Efficiency and Costs on Retail Payment Instruments Usage

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Abstract

This paper relates to the Projeto de Modernização de Instrumentos de Pagamento (Voto Banco Central do Brasil, n°540/2002). Its aim is to measure the social welfare gains due to different payment instruments usage (paper and electronic-based). In order to achieve this, we estimate the elasticities and unit costs of different instruments for Brazil, using internal bank sector costs model as a proxy to social cost.

Worldwide, it is estimated that yearly expenditure with payments is about 3% of a country's yearly GDP. According to the literature, complete migration of paper-based to electronic-based instruments can potentially save about 1% of the GDP, once the results point to electronic instruments costs as some one third of paper-based.

Payment instruments costs were estimated basing on bank's internal costs and number of payments, using a translog function to the cost. The main results confirm the international findings and indicate a potential cost reduction by electronic-based instruments more intense usage.

1 Introduction

A main issue to the Banco Central do Brasil[1] is the pursuit of safety and efficiency of payment systems. Although they do not flow through systemically important systems, the retail payments have a great potential for efficiency gains. Payment services can cost yearly about 3% of a country's GDP, or yet, on average, 5% of a purchase value (Hancock and Humphrey, 1997, [23]).

The Projeto de Modernização dos Instrumentos de Pagamento (Voto BCB n°540/2002) pursuits the stimulation of more socially efficient instruments. In Brazil, the large-scale usage of paper-based payment instruments might be generating inefficiencies and elevating the social cost. After the second half of the 90's, we have observed an increase in electronic payment instruments. However, this migration may be finding barriers caused by coordination failures and incomplete information.

This paper aims to measure the social welfare gains due to different payment instruments usage. The costs of payment instruments at the supply side as a proxy to social cost, implementing an econometric model based on the works of Valverde *et al.* (2002, [36]) and Humphrey *et al.* (2003, [27]). A secondary objective is to make a review of the literature concerning the measurement of electronic-based and paper-based payments costs. Its results may be useful as a basis for an eventual action by the Banco Central do Brasil seeking a higher welfare level.

As defined in the Report on the Brazilian Retail Payment System (BC, 2005, [3]), payment is a resource transfer from payer to payee through a payment instrument. The means of payment are the assets or rights accepted by the payee to liquidate a payment obligation.

Concerning retail payments, these assets and rights consist, basically, of currency outside banks and demand accounts. The instruments are the means used to transfer the resources. The payment instruments can be classified as cash, paper-based instruments and electronic-based instruments.

Retail payment instruments are mainly characterized by the value of the transaction, generally involving one person as one of the parties. Due to their negligible systemic importance, they are generally bilaterally or multilaterally deferred net settled, without clearing guarantees requirements.

Notwithstanding their reduced systemic importance, payment instruments have important roles in the maintenance of confidence in the currency and in the promotion of economic growth. Besides, the greater

[1]Central Bank of Brazil.

efficiency of electronic-based instruments would generally represent social cost reduction as their participation on realized payments has been increasing in comparison with paper-based instruments (BC, 2005, [3]).

Besides cash, there are other available payment instruments, such as: cheques, credit transfers, direct debit and payment cards (credit and debit). When making a payment, the agents involved choose the instrument that will be used to transfer the funds, constrained by the available supply. The usage of each of these instruments has costs, conveniences and problems.

The measurement of costs and efficiencies of the payment instruments is not exempted from difficulties. The literature that estimates such measures is based directly on the social welfare concept or on the usage of financial institutions costs as a proxy to social benefit. Both approaches have their limitations. The first one needs qualitative indicators, which hinders the robustness of its results. The second one concerns only the financial institutions and does not incorporate indirect benefits.

In what follows, Section 2 reviews the literature, presenting the methodologies to measure the cost of payment for different instruments. Section 3 describes the data and methodology actually used. Section 4 analyzes the results obtained and Section 5 concludes this paper.

2 Literature Review

The literature that evaluates the costs and benefits of the EBIs suggests that great savings can be achieved by increasing paper-based instruments substitution.

This literature involves empirical estimations, which regard all the production chain and the usage of payment instruments, and other estimations, which regard only the processing and supply of these instruments. The first approach is more complete, since it encompasses the expenditures incurred by the several participants of the payment chain, but its data are less robust and more difficult to be obtained, while the second, less general, is favored by the availability of its databases and its robustness.

2.1 Cost Calculation Models focusing on the Production Chain

A payment's social cost can be split, according to Humphrey *et al.* (2001, [25]) and Wells (1996, [37]), in payer's cost, receiver's cost, banks' processing cost and settlement cost. The latter can be assumed by the central bank or the clearinghouse of the payment instrument. To calculate the social cost, one should consider, besides the benefits, the effective cost incurred by those participants - the usage prices of each payment instrument - not the fees charged for them[2].

Chakravorti and McHugh (2002, [10]) split the cost calculation problem into: consumer choice; incomes and costs of providing the service from financial institutions; perspective of the receivers (firms); network issues; and the central bank's role in payment systems. The social cost is the sum of real sources of costs, incurred by each participant in order to convert each payment into funds.

Wells (1996, [37]), analyzing the cheques' case, defines the social cost of a single payment as the sum of the costs related to production, usage and instrument processing. An item's social cost would be this cost divided by the number of processed instruments. According to that author, the instruments production cost would be the distribution and printing costs for the cheque. In the case of an ACH[3], it would be the data transmission cost, assumed to be negligible.

The usage cost is the cost that users incur to originate and receive a payment, which is shared among: payer, postage and receiver. For the payer, the cost is the time spent to make a payment, this cost is not considered if the payer is a person. For a legal entity, Wells (1996, [37]), using an enterprise efficiency research, shows that the initial investment needed for electronic payment acceptance can be relatively high. For the US, concerning cheque, there is, yet, the postage cost due to its envelopment and sending. For ACH, this variable would reflect the data sending cost.

The cost for the payment receiver is the time spent from the payment forwarding process to settlement and is equivalent to the payer's cost above. The bank's processing cost would be the internal cost of each instrument's processing, including *software*, *hardware*, transit deposits, fees, employees and fraud costs.

[2]Indeed the fees themselves cannot be used as a proxy for social costs since most of them could be considered as transfers between parties, which may include benefits.

[3]Automated Clearing House.

Note that models that use productive chain require several qualitative variables, which make it difficult to obtain data and hinder the robustness of their conclusions. This may explain why the relative quantity of papers that uses the productive chain approach is small in comparison with those who use the efficiency and cost analysis approach.

2.2 Instruments Processing and Supply Models

Robinson and Flatraaker (1995, [33]) and Flatraaker and Robinson (1995, [16]), based upon a research on banks, present and analyze the relevant costs to make a payment, using bank's internal costs. Gresvik and Owre (2002, [21]) follow this approach too, but they disregard the costs due to external payments, foreign exchange trade and interbank payments, because they are more concerned with retail instruments. Guibourg and Segendorf (2004, [22]) focus on the issues associated with the price signaling at the daily use of payment instruments and, thus, relate the transactions' charged fees to the variable costs.

Valverde *et al.* (2002, [36]) and Humphrey *et al.* (2003, [27]) obtain the costs related to payment instruments indirectly. They both work with banks' operational costs and develop models with the following explaining variables:

1. payment products, here understood as instruments that allow funds transferring. They were divided into: paper-based instruments (cheques and paper credit transfers) and electronic instruments (electronic credit transfers and payment cards);
2. distribution channels service delivery, that could be electronic, by means of Automated Teller Machines (ATM), or directly on a bank branch; and
3. price of production inputs. Capital, labor and materials were considered as inputs.

The model used by both works estimates the internal operational costs as a function of these variables and these factors' cross product. The payment costs are obtained indirectly, using the variables' parameters that contain the observed instruments. In such a way, they indirectly estimate the banks' operational costs from payments realization and the potential saving with the migration from paper-based to electronic-based instruments.

This measurement, although indirect, does not depend on qualitative researches, as those in Wells (1996, [37]).

As seen, most of this literature focuses on bank costs. Those costs present themselves as the most representatives of the whole process. The results obtained are generally robust.

For the Brazilian case, we will focus on the bank costs to identify payment costs, since as far as we are concerned there are not enough data available to perform the productive chain approach.

2.3 Electronic-Based Instruments versus Paper-Based Instruments: Cost Comparison

Following Humphrey *et al.* (1996, [26]), a main question that arises from the usage analysis of the various payment instruments is the potential saving due to the migration from paper-based instruments to electronic-based ones. Wells (1996,[37]) and Humphrey and Berger (1990,[24]), for example, estimate that among the non-cash payment instruments, the cost of paper-based instruments is about two or three times greater than the cost of electronic payments.

Still on this subject, Humphrey *et al.* (1996, [26]) also show that, in the 90's, the costs associated to payments fell about 45% in Europe, mainly due to the reduction in the usage of paper-based instruments; to the economies of scale in the usage of electronic-based instruments; to the reduction of the telecommunication's costs; to banking deregulation; and to the increase of market competition.

Valverde *et al.* (2002, [36]), estimated that for Spain, between 1992 and 2000, savings resulting from migration at the distribution channels, from branch offices to ATMs, and from paper-based to electronic-based payments amounted to €5 billions per year. This amount accounts for 45% of the reduction in operational cost registered in that period, or, in terms of the annual Spanish GDP, 0.7%.

Humphrey *et al.*(2003, [27]), following a similar model for 12 European countries, estimate a reduction of some €32 billions in the annual operational costs, representing 0.38% of these countries annual GDP, between 1987 and 1999. Such contraction is due to an increase of 36% in the relative importance of electronics instruments in comparison to others means of payment combined with an expansion of 32% in the ATMs' share of distribution channels.

In the case of the US, the ratio from banks' assets to operational costs decreased 24% in US, due to the reduction in paper-based payment instruments usage and to the increase in both ATMs and electronic-based instruments usage between 1987 and 1999 (Humphrey *et al.*, 2003, [27]). The average unit cost of the payments diminished 45% and the electronic payments' share doubled. With the reduction of scale economies of paper-based payments due to migration, the unit nominal costs of the processing of these instruments have increased. On the other hand, some technological innovations, such as the use of magnetic ink, standardization, faster machines and truncation reduced cheque's processing cost. The ACH's payment costs, between 1990 and 2000, decreased about 80%. In Europe, Valverde *et al.* (2002, [36]) found that, between 1992 and 1999, the bank's ratio of total assets to operational costs decreased 24%.

Humphrey *et al.* (1996, [26]) also showed that in terms of processing cost incurred by banks, the electronic-based processing cost is about one third of the cheque's processing cost. For the receiver, the cheapest payment is cash, followed by debit cards and cheques. The credit cards' cost is higher, owing to the fees charged.

According to Chakravorti and McHugh (2002, [10]), the reduction in the unit cost stems from scale economies and from the migration to electronic payments. For cheques, the scale economies are limited by the amount of fixed costs. Thus, the average cost has a Leontief-type curve. In the case of electronic payments, there are scale economies and the average cost has a strictly decreasing curve up to some point.

In Norway, the unit cost of electronic payments has decreased while the unit cost of other payment instruments has risen. This was due, mostly, to scale gains and losses stemming from the migration from paper to electronic payments. For paper instruments there was also a reduction on *float* earnings owing to the lowering of both interest rates and settlement time. Gresvik and Owre (2002, [21]) showed that, in Norway, 41% of payment services costs were covered by *floating* in 1988. This figure reduced to 15% in 1994 and zero in 2001, following the Financial Contracts Act (2000) that encouraged banks to recoup their costs on payment services by direct pricing. Thus, the cost recouping from fees charged directly changed from 26% in 1988 to 70% in 2001 (Gresvik and Owre (2002, [21]) and Flatraaker and Robinson (1995,[16])).

In summary, according to the international studies, electronic payment instruments tend to be less costly than the paper-based ones. Thus, we should expect a migration, already confirmed in those studies, from paper-based instruments to electronic-based ones.

2.4 Reasons for the Usage of Paper-Based Payment Instruments

If international evidence indicates that there are important gains by the migration to electronic-based payment instruments, why is the usage of paper-based still so widespread? This question was analyzed in the literature, taking cheques as an example and considering the degree of substitution among several payment instruments.

For Humphrey *et al.* (1996, [26]), cheques are quasi-perfect substitutes for both debit cards and funds transfers in retail clearinghouses. Some of the reasons why electronic instruments migration is not faster may be enumerated and they differ depending on which participant is emphasized: the issuer, the receiver or the financial institution.

Chakravorti and McHugh (2002,[10]), Flatraaker and Robinson (1995, [16]) and Humphrey *et al.* (1996, [26]) enumerate, from the point of view of the user, reasons for non-migration from cheques to electronic instruments: a) cheque's marginal costs tend to zero, that is, some cheques are costless; b) inexistence of additional fees for cheque usage and cheque's float; c) existence of incomplete information about high fees charged for bounced cheques; d) the easiness of cheque usage, since it is the means of payment, excluding cash, more accessible and acceptable on points of sale; e) the resistance of changing to an electronic means, if there is no perception of its real benefits and f) the perception that cheques enhances financial control.

According to the same authors, from the receiver's viewpoint, some explanatory factors for the wide acceptance of cheques in the United States are: a) the verified cheque is the cheapest instrument, since it decreases the default cost; b) the fees paid for cards acceptance are still comparatively too high; c) the high transition costs for electronic payment means acceptance and d) the network rules that tie a product acceptance to others (credit card acceptance is tied to debit card acceptance or card acceptance is tied to every issuer card acceptance)[4].

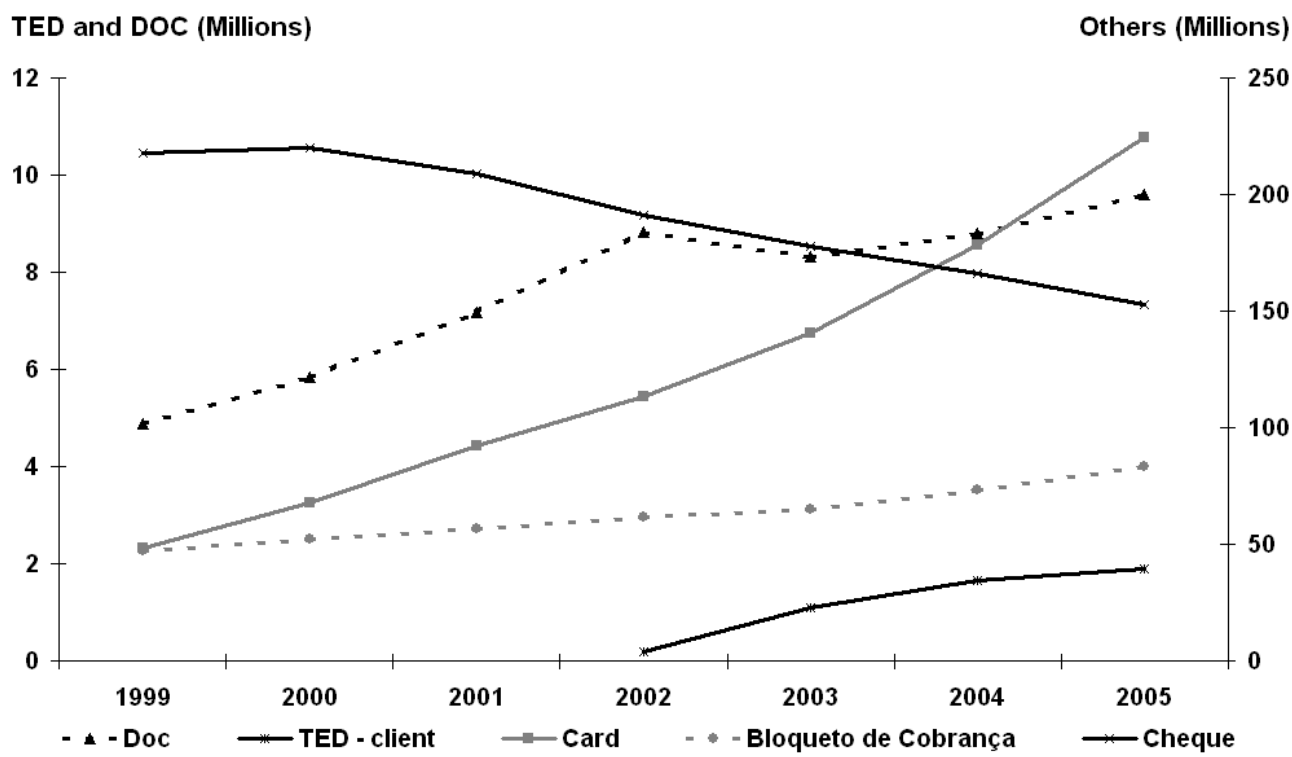
For the financial institution, the reasons are (Chakravorti and McHugh (2002, [10])): a) the difference between cheque's processing costs and electronic instruments processing costs is not too big; b) the earnings due to bounced cheques' fee[5] and c) the competitive pressures make the banks reluctant to apply a *per* cheque fee.

According to Chakravorti and McHugh (2002, [10]), the estimations of social costs justify the usage of electronic payment instruments since they are more efficient than paper-based. Among the G-10 countries, only the US has presented a growth in cheque's volume. This fact might be explained by differences in: a) number of financial institutions per capita; b) cash usage; c) laws and regulations; d) pricing of instruments - for cheques, generally, there is indirect pricing, making its marginal usage cost small or near zero and e) cultural factors as comfort, convenience, habit. In the US, for example, users tend to prefer checks for large value payments.

The recent studies of Garcia-Swartz *et al.* (2006a, [18], 2006b, [19]) justify the delay on paper-based to electronic based instruments substitution in the US, by the small difference in social cost between these instruments when the average transaction values are small. However, according to the same authors, substitution would be an irreversible process.

In Brazil, some reasons that tend to reduce cheques' acceptance are the high rate of cheques' default[6] and the incentive to non-utilization of high values cheques[7] given by the restructuring of the Brazilian Payment System.

The figure below shows the evolution of the volume of payment instruments' transactions:



[4]According to Rochet et Tirole (2006, [34, p.2.]), in 2003, Visa and Mastercard agreed to abandon their honor-all-cards rule (Wall-Mart case) in US.

[5]In 1995, US banks received a revenue of USD 8,1 billion due to overdraft fees while fraud costs amounted to USD 400 million.

[6]According to Banco Central do Brasil data, approximately 2% of cheques in Centralizer Clearance for Cheques and Other Documents (Compe) bounced due to lack of funds in 2002 and 7% in 2006.

[7]Checks with unit value equal to or greater than R$ 5,000.

3 Data and Methodology

3.1 Data

The sources of data used in this work are: questionnaires of the Banco Central do Brasil sent to financial institutions and the Central Bank Information System (Sisbacen).

The data, which comprises the quarters of 2005, were collected from 34 conglomerates[8].

The variables used are[9]:

1) Price of the Capital Input (lr) : Natural logarithm of the ratio of Immobilized Assets to Capital Input Costs.

2) Price of the Labor Input (lw): Natural logarithm of the ratio of Number of Employees to Labor Input Costs.

3) Quantity of Non-Electronic Payments ($lpaper$): Natural logarithm of the quantity of operations using on-us cheques and interbank cheques settled by Compe.

4) Quantity of Electronic Payments ($lcard$): Natural logarithm of the quantity of operations using Credit Documents (DOC), Electronic Funds Transfers (TED)[10], Intrabank transfers between clients, intrabank direct credit[11], direct debit, governmental deposit, non-governmental deposits, debit cards, withdraw cards, credit cards and E-money[12].

5) Labor Input Share ($sharew$): Labor input share in input costs.

6) Input Costs ($lcost$): Natural logarithm of the sum of Capital and Labor input costs.

Other works in this literature, *e.g.* Valverde *et al.* (2002, [36]), use operational costs as a proxy to input costs. We used the input costs instead of operational costs, because the latter embody several costs that are not related to payment instruments costs, *e.g.* fines charged by the Banco Central do Brasil, taxes in general, amortization costs.

Another reason for the usage of the variable input costs is that the cost function must be homogeneous of degree one in input prices while the sum of the labor and capital inputs share in operational costs are lower than the unity.

The descriptive statistics are presented in the following table:

Table1 - Descriptive Statistics

Statistics	lr	lw	lpaper	lcard	lcost	sharew
Mean	-0.338	-0.559	-2.633	-2.744	17.899	0.865
Median	-0.353	-0.623	-1.674	-2.508	17.742	0.879
Standard Deviation	0.825	0.914	3.294	2.717	2.103	0.059
Minimum	-1.749	-4.095	-10.611	-7.906	13.444	0.664
1^{st} Quartile	-0.977	-0.959	-4.494	-4.266	16.304	0.826
3^{rd} Quartile	0.004	-0.184	-0.412	-0.732	19.674	0.907
Maximum	1.950	1.905	2.033	2.794	21.588	0.975

3.2 Methodology

As in the models of Valverde *et al.* (2002, [36]) and Humphrey *et al.* (2003, [27]), costs are explained by payment products and production inputs. The estimated translog cost function and labor share equation are:

[8] In 2005, these conglomerates were responsible for 99% percent of non-electronic payments, excluding cash.

[9] See appendix 2 for more information.

[10] DOCs and TEDs sent and received.

[11] Includes Government.

[12] Directive 1/2006 (2006,[4]).

$$
\begin{aligned}
lcost &= \alpha_0 + \alpha_c lcard + \alpha_p lpaper + \frac{1}{2}\alpha_{cc} lcard\ lcard + \\
&+ \alpha_{cp} lcard\ lpaper + \frac{1}{2}\alpha_{pp} lpaper\ lpaper + \\
&+ \beta_r lr + \beta_w lw + \frac{1}{2}\beta_{rr} lr\ lr + \\
&+ \beta_{rw} lr\ lw + \frac{1}{2}\beta_{ww} lw\ lw + \\
&+ \delta_{cr} lcard\ lr + \delta_{cw} lcard\ lw + \\
&+ \delta_{pr} lpaper\ lr + \delta_{pw} lpaper\ lw \\
Sharew &= \beta_w + \beta_{rw} lr + \beta_{ww} lw + \delta_{cw} lcard + \delta_{pw} lpaper
\end{aligned} \tag{1}
$$

Subject to the following restrictions, from cost function regularity conditions[13]:

$$
\begin{aligned}
\beta_r + \beta_w &= 1 \\
\beta_{rr} + \beta_{rw} &= 0 \\
\beta_{rw} + \beta_{ww} &= 0 \\
\delta_{cr} + \delta_{cw} &= 0 \\
\delta_{pr} + \delta_{pw} &= 0
\end{aligned} \tag{2}
$$

Thus, the usage of each payment product would be reflected in banks' costs, *i.e.,* depending on their production plans, the banks would have different costs. This might show savings from migration to electronic based instruments.

Proposition 1 *The first order coefficients of the translog function represent the input and output price elasticities, i.e.:*

$$
\begin{aligned}
\alpha_c &= \textit{Cost-electronic payments elasticity} \\
\alpha_p &= \textit{Cost-non-electronic payments elasticity} \\
\beta_r &= \textit{Cost-capital elasticity} \\
\beta_w &= \textit{Cost-labor elasticity}
\end{aligned}
$$

Proof. See Appendix 1. ■

The interpretation of the first order coefficients is similar since they all represent that variable's cost-elasticity, evaluated at the mean (be it sample mean or last period mean). In other words, a 1% increase on the variable's mean implies an x% variation on cost, where x is the first order coefficient. For example, a coefficient $\alpha_c = 0.2$ would allow us to say that an increase of 1% on electronic payments would imply an increase of 0.2% on costs.

Proposition 2 *The translog first order coefficients for the input price terms represent the relative participation of such inputs on cost.*

Proof. See Appendix 1. ■

The subclass function obtained if all second order terms are zero is the Cobb-Douglas. In this case, the cost function and the labor share equation to be estimated would be:

$$
\begin{aligned}
lcost &= \alpha_0 + \alpha_c lcard + \alpha_p lpaper + \beta_r lr + \beta_w lw \\
Sharew &= \beta_w
\end{aligned}
$$

Subject to the restriction:

$$\beta_r + \beta_w = 1$$

[13] Those restrictions imply that the translog cost function will be homogenous of degree one in input prices.

3.2.1 Estimation Method

The joint estimation of the translog cost function and the share equations is more efficient than the OLS estimation of each equation if, as theoretically expected, disturbances are correlated across equations[14]. In the case where such correlation is present, Zellner's (1962, [38]) method would be more appropriate than OLS since it includes information about the disturbance variance-covariance matrix (Ω).

As a rule, in practice Ω is unknown, thus in order to estimate it, we could use feasible general least squares (FGLS), which base on the residuals obtained from OLS estimation to estimate Ω. This solution is known as Zellner two-stage method. Again, we could try to refine the estimation of Ω by repeating those steps. This new set of estimators would again allow us to refine our findings, and so on. This method is known as Iterative Zellner and it has been shown that its results converge to maximum likelihood estimators[15].

Since this method is based on the hypothesis that disturbances are correlated across equations, it should be tested whether this condition is valid before using this method. In our work we apply Breusch-Pagan's independence tests[16].

3.2.2 Restriction tests

After the estimation of a translog function, it should be tested whether the Cobb-Douglas specification, a particular subclass commonly used in the literature, would have the same explanatory power than the translog. Should it be the case, by parsimony, it would be preferred to use the latter, which might enhance efficiency.

Hence, the two restriction tests will be performed in this work: LR and Wald.

a) LR

$$\lambda = \frac{\widehat{L}_r}{\widehat{L}_u}$$

where $\widehat{L}_r$ is the log-likelihood of the restricted model and $\widehat{L}_u$ the log-likelihood of the unrestricted one.

The null hypothesis that the restrictions are valid is tested using the fact that:

$$-2\ln(\lambda) \sim \chi^2(N_q)$$

where N_q is the number of restrictions.

b) Wald test

$$W = [c(\widehat{\theta}) - q]' \left(A.Var[c(\widehat{\theta}) - q]^{-1} \right) [c(\widehat{\theta}) - q] \sim \chi^2(N_q)$$

where

$$\begin{aligned} A.Var[c(\widehat{\theta}) - q] &= \widehat{C} A.Var(\widehat{\theta}) \widehat{C}' \\ \widehat{C} &= \left[\frac{\partial c(\widehat{\theta})}{\partial \widehat{\theta}'} \right] \\ N_q &= \#\text{ of restrictions} \end{aligned}$$

Based on these tests, we may infer about homotheticity, homogeneity and unit elasticity of the cost function, *i.e.* whether a subclass of the translog has the same predictive power with fewer parameters [17].

[14] There are no efficiency gains in the case disturbances are not mutually correlated.

[15] See Greene (2003, [20, p.681]).

[16] Note, the test here cited is of independence (1980, [8, p.247]), not heteroskedasticity (Breusch and Pagan (1979, [7])). For the case with several equations, see Monte Carlo tests in Dufour and Khalaf (2002, [15]).

[17] In the case of a translog, the function will be known as :
- homothetic if: $\gamma_{i,j} = 0 \ \forall \ i \in [1, N_y]$ and $\forall j \in [1, N_w]$,
- homogeneous if: $\gamma_{i,i} = 0 \ \forall \ i \in [1, N_y]$ and if it is homothetic,
- unity elasticity if: $\gamma_{j,j} = 0 \ \forall j \in [1, N_w]$ and $\gamma_{m,i} = 0 \ \forall m, j \in N_y$.

Note that the function is named Cobb-Douglas in the case where it satisfies all the conditions aforementioned.

4 Empirical Results

This section presents the results obtained using capital and labor cost as a proxy for costs [18]. The estimated models were[19]:

T1: translog, expansion around sample mean;
T2: translog, expansion around the mean of the last quarter of the sample (fourth quarter of 2005).
C1: Cobb-Douglas, expansion around sample mean;
C2: Cobb-Douglas, expansion the mean of the last quarter of the sample.

4.1 Translog Model

Table 2 shows translog statistics. χ^2 tests imply that explanatory variables are significant as a whole for each of the equations.

Table 2 - FGLS (SUR) estimation, fit of translog

Equation	N	Parameters	RMSE	"R^2"	χ^2	
lcost	136	9	0.930	0.803	2114.81	*
sharew	136	4	0.056	0.996	32428.69	*

* significant at 1%.

Before analyzing the results obtained, statistics concerning the model and restrictions imposed are presented. The following table shows results of Breusch-Pagan independency tests and Wald and LR restriction test:

Table 3 - Independence Test and Restriction tests[20]

Test	Value	Degrees of Freedom
Breusch-Pagan	53.46 *	1
Wald	83.42 *	6
LR	69.20 *	6

* significant at 1%.

Breusch-Pagan test indicates that residuals are cross-correlated, *i.e.*, there are efficiency gains in using Zellner's methodology instead of standard OLS.

Wald and LR suggest that the translog specification is superior to Cobb-Douglas [21], since their null hypothesis is that both specifications have the same predictive power.

Table 4, below, presents evidences that the translog function is also preferable to its subclasses, as χ^2 is significant at 1% in all cases:

Table 4 - Restriction Tests for translog subclasses

Subclass	χ^2	Degrees of Freedom
Homothetic	11.65 *	2
Homogeneous	52.41 *	5
Unity Elasticity	13.78 *	1
Cobb-Douglas	69.20 *	6

* significant at 1%.

Under the light of the results aforementioned, we start analyzing Table 5:

[18] Estimations were obtained using the option 'isure' of the Stata command 'sureg'. It is worth noting that the results would

be the same if we have used the option 'sur' of the 'reg3' command. The 'isure' option is preferred to 'sure' since Zellner Iterative results converge to maximum likelihood estimators.

[19] All estimations were performed using iterated SUR.

[20] Considering the expansion around the mean of the last quarter of the sample, *i.e.* the fourth of 2005.

[21] *Bootstrap* of these statistics confirm the asymptotic results, see Appendix 3.

Table 5 - FGLS (SUR), translog model

Dependent		Model T1			Model T2		
lcost	Independent	Coefficient		S.D.	Coefficient		S.D.
	lcard	0.581	*	0.125	0.578	*	0.127
	lpaper	0.340	*	0.129	0.345	*	0.129
	lcardlcard	-0.037		0,033	-0.037		0.033
	lcardlpaper	0.072	*	0.018	0.072	*	0.018
	lpapellpaper	-0.025		0.025	-0.025		0.025
	lr	0.152	*	0.007	0.151	*	0.007
	lw	0.848	*	0.007	0.849	*	0.007
	lrlr	0.010	*	0.003	0.010	*	0.003
	lrlw	-0.010	*	0.003	-0.010	*	0.003
	lwlw	0.010	*	0.003	0.010	*	0.003
	lcardlr	0.008	*	0.003	0.008	*	0.003
	lcardlw	-0.008	*	0.003	-0.008	*	0.003
	lpaperlr	-0.002		0.003	-0.002		0.003
	lpaperlw	0.002		0.003	0.002		0.003
	constant	20.179	*	0.122	20.341	*	0.126
sharew	*constant*	0.848	*	0.007	0.849	*	0.007
	lr	-0.010	*	0.003	-0.010	*	0.003
	lw	0.010	*	0.003	0.010	*	0.003
	lcard	-0.008	*	0.003	-0.008	*	0.003
	lpaper	0.002		0.003	0.002		0.003

* significant at 1%, ** significant at 5% and *** significant at 10%.

According to Proposition 1, the coefficients *lcard lpapel lr* and *lw* represent the cost elasticity of each variable estimated at the mean (be it sample mean or the mean of the fourth quarter of 2005). In order to obtain unit cost of one of the outputs, it sufficies to calculate the amount in of money given by the variation in cost stemming from the elasticity and divide this amount by the quantity of output that represents 1% of the variable under analysis.[22].

It should be noted that the results are relatively constant [23], independent of the base around which the expansion is performed. Imposing homogeneity of degree one in factor prices does not seem to have a great impact on the results either, as observed in Table 5.

Regarding electronic payments, its coefficient indicates that a 1% increase in this output would generate an increase of 0.58% in costs. Considering the expansion around the last quarter of 2005, this would imply a unit cost of R$1.46. The interval of two standard deviations of this estimation would be [R$0.82, R$2.10]. If the elasticity is estimated around the sample mean, the unit cost would be R$1.45 and the confidence interval [R$0.81, R$2.08].

As to non-electronic payments, a 1% increase would imply a 0.34% increase in costs. Should the expansion around the last period mean be considered, the unit cost would be R$3.11. The two standard deviations confidence interval would be [R$0.79, R$5.43]. Regarding the expansion around the sample mean, unit cost would be R$2.91 and the confidence interval [R$0.74, R$5.07].

Hence, unit costs of non-electronic payment instruments would be 113% higher than electronic ones, basing on the expansion around sample mean, and 100% higher if one considers the other expansion[24].

The coefficient *lcardlpaper* indicates that there is some degree of substitution between electronic and non-electronic means of payments. In the limit, one could try to estimate the potential benefits of migrating

[22]Since the quantity of electronic payments is almost 3.5 times greater than non-electronic payments, the unitary cost of the former could be higher than the latter even in some cases where the elasticity of electronic payments is the highest amongst them.

[23]This implies that seasonal factors are probability not so strong as to significantly alter estimations.

[24]Considering the correlation of the estimators obtained with the expansion around the last quarter of 2005, the probability of the unitary cost of non-electronic payment instruments be higher than electronic-based's one is estimated to be 87%. If one abstracts from the negative correlation between estimators, this probability becomes 91%. Should one consider the expansion around the sample mean, these figures would be 85% and 89%, respectively.

from non-electronic to electronic instruments[25]. Taking the elasticities estimated around the last quarter of 2005 as a proxy, a complete migration would have implied a saving of approximately 0.7% of the Brazilian GDP in 2005. A confidence interval of two standard deviations would be [0.18%, 1.21%].

The inverse of the sum of non-electronic and electronic elasticities $\left(\frac{1}{\alpha_c+\alpha_p}\right)$, an indicator of scale economies, suggest scale economies (1.08) in the supply of these outputs, *i.e.* an increase in these outputs would imply a less than proportional increase in costs.

Regarding inputs, according to estimates, the capital share of costs is around 15% while labor is responsible for 85% and substitution between capital and labor is approximately 0.92[26]. Capital own-price elasticity is around -0.78 and labor own-price elasticity is approximately -0.14. Thus, a 1% increase in the price of capital would imply a reduction of 0.78% in its demand. Considering labor, the same increase would result in a decrease of 0.14%.

4.2 Cobb-Douglas Model

Cobb-Douglas model was shown to be less powerful in statistical grounds than translog for the dataset under analysis. Anyway, for the sake of comparisons, since this model is commonly used in the literature and to test the robustness of our estimations, Cobb-Douglas results are reported in the tables below:

Table 6 - FGLS (SUR), fit of Cobb-Douglas

Equation	N	Parameters	RMSE	'R^2'	χ^2	
lcost	136	3	1.051	0.749	1527.78	*
sharew	136	1	0.059	0.995	29171.70	*

* significant at 1%.

Table 6, χ^2 indicates that independent variables are jointly significant to explain cost function, the same happening to the variables explaining labor share. It is worth noting, however, that the root mean squared error (RMSE) was higher than the one obtained by translog, reinforcing the statistics previously presented.

Table 7 - FGLS (SUR), Cobb-Douglas

Dependent	Model C1				Model C2		
lcost	Independent	Coefficient		S.D.	Coefficient		S.D.
	lcard	0.494	*	0.049	0.494	*	0.049
	lpaper	0.258	*	0.041	0.258	*	0.041
	lr	0.137	*	0.005	0.137	*	0.005
	lw	0.863	*	0.005	0.863	*	0.005
	constant	20.284	*	0.118	20.443	*	0.120
sharew	*constant*	0.863	*	0.005	0.863	*	0.005

* significant at 1%, ** significant at 5% and *** significant at 10%.

The interpretation of the first order coefficients is the same as in the translog case, *i.e.* they represent elasticities. Note that for the case of Cobb-Douglas these elasticities are independent of the point around which the expansion is performed[27]. However, unit costs will still differ from one expansion to another since their averages differ.

Concerning the output electronic payments, its coefficient indicates that a 1% rise of its quantity would increase costs by 0.49%. Considering expansion around the mean of the last quarter of 2005, this would equal to a unit cost of approximately R$1.25, with [R$1.00, R$1.50] as a confidence interval. In the case of expansion around sample mean these figures become R$ 1.23 and [R$ 0.99, R$1.48], respectively.

A one percent increase in non-electronic payments would turn costs 0.26% higher. For the case of expanding around 2005 last quarter's mean, this would imply a unit cost of R$2.33, with [R$1.59, R$3.06]. Considering the expansion around the sample mean, the unit cost would be R$ 2.17 and the confidence interval [R$1.47, R$2.85].

[25] It should be noted that it would be assumed that elasticities do not vary.

[26] Note that in the case of constant returns to scale and unitary elasticity of substitution, we would necessarily have a Cobb-Douglas function.

[27] The constant term is the only one influenced by different expansions.

Therefore, non-electronic unit costs would be approximately 86% higher than electronic ones, considering the expansion around the mean of the last quarter of 2005, or 76% in the case of the other expansion[28].

Taking the estimated elasticities calculated around the mean of the last quarter of 2005 as proxies, a complete migration from non-electronic to electronic means of payment would save approximately 0.52% percent of the Brazilian GDP in 2005, according to the Cobb-Douglas model. A confidence interval for this statistic would be: [0.36%, 0.68%].

The following table summarizes the main results:

Table 8 - Main results

Estimated	Elasticity		Unit Cost	
Model	Non-electronic	Electronic	Non-electronic	Electronic
T1	0.340	0.581	R$2.91	R$1.45
C1	0.258	0.494	R$2.17	R$1.23
T2	0.345	0.578	R$3.11	R$1.46
C2	0.258	0.494	R$2.33	R$1.25

5 Conclusions

This paper, based on 2005 data, showed that, in Brazil, electronic-based instruments are cheaper than paper-based instruments. A complete migration of the latter to the former would have implied a social gain of approximately 0.7% of the annual Brazilian GDP in 2005. Although the measure of social gain is indirect, results are shown to be relatively robust and in line with figures obtained by the international literature.

The literature enumerates several possibilities that could hinder such migration. Among them are: the cultural factors regarding paper-based instruments usage; indirect pricing of instruments by banks; and lack of migration incentives to the relevant agents. Indeed, even though electronic-based instruments may reduce social costs, it may not represent a reduction for every agent, which could lead to strategic behavior against the migration from paper-based to electronic-based instruments.

Typically, as overseers of the payment system, central banks use not only regulation but also moral suasion and their catalyst role to influence the use of payments instruments in their societies. Most of the times, regulation is avoided, not discarded, since it involves business and relationship between clients and banks. So the central banks may use these instruments in order to provide an easier migration from paper-based to electronic-based instruments and a consequent reduction of social costs regarding payment instruments.

It is worth noting that even without any payment systems overseer's policy, there is room for the market to maximize migration potential gains. In this vein, BIS in its 'General Guidance for Payment System Development' (2006) recommends actions such as interoperability among networks processing transactions at the point of sale, especially in POS networks.

A possible extension to this paper is the development of a general equilibrium model that includes not only bank costs but costs and benefits of all participants. Possible effects of the distribution of payment instruments upon monetary policy are also of interest.

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[28] Taking the correlation between estimators into account, for the case of expanding around the mean of last quarter of 2005, the estimations using a Cobb-Douglas specification indicate that the probability that the non-electronic payments unit costs are higher than those of electronics payments are approximately 99%. Abstracting from this negative correlation keeps the probability at 99%. For the expansion around sample mean, these figures turn out to be 98% and 99%, respectively.

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Appendix 1 - Translog function

The translog cost function used in this paper is equivalent to the following second-order Taylor expansion:

$$
\begin{aligned}
T \quad = \quad & \ln\ cost(0,0) + \frac{\partial \ln cost(0,0)}{\partial \ln(card)} \ln\left(\frac{card}{\overline{card}}\right) + \\
& \frac{\partial \ln cost(0,0)}{\partial \ln(paper)} \ln\left(\frac{paper}{\overline{paper}}\right) + \frac{\partial \ln cost(0,0)}{\partial \ln(r)} \ln\left(\frac{r}{\overline{r}}\right) + \\
& + \frac{\partial \ln cost(0,0)}{\partial \ln(w)} \ln\left(\frac{w}{\overline{w}}\right) + \frac{1}{2} \frac{\partial \ln cost(0,0)}{\partial \ln(card)\, \partial \ln(card)} \ln\left(\frac{card}{\overline{card}}\right)^2 + \\
& \frac{1}{2} \frac{\partial \ln cost(0,0)}{\partial \ln(paper)\, \partial \ln(paper)} \ln\left(\frac{paper}{\overline{paper}}\right)^2 + \\
& + \frac{\partial \ln cost(0,0)}{\partial \ln(card)\, \partial \ln(paper)} \ln\left(\frac{card}{\overline{card}}\right) \ln\left(\frac{paper}{\overline{paper}}\right) + \\
& + \frac{1}{2} \frac{\partial \ln cost(0,0)}{\partial \ln(r)\, \partial \ln(r)} \left[\ln\left(\frac{r}{\overline{r}}\right)\right]^2 + \frac{1}{2} \frac{\partial \ln cost(0,0)}{\partial \ln(w)\, \partial \ln(w)} \left[\ln\left(\frac{w}{\overline{w}}\right)\right]^2 + \\
& + \frac{\partial \ln cost(0,0)}{\partial \ln(r)\, \partial \ln(w)} \ln\left(\frac{r}{\overline{r}}\right) \ln\left(\frac{w}{\overline{w}}\right) + \\
& + \frac{\partial \ln cost(0,0)}{\partial \ln(card)\, \partial \ln(r)} \ln\left(\frac{card}{\overline{card}}\right) \ln\left(\frac{r}{\overline{r}}\right) + \\
& + \frac{\partial \ln cost(0,0)}{\partial \ln(card)\, \partial \ln(w)} \ln\left(\frac{card}{\overline{card}}\right) \ln\left(\frac{w}{\overline{w}}\right) + \\
& + \frac{\partial \ln cost(0,0)}{\partial \ln(paper)\, \partial \ln(r)} \ln\left(\frac{paper}{\overline{paper}}\right) \ln\left(\frac{r}{\overline{r}}\right) + \\
& + \frac{\partial \ln cost(0,0)}{\partial \ln(paper)\, \partial \ln(w)} \ln\left(\frac{paper}{\overline{paper}}\right) \ln\left(\frac{w}{\overline{w}}\right) + \mathcal{O}(3)
\end{aligned}
$$

where:

$$
\begin{array}{lll}
\alpha_0 = \ln cost(0,0), & \delta_{cr} = \frac{\partial \ln cost(0,0)}{\partial \ln(card) \partial \ln(r)}, & \delta_{cw} = \frac{\partial \ln cost(0,0)}{\partial \ln(card) \partial \ln(w)}, \\
\alpha_c = \frac{\partial \ln cost(0,0)}{\partial \ln(card)}, & \alpha_{cc} = \frac{\partial \ln cost(0,0)}{\partial \ln(card) \partial \ln(card)}, & \alpha_{cp} = \frac{\partial \ln cost(0,0)}{\partial \ln(card) \partial \ln(papel)}, \\
\alpha_p = \frac{\partial \ln cost(0,0)}{\partial \ln(card)}, & \alpha_{pp} = \frac{\partial \ln cost(0,0)}{\partial \ln(paper) \partial \ln(paper)}, & \delta_{pr} \frac{\partial \ln cost(0,0)}{\partial \ln(paper) \partial \ln(r)}, \\
\beta_r = \frac{\partial \ln cost(0,0)}{\partial \ln(r)}, & \beta_{rr} = \frac{\partial \ln cost(0,0)}{\partial \ln(r) \partial \ln(r)}, & \delta_{pw} \frac{\partial \ln cost(0,0)}{\partial \ln(paper) \partial \ln(w)}, \\
\beta_w = \frac{\partial \ln cost(0,0)}{\partial \ln(w)}, & \beta_{ww} = \frac{\partial \ln cost(0,0)}{\partial \ln(w) \partial \ln(w)}, & \alpha_{rw} = \frac{\partial \ln cost(0,0)}{\partial \ln(r) \partial \ln(w)},
\end{array}
$$

and $\mathcal{O}(3)$ is a third order error term.

Proposition 1) The first order coefficients of the translog function represent the input and output price elasticities, i.e.:

$$\begin{aligned}\alpha_c &= \text{Cost-electronic payments elasticity}\\ \alpha_p &= \text{Cost-non-electronic payments elasticity}\\ \beta_r &= \text{Cost-capital elasticity}\\ \beta_w &= \text{Cost-labor elasticity}\end{aligned}$$

Proof.

$$\begin{aligned}\frac{\partial \ln cost}{\partial \ln (card)} \approx\ & \frac{\partial \ln cost(0,0)}{\partial \ln (card)} + \frac{\partial \ln cost(0,0)}{\partial \ln (card)\, \partial \ln (card)}\left[\ln\left(\frac{card}{\overline{\overline{card}}}\right)\right] + \\ & + \frac{\partial \ln cost(0,0)}{\partial \ln (card)\, \partial \ln (paper)} \ln\left(\frac{paper}{\overline{paper}}\right) + \\ & + \frac{\partial \ln cost(0,0)}{\partial \ln (card)\, \partial \ln (r)}\left[\ln\left(\frac{r}{\overline{r}}\right)\right] + \\ & + \frac{\partial \ln cost(0,0)}{\partial \ln (card)\, \partial \ln (w)}\left[\ln\left(\frac{w}{\overline{w}}\right)\right]\end{aligned}$$

Evaluating the expansion at sample mean, we would have*:*

$$\ln\left(\frac{\overline{card}}{\overline{\overline{card}}}\right) = \ln\left(\frac{\overline{paper}}{\overline{paper}}\right) = \ln\left(\frac{\overline{r}}{\overline{r}}\right) = \ln\left(\frac{\overline{w}}{\overline{w}}\right) = 0$$

Thus*:*

$$\begin{aligned}\frac{\partial T}{\partial \ln (card)} \approx\ & \frac{\partial \ln cost(0,0)}{\partial \ln (card)} = \frac{\frac{\partial cost(0,0)}{cost}}{\left(\frac{1}{card}\partial card\right)} \\ =\ & \frac{\partial cost(0,0)}{\partial card}\frac{card}{cost} = \varepsilon\end{aligned}$$

Mutatis mutandis for the other cases. ■

Proposition 2) The translog first order coefficients for the input price terms represent the relative participation of such inputs on cost.

Proof.

$$\frac{\partial T}{\partial \ln (card)} = \frac{\partial \ln cost}{\partial \ln (r)} = \frac{\frac{\partial cost}{cost}}{\frac{\partial r}{r}} = \frac{\partial cost}{\partial r_i}\frac{r}{cost} = \frac{x_r r}{cost}$$

where x_r is the demand for input r. ■

Appendix 2 - Variables description[29]

Data sources are the financial statements of financial institutions.

1. Capital Cost (K)

K stands for capital costs of the financial institution, computed as the sum of the following items:

Table 9 - Capital Cost (K)

COSIF Code	Description
81706000	Rentals expenses
81709007	Assets Leasing expenses
81721009	Assets maintenance and conservation
81751000	Insurance
81820003	Depreciation

Source: Cosif

2. Labor costs (L)

L in this paper stands for Labor Costs, which include:

Table 10 - Labor Costs (L)

COSIF Code	Description
81718005	Honoraria
81727003	Benefits
81730007	Social Charges
81733004	Remuneration
81736001	Training
81737000	Trainnees Stipends
81760008	Security and Vigilance
81763005	Specialized Technical Services
81772003	International Travels
81775000	Domestic travels

Source: Cosif

3. *Leased Assets, property, plant and equipment in use*

Data from Leased Assets, property, plant and equipment in use were taken from CODE 22000002 in Accounts Plan of the Financial Institutions (Cosif).

4. Labor

Data concerning the number of employees of each financial institution where obtained from data collected from Sisbacen.

[29] All COSIF codes were translated by the authors.

5. Quantity of non-electronic payments (*paper*)

It includes quantity of transactions using on-us cheques and interbank cheques settled by Compe.

6. Quantity of electronic payments (*card*)

It includes the quantity of transactions using Credit Documents (DOC), Electronic Funds Transfers (TED), Intrabank transfers between clients, intrabank direct credit, direct debit, governmental deposit, non-governmental deposits, debit cards, withdraw cards, credit cards and E-money.

Computed Variables

Table 11 - Computed Variables

lr	$\ln\left(\frac{K}{Leased\ Assets,\ property,\ plant\ and\ equipment\ in\ use}\right)$
lw	$\ln\frac{L}{(\#\ of\ employees)}$
$lcost$	$\ln(K+L)$
$sharew$	$\frac{L}{(K+L)}$
$lpaper$	$\ln(paper)$
$lcard$	$\ln(card)$

Appendix 3 - *Bootstrap*

The following table shows bootstrap results for LR and Wald tests, using the null hypothesis that Cobb-Douglas specification has the same explanatory power as translog:

Table 12 - semiparametric *Bootstrap* of LR and Wald

Test	Value	S.D. (Bootstrap)	
LR	69.202	4.782	*
Wald	83.423	5.077	*

* significant at 1%.

# of bootstraps 19999.

At a 1% confidence level, the results described in the main text, indicating that translog should be preferable to Cobb-Douglas, are confirmed.