bitcoin (upper case B) to label the protocol, software, and community, and bitcoin (lower case b) to label the coins themselves.
[43] Many other cryptocurrencies have built upon the Bitcoin protocol.
[44] https://blockchain.info.charts/market-cap.

by bank transfer— though some do accept payment cards. In the case of Bitcoin, according to one study, 45 percent of Bitcoin currency exchanges later closed (Moore and Christin). Some closures happened as a result of a security breach. For example, Mt. Gox collapsed in early 2014 along with the disappearance of bitcoins valued at $460 million.[45] Exchange collapses matter because many users treat the exchanges more like banks than traditional currency exchanges. Out of convenience (and a misperception of better security), many users who buy bitcoins and other cryptocurrencies choose to leave them in accounts at the exchange. In this case, if the exchanges close, they do not have control of the associated private keys and therefore can lose all money stored at the exchange.

Further operational risks involve the theft of privately held cryptocurrencies, or those currencies held at cloud service providers. Because payments are irrevocable, when cryptocurrencies are stolen there is no recourse. Any accidental disclosure of private key information can lead to theft. Also, malware has been deployed to specifically search for private keys associated with various cryptocurrencies. Hence, the security of devices storing the private keys is crucial.

Apart from operational security risks, cryptocurrencies exhibit considerable currency risk as evident with Bitcoin. The exchange rate of a bitcoin to U.S. dollars or other currencies has fluctuated wildly (and may explain why Bitcoin has attracted widespread media interest). As recently as January 2013, the USD-BTC exchange rate was $13. It peaked at over $1,000 per bitcoin in late 2013 and has gyrated wildly ever since, falling to an exchange rate of $239 in May 2015.

In theory, cryptocurrencies could entice end users to shift away from existing payment methods. Although cryptocurrencies offer weak or no consumer protections, their rules are often

[45] http://www.wired.com/2014/03/bitcoin-exchange/.

very favorable to those accepting payments, such as merchants. Payments in most cryptocurrencies do not have any required transaction fee (though a very small voluntary fee is often paid to support entities who verify transactions). Payments with cryptocurrencies are irrevocable by design. In this way, cryptocurrencies are more like cash than payment cards. While this might put off wary consumers, merchants may be attracted by the prospect of no chargebacks. This may be a reason why Bitcoin is currently accepted by e-commerce companies including Overstock and Newegg. Furthermore, some companies facilitate cryptocurrency payments. For example, Bitpay offers a service to merchants that makes it very easy to accept payments in bitcoin and charges no transaction fee to participating merchants. As of May 2015, over 60,000 organizations accept bitcoin payments via Bitpay, and their system is configured so that merchants have the option of immediately converting bitcoins into dollars or the currency of their choice.

To date, cryptocurrencies have made more progress in establishing a seamless process in the market for remittances with low fees. They offer users of international payments less costly choice than traditional international payments that carry high fees. For example, BitPesa lets people send money online to Kenya or Tanzania for withdrawal locally through M-PESA, the popular mobile phone-based payment service.[46] BitPesa charges a 3 percent transaction fee, considerably lower than its competitors.

However, challenges still remain for any cryptocurrency to attract widespread adoption. First, operational risks must be overcome. Unfortunately, solving them could make cryptocurrencies far less attractive to merchants than is currently the case. For example, if transactions became revocable, chargebacks could become a reality. Similarly, in order to cover the costs of fraud, transaction fees may need to be introduced. Second, currency risks must be

[46] https://www.bitpesa.co.

addressed, especially for Bitcoin. At present, solutions exist to protect merchants from currency risk but corresponding solutions for consumers are not as mature or widely available. For Bitcoin to succeed as a payment method, an end-to-end solution is needed that leverages the Bitcoin network but without requiring either party to hold bitcoin deposits.

The big unresolved issue for Bitcoin or any other cryptocurrencies is that while it has demonstrated a novel use of technology to ensure the integrity of payment information, it has not developed supporting institutions to protect end-to-end security, or the security of the overall ecosystem. Established payment systems, in contrast, have long histories of using a control structure supported by laws, rules, practices, and enforcement, to limit operational risk, including fraud risk. The lack of institutional governance in cryptocurrencies is readily apparent in the inability to root out fraud, support a stable infrastructure for exchange, and assure consumers that they will remain safe while engaging with the system. The open question is how cryptocurrencies can overcome a legacy of insecurity and build the credibility and confidence needed to attract participation from the broader public.

4.5 Lessons learned from case studies

The four case studies in this section demonstrate that substantial interdependence in modern payments systems poses significant challenges to improving security. Adopting alternative techniques, business practices, or processing options often involves difficult coordination across various types of payment participants, which may make the status quo appear satisfactory.

As discussed in the previous section, the structure of the coordination game can change in a manner that incentivizes payment participants to adhere to a coordinated security improvement effort. Take for example the first case study, 3DS adoption. Some changes can be prompted by

policy actions, such as those taken by the Bank of France, while others can arise organically within an industry, such as in the UK. The Bank of France's success may be due to leadership advantages to promote collaboration. The Bank of France is a neutral entity and can more easily build trust among payment participants. It has an authoritative voice for societal interests with a perspective beyond the boundaries of the payment industry. With a long-term focus, it can bring salience to options with extended payoffs. By observing these payoffs, other efforts, such as the UK's may follow.

In the second case study the payment card industry created the PCI SSC more than ten years ago to develop and promote improved methods of securing data. The Council has played a key coordinating role in developing and maintaining the PCI DSS. While the Council, together with the major card brands that enforce PCI DSS, has increased the PCI DSS compliance rates by merchants, data breaches that exposed millions of payment card accounts have occurred in the last few years. It is difficult to assess whether the proliferation of breaches were caused by ineffective leadership or exogenous factors, such as the number of endpoints that has expanded rapidly in the last several years. In either case, public policy could help strengthen involved parties' incentives to protect sensitive data. For example, well-designed data breach disclosure laws incent parties to put more efforts into protecting sensitive data (Schuman); and financial institution oversight includes a review of payment operations the bank conducts and methods the bank should have in place to monitor and deter fraud in its payment operation (Federal Financial Institution Examination Council). Public policy could also help induce involved parties to adopt encryption or tokenization, the protocol that complements or substitutes the protocols of protecting sensitive data.

The third case study, mobile payments, offers a leap-ahead technology. If implemented

carefully and adopted widely, mobile payments can substantially enhance security. Apple, Google, and other nonbank payment providers recognize the challenge of adoption by end users and are taking steps to enhance products to make them more compelling to consumers and merchants. At the same time, added risk comes from multiplying the endpoints and devices where payments are made and from the proliferation of developers with their own mobile payment applications. In the mobile payments space, no entities play the industry-wide leadership role to coordinate adoption or ensure security, suggesting a role for public authorities. To that end, the Federal Reserve Banks of Boston and Atlanta have convened the Mobile Payments Industry Workgroup (MPIW) to facilitate discussions among the stakeholders as to how a successful mobile payments system could evolve in the United States.

Cryptocurrencies may be the most vexing of the four case studies. There has been an explosion of cryptocurrency products, yet many do not have a control structure that will reliably ensure their integrity beyond what cryptography protocols can guarantee. In some cases, a control structure is antithetical to the cryptocurrency concept. As other case studies suggest, however, a strong governance mechanism with clear responsibility and authority to implement innovations is critical to ensure system integrity. Public authorities are currently trying to fill this void by working to understand cryptocurrency systems and developing parameters within which cryptocurrency systems may safely operate.[47] Whether this oversight can balance the need for integrity with the flexibility demanded by cryptocurrency users remains a question.

As each case study suggests, leadership in collaborative efforts is important to appropriately modify the structure of coordination games. Consistent with game theorists' claims, it is observed that the quality of leadership, or the lack thereof, matters (Myerson). Effective leadership requires strong commitment, credibility, and understanding conflicts of

[47] See http://www.entrepreneur.com/article/245994.

interests across various parties. These attributes help leaders effectively reconcile the conflicts of interests and facilitate involved parties in building trust. That trust may lead to collaboration on establishing rules or guidelines concerning property rights, distribution of costs and liability, or limited available options to each party. The attributes also help leaders improve involved parties' expectations for prospects and outcomes of collaboration and thereby induce these parties to collaborate effectively.

As history has shown, if participants lose confidence, a payment system can collapse, causing deep economic consequences (Richardson). Some payment systems, such as payment card systems, have grown to be large enough to generate significant disruption from a large security failure. Beyond the payment systems' operators and financial institutions, the economy has a considerable stake in their systems' security. Thus, a strong leadership to coordinate collaborative efforts inside and outside of particular payment systems would be indispensable in providing useful mechanisms that increase incentives to secure payments.

5. Summary and a look ahead

This paper has shown that modern retail payments systems and their security are characterized by several economic principles which make it difficult for markets to reach a socially desirable level of security. Interdependencies, especially across various parties who participate in electronic payments systems to initiate, process, settle, and protect electronic payments, imply potential coordination failure; nevertheless, successful coordination is critical to better protect electronic payments systems.

To understand and help overcome coordination challenges, a game theory approach provides a useful framework. The approach enables us to evaluate if a given game can achieve superior outcomes and if not, to identify sources of conflicts. The approach also helps construct

security strategies: payments systems operators and public authorities can use a variety of tools, including liability, pricing, standards, and mandates, among others, to change the structures of games so that the equilibrium will shift from a socially inferior outcome to socially superior outcome.

While payment participants put significant individual effort into building strong defenses that contributes to maintaining public confidence, the industry has also made efforts to collaborate to improve retail payments security. When successful, collaborative efforts are often more effective than individual efforts to improve security; however, the four case studies suggest that coordination is a significant challenge. For collaboration to succeed, effective leadership is crucial.

When considering security improvements from a broad and long-term perspective, public authorities may be better suited for leadership roles than private entities. For example, as a neutral, trusted entity, a public authority may be able to spur adoption of security improvement that requires significant up-front investment by certain parties but promises long-term security improvement to society as a whole. Private entities, especially for-profit firms, may not be able to wait for the payoff from a long-term project as their shareholders typically require results in the relatively short term.

Public authorities have become more active in raising concerns over security of payments. For example, in Europe, public authorities took leadership roles in strengthening online payment security, while they also sought collaboration by industry participants. In January 2003, the European Central Bank (ECB) published a report on security of internet transactions and recommended stronger protections of sensitive data and the use of two-factor authentication for payments initiated via a web browser (ECB). The guidelines on security of internet payments

were initially developed by the European Forum on the Security of Retail Payments (also known as SecuRe Pay), whose membership consists of bank supervisory authorities in the European Union, with significant contributions from payment service providers. The European Banking Authority (EBA) issued final guidelines based on the ECB recommendations in December 2014 (EBA).[48]

In a similar vein, the Federal Reserve System's Secure Payments Task Force recently engaged a large group of stakeholders with diverse opinions and interests to work toward the common goal of improved payment security. The group's diversity serves the crucial purpose of identifying where strategies to secure payments do not appropriately balance the interests of all payment participants. The Federal Reserve's leadership of the Task Force can contribute a voice for the broad public interest and a long-term perspective on payment security.

While coordination resulting from recommendations of the Task Force can help ensure the integrity of payments, it may require short-term sacrifice from some payments participants. Leadership by a neutral, respected party such as the Federal Reserve may be a key to focusing participant attention on long-term outcomes that will improve confidence in evolving payment systems, ensure that payment innovators can build secure products, and ensure that payment participants can safely enjoy leading edge payment technology.

If successful, the collaborative efforts of the Task Force will lead to a more secure and safe payment system. New challenges will nevertheless arise, as they do today, and the payments industry will need to continue to adapt to the changing threat environment.

Time will tell whether the United States can successfully achieve its payments security goals in the longer term with industry collaboration supported by the Federal Reserve exerting a

[48] The EBA guidelines have the force of law behind them. Further refinement of requirements for security of internet payments is expected with an upcoming revision to the EU's Payment Services Directive,

facilitation role. The underlying characteristics of payments that lead to challenges in implementing security may become more important with the continuing shift from paper to electronic payments and the proliferation of endpoints where payments can be accepted and initiated. A longer-term solution may require formal oversight of payment security and integrity, where policymakers can exercise stronger leadership to promote security solutions that are consistent with the long-term needs of all payments participants.

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Appendix A: Costs and benefits of 3DS adoption

In the case of 3DS, issuers and merchants weigh costs and benefits while evaluating whether to adopt or not. Table A1 shows the major factors to consider. Both issuers and merchants bear the costs of fixed investments as well as ongoing costs of operations and maintenance. Moreover, a cardholder must be registered with the card issuer to use 3DS, and the checkout process for unregistered cardholders is interrupted for registration, further deterring the customer from completing the purchase. Positive factors include reduced rates of fraud, and for merchants, a lower interchange fee in some cases and a payment guarantee.[49]

Table A1: Evaluating Adoption of 3DS

	Costs	Benefits
Issuer	Fixed investments Ongoing operation and maintenance Lower interchange fees	Fraud reduction Reduction in costs associated with initiating fraud chargebacks
Merchant	Fixed investments Ongoing operation and maintenance Lost sales (first-mover merchants) -higher rates of cart abandonment	Payment guarantee - shift of fraud liability to issuers Lower interchange fees Potential for added sales - more secure card payments adds to consumer confidence in ecommerce and increases online shopping

Source: Adapted from Smart Card Alliance

[49] MasterCard sets a lower interchange fee. Visa sets a lower interchange fee on signature debit cards and no-rewards credit cards.