Payment Instruments, Financial Privacy and Online Purchases

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Abstract

The protection of financial personal data has become a major concern for Internet users in the digital economy. This paper investigates whether the consumers' use of non-bank payment instruments that preserve financial privacy from banks and relatives may increase their online purchases. First, we construct a model in which a non-bank institution provides a payment instrument and competes with a bank for consumers who purchase a standard and a privacy-sensitive good at an online retailer. We show that the use of the non-bank payment instrument increases the total demand of online consumers. Secondly, we test this prediction by analyzing the purchasing decisions and the use of bank and non-bank payment instruments of a representative sample of French Internet consumers in 2015. Using three econometric methods, namely an ordered probit model, a linear probability model and a Bayesian Markov Chain Monte Carlo model, to account for a potential endogeneity problem, we find evidence that the use of non-bank payment instruments positively influences consumers' online purchases.

Key Words: Payments, financial privacy, electronic commerce, endogenous binary variable model.

JEL Classification: G21, G23, L81, L86.

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1 Introduction

The protection of personal data has become a major concern in the digital economy (Acquisti et al., 2015). Everyday, numerous newspapers, TV programs and online articles make the headlines on government surveillance programs, data security breaches at major retailers, business tracking and profiling strategies, etc. In reaction, more and more people fear being watched online,[1] and thus have begun to change the ways they use technologies. A recent survey of the Pew Research Center in 2015 reports for example that "34% of those who are aware of the surveillance programs have taken at least one step to hide or shield their information from the government; [...] 17% changed their privacy settings on social media; [...] 14% say they speak more in person instead of communicating online or on the phone; and 13% have avoided using certain terms in online communications."

Consumers' privacy concerns are not only related to traces left during Internet sessions. They are also concerned by the privacy of their financial transactions. Most of the online transactions are today paid with debit and credit cards that leave traces at retailers but also on checking accounts. These traces contribute in many ways to the provision of bank services. In payment activities, card traces are exploited to offer rewards but also premium financial services and commercial recommendations. In credit activities, payment information are collected to calculate credit scores (such as the FICO score) that are extensively used to grant credits.[2] For these reasons, consumers can be reluctant to shop online with payment cards and disclose personal data to banks either to preserve a high credit score, to avoid to be tracked[3], or simply not to be targeted and solicited. Beyond bank considerations, consumers may also want to hide information from relatives or other people (in the case of joint accounts), or from government-related institutions who may access bank statements.

To summarize, consumers may be concerned with their financial data for various reasons,

[1] A survey of the Pew Research Center entitled "Public Perceptions of Privacy and Security in the Post-Snowden Era" reports that 62 per cent of respondents do not think it is a good thing for society if people believe they are being watched online.

[2] Payment history accounts for 35 per cent of the FICO credit score and is the most important factor (here; last visit: 23/11/2015).

[3] An article on the Belgium RTBF website in November 2015 relates the story of a researcher that saw a bank transfer from an NGO helping victims of the civil war in Syria blocked by her bank because the word 'Syria' appeared in the title of the transaction. It was a legitimate reimbursement of travel expenses, but the bank considered it as a potential attempt at money laundering or funding of terrorist activities. The article can be retrieved at the following address; last visit: 11/12/2015.

and decide not to use debit and credit cards, or other bank payment instruments (such as checks, etc.) that disclose personal data. To protect their financial data, privacy-minded users may therefore decide to use other payment instruments that are not directly attached to their bank checking account. These payment instruments can be delivered by other financial intermediaries or private companies whom we will refer to as "non-bank payment instruments" in the sense that they are not delivered by the consumer's bank and that they are not directly related to the consumer's bank checking account. For example, at the time of the survey that we use in this paper, a transaction carried out with PayPal cannot be completely tracked by the bank even though the consumer uses the debit or credit card issued by his bank: a transaction made with PayPal does not give rise to a similar writing on the consumer's checking account and the bank has neither information on the type of product purchased nor information on the type of retailer. Similarly, the use of electronic payments systems such as electronic currencies (Bitcoin and other cryptocurrencies) are completely anonymous and disconnected from bank accounts.[4] Such payment services may therefore be used by consumers in online purchases to preserve personal data from banks and relatives. As a consequence, the use of non-bank payment services may allow consumers to purchase online goods that they would not have purchased with bank payment instruments, resulting in an overall positive impact on online purchases.

This paper investigates whether the use of non-bank payment instruments that preserve financial privacy from banks, relatives or government-related institutions may increase online purchases. We construct a model that analyzes the competition between a bank and a non-bank institution that provide a payment instrument to purchase two goods at an online retailer: a standard good and a privacy-sensitive good (such as medication, healthcare expenses, gifts, gambling, adult products and so on). Consumers are concerned about the tracking of their financial data by the bank. To model financial privacy concerns, we assume that consumers incur an additional cost when purchasing the privacy-sensitive good using the bank payment instrument. We show that consumers who do not want to purchase the privacy-sensitive good when there is only a bank payment instrument to pay the transaction can now buy online when an alternative non-bank service is provided, resulting in an increase of the demand of online consumers. We test this result by analyzing the purchasing decisions as well as the use of bank and non-bank pay-

[4]The 2014-2015 Survey of Consumer Payment Choice (SCPC) from the Federal Reserve Bank of Boston indicates that about 20 per cent of the US consumers adopted virtual currencies because they distrust banks or sovereign currency or because they want to make payments anonymously (Schuh and Shy, 2016).

ment instruments by a representative sample of 1,000 French Internet consumers in 2015. Using three econometric methods, namely an ordered probit model, a linear probability model and a Bayesian Markov Chain Monte Carlo model, to account for a potential endogeneity problem, we find evidence that the use of non-bank payment instruments that is mainly driven by financial privacy concerns positively influences consumers' online purchases.

This paper contributes to the economic literature on three dimensions. First, previous contributions in the economic literature have separately focused on privacy, payments and online purchases. To the best of our knowledge, this paper is the first to merge these different strands of the literature and to analyze how financial privacy concerns may induce consumers to choose different payment instruments in order to keep their financial and personal data private. As the review of the literature will show, financial privacy has only been studied from the viewpoint of the regulation of financial intermediaries. Our paper contributes therefore to the literature by showing that financial privacy is also a concern for consumers that should be taken into account to promote a sound development of the digital economy. Second, we construct an original theoretical framework to analyze how the existence of privacy-sensitive goods may induce consumers to use non-bank payment instruments to protect their financial data. Third, this paper proposes an original estimation method to test the model predictions. We use Bayesian econometrics to estimate an endogenous binary variable model that deals explicitly with the existence of a potential endogeneity issue if the use of non-bank payment instruments is correlated with unobservable variables that influence online purchases.

The article proceeds as follows. Section 2 provides a discussion of the relevant literature. Section 3 presents our model of choice of payment instrument and consumption. Section 4 presents the equilibrium strategies. Section 5 describes the data, present the estimation strategy and discuss the estimation results. Section 6 concludes.

2 Related literature

This paper studies how consumers may adopt strategic behaviors when using payment instruments in online purchases to protect their financial privacy from banks and/or relatives. It is at the crossroads of different strands of the literature on the economics of privacy, the regulation of financial privacy, information sharing between banks, and the economics of payments.

First, two papers on the economics of privacy analyze the link between privacy issues and electronic commerce. Akhter (2012) analyzes survey data from a sample of 1,097 Internet subscribers in three Midwest states in the United States. The author finds that privacy concern has a negative and statistical significant influence on online spending. Similarly, Tsai et al. (2011) design an experimental study based on a search engine that displays the privacy policies of specific online shopping sites. They test whether participants presented with salient privacy information would be more likely to purchase from sites with privacy indicators than participants who did not see that information. They find that participants provided with salient privacy information took that information into consideration, making purchases from websites offering medium or high levels of privacy. Overall, these papers show that privacy concerns negatively affect online purchases. Our paper confirms in part their findings as we find that privacy-minded users purchase less online than the others. However, we also find evidence that online consumers may adopt strategies to protect their privacy from banks and relatives by using non-bank payment instruments, resulting in a positive influence on online purchases.

The literature on the economics of privacy has also considered the use of strategies by consumers to avoid price discrimination (Acquisti et al. (2015)). For instance, Villas-Boas (2004) show that consumers can postpone their purchase to avoid being identified by the price-discriminating firm. Likewise, Conitzer et al. (2012) show that consumers can decide to remain anonymous from the retailer in order to avoid price discrimination. We extend this idea in our paper by showing that consumers may adopt strategies in order to avoid discriminatory practices based on their transaction history by financial institutions (scoring practices and other commercial use of personal data).

A number of other studies have also specifically focus on the effects of financial privacy regulations. In the U.S. for instance, the Gramm-Leach-Bliley Act (GLBA) allows a variety of financial institutions to collect, share and use personal information about their customers. The GLBA requires financial institutions to provide each consumer with a privacy notice explaining the exploitation of their personal data. The notice must also identify the consumer's right to opt out of the information being shared with unaffiliated parties. However, there are two main exemptions that authorizes information sharing despite objections from consumers: first it allows an institution to disclose personal information to affiliated institutions without providing notice of the disclosure and an opportunity to opt out; second, it allows an institution to disclose non-public personal financial information to non-affiliated third parties that jointly offer marketing with the original institution. If Lacker (2002) argues that the market for financial privacy has the characteristics that should yield efficient outcomes, Swire (2002) advances that the GLBA could lead financial institutions to review their data exploitation practices and to get rid of those with a low respect of privacy. The GLBA has also drawn criticisms concerning the level of its privacy protection. Janger and Schwartz (2002) for example consider that consumers are not sufficiently informed and that this lack of information reduces their bargaining power with financial institutions. Concerning the impact of the GLBA, Sheng and Cranor (2006) find that the sharing of information about consumers between affiliates and non-affiliates has increased since the adoption of the GLBA. Similarly, Cranor et al. (2013) show that an important number of financial institutions shares consumers' data without allowing them to limit or to stop data disclosure.

The legislation regarding financial privacy in Europe is less permissive than in the U.S. Financial privacy is regulated by the Data Protection Directive 95/46/ec, which allows financial institutions to collect data about consumer identification data and products and services management, but not to sell or share them with non-affiliates. Financial institutions can share data among affiliates, but not without an authorization by both privacy regulation authorities and consumers. Jentzsch (2007) finds however that financial privacy regulation in Europe does not significantly reduce credit reporting practices. U.S. financial institutions have a more intensive use of credit reporting, but the difference is not imputable to differences in regulation between Europe and the U.S. Our analysis does not directly deals with the efficiency of financial privacy regulations but show however that consumers are sensitive to financial privacy concerns and that prohibiting banks to communicate financial information with non-affiliates allow precisely strategic consumers to shop more often online.

This paper is also related to the literature on information sharing in credit markets. Pagano and Japelli (1993) showed that information sharing between lending institutions helps decreasing adverse selection, a decrease that can take the form of a lower amount of loans to risky borrowers (Hertzberg et al. (2011)). Information sharing also yields an increase in the effort of potential borrowers (Padilla and Pagano (1997) and Padilla and Pagano (2000)), but also lower competition in the market (Bouckaert and Degryse (2006)). Karapetyan and Stasescu (2014) show that this lower competition can lead to higher information acquisition in the credit market. Recently, Kim and Wagman (2015) argue that consumer information exchange in financial markets can lead to lower prices for consumers and to higher screening of financial products applicants, which induces an increase in ex-ante social welfare. Shy and Stenbacka (2015) analyze how firms make higher profits in a situation of weak privacy protection where firms can easily share consumer information than in a situation of strong privacy protection. Our paper differs from theses studies in that we analyze information acquisition by financial institutions, but from the perspective of the consumers, that is their willingness to let financial institutions access their online purchases history.

Finally, our paper is also linked to the literature about the choice of payment instruments, a choice that can be affected by anonymity. While Markose and Loke (2003) suggest that there is a perfect substitution between cash and card payments, Drehmann et al. (2002) argue that the fact that cash preserves anonymity makes card payments not a perfect substitute. Using survey data about the German payment behavior, von Kalckreuth et al. (2014) find that the anonymity permitted by a payment instrument explains its adoption. Anonymity is also a key feature of payment instruments such as Bitcoin. According to Kahn and Linares-Zegarra (2015), this desire for anonymity could in part be explained by the risk of identity theft. We show in this paper that consumers may want to choose payment instruments more respectful of their financial privacy for other reasons that identity theft, mainly for keeping banks and relatives from having access to their transaction history.[5]

3 Model

We construct a model to study how the availability of a non-bank payment instrument that protects financial data from banks affects the consumers' purchasing decisions. To do so, we analyze two market structures. First, we study the case in which a bank is in a monopoly position to provide a payment instrument. Consumers purchase at an online retailer two goods using the payment instrument offered by the bank, a standard good and a privacy-sensitive good; there is no alternative payment instrument. In the second market structure, the bank is in competition (duopoly) with a non-bank institution to provide a payment instrument, and consumers can choose between the two payment instruments to purchase the two goods. Finally, we compare

[5]The social consequences of surveillance by relatives and friends are studied by sociologists such as Castells (2001).

purchasing decisions when consumers have the choice to use only a bank payment instrument or a bank and an alternative payment instrument.

In this section, we first define the objective functions of the consumers, of the retailer and of the financial intermediaries. We also describe the timing of the game. Second, we analyze the equilibrium strategies. Finally, we comment on the results of the model.

3.1 Consumer preferences and demand functions

Consumers have financial privacy concerns. They do not necessarily want to disclose personal data to financial intermediaries when using payment instruments. In the model, consumers are supposed to be uniformly distributed over a unit line according to their sensitivity to financial privacy ($x \in [0, 1]$). They can purchase two goods (indexed by $i = \{1, 2\}$) at a price $p_i > 0$ using a payment instrument k offered either by a bank (b) or a non-bank (a) (indexed by $k = \{a, b\}$). A non-bank institution can be an online financial intermediary such as Paypal.[6]

Buying online and using a payment instrument provides a direct utility related to the valuation of the good (v_i) but also involves a cost (cx) where c is the marginal cost related to the disclosure of personal data to financial intermediaries. We assume that $v_2 > v_1$, which translates the fact the first good is the outside option for which there is no privacy concern, and the second good has a higher value but is also associated with privacy concerns. We also assume that c is the same when using the payment instrument offered by a or b for good 1. When purchasing good 2, the consumer supports an additional cost α ($\alpha \in]0, 1]$) if she uses the payment instrument provided by the bank. Consumers are therefore more concerned by privacy issues when purchasing good 2 using the card provided by the bank. The utility functions of consumers are given by equations (1) and (2).[7]

For good 1:

$$U_1 = \begin{cases} v_1 - p_1 - cx - f^b & \text{if she uses (b),} \\ v_1 - p_1 - cx - s & \text{if she uses (a),} \\ 0 & \text{if she does not buy the good.} \end{cases} \tag{1}$$

[6]Consumers have unit demands (separately) for goods 1 and 2.

[7]In the rest of the model, subscript denotes the type of good (1 or 2). The first superscript denotes the financial intermediary (the bank b or the non-bank a) whereas the second superscript denotes the market structure (monopoly m or duopoly d). For example, $d_1^{a,d}$ denotes the demand of good 1 for the non-bank in a duopoly situation.

For good 2:

$$U_2 = \begin{cases} v_2 - p_2 - c(1+\alpha)x - f^b & \text{if she uses (b),} \\ v_2 - p_2 - cx - s & \text{if she uses (a),} \\ 0 & \text{if she does not buy the good,} \end{cases} \quad (2)$$

where f^b is the fee charged by the bank to use the payment instrument (b), and s the cost of using the alternative payment instrument (a). s includes, among other things, the inconvenience and the technical difficulties of using an alternative payment instrument.

3.2 The retailer

The retailer respectively charges prices p_1 and p_2 for goods 1 and 2, and proposes both payment instruments. The retailer pays a fee g^k if consumers purchase a good using the payment instrument a or b. The profit function of the retailer can be written as:

$$\Pi^r(p_i) = \sum_i d_i^b(p_i - g^b) + \sum_i d_i^a(p_i - g^a).$$

3.3 The financial intermediaries

The profit functions of the financial intermediaries differ. The bank charges a fee f^b to consumers and a fee g^b to the retailer on each transaction. The non-bank institution only charges a fee g^a on each transaction accepted by the merchant.

The profit function of the bank can be written as follows:

$$\Pi^b(f^b, g^b) = \sum_i d_i^b(f^b + g^b).$$

Similarly, the profit function of the non-bank is:

$$\Pi^a(g^a) = \sum_i d_i^a g^a.$$

3.4 Timing of the game

The timing of the game is in three steps:

- Stage 1: The financial intermediaries set f^b, g^b and g^a.

- Stage 2: The retailer charges p_1 and p_2 for goods 1 and 2, respectively.
- Stage 3: The consumers purchase the goods or not, and choose the payment instruments.

In the following, we look for the subgame perfect equilibrium, and solve the game by backward induction.

4 Equilibrium strategies

4.1 Monopoly (m)

Stage 3: purchasing and payment decisions

The demand faced by the retailer (r) using the bank payment instrument is constructed from the segment of consumers who have a strictly positive utility of purchasing the goods. The consumer who is indifferent between purchasing or not good 1 is determined by the following expressions:

$$v_1 - {p_1}^m - cx - f^{b,m} = 0, \tag{3}$$

$$\hat{x}_1^{b,m} = \frac{v_1 - {p_1}^m - f^{b,m}}{c}. \tag{4}$$

Similarly, the indifferent consumer between purchasing or not good 2 is determined by:

$$v_2 - {p_2}^m - c(1+\alpha)x - f^{b,m} = 0, \tag{5}$$

$$\hat{x}_2^{b,m} = \frac{v_2 - {p_2}^m - f^{b,m}}{c(1+\alpha)}. \tag{6}$$

The retailer faces the aggregate demand:

$$d^{r,m} = \hat{x}_1^{b,m} + \hat{x}_2^{b,m} = \frac{v_1 - {p_1}^m - f^{b,m}}{c} + \frac{v_2 - {p_2}^m - f^{b,m}}{c(1+\alpha)}. \tag{7}$$

Stage 2: the optimal prices

In the second stage of the game, the retailer maximizes its profit function (concave in ${p_1}^m$ and ${p_2}^m$). The profit function can be written as:

$$\Pi^{r,m}({p_i}^m) = \hat{x}_1^{b,m}({p_1}^m - g^{b,m}) + \hat{x}_2^{b,m}({p_2}^m - g^{b,m}). \tag{8}$$

Replacing Equations (4) and (6) in Equation (8) and differentiating with respect to p_1^m and p_2^m, we obtain:

$$\frac{\partial \Pi^{r,m}}{\partial p_1^m} = 0 \Rightarrow p_1^{m*} = \frac{v_1 + g^{b,m} - f^{b,m}}{2}, \tag{9}$$

and

$$\frac{\partial \Pi^{r,m}}{\partial p_2^m} = 0 \Rightarrow p_2^{m*} = \frac{v_2 + g^{b,m} - f^{b,m}}{2}. \tag{10}$$

Stage 1: the optimal bank fees and the total demand

In the first stage of the game, the monopoly maximizes its profit function with respect to its fees $f^{b,m}$ and $g^{b,m}$:

$$\Pi^{b,m}(f^{b,m}, g^{b,m}) = \left(\hat{x}_1^{b,m} + \hat{x}_2^{b,m}\right)\left(f^{b,m} + g^{b,m}\right). \tag{11}$$

The problem can be reduced to a one variable maximization problem:

$$\frac{\partial \Pi^{b,m}}{\partial (f^{b,m} + g^{b,m})} = 0 \Rightarrow \left(f^{b,m} + g^{b,m}\right)^* = \frac{v_2 + (\alpha+1)v_1}{2(\alpha+4)}. \tag{12}$$

Combining Equations (4), (6), (9), (10) and (12), the optimal profit of the bank in monopoly is therefore:

$$\Pi^{b,m*} = \frac{\left((1+\alpha)v_1 + v_2\right)^2}{8c(1+\alpha)(2+\alpha)}. \tag{13}$$

To conclude this monopoly game, the demands for the retailer and the bank are similar as all the payments are realized with the only bank payment instrument. Replacing Equations (9), (10) and (12) in Equation (7), we then obtain:

$$d_1^{r,m*} = d_1^{b,m*} = \frac{(3+\alpha)v_1 - v_2}{4(\alpha+2)c},$$

and

$$d_2^{r,m*} = d_2^{b,m*} = \frac{(2\alpha+3)v_2 - (1+\alpha)v_1}{4(\alpha+1)(\alpha+2)c}.$$

The total demand for goods 1 and 2 in the monopoly case is therefore:

$$D_{total}^m = d_1^{r,m*} + d_2^{r,m*} = \frac{v_2 + (\alpha+1)v_1}{4c(\alpha+1)}. \tag{14}$$

4.2 Duopoly (d)

In the duopoly case, consumers have the option to use either the payment instrument provided by a bank or an alternative payment instrument offered by a non-bank institution.

Stage 3: purchasing and payment decisions

For each good, the demands for the bank and the non-bank are determined by two indifferent consumers: the consumer who is indifferent between purchasing using a payment instrument a or b or not purchasing at all; the consumer who is indifferent between purchasing the good using payment instrument a or b.

We show in Appendix A.1 that f^b is necessarily lower than s at the equilibrium of the game[8]. In this case (a) is always dominated by (b). This means that consumers have only the choice for good 1 between purchasing the good with b or not purchasing at all. Regarding good 2, the trade-off between a and b is still available even though $f^b < s$ because consumers incur an additional cost α due to privacy when using b but not a.

As a consequence, the consumer who is indifferent between purchasing or not good 1 using the bank payment instrument is determined by the following expression:

$$v_1 - {p_1}^d - cx - f^{b,d} = 0, \tag{15}$$

$$\hat{x}_1^{b,d} = \frac{v_1 - {p_1}^d - f^{b,d}}{c}. \tag{16}$$

For good 2, the indifferent consumer between using b or a is given by:

$$v_2 - {p_2}^d - c(1+\alpha)x - f^{b,d} = v_2 - {p_2}^d - cx - s, \tag{17}$$

$$\hat{x}_2^{a,b,d} = \frac{s - f^{b,d}}{c\alpha}. \tag{18}$$

The indifferent consumer between purchasing or not good 2 is determined by:[9]

$$v_2 - {p_2}^d - cx - s = 0, \tag{19}$$

[8]There is another case where the bank can capture the overall demand by setting a lower fee, which prevents the non-bank from entering the market. We do not analyze this particular case as we precisely want to study the competition between a bank and a non-bank in providing payment instruments.

[9]See Appendix A.2 for more details on the computation of the locations of the indifferent consumers.

$$\hat{x}_2^{a,d} = \frac{v_2 - {p_2}^d - s}{c}. \tag{20}$$

The retailer faces the aggregate demand, while the two financial intermediaries face their own individual demands:

$$d^{r,d} = {d_1}^{r,d} + {d_2}^{r,d} = \hat{x}_1^{b,d} + \hat{x}_2^{a,d} = \frac{v_1 - {p_1}^d - f^{b,d}}{c} + \frac{v_2 - {p_2}^d - s}{c}, \tag{21}$$

$$d^{b,d} = {d_1}^{b,d} + {d_2}^{b,d} = \hat{x}_1^{b,d} + \hat{x}_2^{a,b,d} = \frac{v_1 - {p_1}^d - f^{b,d}}{c} + \frac{s - f^{b,d}}{c\alpha}, \tag{22}$$

$$d^{a,d} = d_2^{a,d} = \hat{x}_2^{a,d} - \hat{x}_2^{a,b,d} = \frac{v_2 - {p_2}^d - s}{c} - \frac{s - f^{b,d}}{c\alpha}. \tag{23}$$

Stage 2: the optimal prices

In the second stage of the game, the retailer maximizes its profit function. Under the duopoly case, we have:

$$\Pi^{r,d}({p_i}^d) = \hat{x}_1^{b,d}({p_1}^d - g^{b,d}) + \hat{x}_2^{a,b,d}({p_2}^d - g^{b,d}) + \left(\hat{x}_2^{a,d} - \hat{x}_2^{a,b,d}\right)({p_2}^d - g^{a,d}), \tag{24}$$

Replacing Equations (16), (18) and (20) in Equation (24), and differentiating with respect to p_1^d and p_2^d, we obtain:

$$\frac{\partial \Pi^{r,d}}{\partial p_1^d} = 0 \Rightarrow p_1^{d*} = \frac{v_1 + g^{b,d} - f^{b,d}}{2}, \tag{25}$$

$$\frac{\partial \Pi^{r,d}}{\partial p_2^d} = 0 \Rightarrow p_2^{d*} = \frac{v_2 - s + g^{a,d}}{2}, \tag{26}$$

Stage 1: the optimal bank fees and the total demand

When the bank and the non-bank compete, the bank faces the demands $d_1^{b,d}$ and $d_2^{b,d}$ and its profit can be written as:

$$\Pi^{b,d}(f^{b,d}, g^{b,d}) = d^{b,d}(f^{b,d} + g^{b,d}). \tag{27}$$

The non-bank is only operating in the duopoly market structure, and makes no profits on good 1 given that $f^b < s$. The demand faced by the non-bank is $d_2^{a,d}$ and the profit is:

$$\Pi^{a,d}(g^{a,d}) = d^{a,d} g^{a,d}. \tag{28}$$

The bank profit is maximum at $(f^{b,d*}, g^{b,d*})$ with:

$$f^{b,d*} = 0, \tag{29}$$

$$g^{b,d*} = \frac{\alpha v_1 + 2s}{2\alpha}, \tag{30}$$

(see Appendix A.3 for a complete analysis).

In response, the fee charged by the non-bank is:

$$g^{a,d*} = \frac{\alpha v_2 - (2+\alpha)s + 2f^{b,d}}{2\alpha} = \frac{\alpha v_2 - (2+\alpha)s}{2\alpha}. \tag{31}$$

Combining Equations (22), (25), (26), (29) and (30), the optimal profit of the bank in duopoly is therefore:

$$\Pi^{b,d*} = \frac{(\alpha v_1 + 2s)^2}{8\alpha^2 c}. \tag{32}$$

Combining Equations (23), (25), (26) and (31), the optimal profit of the non-bank in duopoly can be written as follows:

$$\Pi^{a,d*} = \frac{(\alpha v_2 - \alpha s - 2s)^2}{8\alpha^2 c}. \tag{33}$$

To conclude the analysis of the duopoly game, we compute the demand for both financial intermediaries.

Replacing Equations (25), (26), (29), (30) and (31) in Equation (22) and (23), we then obtain:

$$d_1^{r,d*} = d_1^{b,d*} = \frac{\alpha v_1 - 2s}{4\alpha c},$$

$$d_2^{b,d*} = \frac{s}{\alpha c},$$

$$d_2^{a,d*} = \frac{\alpha v_2 - (\alpha+2)s}{4\alpha c},$$

$$d_2^{r,d*} = d_2^{a,d*} + d_2^{b,d*} = \frac{\alpha v_2 - \alpha s + 2s}{4\alpha c}.$$

The total demand for goods 1 and 2 in the duopoly case is therefore:

$$D^d_{total} = d_1^{r,d*} + d_2^{r,d*} = \frac{v_1 + v_2 - s}{4c}. \tag{34}$$

4.3 Results and comparison

We now have all the elements to answer the initial question: does the availability of a non-bank payment instrument that protects financial privacy from banks affect the consumers' purchasing decisions? In other words, do non-bank payment services allow consumers to purchase online goods that they would not have purchased with bank payment instruments?

To answer this question, we need to compare the total demand for goods 1 and 2 in the monopoly and the duopoly games, that is we compare Equation (14) to Equation (34).[10]

Proposition 1 *: $D^d_{total} > D^m_{total}$ (proof: see Appendix A.4).*

Proposition 1 confirms that the availability of a non-bank payment instrument that preserves financial privacy from banks increase the total demand of goods 1 and 2 in the case of the duopoly with respect to that in the monopoly. The increase in the total demand results from two opposite economic forces according to the value of α, s, v_1 and v_2, i.e. a positive market expansion effect and a negative competition effect.

A strong market expansion effect arises when the cost α associated with financial privacy is large enough. In that case, the demand for good 2 is always greater under duopoly than under monopoly. When α is large and the value v_2 of good 2 is also large, the demand for good 1 under duopoly also increases[11]: as the competition between the bank and the non-bank becomes tougher on the market for good 2, the bank reduces the fees which also increases the demand for good 1.

For high values of α and a small market for good 2, the bank will focus on the market for good 1 by increasing its fees, which reduces the demand. However, overall, the total demand for good 1 and good 2 still increases, as the increase in the demand for good 2 is greater than the reduction of the demand for good 1.

A large value of the cost s of using the non-bank payment instrument also increases the demand for good 2 under duopoly, as it increases the demand for good 2 using the bank payment instrument more than it decreases the demand using the non-bank payment instrument.

[10] Restricting the analysis for the demand for good 2 is not enough as an increase in the demand for good 2 could be offset by a decrease in the demand for good 1 due to competition, resulting in a reduction of the total demand.

[11] v_2 has a negative effect on the demand for good 1 in the monopoly case, but not in the duopoly case.

When the cost α related to financial privacy is low, the competition effect becomes stronger. The demand for good 2 is larger under duopoly than under monopoly when the value v_1 of good 1 and the cost s to use the non-bank payment instrument are large. However, the demand for good 1 decreases under duopoly for large values of v_1 and of s. Indeed, demand for good 1 under monopoly is more sensitive to an increase in v_1 and s than the demand for good 1 under duopoly: without competition, the bank has less constraints to set its fees. Nevertheless, the aggregate demand is always larger under duopoly than under monopoly for small values α, as the increase in the demand for good 1 is larger than the decrease in the demand for good 2, under our relatively general assumptions.

5 Empirical investigation

In this section, we test whether the use of a non-bank payment instrument by consumers has a positive impact on their online purchases. We first introduce the survey used to collect the data, and second, we present descriptive statistics. Third, we describe the estimation strategy and define the variables used in the regressions. Finally, we discuss the estimation results.

5.1 Survey design and descriptive statistics

We use a survey conducted in May 2015 by ACSEL/Caisse des Dépôts on a sample of 1,000 French Internet users aged 15 years and older. The survey was drawn from access panels (directories of people willing to participate in surveys on a regular basis). The sample is representative of the French Internet population (in terms of age, sex, socioeconomic classification, urban areas and Internet use). The survey has been conducted using online questionnaires.

The main objective of the survey is to measure the level of trust of Internet users in several online services (bank, administration, etc.). The survey is divided into several parts that deal with Internet access and use, e-commerce, payment instruments, online banking, online communication (chats, blogs, etc.), social networks, online administration, cloud services, Internet of things, security and authentication, personal data and privacy. We focus our empirical study on the questions related to e-commerce (frequency of purchase, average monthly spending, trust in online retailers, security and privacy policy, etc.) and online payments. We now describe these questions in more detail.

French e-commerce is one of the most developed in Europe. In 2014, 34.7 millions of online consumers (79 per cent of french Internet users) spent 57 billion euro in 164,000 online retailers (FEVAD, 2015). In our survey, 81 per cent of the respondents (811 respondents) in 2015 report to have made at least one online purchase during the last 12 months. Figure 1 displays the distribution of the frequencies of online purchases. The mode of the distribution is "More than once a month" (49 per cent). Overall, 62 per cent of the online consumers claim to make more than one purchase per month.

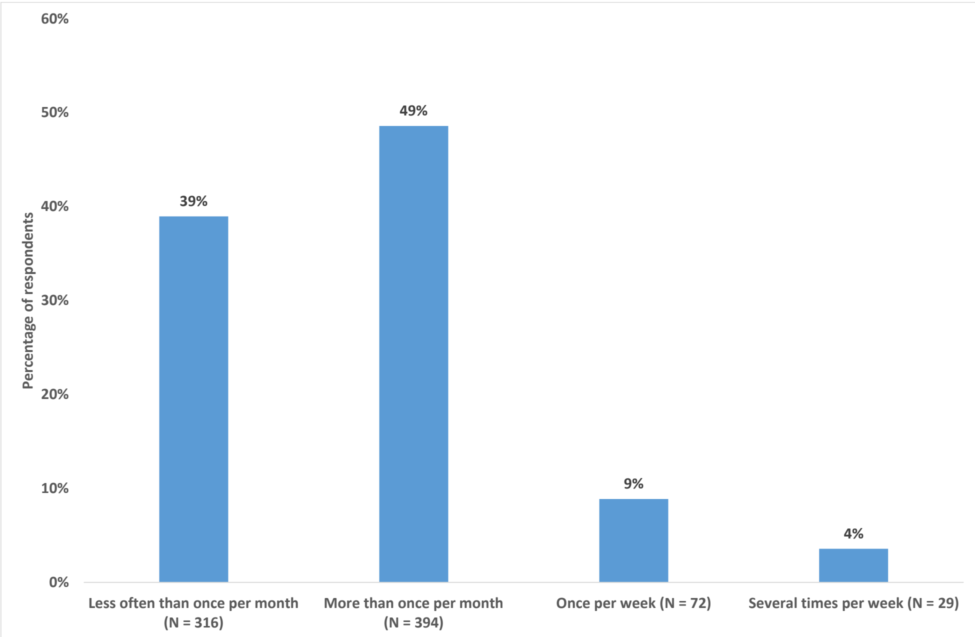

Figure 1: Frequencies of purchases of online consumers

Consumers use several payment instruments (Figure 2) for their online purchases. Payment cards provided by banks[12] and PayPal are by far the two most used payment instruments: 95 per cent declare using a payment card, and 36 per cent PayPal.[13] We also observe that 22 per cent of the respondents use other payment instruments. We know that 11 per cent of the respondents use gift cards that are redeemable only for purchases at retailers and that cannot be cashed out. The

[12]95 per cent of the payment cards issued in France are debit cards (see Bagnall et al. (2016)).

[13]As from April 2015, 165 million of PayPal accounts are active with an average of 23 transactions by account in the first quarter of 2015. At the end of March 2015, 30 per cent of US online transactions were made using PayPal (retrieved from Paypal.com). No public data are provided for France.

remaining 11 per cent of the respondents use other unknown payment instruments.

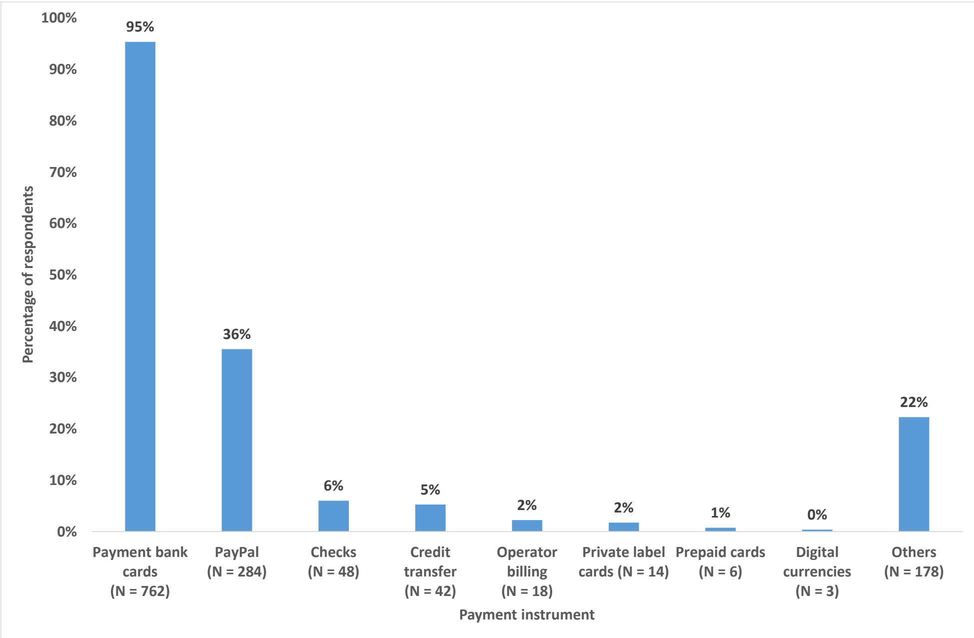

Figure 2: Use of payment instruments

Among online consumers, 53 per cent only use one payment instrument, 29 per cent use two payment instruments, and 17 per cent use three or more payment instruments. Internet users who only use one payment instrument prefer payment cards provided by banks (94 per cent), while only two per cent of them prefer PayPal. People using two or more payment instruments prefer payment cards and PayPal (66 and 58 per cent, respectively). The use of the other payment instruments is limited. It is worth noting for our purpose that PayPal is not accepted by all retailers in France, which explains its limited rate of penetration. For instance, Amazon does not accept PayPal payments. However, it is crucial for the rest of the analysis to keep in mind that a retailer who accepts PayPal in France always accepts a payment card.[14] As a consequence, using PayPal is a real choice for a consumer as he could have used his bank card instead.

To summarize, consumers can use payment instruments provided by banks such as payment cards, checks, and credit transfers that are related to their bank account. They can also use other

[14]PayPal transaction fees are above 1.9 per cent with respect to standard card payment fees and can reach 3.4 per cent for transactions prices below euro 2,500 in France.

payment instruments that are not attached to their bank account, i.e. some payment instruments provided either by other financial intermediaries such as PayPal or private companies such operator billing, private label cards, prepaid cards, and digital currencies. In Figure 3, we note that 54 and 2 per cent of the respondents report that they exclusively use bank or non-bank payment instruments, and 24 per cent report that they use both bank and non-bank payment instruments. A significant proportion of French online consumers use therefore both bank and non-bank payment instruments.

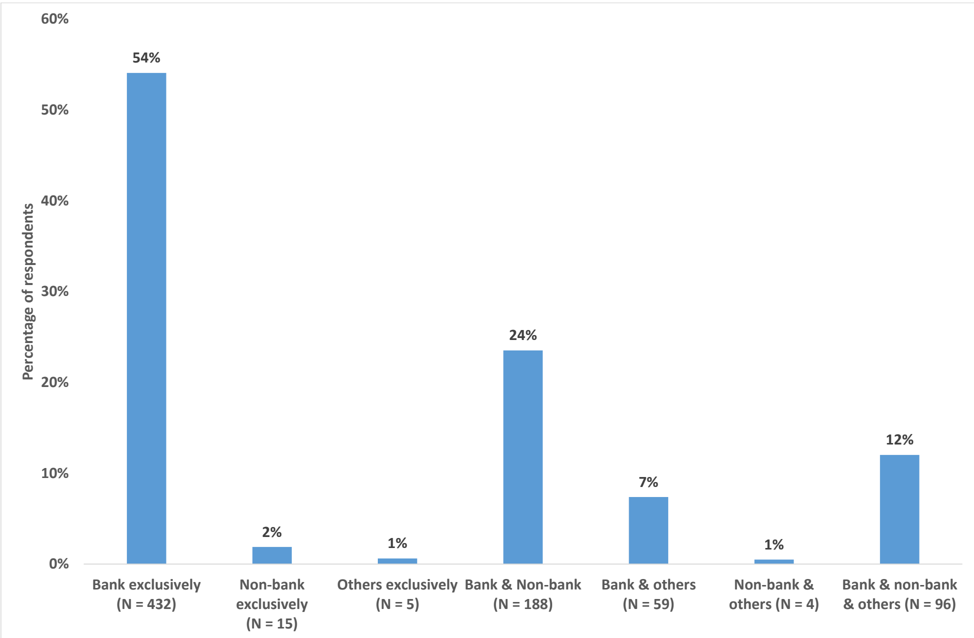

Figure 3: Exclusive use of bank and non-bank payment instruments

These preliminary descriptive statistics raise the question of the motivation of consumers to use non-bank payment instruments for their online purchases. In this paper, we hypothesize that they use in part non-bank payment instruments to protect their financial privacy. Convenience, security and person-to-person transfers are further characteristics that could also explain the use of non-bank payment instruments. We explain below how we control for these other dimensions in the econometric analysis.

Using a bank payment instrument leaves indeed a trace on the bank account such as the name of the retailer, the amount of the transaction, its date, etc. By contrast, using a non-bank payment instrument does not necessary leave a trace on the bank statement. For example, when using PayPal, Internet users have two options. First, they can decide to credit their online PayPal account, which allows them to directly pay online. In that case, banks have absolutely no information on online purchases.[15] Second, they can decide to register and to use the payment card provided by their bank. In that case, all payments made using PayPal are reduced to a single line on the bank account and banks have only the aggregate amount of online payments carried out on a given period, but not the characteristics of each payment. Likewise, prepaid cards, virtual currencies and the payment services provided by internet providers or private companies (operator billing) cannot be tracked by banks.

Internet users are aware of the characteristics of the payment instruments provided by banks and non-banks. They may decide, for various reasons, to purchase online goods using non-bank payment services to protect personal information from further uses by the banks. For example, Internet users may want to avoid to be profiled or targeted by financial commercial campaigns. Others may be simply unwilling to let relatives access financial information on a bank statement. Regardless of the reason, consumers may purchase online goods that they would not have purchased using a bank payment instrument if they have the option to use a non-bank payment instrument that protect their financial privacy. To sum up, individual demands may increase with the use of non-bank payment instruments, as we showed in Proposition 1.

5.2 Endogenous use of payment instruments: econometric methodology

We test whether the use of non-bank payment instruments, when controlling for various other effects, positively influences consumers' online purchases. The dependent variable, "Purchase", is the frequency of online purchases: "less often than once per month", "more than once per month", "once per week", and "several times per week". Six groups of explanatory variables are used in the regression described in Equation (35):

[15]This situation can be compared to the use of cash at point-of-sale transactions. Cash is anonymous and cannot be tracked by banks.

$$
\begin{aligned}
(\text{Purchase})_i = \alpha &+ \beta_1(\text{Use of non-bank payment instruments})_i \\
&+ \beta_2(\text{Financial info stored on e-commerce websites})_i \\
&+ \Sigma_{j=3}^{j=4}\beta_j(\text{Empowerment})_i \\
&+ \Sigma_{j=5}^{j=7}\beta_j(\text{Risk})_i \\
&+ \Sigma_{j=8}^{j=13}\beta_j(\text{Online activity})_i \\
&+ \Sigma_{j=14}^{j=19}\beta_j(\text{Individual variables})_i
\end{aligned}
\tag{35}
$$

First, we use a binary variable "Use of non-bank payment instruments" that indicates whether a respondent uses a non-bank payment instrument. As suggested in the theoretical model, we expect to find that the use of a non-bank payment instrument that preserves financial privacy is positively correlated with online purchases.

Second, Internet users may prefer to use non-bank payment instruments for other reasons than financial privacy such as convenience and efficacy. For example, some online retailers offer the possibility to store personal financial information on their websites to save time during the checkout process. This is especially important concerning PayPal, which allows consumers to pay online only by logging into their PayPal account. As PayPal is the most used non-bank payment instrument in the data set, we want to control for this effect in order to isolate an eventual financial privacy effect. As a consequence we introduce a variable named "Financial info stored on e-commerce websites" that determines whether a consumer has stored financial information at online retailers.

Third, we include two variables related to the empowerment of Internet users ("Empowerment"): the use of ad-blockers and privacy enhancing web browser extensions ('Ghostery' or 'HTTPS everywhere' for example). We expect these variables to be positively correlated with online purchases. The intuition is simple: as people are more aware of the potential negative incidences of privacy issues (such as tracking, profiling, solicitation, etc.), they start adopting privacy enhancing tools. Once protected, they are inclined to trust e-commerce more and also to purchase more.

Four, we include three variables related to the risks of electronic commerce ("Risk"): whether the respondent deleted cookies during the past year, the perceived risk of banking details being hacked on electronic commerce websites, and finally the perceived risk of banking details being consulted by third parties on online banking websites. This type of variables has been previously used by Akhter (2012) and Tsai et al. (2011). The authors find evidence of a negative impact of privacy concerns on online purchases. We expect these variables to be negatively correlated with the frequency of online purchases.

Five, we control for the level of the respondents' online activities ("Online activity"). Assessing this is important as the use and knowledge of non-bank payment instruments might importantly be correlated with online experience. People may indeed be driven to use several payment instruments when shopping online as they may purchase to various online retailers. We control for this effect by using a variable that indicates the number of payment instruments used in online purchases. This knowledge of alternatives to bank payment instruments may also be the consequence of a general online experience. We take this experience into account with a binary variable that indicates whether an individual connects to the Internet every day, a binary variable for the number of passwords used to secure online accounts (1 = more than 10, 0 = less than 10), and finally whether individuals use online banking. We also use average online spending (less than euro 50, between euro 50 and euro 250) to determine the link between online spending and purchase frequency.

Finally, we control for various individual variables ("Individual variables"): whether the respondent has children or not, the socio-economic category (1=employed, worker or farmers, 0 = other categories), the age category (15-24, 25-34, 35-49, 50+), the level of education (no diploma, high school, undergraduate and graduate studies). These variables also might be related to online experience, as younger individuals or more educated ones for example could be more aware of the variety of payment solutions available online.

The main econometric concern with Equation (35) is related to a potential endogeneity issue if the use of a non bank-payment instrument is correlated with unobservable variables that influence the frequency of online purchases. To be more precise, the use of a non-bank payment instrument may affect the frequency of online purchases. In this case, the coefficients estimated by OLS can be biased. In this section, we address this potential issue by using an endogenous binary variable model that explicitly models the correlation between the latent variable that explains the use of a non-bank instrument ($non\text{-}bank_i$) and the frequency of online purchases ($purchase_i$). Equation (36) determines the outcome of the use of a non-bank payment instrument. We define *non-bank$_i$* as a binary variable corresponding to the use of a non-bank payment instrument:

$$\text{non-bank}_i = \begin{cases} 0 & \text{if } w_i \leq 0, \\ 1 & \text{if } w_i > 0. \end{cases} \tag{36}$$

with:

$$w_i = X_i\beta + \epsilon_{non-bank,i}, \tag{37}$$

where w_i is a latent variable, β is of dimension k, and X_i is a set of control variables.

We rewrite Equation (35) to explicitly model the potential correlation between unobservable variables in the following way:

$$\text{purchase}_i = \text{non-bank}_i\delta + V_i\gamma + \epsilon_{\text{purchase},i}, \tag{38}$$

where V_i is a set of exogenous explanatory variables that influences $purchase_i$ defined in Equation (35), and δ is the parameter associated with the endogenous binary variable. We assume that $\epsilon_i = (\epsilon_{non-bank,i}, \epsilon_{purchase,i})'$ is normally distributed with mean $(0,0)'$ and covariance Σ for $i = 1, \ldots, n$:

$$\Sigma = \begin{bmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{bmatrix}. \tag{39}$$

The parameter ρ represents the correlation between the unobservable variables. Parameter σ^2 is the variance of $\epsilon_{purchase,i}$. As the variance in Equation (37) is not identified, we normalize it to 1. This is standard restriction in probit models (Wooldridge, 2006).

We estimate the equations using three econometric methods, namely an ordered probit model, a linear probability model estimated by OLS and a Bayesian Markov Chain Monte Carlo model.[16] First, we assume that there is no endogeneity issue and estimate Equation (37) using an ordered probit specification and a linear probability model estimated by OLS. These estimates are not

[16]In principle, the parameters of the system of equations could also be estimated by Maximum Likelihood. However, Waelbroeck (2005) and others have shown that this method provides less reliable estimates of the elements of the covariance matrix of unobservable variables than the Bayesian method. See for a general introduction to numerical Bayesian tools (Greenberg, 2014). The identification of the endogenous effect in this model is guaranteed by the non-linearity of the probability to use a non-bank payment instrument. The estimation procedure can be carried on with the same set of explanatory variables in the two equations, contrary to instrumental variable method that requires some variables to be excluded in linear regression models. Instrumental variable estimation results yields the same results as OLS and are available upon request.

biased if $\rho = 0$. The linear probability model does not not take into account the qualitative nature of the dependent variable but directly provides partial effects of the explanatory variables.

Second, we estimate the system of Equations (36), (37) and (38) using an MCMC method that can deal with the case $\rho \neq 0$.[17] The idea is to use "data augmentation" to simulate observations for the unobservable endogenous latent variable w_i of Equation (37) and to draw simulations from the full posterior distribution of β, δ, γ, ρ, σ, and w_i.[18] Indeed, once we observe or simulate w_i in Equation (37), the system of Equations (37) and (38) is a simple Seemingly Unrelated Regression model (SUR).

5.3 Results and interpretation

Estimation results are reported in Table 1.[19] Parameters of Equation (35) are estimated using three econometric methods: an ordered probit model that we estimate by maximum likelihood in column (1); a linear probability model that we estimate by OLS in column (2), and by Bayesian MCMC methods in column (3). Results in the first two columns do not take into account the potential endogeneity of the use of a non-bank payment instrument while those in column (3) do.[20]

First, we find a significant negative correlation between unobservable variables of the system of Equations (36), (37) and (38) which leads the OLS to underestimate the effect of the use of non-bank payment instruments on online purchases. As indicated in Table 1, the coefficient ρ is about -0.57 per cent. It was therefore important to account for a potential endogeneity

[17] Bayesian MCMC methods are based on a simulation of a Markov process in the parameters space (including the latent variables), which converges to a limiting distribution that it is exactly the posterior distribution of the parameters. Each parameter is simulated sequentially from its posterior conditional distribution with the Gibbs algorithm. When the exact posterior conditional distribution is not available, the Metropolis-Hastings algorithm simulates a draw by using a probabilistic acceptance method. The details of this procedure are available upon request and are also described in the context of an ordinal endogenous variable model by Bounie et al. (2016).

[18] Data augmentation exploits the latent variable structure of multinomial probit models by simulating the latent variables from truncated normal distributions, generating additional data. The full posterior distribution of the parameters and of the latent variables is much simpler to analyze.

[19] We restrict the sample to respondents who only use either bank or non-bank payment instruments; we therefore omit people who use other payment instruments. We also estimated parameters of the model by including respondents who use other payments instruments (gift cards and others) and obtain similar results that are available upon request. For reason of convenience, we did not report the control variables related to "Online activity" and "Individual variables"; the results are also available upon request.

[20] Regarding the MCMC model, we excluded the variable "Number of payment instruments" from the first stage equation because it was too collinear with the use of non-bank instruments. The table of correlation between all variables is omitted to save space and is available upon request.

related to the use of non-bank payment instruments. We find indeed a statistical significant effect at the 5 per cent level of about 0.99 of this variable on the frequency of purchase. In other words, for consumers who carry out on average "once purchase per month", using a non-bank payment instrument increases the frequency of purchase to "once per week".[21] Going back to Proposition 1 of the model, the estimation results confirm that the availability of non-bank payment instruments may contribute to increase individual consumer demand. Note that the positive effect of using non-bank payment instruments is robust to the specification used as it equals 0.25 per cent for the OLS regression and it is also significant at the 5 per cent level for the ordered probit model.

It is important to outline that we control for various other factors that might increase the use of non-bank payment instruments. Amongst them, the convenience of using online payment instruments (measured by the variable that determines whether a consumer has stored financial information online) is strongly positive, which shows that it was therefore important to capture this (efficacy) dimension of online payment instruments that is not related to financial privacy.

In Table 1, we also note an interesting result related to the estimated effects of using privacy-enhancing technologies on the frequency of purchases. As commented in Section 2, the existing literature suggests that people who are more concerned with their online privacy are likely to purchase less. Our results suggest that the relation is more subtle. First, the coefficients associated with the variables "use of privacy enhancing browser extensions" are positive and significant at the 10 per cent level for the OLS and the ordered probit models, which means that as people become more familiar with privacy issues and adopt privacy enhancing tools, they start to trust e-commerce more and also to purchase more. Secondly, the coefficients associated with the variables related to risks associated to unauthorized uses of personal data ("deleting cookies" and "bank frauds") are negative and confirms the results found in the existing literature (Acquisti et al., 2015). These two results seem to indicate that there are probably two types of Internet users. On the one hand, there are people who are afraid of making online transactions and who reduce in turn their online purchases. On the other hand, there are Internet users who adopt protection technologies and who trust e-commerce more, resulting in an increase of their online purchases.

[21] The dependent variable can take on 4 values, 1 to 4, with an average of 1.77 (see Table A2 in Appendix B), which corresponds to a purchase "once per month". Increasing the variable to 0.99 increases the frequency to 3 which corresponds to "once per week".

These two effects should be investigated further.

Table 1: Estimation results

	Column (1)	Column (2)	Column (3)	
			MCMC	
Dependent variable: Frequency of purchase	Ordered probit	OLS	Step 1: Use of non-bank payment instruments	Step 2: Frequency of purchase
Payment instruments				
Use of non-bank payment instruments	0.432^{**} (0.179)	0.250^{**} (0.103)		0.993^{**} (0.408)
Convenience				
Financial information stored on e-commerce websites	0.336^{***} (0.105)	0.206^{***} (0.0610)	0.415^{***} (0.119)	0.096 (0.092)
Empowerment				
Use of ad-blockers	0.138 (0.107)	0.075 (0.0614)	0.025 (0.123)	0.074 (0.070)
Use of privacy enhancing web browser extensions	0.291^{*} (0.161)	0.181^{*} (0.0945)	0.352^{*} (0.183)	0.070 (0.123)
Risk				
Deleting cookies	-0.140 (0.121)	-0.0837 (0.0691)	0.380^{***} (0.138)	-0.181^{*} (0.094)
Perceived risk of banking details being hacked on e-commerce websites	-0.441^{***} (0.162)	-0.271^{***} (0.0935)	0.034 (0.180)	-0.270^{***} (0.107)
Perceived risk of banking details being consulted on online banking websites	-0.232^{***} (0.103)	-0.140^{**} (0.059)	0.113 (0.118)	-0.172^{**} (0.070)
Online activity	Yes	Yes	Yes	Yes
Individual variables	Yes	Yes	Yes	Yes
Constant		1.969^{***} (0.230)	-1.248^{***} (0.402)	1.898^{***} (0.256)
Constant cut 1	-0.561 (0.400)			
Constant cut 2	1.188^{***} (0.402)			
Constant cut 3	1.910^{***} (0.408)			
ρ				-0.567^{*} (0.299)
σ				0.765^{***} (0.057)
Observations	566	566	566	566
Pseudo R^2 - R^2	0.1122	0.2060		
Prob > $\chi 2$	0.000			
Note:	*p<0.1; **p<0.05; ***p<0.01			

6 Conclusion

Our theoretical and empirical results clearly show that the relationship between privacy and online purchases is subtle. On the one hand, as the existing literature has shown, general privacy concerns tend to decrease online spending. On the other hand, some Internet users do not necessarily want to be identified by the bank during all their online activities. They are ready to take actions to hide some of their purchases from the bank or relatives. Using what we have called non-bank payment instruments such as PayPal and virtual currencies allows these consumers to purchase privacy-sensitive goods and to increase their online purchases. These findings have two main implications.

First, there is a recent trend by large financial institutions and 'Fintech startups' to propose more personalized payment solutions such as personalized coupons. We believe that financial intermediaries should think about enlarging their portfolio of online payment instruments to account for different levels of privacy: secure identification for the payment of local or federal taxes, anonymous transactions for gifts and for the purchase of privacy-sensitive goods. This approach could be paralleled to the European EIDAS regulation on electronic transactions that acknowledges the concept of federation of identities and leaves the door open for pseudonymized transactions.

Second, payment instruments and bank accounts provide useful and ongoing information on consumers' financial statements (overdrafts, revenues, etc.). By analyzing these traces, banks can evaluate the creditworthiness of consumers and the potential risks of lending money. They can also monitor borrowers to mitigate losses due to bad debt. Following Mester et al. (2007), providing deposit-taking and lending jointly is a capital advantage for banks in the competition with non-bank institutions that do not manage checking accounts. However, the development of non-bank institutions in the domain of payments could seriously affect this competitive advantage. If a significant fraction of consumer payments are carried out with non-bank institutions, banks will have in return less transactions to manage, and hence less information to make lending decisions. In the end, the profitability of banks could be affected.

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A Appendix: proofs

A.1 Appendix: $f^{b,d^*} < s$

We can depict different cases regarding the demand of the bank in the duopoly:

- $f^b > s$ which brings no demand to the bank,
- $f^b = s$ which brings no demand to the bank for good 2. The bank and the non-bank equally share the demand for good 1,
- $f^b < s$ which brings no demand to the non-bank for good 1. The bank and the non-bank compete for good 2.

The bank will obviously never choose $f^b > s$ as it will generate no profit. It decides between the two other solutions. We can show that the profit of the bank at the equilibrium when $f^b < s$, i.e. Π^{b,d^*}, is greater than the profit of the bank when $f^b = s$, i.e. $\Pi^{b,d}|_{f^{b,d}=s}$.

The profit of the bank at the equilibrium is:

$$\Pi^{b,d^*} = \frac{(\alpha v_1 + 2s)^2}{8\alpha(\alpha+2)c}.$$

The profit of the bank when $f^b = s$ is:

$$\Pi^{b,d}|_{f^{b,d}=s} = \frac{(18v_1 - 4v_2 - 5s)^2}{2888c}.$$

We have:

$$\Pi^{b,d^*} > \Pi^{b,d}|_{f^{b,d}=s} \Leftrightarrow \frac{(37\alpha v_1 - 4\alpha v_2 - 5\alpha s + 38s)(4\alpha v_2 + \alpha v_1 + 5\alpha s + 38s)}{2888\alpha^2 c} > 0,$$

which is positive for $v_1 > \frac{4\alpha v_2 + (5\alpha - 38)s}{37\alpha}$. The demand for $\Pi^{b,d}|_{f^{b,d}=s}$ is positive for $v_1 > \frac{4v_2+5s}{18}$. As the second condition binds the first, we finally have: $\Pi^{b,d^*} > \Pi^{b,d}|_{f^{b,d}=s}$.

A.2 Appendix: indifferent consumers in the duopoly

There is no indifferent consumer between not purchasing good 2 and purchasing it with (b), but only one indifferent consumer between not purchasing good 2 and purchasing it with (a). This means that it always brings more utility for a consumer indifferent between purchasing or not good 2 to purchase with (a) rather than with (b):

$$\hat{x}_2^{b,d} < \hat{x}_2^{a,d}.$$

The indifferent consumer between not purchasing good 2 and purchasing it with (b) is given by:

$$v_2 - p_2 - c(1+\alpha)x - f_b = 0,$$

$$\hat{x}_2^{b,d} = \frac{v_2 - p_2 - f_b}{c(1+\alpha)}.$$

For a consumer indifferent between purchasing or not good 2, purchasing with (a) is more satisfactory than with (b):

$$\hat{x}_2^{a,d} = \frac{v_2 - p_2 - s}{c}.$$

We then have:

$$\hat{x}_2^{b,d} < \hat{x}_2^{a,d} \Leftrightarrow \frac{v_2 - p_2 - f_b}{c(1+\alpha)} < \frac{v_2 - p_2 - s}{c},$$

$$\Leftrightarrow s < \frac{\alpha(v_2 - p_2) + f_b}{1+\alpha}.$$

This gives us $s \in]f_b; \frac{\alpha(v_2-p_2)+f_b}{1+\alpha}[$, and guarantees that we only have two indifferent consumers for good 2: the one indifferent between not purchasing and purchasing with (a), and the one indifferent between purchasing with (a) or (b).

This assumption guarantees that there is always a positive demand for (a) in the duopoly. Indeed, if s is too large, the non-bank is not competitive.

A.3 Appendix: critical solutions

A.3.1 Critical solution in the monopoly case

In the monopoly case, only the bank operates on the market. Its profit can be written as:

$$\Pi^{b,m}(f^{b,m}, g^{b,m}) = (g^{b,m} + f^{b,m})\Big(\frac{v_2 - g^{b,m} - f^{b,m}}{2(\alpha+1)c} + \frac{v_1 - g^{b,m} - f^{b,m}}{2c}\Big).$$

In the first stage of the game, the monopoly maximizes its profit function which leads to its optimal fees:

$$\frac{\partial \Pi^{b,m}}{\partial f^{b,m}} = 0 \Rightarrow f^*_{b,m} = \frac{(1+\alpha)v_1 + v_2 - 2(\alpha+2)g^{b,m}}{2(2+\alpha)},$$
$$\frac{\partial \Pi^{b,m}}{\partial g^{b,m}} = 0 \Rightarrow g^*_{b,m} = \frac{(1+\alpha)v_1 + v_2 - 2(\alpha+2)f^{b,m}}{2(2+\alpha)}.$$

We have a multiple equilibrium issue which can be simplified to a one variable maximization problem, where $g^{b,m} + f^{b,m} = h^{b,m}$:

$$\Pi^{b,m}(f^{b,m}, g^{b,m}) = h^{b,m}\Big(\frac{v_2 - h^{b,m}}{2(\alpha+1)c} + \frac{v_1 - h^{b,m}}{2c}\Big).$$

By differentiating the previous expression with respect to fees, we obtain:

$$\frac{\partial \Pi^{b,m}}{\partial h^{b,m}} = 0 \Rightarrow h^{b,m*} = (g^{b,m} + f^{b,m})^* = \frac{v_2 + (\alpha+1)v_1}{2(\alpha+4)}.$$

As the second derivative is negative, we have a maximum with $h^{b,m*}$.

A.3.2 Critical solution in the duopoly case

In the duopoly case, the bank and the non-bank provide to the consumers a payment instrument b and a, respectively. The profit function of the bank is:

$$\Pi^{b,d}(f^{b,d}, g^{b,d}) = (g^{b,d} + f^{b,d})\Big(\frac{v_1 - g^{b,d} - f^{b,d}}{2c} + \frac{s - f^{b,d}}{\alpha c}\Big).$$

In the first stage of the game, both financial intermediaries maximize their respective profit function. The maximization of the bank's profit function leads to the following critical point:

$$\frac{\partial \Pi^{b,d}}{\partial f^{b,d}} = 0 \Rightarrow f^{b,d*} = \frac{\alpha v_1 + 2s}{2},$$
$$\frac{\partial \Pi^{b,d}}{\partial g^{b,d}} = 0 \Rightarrow g^{b,d*} = -\frac{\alpha v_1 + 2s}{2},$$

which cancel the profit function.

The determinant of the hessian matrix for the bank decision regarding $g^{b,d}$ and $f^{b,d}$ is $D = \frac{\partial^2 \Pi^{b,d}}{\partial^2 f^{b,d}} \frac{\partial^2 \Pi^{b,d}}{\partial^2 g^{b,d}} - \left(\frac{\partial^2 \Pi^{b,d}}{\partial f^{b,d} \partial g^{b,d}}\right)^2 < 0$. As there is only one critical point and it cancels the profit function as a saddle point, we look then for the constrained equilibrium.

First case: $\Pi^{b,d}(f^{b,d}, 0)$

$$\Pi^{b,d}(f^{b,d}, 0) = (f^{b,d})\Big(\frac{v_1 - f^{b,d}}{2c} + \frac{s - f^{b,d}}{\alpha c}\Big)$$
$$f^{b,d*} = \frac{\alpha v_1 + 2s}{2\alpha + 4} \Leftrightarrow \Pi^{b,d}(f^{b,d*}, 0) = \frac{(\alpha v_1 + 2s)^2}{8\alpha(\alpha + 2)c}$$

Second case: $\Pi^{b,d}(f^{b,d}, \frac{\alpha v_1 + 2s - (\alpha+2) f^{b,d}}{\alpha})$

$$\Pi^{b,d}(f^{b,d}, \frac{\alpha v_1 + 2s - (\alpha + 2) f^{b,d}}{\alpha}) = 0$$

Third case: $\Pi^{b,d}(0, g^{b,d})$

$$\Pi^{b,d}(0, g^{b,d}) = (g^{b,d})\Big(\frac{v_1 - g^{b,d}}{2c} + \frac{s}{\alpha c}\Big)$$
$$g^{b,d*} = \frac{\alpha v_1 + 2s}{2\alpha} \Leftrightarrow \Pi^{b,d}(0, g^{b,d*}) = \frac{(\alpha v_1 + 2s)^2}{8\alpha^2 c}$$

Fourth case: $\Pi^{b,d}(\frac{\alpha v_1 + 2s - \alpha f^{b,d}}{\alpha}, g^{b,d})$

$$\Pi^{b,d}(\frac{\alpha v_1 + 2s - \alpha f^{b,d}}{\alpha}, g^{b,d}) = 0$$

As $\Pi^{b,d}(0, g^{b,d^*}) > \Pi^{b,d}(f^{b,d^*}, 0)$, the solution $f^{b,d^*} = 0$ and $g^{b,d^*} = \frac{\alpha v_1 + 2s}{2\alpha}$ maximizes the profit function.

The total demand in the case of the duopoly for the bank is composed from the demand for the first good and the demand for the second good. The fact that the demand for the second good for the bank is not impacted by the price makes it dependent only from the fee $f^{b,d}$. The demand for the first good has a monopoly form as the bank is the only payment instrument on the market for good 1. The bank has two instruments to monetize its demand: $f^{b,d}$ which is the fee per transaction paid by the consumers and $g^{b,d}$ which is the fee per transaction paid by the retailer. On the contrary to the monopoly case, the fees have not a symmetrical effect on the demand. From that point we can notice that an increase in $f^{b,d}$ has a larger negative impact on the total demand of the bank than $g^{b,d}$. Having two instruments allow the bank to absorb the loss from an increase in the first fee with a decrease in the second fee. However, as it is not symmetrical and an increase in $f^{b,d}$ causes more damage on the demand than an increase in $g^{b,d}$, an optimal choice is to set $f^{b,d} = 0$ to limit the negative impact on the demand and to compensate with a higher $g^{b,d}$.

A.4 Appendix: proof of Proposition 1

$$D^d_{total} > D^m_{total} \Leftrightarrow \Delta_{total} \equiv \frac{\alpha v_2 - (\alpha + 1)s}{4(\alpha + 1)c} > 0$$

The condition for $d_2^{a*} > 0$ is $v_2 > \frac{s(\alpha+2)}{\alpha}$ which ensures $D^d_{total} > D^m_{total}$. We can say that the total demand is greater under the duopoly than in the monopoly.

Analyzing the effect in decomposing the total demands, we denote D^m_2 the demand for good 2 in the monopoly case and D^d_2 the demand for good 2 in the duopoly case. We have the following condition:

$$D_2^d > D_2^m \Leftrightarrow \Delta_2 \equiv \frac{(\alpha^3 + \alpha^2 - \alpha)v_2 + (\alpha^2 + \alpha)v_1 + (4(\alpha + 1) - \alpha^3 - \alpha^2)s}{4\alpha(\alpha + 1)(\alpha + 2)c} > 0$$

The difference in the demand for the first product depends on the value of v_1, v_2, α and s, which directly impacts the size of the total fee $f^b + g^b$ and by extent the demand for good 2. A large v_1 decreases more the monopolistic demand for good 2 than it decreases the duopolistic one, hence increasing Δ_2. A high s increases the duopolistic demand, therefore increasing Δ_2. The impact of v_2 is more complex. A high v_2 would increase more the duopolistic demand than the monopolistic one only if $\alpha > \frac{\sqrt{5}-1}{2}$. If this last condition holds, we can say that $D_2^d > D_2^m$. However, for a lower α, it has to be compensated with high v_1 and s. Overall, we can say that for a large α D_2^d is always greater than D_2^m.

Denoting D_1^m the demand for good 1 in the monopoly case and D_1^d the demand in the duopoly case, we have the following condition:

$$D_1^d > D_1^m \Leftrightarrow \Delta_1 \equiv \frac{\alpha v_2 - \alpha v_1 - 2s(\alpha + 2)}{4\alpha(\alpha + 2)c} > 0$$

The difference in demand for the first product depends on the value of v_1, v_2, α and s, which directly impacts the size of the total fee $f^b + g^b$ and by extent the demand for good 1. Having a large v_2 will make the monopolistic total fee increase, and by extent decreases the demand for good 1 under monopoly. Therefore, it increases Δ_1. However, a large v_1 increases more the duopolistic fee than the monopolistic one, thus decreasing Δ_1. A large s increases the duopolistic fee, therefore decreasing Δ_1.
The impact of α is positive if $v_2 > v_1 + 2s$.

B Appendix: descriptive statistics

Table A1: Statistics - Binary variables

	N	Mean	St. Dev.	Min	Max
Payment instruments					
Use of non-bank payment instruments	722	0.35	0.48	0	1
Use of other payment instruments	722	0.10	0.31	0	1
Convenience					
Financial information stored on electronic commerce websites	811	0.449	0.498	0	1
Privacy					
Use of ad-blockers	1000	0.444	0.497	0	1
Use of privacy enhancing web browser extensions	1000	0.127	0.333	0	1
Risk					
Deleting cookies	1,000	0.703	0.457	0	1
Perceived risk of banking details being hacked on electronic commerce websites	1,000	0.860	0.347	0	1
Perceived risk of banking details being consulted by third parties on online banking websites	1,000	0.458	0.498	0	1
Online activity					
Using Internet several times every day	1,000	0.641	0.480	0	1
More than 10 passwords	1,000	0.170	0.376	0	1
Average monthly spending in electronic commerce inferior to euro 50	723	0.408	0.492	0	1
Average monthly spending in electronic commerce between euro 50 and euro 250	723	0.519	0.500	0	1
Using online banking	1,000	0.855	0.352	0	1
Control variables					
Having children	1,000	0.262	0.440	0	1
Lower socioeconomic classification	1,000	0.294	0.456	0	1
Inactives	1,000	0.40	0.49	0	1
Being between 15 and 24 years old	1,000	0.182	0.386	0	1
Being between 25 and 34 years old	1,000	0.159	0.366	0	1
Being more than 50 years old	1,000	0.397	0.490	0	1

Table A2: Statistics - Frequency of purchase

Less often than once per month = 1	More than once once per month = 2	Once per week =3	Several times per week = 4	N	Mean	St. Dev.
316	394	72	29	811	1.77	0.75

Table A3: Statistics - Number of payment instruments

One = 1	Two = 2	Three or more = 3	N	Mean	St. Dev.
316	394	72	811	1.77	0.75

Table A4: Statistics - Education

No diploma = 1	High school diploma = 2	Undergraduate and graduate studies = 3	N	Mean	St. Dev.
231	253	516	1000	2.285	0.82