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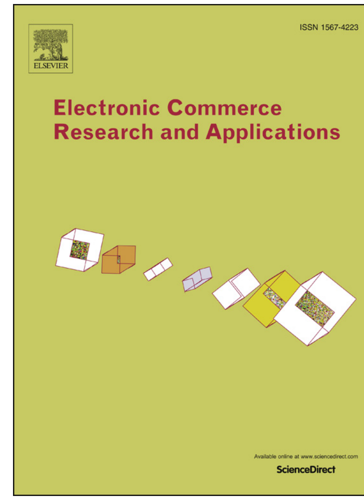

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PII: S1567-4223(16)30035-7
DOI: http://dx.doi.org/10.1016/j.elerap.2016.06.001
Reference: ELERAP 671

To appear in: *Electronic Commerce Research and Applications*

Received Date: 4 May 2015
Revised Date: 2 June 2016
Accepted Date: 2 June 2016

Please cite this article as: R.M. Grüschow, J. Kemper, M. Brettel, How do different payment methods deliver cost and credit efficiency in electronic commerce?, *Electronic Commerce Research and Applications* (2016), doi: http://dx.doi.org/10.1016/j.elerap.2016.06.001

HOW DO DIFFERENT PAYMENT METHODS DELIVER COST AND CREDIT EFFICIENCY IN ELECTRONIC COMMERCE?

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Last revised: June 1, 2016

ABSTRACT

Using unique data consisting of more than 16.3 million sales transactions provided by a leading European fashion e-commerce company, this study evaluates several payment instruments, including invoices, credit cards, PayPal payments, and prepayments, from an online retailer's perspective in terms of cost and credit efficiency. The authors identify the transaction size, allowance costs for fraudulent customers, and type of credit card provider that influence retailer transaction costs. Moreover, the results reveal that, for small transaction sizes, invoices are the most cost-efficient payment method, while prepayments dominate for large transaction sizes. Electronic payments in terms of both credit card and PayPal cause higher payment costs, and do not show scale efficiency in e-commerce. Furthermore, this research illustrates differences in the collection time of accounts receivable across payment methods, implying the cost of capital that arises for the retailer. The results lead to the conclusion that prepayments and PayPal payments are associated with the lowest cost of capital.

Keywords: Credit efficiency, credit cards, e-commerce, electronic payments, online retailing, Paypal, prepayments, retail payments, transaction costs, working capital.

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1. INTRODUCTION

The mode of payment that is offered to customers is important for a retailer's marketing and financial objectives, and has direct implications for a firm's profitability (Ingene and Levy, 1982). In particular, the increasing volume of worldwide transactions due to a still growing number of Internet shoppers (Pozzi, 2013), substantial innovations in payment technology and infrastructure (Kahn and Roberds, 2009), and significant changes in consumer payment habits (Pimentel, 2013; Schuh and Stavins, 2010) require new ways of handling payments in business-to-consumer markets in e-commerce (Stroborn et al., 2004).

Considering this background, it is not surprising that researchers have examined why individuals and firms use different payment instruments (Garcia-Swartz et al., 2006a; ten Raa and Shestalova, 2004). Although this is highly relevant for academics and practitioners, empirical evidence regarding payment costs and its influence on the payment choice is scarce (Hancock and Humphrey, 1998; Klee, 2008). The perspective of a retailer has yet to be explored in depth due to the absence of appropriate data (Dahlberg et al., 2008; Grewal and Levy, 2007). Previous studies on the economics of payment instruments used survey data (Garcia-Swartz et al., 2006a, 2006b; Hayashi and Keeton, 2012) or aggregated statistics (ten Raa and Shestalova, 2004), but did not have access to transaction-level data (Kahn and Roberds, 2009). Depending on the granularity of the data available, prior research has reported a wide variance in cost rankings and contradictory results, as well as divergent managerial conclusions (Hayashi and Keeton, 2012; Shampine, 2009, 2007). This topic has been identified as an important area for future research, since the two main questions "What does it cost to make a payment?" (Humphrey et al., 2003) and "Which payment instrument turns out to be the least expensive depending on the transaction size?" still have not been answered (Humphrey, 2010). Specifically, researchers have called for further research involving the collection of detailed data on an individual consumer and bank level to examine the complexity of financial payment instruments and consumer behavior (Scholnick et al., 2008). The dependency of the payment choice on the transaction value requires a detailed analysis of the market place and the associated transaction costs with regard to each payment method (Shy and Tarkka, 2002).

As a consequence, this study analyzes how retailers can provide cost and credit-efficient payment services in e-commerce. We offer three main contributions to the field.

From a conceptual viewpoint, we expand the well-established *transactions demand for cash framework* by Baumol (1952) and Tobin (1956) to an e-commerce environment by introducing Internet-specific payment instruments, such as invoices, credit cards, PayPal payments, as well as prepayments. We also include online payment systems-related transaction costs components, such as customer payment default costs and cost of capital. Compared to previous research, our estimation model gives a more holistic picture of the transaction costs retailers incur when providing payment services in their Internet businesses, and hence it offers opportunities for retailers in terms of lowering customer servicing costs and achieving greater efficiency (Kalaignanam et al., 2008; ten Raa and Shestalova, 2004). We also add to the Finance literature that has called for research into the relationship between different payment instruments, deposit reactions, and profitability (Bounie and Gazé, 2009; Santomero, 1984; Shy and Tarkka, 2002).

From an empirical viewpoint, we make a contribution by testing this theoretical model and deriving cost rankings of online payment instruments on the basis of a proprietary dataset from an online fashion retailer. It consists of more than 16.3 million actual customer sales transactions. This approach is unique, since existing research on the economics of payment instruments has not focused on the retailer's perspective or electronic transaction methods due to the scarcity of proprietary, transaction-level, supply-side data (Kahn and Roberds, 2009; ten Raa and Shestalova, 2004).

Ultimately, this research explores the differences in the collection time of the accounts receivable across payment methods and its respective influence on a firm's profitability. We consider the cost of capital as a component of the relevant transaction cost for retailers when they offer payment services in e-commerce. Thus, for the first time, we have connected payment and working capital management – two business disciplines often treated separately by operations management (Balakrishnan, 2011; Protopappa-Sieke and Seifert, 2010). Our regression results enhance retailer knowledge about how much capital is tied up in open customer transactions. This detailed knowledge is important in that it is useful towards initiating significant cost savings and working capital reductions to increase a firm's profitability and shareholder value (Kieschnick et al., 2013; Lieber and Orgler, 1975).

2. CONCEPTUAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

2.1. Literature Review

Drawing on the transaction cost theory, researchers have modeled the demand of cash by applying an inventory-theoretic approach in which money and goods are treated symmetrically in budget constraints (Baumol, 1952; Tobin, 1956). These models follow the assumption that transactions demand for cash, represented by the "*holder's inventory of the medium of exchange*," increases with the transaction size and the withdrawal conversion cost between cash and deposits, but decreases with the interest rate on the deposits (Baumol, 1952, p. 545). Consumer choice theory examines the relationship between individual consumer preferences focusing on the consumption of goods and services with regard to consumer expenditure constraints. Based on a utility model, rational individuals choose competing and substituting products when trying to maximize their overall satisfaction (Lancaster, 1966; Thaler, 1980; Uzawa, 1960). Building on the transactions demand for cash framework by Baumol (1952) and Tobin (1956), researchers have incorporated profit-maximizing consumer behavior and successively expanded it for more complex situations. Those include additional payment instruments besides cash (Santomero and Seater, 1996; Santomero, 1979; Whitesell, 1992). For instance, Whitesell (1992) assumes that rational customers choose payment instruments that minimize associated transaction and holding costs. Next to the strict cost-based approach, researchers identify a number of non-pecuniary determinants of payment choice with individual preferences towards, for example, convenience, reliability, safety, speed of transaction and, recordkeeping (Borzekowski et al., 2008; Fusaro, 2013).

2.2. Hypotheses Development

Following the lead of Baumol (1952) and Tobin (1956), we start our hypothesis development with the core transactions demand for cash framework. According to this traditional cost-based approach, Whitesell (1989) assumes that consumer transaction costs – and thus the choice of payment – solely depends on the size of the respective transaction (Whitesell, 1992). Analyzing transaction costs to merchants in traditional retailing, ten Raa and Shestalova (2004) found strong evidence that the costs of making a payment increase with the number of transactions as well as their respective value. Further empirical research in brick-and-mortar retailing illustrates that average costs of making a payment crucially depend on the amount purchased, and vary widely across transaction instruments (Bergman et al., 2007; Boeschoten, 1998; Brits and Winder, 2005; Garcia-Swartz et al., 2006a, 2006b). The first hypothesis follows Baumol (1952), Tobin (1956), and Whitesell (1989, 1992) and builds on the empirical results shown in offline retailing expecting that:

- **Hypothesis 1 (The Transaction Size-Payment Cost Relationship Hypothesis).** *The transaction size has a positive influence on retailer payment costs in e-commerce.*

In order to evaluate competing payment instruments in terms of cost efficiency and derive respective cost rankings, researchers divide transaction costs into a fixed and a variable component (Brits and Winder, 2005; Guibourg and Segendorff, 2007). Fixed costs incur each time a transaction is carried out, including, for example, bank charges, costs of payment equipment or software provision, expenses for credit card authorization and verification processes, and the costs of time allocated for bookkeeping or handling the dunning process (Bounie and Gazé, 2009; Chou et al., 2004; Koivuniemi and Kemppainen, 2007). Variable costs arise every time an exchange is made and depend on the value of the transaction (Chou et al., 2004; White, 1975). Payment methods differ in variable transaction costs in terms of (i) transaction fees charged to merchants by payment service providers, (ii) the cost of theft, and (iii) interest expenses on the transaction size during the time interval between the transaction date and receipt of money into the merchant’s account (Bounie and Gazé, 2009; Chakravorti and To, 2007; ten Raa and Shestalova, 2004). Following Shy and Tarkka's (2002) hypothesis implying each payment instrument will dominate a particular transaction size, we expect that payment methods in e-commerce also differ in terms of fixed and variable transaction costs.

According to Guibourg and Segendorff (2007) as well as Bleyen et al. (2010), both invoice and prepayment can be categorized as paper-based credit transfers in which customers instruct their account-holding bank to push money to a seller’s account (Leibbrandt, 2010; Stroborn et al., 2004). To process paper-based credit transfers, fixed setup costs to the merchant are low, since the payments are made through a bank’s infrastructure, and no installation of new technologies or security devices are needed by the retailer (Stroborn et al., 2004). Since money in these cash-equivalent payments is physically mailed from the customer to the retailer (Zhang and Li, 2006), variable costs are high as a result of the operating expenses of manually handling the payment instrument, such as mail, printing, and information conversion costs (Bergman et al., 2007; Borzekowski and Kiser, 2008). Considering fixed and variable cost attributes of paper-based credit transfers, we suggest that invoices and prepayments will be cost-efficient to the merchant – especially for small transaction online purchases.

Credit cards are *electronic pull payment systems* in which card owners authorize the card processor to debit the amount of purchased goods (Kim et al., 2010). To electronically process credit card transactions, payment costs to the merchant occur due to credit verification, bookkeeping, and communication between the central operators of the payment system (Shy and Tarkka, 2002). One cost component relevant for retailers is the interchange fee, typically amounting from 2% up to 6% of the transaction size (Choudhary and Tyagi, 2009; Wang, 2010). This processing fee is individually negotiated between the merchant and payment service providers, and dependent on a retailer's market power, effort in bargaining, sales characteristics, as well as industry specification (Chakravorti and To, 2007; Ingene and Levy, 1982). As a result, credit cards are often used in large purchases, since high fixed costs are disproportionally expensive for small value transactions (Kim et al., 2010). As card payments avoid physical handling costs due to automatic payment collection and information processing (Shy and Tarkka, 2002), we expect credit card payments in e-commerce to be cost-efficient for large transaction sizes. PayPal is an innovative web-based electronic payment vehicle allowing money transfers to be made through the Internet (Kuttner and MacAndrews, 2001). Processing online payments, PayPal charges merchants in Germany a variable fee in a range from 1.5% up to 1.9%, as well as a constant term per transaction of €0.35 – depending on a merchant's monthly sales volume, the average amount of usage within the last 90 days, as well as the transaction value per order (PayPal, 2014). PayPal can be either used as electronic money or as giro money acting as a front-end for debit or credit cards (Bleyen et al., 2010). From a seller's perspective, both types of PayPal usage are equivalent in terms of convenience and costs (Zhang and Li, 2006) – hence similarities in processing PayPal and credit card transactions do exist.

In summary, variable costs of electronic payments decline when the degree of automation is high (Guibourg and Segendorff, 2007). Therefore, electronic credit transfers are shown to raise economies of scales, due to automatic information processing with only incurring communication costs (Arango and Taylor, 2008; Humphrey et al., 2001). Accordingly, variable costs for electronic payment instruments are lower in high value transactions compared to account-based credit transfers in offline retailing (Guibourg and Segendorff, 2007; ten Raa and Shestalova, 2004). We follow these arguments found in literature for the e-commerce environment and hypothesize that:

- **Hypothesis 2 (The Transaction Size Efficiency Hypothesis).** *Small transaction sizes favor invoices and prepayments, while large transaction sizes are cost-efficient for credit card and PayPal.*

There are a number of frameworks related to cash in organizations: for example, the *cash cycle* concept by Gitman (1974), the *cash conversion cycle* by Richards and Laughlin (1980), and the *net trade cycle* by Shin and Soenen (1998). Each evaluated effective working capital management by estimating the time interval between expenditures on purchases and recovery of receipts from sales. Shin and Soenen (1998) studied a sample of 58,985 American companies and found that managers can significantly increase a firm's profitability and liquidity by reducing the length of the net trade cycle. Deloof (2003) shows that both the number of days of accounts receivable and inventories are negatively correlated with a firm's gross operating income. Hence, a substantial reduction in working capital allows firms to expand their businesses or run their businesses with the same level of cash (Humphrey et al., 2001). Murphy (1977), Whitesell (1989) and Shy and Tarkka (2002) emphasize that in addition to direct operating costs, also foregone interest on balances increases with a greater time difference between the purchase date and the due date of bills, and this represents a relevant cost component in retailing. Consequently, if interest is considered, the order date on which customers purchase, as well as the date the merchant is credited, are of great importance (Juang, 2007). Delays in the receipt of payments significantly increase a firm's outstanding accounts receivable. So postponements of payments extend the order-to-cash cycle, a cause of additional working capital (Mian and Smith, 1992). A greater level of working capital, in turn, implies the need for additional investment that must be financed and therein incurs interest expenses (Kieschnick et al., 2013). Since credit sales compared to cash transactions result in higher financing costs at the retailer – due to the spatial separation between customer purchases and money received from the payment provider (Grant, 1983; Ingene and Levy, 1982) – we suggest that payment methods in e-commerce differ significantly in terms of the collection time of accounts receivable.

To analyze the working capital requirements associated with invoices, credit cards, PayPal payments and prepayments, we apply the classification framework of Stroborn et al. (2004). It divides payment instruments into these categories: *pre*-paid, *pay now*, and *pay later*. It also refers to the moment the customer is debited during the shopping trip. In invoiced orders, retailers deliver products prior to issuing the bill and receiving money from the customer (Stroborn et al., 2004). Consequently, the seller extends credit to the buyer (Ng et al., 1999), and sales are recorded in the merchant's balance as open accounts receivable, presenting an illiquid asset until the payment is received (Klapper, 2006). For credit cards, also a postpaid transaction instrument (Chou et al., 2004), the customer's account is debited on an average of 25 days after the purchase (Garcia-Swartz et al., 2006a). From a retailer's perspective, the funds usually are available in the merchant's account within the next two business days (Chakravorti and To, 2007). In orders made by PayPal, customers mail the money to the seller's PayPal account the moment the purchase occurs (Au and Kauffman, 2008). Even more restrictive, prepayments force customers to pay for their shopping purchases before receiving the products from the retailer (Shugan and Xie, 2000). Buyers will extend credit to the seller which, in turn, can be immediately used to finance a merchant's operations (Ng et al., 1999). Drawing from attributes of payment instruments under examination, we hypothesize that:

- **Hypothesis 3 (Working Capital and Cost of Capital Hypothesis).** *Working capital requirements and arising cost of capital are highest for invoice payments, followed by credit card, then PayPal – and lowest for prepayment transactions.*

3. METHODOLOGY

3.1. Data

To test the hypotheses, we acquired a unique set of transaction-level data from a leading fashion e-commerce company. The retailer exclusively sells through the online channel. The product assortment consists of clothes, shoes, and accessories for women, men, and children, including over 1,500 global as well as national brands and private labels.

The data sample on daily transaction records covers January to December 2013, with a total of more than 16.3 million sales transactions. The data include customer purchases from the German online shop processed by four payment methods common in e-commerce business: invoices, credit cards, PayPal transactions, and prepayments.

The data originated in the company's enterprise planning system, with information on the merchant's fixed and variable costs of providing payment services in Germany. The retailer offers its customers all four methods free of charge. With invoice transactions, customers have a 14-day period to balance the open invoice after receiving the products. The credit card option allows settlement by the major card associations, Amex, MasterCard, and Visa. For credit card and PayPal transactions, the payment services offer escrow for the payment. In prepayment transactions, buyers have seven working days to advance their purchases until the products are handed back to the store. Table 1 gives an overview of which cost components are relevant for each payment instrument under study.

Table 1. Composition of payment costs by payment instruments

Payment Costs	Invoices	Credit Cards	PayPal Payments	Prepayments
Bank fees	6.68%	0.00%	0.00%	30.46%
Transaction fees	0.00%	95.92%	93.61%	0.00%
Risk check[1]	17.16%	2.12%	3.32%	35.65%
Dunning/Fraud[2]	59.24%	0.00%	0.00%	0.00%
Others[3]	16.91%	1.97%	3.07%	33.89%
Total	100.00%	100.00%	100.00%	100.00%

Note: [1]Risk check costs for external risk validation (executed if customer is new to the retailer independent of the payment method); [2]Dunning/Fraud covers allowance costs in case of customer payment defaults and expenses for dunning management. Allowance costs can amount up to the entire transaction size, and are fully reflected in a company's balance sheet; [3]Others includes account administration fees, collection charges, and fixed costs for paygate providers (worldpay, PAYONE, Maksuturva).

The primary data contain information on every checkout transaction: orders, payments and return dates; transaction sizes, number of payments per order, types of credit card used, and online shopping trip specific information – for example, information on a customer's payment default, and the number of sold or returned items.

To eliminate data variance and help the estimation algorithm to find convergence in the original data sample, we excluded implausible observations, such as allowances greater than the value of the total order transaction, from the dataset. Following this process, we were left with a total number of 16,373,935 observations on 12,314,326 invoices, 1,676,636 credit card transactions, 1,822,610 PayPal payments, and 560,363 prepayment transactions.

Furthermore, we created three dummy variables in order to disclose their moderating influence on retailer payment costs. First, we generated a dummy transaction number entitled '*TN*' that takes the value 1 if only a single customer payment occurs to settle the open invoice (*TN1*), and 0 in case a customer takes either none or more than one payment actions to settle the open account (*TN2*). The latter can be the case if orders are returned from customers back to the retailer (Zhang and Li, 2006). Second, we accounted for payment default and fraud, introducing the dummy payment default '*PD*' that displays *one* if payment default occurs and allowance costs arise to the retailer, and *zero* otherwise. Third, we created a variable '*CC*' to control for the type of credit card provider (Amex, Visa, and MasterCard). Table 2 presents descriptive statistics for the dataset.

Table 2. Descriptive statistics primary dataset, subdivided into payment methods

Variable	Mean	Median	Std. dev.	Min	Max
PC (€)	0.51	0.10	3.32	0.00	1,502.32
TS (€)	57.25	39.95	70.21	0.00	6,418.40
CT (€)	15.50	11.00	24.06	0.00	480.96
Dummy TN	0.75	1.00	0.43	0.00	1.00
Dummy PD	0.00	0.00	0.05	0.00	1.00
CC0	0.00	0.00	0.06	0.00	1.00
CC1	0.05	0.00	0.22	0.00	1.00
CC2	0.05	0.00	0.22	0.00	1.00

Note: Payment costs (PC), transaction size (TS), transaction number (TN), collection time (CT), payment default occurrence (PD), credit card provider (CC).

3.2. Estimation Approach

We focus on the retailer's perspective, since this approach enables us to directly measure customer choice of payment and costs of payment provision. The study aims to deconstruct the specific drivers of transaction costs to merchants. We did ordinary least squares (OLS) regression analysis individually for each of the four payment methods: invoices, credit card and PayPal payments, and prepayments. This approach is consistent with the studies of Boeschoten (1998) and ten Raa and Shestalova (2004), who also estimated separate cost functions for each transaction instrument. The base research model is represented with Equation 1:

$$PC_{i,t} = \beta_{1,2} + \left(\beta_3 + \beta_4 \cdot PD_{i,t} + \beta_5 \cdot CC1_{i,t} + \beta_6 \cdot CC2_{i,t}\right) \cdot TS_{i,t} + \varepsilon_{i,t} \quad (1)$$

The dependent variable $PC_{i,t}$ represents the payment costs needed to provide one single check-out transaction at order time *t* associated with payment method *i*. In line with ten Raa and Shestalova (2004), payment costs (*PC*) are measured in an aggregated manner as the sum of costs outlined in Table 1. *PC* estimated using a set of explanatory variables. First, we accounted for the occurrence of different numbers of payment actions customers need to settle their open accounts which, in turn, determines the retailer's level of payment costs for each transaction. The transaction number *TN1* and *TN2* is set as binary as outlined in Equation 2:

$$\beta_{1,2} = \begin{pmatrix} \beta_1 \cdot \mathrm{TN1}_{i,t} \,|\, \mathrm{TN}_{i,t} = 1 \\ \beta_2 \cdot \mathrm{TN2}_{i,t} \,|\, \mathrm{TN}_{i,t} = 0 \vee \mathrm{TN}_{i,t} > 1 \end{pmatrix}. \tag{2}$$

Second, we follow Whitesell (1989) and incorporated the transaction size $TS_{i,t}$ as an explanatory variable in the model to assess its impact on payment costs. This captures gross sales of a single shopping trip during the purchase, and its depends on the number of items ordered and their values.

We also added online payment method-specific variables, such as controls for payment default and the type of credit card provider. Since invoice payments are post-payments (Stroborn et al., 2004), customer default can occur upon delivery. Considering payment default, we incorporate the interaction term $TS{:}\ PD_{i,t}$ in the research model accounting for the full or partial depreciation of the transaction value that retailers incur. In addition, the type of credit card provider is expected to influence payment costs. Therefore, we inserted the variables $CC1_{i,t}$ and $CC2_{i,t}$ as interaction terms with the transaction size in the model by setting one credit card provider ($CC0_{i,t}$) as regression reference level or base case. Finally, $\varepsilon_{i,t}$ is the error term.

The *cost of capital* concept (Modigliani and Miller 1958) is an essential basis for rational investment decision-making within the firm. Building on this concept, we will use an opportunity cost approach to quantify working capital differences across payment methods. Since retailers are assumed to choose the respective payment method in which benefits due to a fast money receipts are high (Chircu and Mahajan, 2006; Whitesell, 1989), we built upon the base model shown in Equation 1, successively adding the cost of capital ($CoC_{i,t}$) to the sum of payment costs, and repeating the model estimation in a similar setting by considering total transaction costs $TC_{i,t}$ as outlined in Equation 3:

$$\mathrm{TC}_{i,t} = \mathrm{PC}_{i,t} + \mathrm{CoC}_{i,t} \tag{3}$$

To estimate the cost of capital for each order position, we followed Ingene and Levy (1982):

$$\mathrm{CoC}_{i,t} = \mathrm{TS}_{i,t} \cdot \left((1 + \mathrm{WACC})^{\left(\frac{\mathrm{CT}_{i,t}}{365}\right)} - 1 \right), \tag{4}$$

where the collection time $CT_{i,t}$ is the interval between order and payment date – measuring the days needed to collect outstanding invoices of a single order. In case customers needed more than one payment action to settle the open invoice, the date of the first payment was taken into account when calculating the collection time.

We also followed Modigliani and Miller (1958) and Miles and Ezzell (1980), using the weighted average of a firm's after-tax costs of debt and equity (*WACC*) as an appropriate interest rate to discount the transaction size and determine the present value of each customer order. We calculated cost of capital for each transaction using a *WACC* representative for Internet retail business proposed by Damodaran (2014) amounting to 10.24%. This was derived from an average collected in January 2014 of 31 European Internet retailers' levered beta of 1.17, a market risk premium of 6.29%, a risk-free rate of 3.04%, and tax as well as debt adjustments of 0.16%. For computational convenience, we proceed with a *WACC* of 10%.

3.3. Model Diagnostics

The regression models resulted in a reasonably good fit with an adjusted R^2 in the range of 0.46 in the model of invoice payments, and up to 0.99 in the PayPal estimation model. To assure the validity of estimates, we ran tests to check for common model biases, and take corrective actions if they wer necessary. To deal with multicollinearity, we calculated pairwise correlations of the variables in each estimation model. Since all calculated correlations were below the Kennedy (2008) threshold of 0.8, multicollinearity was not critical. Furthermore, we individually tested the econometric models against the presence of heteroskedasticity by executing the Breusch and Pagan (1979) test. We were not able to reject the hypothesis of heteroskedasticity ($p < 0.01$). Thus, we corrected for heteroskedasticity using Huber-White robust standard estimators (White, 1980).

4. RESULTS

4.1. Payment cost estimation

In the first step, we estimate payment costs associated with invoices, credit card and PayPal payments, and prepayment transactions. Table 3 reports the results of OLS regression analyses.

Table 3. Regression results for payment method costs

Variable	Invoices		Credit Cards		PayPal Payments		Prepayments	
TN1	0.04 ***	(0)	0.21 ***	(0)	0.46 ***	(0)	0.11 ***	(0)
TN2	0.13 ***	(0)	0.36 ***	(0.01)	0.88 ***	(0.01)	0.15 ***	(0)
TS	0.00 ***	(0)	0.03 ***	(0)	0.01 ***	(0)	0.00	(0)
TS: PD	0.31 ***	(0)						
TS: CC1			-0.01 ***	(0)				
TS: CC2			-0.01 ***	(0)				
Observations	12,314,326		1,676,636		1,822,610		560,363	
Adj. R^2	0.46		0.94		0.99		0.79	

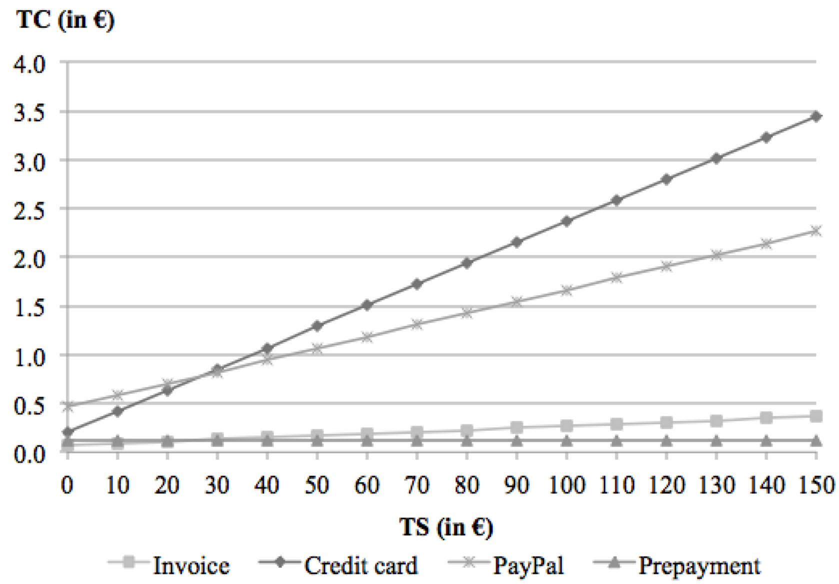
Note: . = $p < 0.1$, ** = $p < 0.01$, *** = $p < 0.001$. Huber-White robust standard errors in parentheses.

For three out of the four payment instruments, the results show a significant positive influence of the transaction size on retailer payment costs in e-commerce. In particular, payment costs for invoices, credit card payments, and PayPal payments are strongly and positively influenced by the transaction size. This finding reaffirms Whitesell (1989), implying that the transaction size is a determinant in of retailer transaction costs. Even though transaction size in the model for prepayments is not significant, the regression results for invoices, credit card and PayPal payments support the Transaction Size-Payment Cost Relationship Hypothesis (H1).

To discover the differences across payment instruments and test the Transaction Size Efficiency Hypothesis (H2), we used the regression results in Table 3, and derived payment cost schedules for invoices, credit card and PayPal payments, and prepayments. Furthermore, we calculated the breakeven points between the payment cost functions. Figure 1 presents the cost schedule for each payment method as a function of transaction size.

The cost functions of the payment instruments show significant differences in both fixed costs, represented by the respective intersection point with the *y*-axis, as well as in variable costs, reflected in the slope of each cost function. Turning to fixed costs, the intercepts of the payment cost functions and the *y*-axis in both credit card and PayPal payments are above those of invoice-based payments and prepayments. These findings are consistent with prior research (ten Raa and Shestalova(2004), Brits and Winder 2005), who showed that electronic card payments had higher fixed costs in comparison to paper-based transaction methods. With respect to the variable costs, the effect of the transaction size on credit card and PayPal payment costs was even higher when compared to that of invoice and prepayment, which only slightly increased per additional Euro sales.

Figure 1. Costs of payment methods as a function of the transaction size



Taking both fixed and variable transaction costs into account, prepayments and invoices outperform credit card and PayPal payments for small and large transaction sizes. For small transaction sizes up to €22, invoices appeared to be the most cost-efficient payment method, while prepayments dominates the other methods for transaction sizes above this threshold. Comparing only electronic credit transfers, credit card payment is cost-efficient for purchases of up to €27, while larger transaction sizes favor PayPal. Contrary to prior empirical findings, in e-commerce the variable costs of credit card payments and PayPal transactions were proportionally higher compared to those of other payment types. The explanation is the presence of the variable interchange fee charged by payment service providers, which carries more weight in e-commerce than in traditional retailing, and thus makes credit card transactions the most costly in this setting. We also found significant differences in the variable factoring fees across the three major credit card providers $CC1_{i,t}$, $CC2_{i,t}$, and the reference level $CC0_{i,t}$. Figure 1 shows the influence of credit card providers on total payment costs, reflecting each variable by its respective weight in the overall cost function of credit card payments (*CC0* 3.2 %, *CC1* 47.8 %, and *CC2* 49.0 %).

In addition, the results identify customer payment defaults and fraud that increased payment costs of invoice transactions per additional Euro sales. This result confirms that merchants perceived higher transaction risk in e-commerce compared to offline retailing, since online transactions are characterized by a greater temporal separation between the time of purchase and the possession of physical products, diminishing the information asymmetry between sellers and buyers, as well as the electronic spatial proximity of the trading parties (Biswas and Biswas, 2004; Varadarajan and Yadav, 2002). Consequently, accounting for customer payment defaults in invoice payments is highly important when providing cost-efficient payment since the invoice cost function – and hence all respective switching points – are shifted upwards in cases of payment default. In our dataset, payment default occurs in 0.35 % of all invoice payments. Therefore, the influence of payment defaults on total payment costs of invoices is extenuated in Figure 1, as each variable is reflected by its respective weight in the overall cost function.

Altogether, our results reveal significant differences between payment costs in online and offline retailing. Invoices and prepayments, which are not present in traditional business-to-consumer store settings, are cost-efficient alternatives in online retailing. Contrary to the Transaction Size Efficiency Hypothesis (H2), electronic card transfers do not boost scale efficiency. On the one hand, the cost advantages of invoices and prepayments occur because they do not incur physical handling costs, such as expenses of counting, storing, and transferring notes and coins. On the other, merchants do not face high interchange fees as a big portion of costs when processing credit card and PayPal transactions.

4.2. Transaction Cost Estimation

In the second step, we follow Equations 3 and 4, continuing with the estimation of total transaction costs by taking working capital aspects into account. The summarized OLS regression results, including cost of capital using a *WACC* of 10%, are shown in Table 4. Considering the cost of capital lets us refine the cost functions and switching points for the estimated coefficients for each payment type. Figure 2 shows the adjusted transaction cost schedules as a function of transaction value.

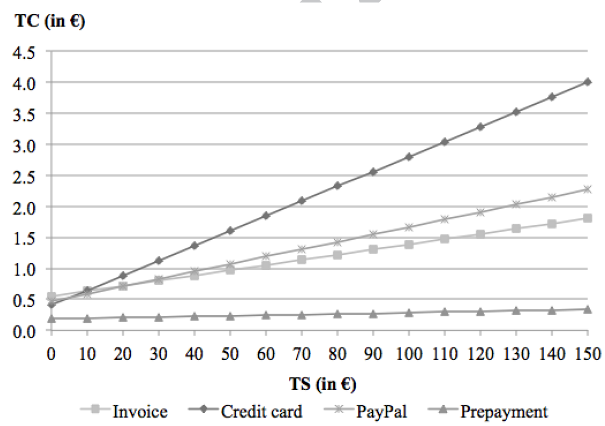
Comparing the cost functions in Figures 1 and 2, we identified changes in the intercept and slope of the cost schedules. Furthermore, the results reveal strong differences in the collection time of accounts receivable and the cost of capital across the payment. Prepayment fixed transaction costs increased by 1.6 times when accounting for cost of capital. The retailer caused this by blocking the inventory of items purchased for up to one week: until payment was received and the order was delivered. However, also on the basis of transaction costs, prepayment still was the most cost-efficient. Payment by PayPal does quite well for collecting open accounts receivable. The regression coefficients did not show a significant increase due to the additional cost of capital though, making PayPal a highly competitive payment method in terms of total transaction costs.

Table 4. Regression results, including additional cost of capital using a *WACC* of 10%

Variables	Invoices		Credit Cards		PayPal Payments		Prepayments	
TN1	0.45 ***	(0)	0.40 ***	(0)	0.46 ***	(0)	0.18 ***	(0)
TN2	0.73 ***	(0)	0.89 ***	(0.02)	0.91 ***	(0,01)	0.29 ***	(0.01)
TS	0.01 ***	(0)	0.03 ***	(0)	0.01 ***	(0)	0.00 ***	(0)
TS: PD	0.32 ***	(0)						
TS: CC1			-0.01 ***	(0)				
TS: CC2			-0.01 ***	(0)				
Observations	12,314,326		1,676,636		1,822,610		560,363	
Adj. R^2	0.47		0.69		0.97		0.47	

Note: . = $p < 0.1$, ** = $p < 0.01$, *** = $p < 0.001$. Huber-White robust standard errors in parentheses.

Figure 2. Costs of payment methods with cost of capital, as a function of the transaction size



In contrast, credit card payments and invoicing showed a significant cost increase when considering the cost of capital. In line with the Working Capital and Cost of Capital Hypothesis) (H3), both the invoice and credit card cost functions move upwards, resulting in 7.8 times higher fixed costs for invoices, and twice as high costs for credit card transactions. With regard to the variable transaction costs, the slope of the invoice cost function increased by 4.3 times, while credit card costs grew by only 10% due to the added cost of capital. These results also supported the Working Capital and Cost of Capital Hypothesis) (H3). This implies that invoiced transactions required the highest level of working capital, since the collection time depends on a customer’s willingness-to-pay in a timely manner, as well as the retailer's performance collection management and follow-ups. Although customers are charged later for purchases processed by credit card (Kim et al., 2010), our results revealed that the retailer is paid by the issuing bank sooner, and so its cost of capital is lower for credit card transactions in comparison to invoice payments. Overall, our results confirm Hypothesis 3.

Prepayment in out research had the highest cost-efficiency, and lso when the cost of capital was considered. Comparing invoicing, credit cards, and PayPal-based payments, we found that credit card payment was the most cost-efficient for transaction values below €5; but PayPal was best at transaction sizes between €5 and €22; while for large transactions the effect of expensive credit card and PayPal interchange fees outweighed the time efficiency in the accounts receivable collection, and favored invoicing to be most cost-efficient.

4.3. Sensitivity of Estimates for Variations in the Firm's Discount factor

Finally, we evaluated the sensitivity of the regression results for changes in the *WACC*. We performed regression analysis, using interest rates of 5% and 15% to contrast differences with respect to the base case with a *WACC* of 10 %. Table 5 summarizes the results of the sensitivity analysis.

Table 5. Sensitivity of transaction cost estimates to changes in the *WACC*

WACC	Invoice		Credit card		PayPal		Prepayment	
5%	60.43	(2)	92.36	(4)	99.87	(3)	70.70	(1)
10%	**100.00**	**(2)**	**100.00**	**(4)**	**100.00**	**(3)**	**100.00**	**(1)**
15%	137.96	(3)	107.38	(4)	100.13	(2)	127.72	(1)

Note: Regression methodology and dataset are similar to the presented base case (*WACC* of 10 %). Regression output of case studies omitted for brevity. Base case parameter estimates for a sample transaction size of €100 are set as the reference level (=100). The relative position of payment methods in the cost ranking shown is shown in the parentheses.

Table 5 shows that a 5% increase in the *WACC* lifts the transaction cost functions of each payment instrument, depending on the payment instrument's individual ratio of payment costs and cost of capital. This *WACC effect*, in turn, entails new intersection points between the cost functions compared to the initial base case. For illustration purposes, in the base case the merchant's cost ranking are prepayments, invoicing, PayPal payments, and credit card payments – starting with the most cost-efficient payment method. For a *WACC* of 15%, the cheapest payment instrument is prepayments, followed by PayPal payments, invoicing, and then credit card payments. At an interest rate of 5%, the cost ranking is similar to the base case. In summary, the effect of the interest rate on the optimal payment provision was significant, and led to substantial changes in a retailer's cost ranking. So firms have to account for this *WACC* effect by estimating transaction costs for their individual interest rates.

5. DISCUSSION

This article examined consumer payment choice and a retailer's transaction costs when for payment services in e-commerce. We derived transaction costs for online payment instruments, including invoices, credit card and PayPal payments, and prepayments as a function of transaction value. The results revealed differences in payment costs and the collection time of accounts receivable across the methods under study. We next will discuss some theoretical and managerial implications of this research, and provide avenues for future research.

5.1. Academic Contribution

The theoretical contribution of this research is threefold. First, we applied the transactions demand for cash framework to evaluate a retailer's choice of payment method offering. Compared to prior studies, we expanded the existing theoretical framework by incorporating (i) new payment methods such as invoices, credit card and PayPal payments, as well as prepayments; and (ii) e-commerce-specific cost components, for example, allowance costs as well as cost of capital. Further, we adopted the traditional framework and used disaggregated transaction-level data in studying payment choices and transaction costs for the online retailer. The presented estimation framework provides a basis to estimate retailer transaction costs, and can be used in future research. For instance, future studies that analyze customer usage of payment services, estimate banks or credit card provider payment production costs, or measure the social welfare costs of transaction instruments can build upon our cost-based estimation model. Moreover, the results of this study support researchers working on the market of transactions demand for alternative payment instruments, such as cash cards and electronic money, or payment card network economies – since we focused on the retailer's perspective of the market.

Second, our approach is unique as it follows the need to analyze payment services on the basis of large data, since prior research was mostly limited to surveys and aggregate statistics. We explored the use of large transaction-level dataset to derive cost functions out of more than 16.3 million actual customer sales. One advantage of using this kind of data lies in the vast amount of observations, the accuracy, as well as the direct observation of real-world exchange behavior (Klee, 2008). Furthermore, the dataset captured a retailer's internal costs and market externalities due to monopolistic or oligopolistic market power and governmental regulations. An example is the institutional pricing of banks, credit card networks and payment service providers. These characteristics, favor the explanatory power of the results and lead to better theory building.

Third, with regard to the results, we showed that transaction costs were driven by the transaction size of the purchased product. Furthermore, we identified a number of additional e-commerce-specific cost drivers other than transaction size for each payment method, such as allowance costs due to a customer's payment default as well as type of credit card provider. Prepayment and invoicing dominated credit card and PayPal payments in terms of transaction cost efficiency irrespective of the transaction size. These findings answered our research question: "Which payment method is most cost-efficient to offer in specific shopping situations?" Our cost figures extend prior research, since we discovered differences in payment cost rankings in online versus offline retailing. In contrast to offline retailing, the electronic payment instruments, credit cards and PayPal, did not show scale efficiency from a merchant's perspective. Finally, we identified large differences in accounts receivable collection times across payment methods, and demonstrated that cost of capital was a relevant cost driver that has to be considered when economically evaluating payment instruments.

5.2. Managerial Implications

Competition in Internet retailing is fierce, and retailers operate on thin profit margins (Choudhary and Tyagi, 2009). Cost-efficient processing and low working capital requirements are highly important for retailer competitiveness and profitability, as a result (Protopappa-Sieke and Seifert, 2010). As of yet though it is not clear which payment instrument is most cost-efficient for retailers to offer in specific shopping situations (Humphrey, 2010).

We addressed a highly relevant question for practitioners by evaluating the cost efficiency of a retailer's payment provision. Three managerial implications are suggested by our results. First, this study enhances the understanding of the payment costs and cost of capital associated with each payment instrument. A more complete picture of the cost drivers inherent in each payment transaction enables managers to identify internal and external optimization potential to reduce the costs of acquiring, holding, maintaining, and transacting payment services. For instance, we showed that a merchant's payment costs in credit card transactions depends on the proportional interchange fee that, in turn, varies across payment providers. Variance in the transaction fee can be explained by retailer size and market power (Ingene and Levy, 1982; Rochet, 2002). Differences in credit card fees across payment service providers or banks can be renegotiated, or used to refine a retailer's adoption of payment systems, with the objective of reducing transaction costs and increasing profitability.

Second, the cost-based approach enables retailers to evaluate their current payment offer for customers in specific shopping situations in terms of transaction costs and working capital requirements. Both estimated cost functions and intersection points provide useful cost-efficient reference levels for retailers that can be considered when deciding which payment method to offer in specific shopping situations. For example, imagine a returning customer who usually prefers to make a credit card payment but pays the open invoice always in a single payment before the due date and will not default. In this situation and a given transaction value of €100, the transaction costs for the credit card are the highest (€2.80) – followed by a PayPal payement (€1.67), then invoicing (€1.39) – and lowest for prepayment (€0.28). This will allow the retailer to give incentives to its customers to steer them towards the most cost-efficient payment instruments. While the answer to the question of how to direct customers from one to another payment method lies beyond the scope of this study, the literature has discusses several options to influence customer payment choices. For instance, Bolt et al. (2010) studied the effects of surcharging card payments; Carbó-Valverde and Liñares-Zegarra (2011), Simon et al. (2010) as well as Ching and Hayashi (2010) focused on loyalty and reward programs; while Choudhary and Tyagi (2009), Grant (1985) as well as Ingene and Levy (1982) concentrated on discount offerings to induce cash rather than credit card payments. Turning back to our example, retailers can incentivize their customers by offering discounts for PayPal and invoice payments in the amount of €1 and €2 for prepayments. For successful payment steering, the retailer will save on each PayPal transaction €0.13, amounting to 4.7%; in invoice payments €0.41 representing 14.8%; and in cases of prepayments €0.51, which is an 18.4% cost reduction when servicing these customers.

Finally, we shed light on the question of how online retailers should effectively offer payment methods towards their customers if both cost-efficiency and working capital requirements are considered. The results of the working capital analysis illustrated substantial differences in the collection time of accounts receivable from one to another payment method. Moreover, cost of capital was identified to be a key cost portion in total retailer payment transaction costs. Therefore, when considering the presented knowledge on the working capital requirements induced by each payment instrument, retailers can adjust their payment provisions, and have the opportunity to achieve their order-to-cash conversion, reduce asset investments, increase liquidity, and improve overall financial as well as operational efficiency for every single order (Ellinger et al., 2011). This is especially important if financially-constrained firms employ expensive external financing to cover their operations (Baños-Caballero et al., 2014).

5.3. Limitations and Future Research

We based this study on a large dataset involving 100,000 customers over a year, alleviating concerns of common-source bias and robustness. Nevertheless, researchers should study retailer transaction costs using similar real-world transaction-level data from retailers across different industries and product segments, as well as involving customers of different characteristics to complement our findings, test the validity, and assure their generalizability.

In a similar vein, generalizations should be made cautiously, as data and presented results are limited to customer transactions and transaction costs in the German web shop. Differences in individual payment behavior, the payment mix, and a retailer's transaction costs for payment services offered will exist in alternative institutional contexts – especially outside of the European Union. Future studies should extend to firms and customers from a wide variety of institutional contexts, including both industrialized and less-developed countries.

Moreover, future research should extend the presented setting to traditional brick-and-mortar retailing and to the mobile commerce environment, since multi-channel selling becomes more and more important for retailers (Chu et al., 2007; Schoenbachler and Gordon, 2002). Different sales channels carry overlapping but also new payment solutions, such as cash, debit cards, cash cards, or electronic payment instruments and specific transaction cost components (Chou et al., 2004; Dahlberg et al., 2008; Stroborn et al., 2004). To give multi-channel retailers further managerial guidance in the payment offering, research should also focus on these alternative sales channels and payment instruments for developing cost and credit-efficient payment provision strategies.

Finally, this research followed a cost-based approach and focused on the influence of the transaction size on retailer transaction costs. Researchers have suggest non-pecuniary determinants of the payment choice with individual preferences towards, for example, convenience, reliability, safety, speed of transaction, and recordkeeping (e.g., Amromin et al., 2007; Hirschman, 1982; Jonker, 2007). Future studies should examine the impact of these factors on payment choice and the resulting influence on operating retailer transaction costs. We hope our study enriches the current understanding of transaction costs in e-commerce, and motivates others to engage in innovative new research.

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APPENDIX

Differences in Functionality for Payment Instruments

Prevailing Internet payment methods currently in operation in Germany – invoices, credit card and PayPal payments, and prepayments, all have specific attributes and differ in functionality. Consequently, they lead to different administrative actions. In particular, invoices and prepayments are account-based credit transfers in which buyers instruct their account-holding banks to transfer money to the seller's account (Leibbrandt, 2010; Stroborn et al., 2004). Credit card payments and PayPal transactions, in contrast, are electronic funds transfers where buyers authorize card issuers or PayPal to complete their purchase (Au and Kauffman, 2008; Kim et al., 2010). Such variation in functionality implies different combinations of fees charged by banks and payment service providers (e.g., bank costs or interchange fees, but also risk differences and different cost of capital effects (Santomero and Seater, 1996; Stroborn et al., 2004; Zhang and Li, 2006).

Differences of Payment Instrument Risks

In invoicing and credit card transactions, buyers receive products prior to paying (Stroborn et al., 2004). Both payment instruments grant an implicit warranty to buyers by giving them time to verify the quality of products and services prior to payment (Lee and Stowe, 1993). This trade credit reduces risk from a buyer's perspective by minimizing information asymmetries associated with the services of the seller (Smith, 1987; Taylor, 1974). From a seller's viewpoint, post-pay transaction instruments extend credit to the buyer, and the merchant bears the full risks of customer payment defaults and early product depreciation in the event of damaged product returns (Anderson et al., 2009; Ng et al., 1999; White, 1975). Post-pay transactions via invoice are highly trust-sensitive, and based on a merchant's belief in a buyer's capability and intention to balance the open account (Knack and Keefer, 1997). In credit card transactions, the issuers bear the merchant's risk and provide unsecured lines of credit to consumers that must be repaid in full at the end of month (White, 2007). In contrast, advanced payments via prepayment and PayPal funds are submitted from buyers to sellers prior or during the delivery of the products and are a signal of customer creditworthiness minimizing seller uncertainty in the exchange (Mateut and Zanchettin, 2013; Stroborn et al., 2004). Prepayments leave buyers facing the highest risks regarding the overall transaction process due to possible opportunistic behavior of the seller, potential delivery of inferior product quality, or an absence of abiding by the promised contract terms (Lee and Stowe, 1993; Taylor, 1974).

Cost of Capital and Payment Instruments

A company's accounts receivable collection time depends on the merchant's credit terms granted to its customers, as well as consumer attitudes towards debt and their willingness-to-pay (Özbayrak and Akgün, 2006). The credit granted to the customer is inseparably linked with the payment method since payment services differ in terms of the timing when the buyer is debited during the purchase process. When customers use invoice for settlement, sellers provide an unsecured line of credit to customers, as they consume products before being debited for the purchase (Gourville and Soman, 1998). Another important aspect is the customer's individual intention to balance the open account in a timely manner (Jiang and Dunn, 2013; Matuszyk et al., 2010). The customer's timing to settle an open account is foremost relevant with *push transactions* such as invoice and prepayment in which the buyer initiates the transfer of funds to the seller (Leibbrandt, 2010). In contrast, credit cards – as well as PayPal – are *pull payments* in which the transaction is authorized and issued at the moment of purchase (Kim et al., 2010; Rochet, 2002). Therefore, credit card processing depends on the credit card provider and usually takes up to three working days until the funds are available in the retailer's account (Chakravorti and To, 2007). In PayPal exchanges funds, are wired instantaneously to the merchant's PayPal account with direct liquidity effect, and no clearing and settlement system exists (Au and Kauffman, 2008; Kuttner and McAndrews, 2001).

Highlights

- We derive retailer transaction cost functions of online payment instruments
- Our analysis is based on a unique dataset consisting of 16m sales transactions
- Invoice is the most cost-efficient payment method for small transaction sizes
- Prepayment is the preferable payment method for transactions above a value of € 22
- Credit card and PayPal cause higher costs and do not show scale efficiency