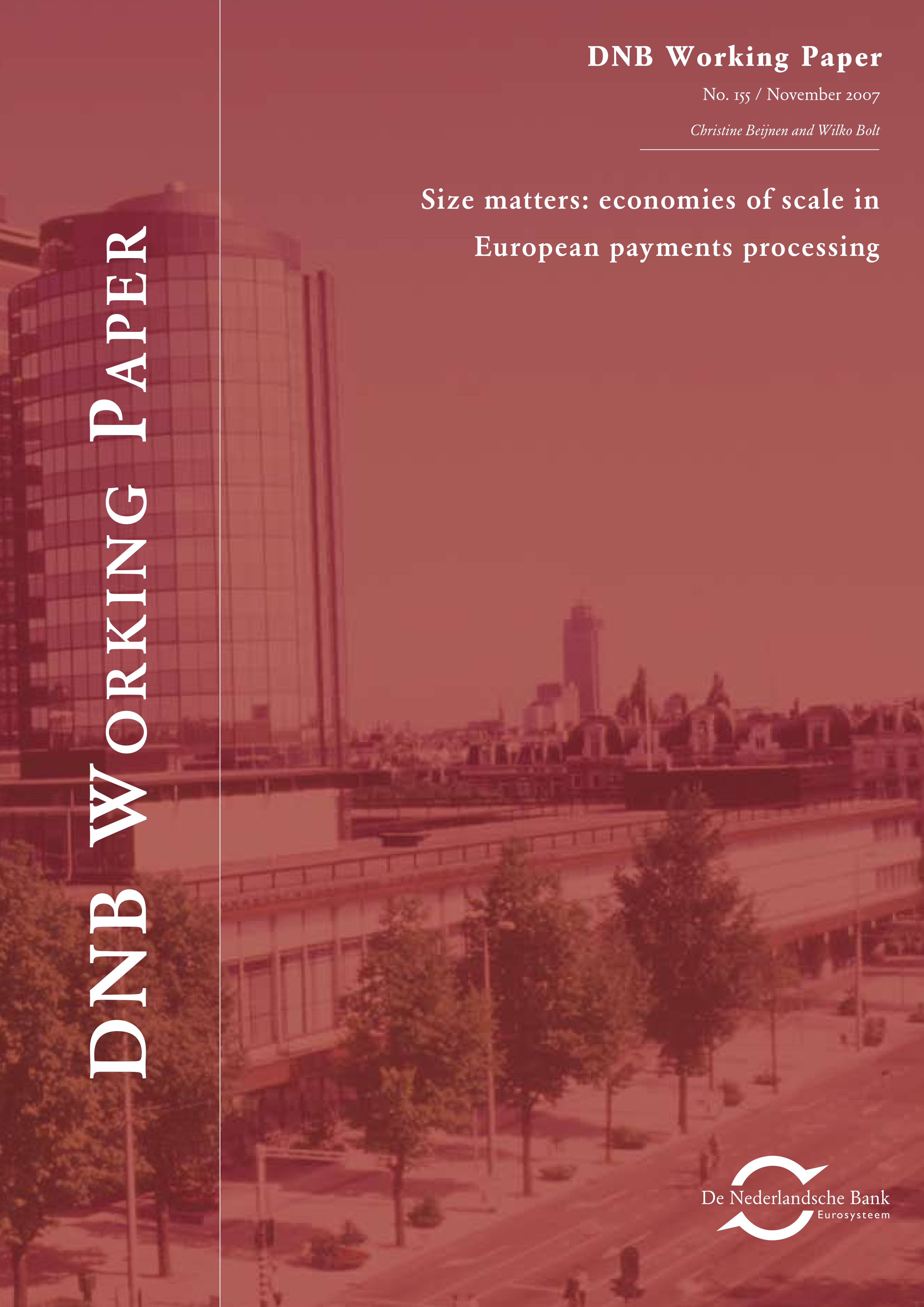

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Christine Beijnen and Wilko Bolt

Size matters: economies of scale in European payments processing

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* Views expressed are those of the author and do not necessarily reflect official positions of De Nederlandsche Bank.

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Size Matters: Economies of Scale in European Payments Processing

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Abstract

This paper investigates the existence and extent of economies of scale in the European payment processing industry. It is expected that the creation of a Single European Payments Area (SEPA) will spur consolidations and mergers among European payment processors to more fully realize payment economies of scale. We find evidence for the existence of significant economies of scale using data of eight European payment processors during the years 1990-2005. The analysis also reveals that ownership structure is an important factor to explain cost differences across European ACHs.

Keywords: SEPA, payment scale economies, ACHs, ownership
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1 Introduction

European payments markets are subject to intense and rapid transformation. After the introduction of euro banknotes and coins in 2002, the European Commission aimed at achieving further integration of European retail payments markets. The goal of a Single European Payments Area (SEPA) is to facilitate the emergence of a competitive, intra-European market by making cross-border payments as easy as domestic transactions and, importantly, at a lower cost. Currently, European payments markets are still highly fragmented, mostly tailored to the individual needs and preferences of the respective national retail payment markets. SEPA, with its harmonization and restructuring efforts, is an important driver to open up these national markets, allowing effective competition and fostering innovation in the euro area. However, for SEPA to succeed, separate domestic national payments infrastructures must be replaced with a pan-European structure which could more fully realize payment economies of scale. Ultimately, with sufficient competition these induced cost reductions should be passed onto end-users in the form of lower payment prices.

It is likely that SEPA will spur consolidations and mergers among European payment processors. In order to maintain or increase market share, European payment processors will be looking for partners and alliances. One such partnership has already been formed. Interpay, the Dutch ACH, just completed a merger with Transaktionsinstitut, its German equivalent. The new merged company–called Equens–will double its annual payment volume to 7 billion processed transactions, and is now ranked the second largest payment processor center in Europe. Given strong potential for positive scale effects, Equens will be more cost-effective and thus more competitive in the intra-European payments industry.[2] Our focus is on estimating such potential scale effects in this industry.

Another significant trend within the European payments processing industry involves changing ownership structures of European ACHs. In some European countries, ACHs are operated and managed by central banks, while in other countries they are managed by private institutions, mostly commercial banks. If central bank owned processors aspire to become a pivotal player within the SEPA environment, they need to change their governance structure from publicly to privately owned institutions. The purpose is to create a level playing field and boost competition in this new pan-European industry. In this light, the French payments processor, the largest with almost 12 billion payments a

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[2] In a recent interview (in Dialogue, Q4 2006, p.10), Ben Haasdijk–former chairman of Equens– stated "scale was the main driver for the merger that gave birth to Equens" and that "we will be passing on benefits of scale we achieve."

year, has recently switched its governance from public to private. Other countries such as Italy and Luxembourg have opted to transfer their total domestic payments processing volume to a commercial banks' owned pan-European ACH, called STEP2. Accordingly, we conjecture that ownership structures have bearings on cost differentials across European ACHs.

This paper estimates payment scale economies for the European payment processing industry, taking into account differences in ownership structure. Using heretofore unavailable payment processing cost data, our analysis sketches the potential cost benefits from consolidating electronic payment processing across European borders. Our data set runs from 1990-2005, and is complemented by labour and capital cost information, as well as information about governance and ownership structures. A translog function approach is used to derive scale economies for payment processing as a whole ("single output model"), but also for bill payments and point-of-sale payments separately ("double output model"). Our main results indicate the existence of significant economies of scale for payment processing, and reveal that ownership structure is an important factor to explain cost differences across European ACHs.

At present, only a few studies exist that particularly deal with economies of scale for the European payments industry. This paper tries to fill that gap. The remainder is as follows. The next section briefly discusses related literature, while in section 3 the data is described in more detail. Section 4 explains the translog function approach and presents the estimation results, along with thorough discussion of the induced payment scale economies. Section 5 concludes.

2 Related Literature

While empirical analyses on scale economies in the European payments industry are scarce, several studies do exist for US settlement and payment processing systems. These studies were largely triggered by the far-reaching consolidation process of Federal Reserve payment processing systems that occurred in the nineties.

In an early study, Humphrey (1984) reported the existence of large economies of scale economies for ACHs and securities settlement, but claimed that the wiring of interbank settlement funds (i.e. Fedwire) has constant returns to scale. His analysis was based on a single-output model. Bauer and Ferrier (1996) estimated single cost functions for check, ACH and Fedwire services by using data over the 1990-1994 period. They specified a translog cost function and found significant economies ACH, but Fedwire scale economies appeared to be almost exhausted. They concluded that consolidation to one payment processing platform is justified. In addition, they found large rates of technological change for ACHs and Fedwire processing. Check processing, which is more labour-intensive, seemed to suffer the fate of technological "regress", and was not much affected by technological change in terms of cost savings.

Using panel data, Humphrey, Hancock and Wilcox (1999) found evidence of scale economies for Fedwire. Finally, Adams, Bauer and Sickles (2002) examined whether the Federal Reserve's payment processing services reveal economies of scale and scope. A multi-product translog model with three outputs, viz. ACH services, Book-entry securities and Fedwire services, was estimated. They found little consistent evidence of economies of scope but did detect significant economies of scale.

A first European scale economies study on payment systems was carried out by Khiaonarong (2003). He estimates a simple log-linear cost function by using data of 21 payment systems and found substantial scale economies. He stressed the importance of ownership structure in payment systems and institutional setting. Bolt and Humphrey (2005) examine the potential for scale and scope economies of the Eurozone large-value interbank payment system Target. Due to lack of detailed cost data, the authors use estimation results of Khiaonarong (2003) and Federal Reserve studies. Based on this evidence, they argue that if Target succeeds in consolidating to a single platform, it would be able to realize strong economies of scale. In Bolt and Humphrey (2007), a data set including 11 European countries over 18 years is used to explain movements of operating costs in the banking sector as a function of transaction volumes of four separate payment instruments, and wages and capital costs. Their primary focus is on scale economies of card payments. Their results indicate that consolidation of card payment processing across Europe could lead to significantly lower average costs per transaction.

Other empirical research on economies of scale focused on European securities and settlement systems. The securities and settlement industry is closely related to the ACH market in terms of processing. A first comprehensive attempt to estimate economies of scale and scope in securities depository settlement industry has been done by Schmiedel, Malkamäki, and Tarkka (2006). Their data set consists of 14 institutions in Europe, North America and Asia-Pacific. The sample period is 1993-2000. In order to evaluate economies of scale, both a single and a multi-output, translog cost function is estimated. The results show clear evidence of economies of scale. In the single output case, cost would increase by 69 percent when the number of securities settled is doubled. In the multiple output case, doubling of both outputs leads only to a 53 percent increase in total costs. These findings would support new alliances or mergers among settlement institutions.

An alternative method to estimate economies of scale is proposed by Van

Cayseele and Wuyts (2006). They argue that central security depository systems (CSDs) are heterogeneous. They apply a fixed effects regression model to correct for heterogeneity. Their results suggest that economies of scale are present for all settlement institutions.

To our knowledge, there has been no empirical analysis done yet on estimating economies of scale in the European ACH market. Our study provides preliminary scale economy information that may be helpful in outlining possible benefits arising from consolidation of ACHs across the Euro zone.

3 Data Description

Detailed, publicly available, cost data on payments are hard to find, and the data used for our analysis come from a variety of sources. First, payment cost data were retrieved from annual reports if possible, or by direct (bilateral) communications. In our analysis, we focus on total operating cost, composed of all labour, materials, outsourcing, capital consumption costs, but no interest expenses. Interest payments are excluded here, since they are functionally separable from the operating expense of providing payment services and their delivery to users. Second, payment volume data are obtained from ECB's "Blue Books" and BIS' "Red Books" for the years 1990-2005. These books do not only provide information about the total number of processed payment transactions, but also separately about payment volumes of credit transfers, direct debits, checks, and payment cards (debit and credit). Additional payment volume information was collected from the individual processors' Internet sites and their annual reports. Third, we used information about total labour cost in the banking sector, along with data on numbers of staff in the banking sector, to compute an annual wage rate as an input price. These data were retrieved by using central bank statistics, national account statistics, and banking associations statistics across countries.[3] Further, we used the nominal interest rate as a simple measure of capital cost.[4] In total, we have information about eight European payment processors with a total number of observations of 67.

Table 1 in the appendix gives an overview of the sample processing institutions,

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[3] See also Bolt and Humphrey (2007) for data issues regarding measurement of labour costs of banking sectors across countries. Some missing values in some series were estimated by simple inter- and extrapolations.

[4] Using real interest rates did qualitatively change the results. Alternatively, Schmiedel et al (2006) propose to use expenditures on information and communication technology as a share of nominal fixed income as a capital cost input price. However, including this variable yields spurious results in our analysis.

together with some basic overall descriptive statistics. Note that the panel used in our analysis is heavily unbalanced, so we must be cautious when interpreting the estimation results. Our sample includes some large processors, as well as some small ones, which affects the skewness of the data. Four out of eight processors are owned by central banks, which may–we conjecture–have its effect on cost structures. Also notice the large variation in average operating cost, ranging from 0.2 cent to 46 cents, which is naturally volume-related.

4 Model Specification and Results

This section estimates payment scale economies for the European payment processing industry. Size and scalability are important in payment systems due to their high capital-intensities. Electronic payment systems require considerable up-front investments in processing infrastructures, highly-secure telecommunication facilities and data storage, and apply complex operational standards and protocols. Therefore, with high fixed costs, unit costs should fall when payment volume increases.

In this section, we will first specify our translog cost equation. Then we estimate various types of models, and discussing the obtained scale effects.

4.1 The model: A translog function approach

The variation in total operating cost across eight European payment processors over 1990-2005 is used in a translog cost function to derive economies of scale. Since the translog function incorporates higher order and interaction terms between the regressors, it is able to allow for a variation in economies of scale depending on the level of processing volume. The general form of a translog function linking operating cost (OC) to two outputs (Q_i) and two input prices (P_k), where we include a dummy for ownership structure and a time dummy for technological change, is written as follows:

$$\ln OC = \alpha_0 + \sum_{i=1}^{2} \alpha_i \ln Q_i + 1/2 \sum_{i=1}^{2}\sum_{j=1}^{2} \alpha_{ij} \ln Q_i \ln Q_j + \sum_{i=1}^{2}\sum_{k=1}^{2} \delta_{ik} \ln Q_i \ln P_k + \sum_{k=1}^{2} \beta_k \ln P_k + 1/2 \sum_{k=1}^{2}\sum_{m=1}^{2} \beta_{km} \ln P_k \ln P_m + \gamma_1 DPRIVATE + \gamma_2 TIME. \quad (1)$$

We added two dummies, $DPRIVATE$ and $TIME$. Dummy $DPRIVATE$

represents the ownership structure of payment processors, which takes on the value 0 if it is owned and managed by central banks, otherwise 1. We conjecture that processors that are owned by national central banks are more heavily (cross-)subsidized than commercial processors, so that reported cost data only partially reflect true underlying payment processing costs. Hence, we assert that privately owned processors show higher cost levels compared to central bank owned ACHs. Dummy $TIME$ represents technological progress and γ_2 should take a negative sign to indicate cost reductions as time passes by. That is, the cost curve shifts down as new technologies are adopted over time. In particular, in electronic payment systems, innovations in low-cost data storage and real-time processing and transmission have considerably lowered the unit costs of making payments over the last two decades.

Economies of scale in a multi-output environment are measured as:

$$S = \sum_{i=1}^{n} \frac{\partial OC/OC}{\partial Q_i/Q_i} = \frac{\partial \ln\, OC}{\partial \ln Q_i}, \tag{2}$$

where $\epsilon_i = \partial \ln\, OC/\partial \ln Q_i$ is usually called the scale elasticity with respect to output i.[5] Economies of scale exist if S is between zero and one, that is, $0 < S < 1$. Constant returns to scale are obtained for $S = 1$, and diseconomies of scale exist for $S > 1$.

Note that simple loglinear models which only depend on payment volume are derived when imposing $\alpha_{ij} = \beta_{km} = \delta_{ik} = \beta_k = 0$ in equation (1). More complex translog models incorporating input price movements but without second-order or interaction effects correspond to $\alpha_{ij} = \beta_{km} = \delta_{ik} = 0$. As shown in the next subsection, these simultaneous (linear) restrictions can easily be tested applying Wald or Likelihood Ratio tests.

4.2 Estimation results and scale effects

In this section we present our estimation results, compare models, and discuss induced scale effects. We will proceed by first analyzing simple loglinear models, and then move to more complex translog models.

4.3 A first insight: Simple loglinear models

Simple loglinear models may already provide us with some first understandings of possible scale effects. We do not yet include possible effects of input

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[5] Often in practise, economies of scale are roughly measured by marginal cost over average cost, using $S = \frac{dOC}{dQ}\frac{Q}{OC} = \frac{MC}{AC}$ in a single output environment.

prices, but just regress (log) operating cost on (log) total payment volume, the ownership dummy, and time. Table 2 in the appendix gives the result.

Not surprisingly, we see in all three regressions a strong dependence on total payment volume. The ownership dummy is also significant, indicating that central bank owned payment processors show lower cost. In particular, by incorporating the dummy $DPRIVATE$ the overall fit is hugely increased. The adjusted R-squared jumps from 0.59 to 0.87, and the (significant) economies of scale parameter S becomes much smaller, indicating a larger potential of positive scale benefits. Assuming that technology is a "non-rival good" and economies of scope play a lesser role than scale effects, these simple estimations suggest that central banks cross-subsidize their processors to a higher degree than privately owned processors.[6] The effect of technological change $TIME$ in table 2 is not yet convincing. It has the wrong sign and is not statistically significant.

After a simple transformation, the regression models 1a) and 1b) exactly correspond to the fitted lines in the scatter diagrams of Figure 1. The estimated slope coefficients reveal a crude measure of scale economies. The steeper the line, the larger the scale effects. More precise, the (negative) slope of the fitted line is equal to $S-1$. In the right panel of figure 1, we corrected for ownership by including dummy DPRIVATE. On average, the group of privately owned processors (indicated by a square in the graph) corresponds to a significantly higher cost level than its central bank owned counterpart (indicated by a plus).

Since there are no higher-order or interaction terms present, the scale measure does not vary with total volume. This means that every payment processing site–small or big–realizes the same positive scale effects. This restriction will be relaxed below when we analyze the translog specification. Given the estimation results of model 1c), doubling total payment volume would only increase total operating cost with about 30 percent. Consequently, average processing cost should fall, and preferably passed onto the end-users. This finding would provide a strong incentive to consolidate processing arrangements across European borders to realize these volume-related benefits.

However, these potential scale effects must obviously be adjusted for possible influences of technological change and developments of input prices over time. As well, one should account for potential higher-order effects and interaction amongst the explanatory variables. This is just what the translog function estimation in the next subsections tries to do.

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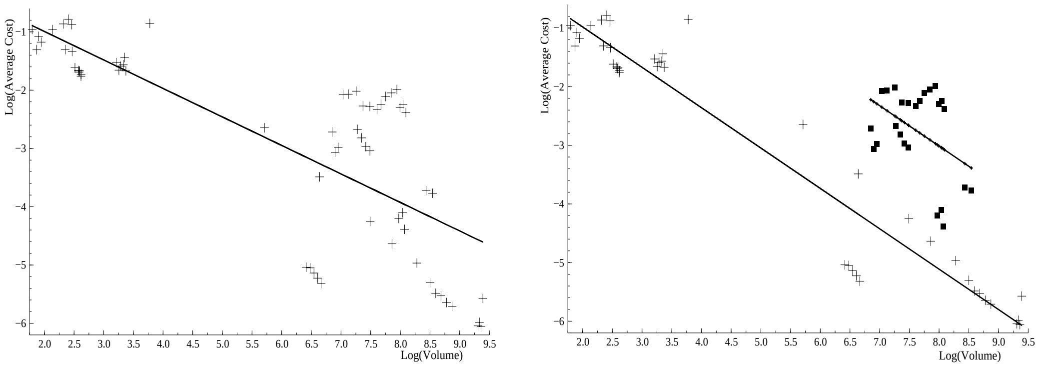
[6] Adams, Bauer and Sickles (2002) found little evidence of scope economies in Federal Reserve payment processing.

Fig. 1. Economies of scale: simple loglinear relations



Note: Panel a) log of average costs versus log of total volume, not corrected for ownership structure; panel b) log of average costs vs log of total volume, including ownership dummy $DPRIVATE$.

4.3.1 A single output translog model

The main task of ACHs is processing payments. It is therefore natural to first study the model with only one single output, in this case total payment volume. Equation (1) is then reduced to:

$$\begin{aligned}\ln OC = {} & \alpha_0 + \alpha_1 \ln Q + \frac{\alpha_{11}}{2}(\ln Q)^2 + \sum_{k=1}^{2} \delta_k \ln Q \ln P_k + \sum_{k=1}^{2} \beta_k \ln P_k + \\ & \frac{1}{2}\sum_{k=1}^{2}\sum_{m=1}^{2} \beta_{km} \ln P_k \ln P_m + \gamma_1 DPRIVATE + \gamma_2 TIME, \end{aligned} \tag{3}$$

where $Q = VOL$ denotes total payment volume, $P_1 = WAGE$ denotes the input price for labour, and $P_2 = INTRATE$ the input price for capital.[7]

Tabel 3 in the appendix shows the estimation results for two translog model specifications. Both translog regressions improve on the simple loglinear models of the previous subsection in terms of goodness of fit and explanatory power. Model 2a) is a log-linear translog specification, and by estimating one extra parameter (i.e. β_1) compared to model 1c), the log-likelihood increases with more than 10 points, which is clearly significant. The adjusted R-squared increases from 87 to 91 percent. Model 2b) is the fully specified translog model, incorporating all higher-order and interaction terms. By calculating two times

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[7] The standard linear restrictions of coefficient symmetry and linear homogeneity in input prices will be imposed ex ante, but can be tested applying Wald or Likelihood Ratio test-statistics. In the single output case, it must hold that $\beta_{21} = \beta_{12}$, $\beta_1 = 1 - \beta_2$, $\gamma_1 = -\gamma_2$, and $\beta_{11} = \beta_{22} = -\beta_{21}$.

the difference in log-likelihoods and applying a likelihood ratio test, model 2b) is preferred over model 2a): $2 * (46.9 - 41.3) = 11.2 > 7.81 = X_3^2$ on a 5-percent level.[8]

In model 2b) the ownership dummy $DPRIVATE$ remains significant. Note that model 2b) allows for a significant time dummy TIME as well (at the 5% level). It shows that technological change reduced processing costs at a five percent yearly rate, which is a similar finding as in Bauer and Ferrier (1996) for Fedwire payment services, and Schmiedel et al (2006) for the securities settlement industry. Moreover, the derived (average) economies of scale measure is fairly stable across the two regressions of the single output translog model, indicating an S-measure of around 25 percent. In both models the economies of scale measure is significantly different from 0 (i.e. maximum scale effects) and from 1 (i.e. no scale effects).[9] In contrast to model 2a), the economies of scale measure of model 2b) varies with payment volume, which allows us to separate individual payment processors in terms of scale effects. Table 5 in the appendix shows the results. The largest ACHs show economies of scale between 0.10-0.20, i.e., SIT-France (0.10), VOCA-UK (0.11), TAI-Germany (0.18), Interpay-Netherlands (0.18), and SIBS-Portugal (0.21). These figures indicate that the larger processors still have potential to benefit from further scale expansions. The scale measure of the smallest processors is more volatile, 0.06 (CEC-Belgium), 0.36 (LIPS Net-Luxembourg), and 0.49 (Dias-Greece). Unlike the effect on cost levels, there seems no apparent influence of ownership structure on the level of economies of scale.

In figure 2 we show the predicted average curves based on model 2b). In the left panel, central bank owned processors are depicted, and we split up the sample in before 2000 (1990-1999) and after 2000 (2000-2005) to graphically assess the impact of technological change. We observe the downward sloping nature of the average cost curve, and that it shifted down and rightward over time. For large payment volumes (i.e larger than 10 billion), model 2b) predicts an average cost of about 0.5 eurocent per transaction, which is similar to the US finding for ACHs (see Bauer et al., 2002). The picture is less clear in panel b) which shows the privately owned processors. We also observe a slight downward shift in cost curves, but the lack of data observations prevents us to make more specific statements. Our model predicts an average cost of around 2-2.5 eurocent per transaction for large payment volumes, say larger than 5 billion, for privately owned processors.

The recent merger of two privately-owned processors, Dutch Interpay and Ger-

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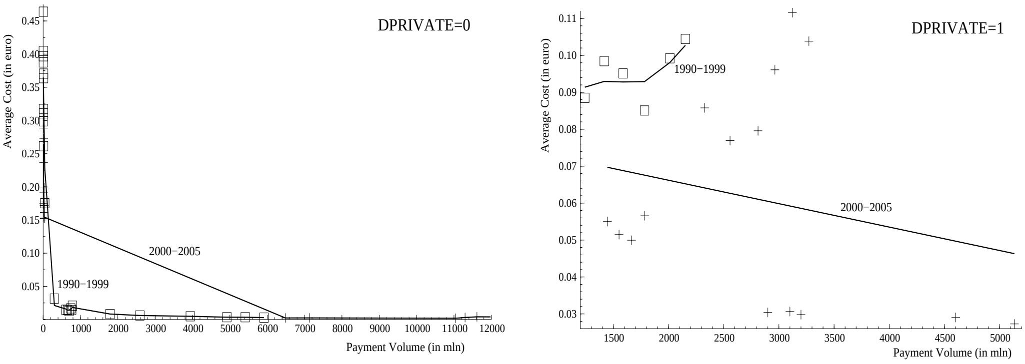
[8] Since we used a (non-linear) Newey-West procedure to estimate the standard errors, the standard F-stats to test for linear restrictions are not applicable.

[9] If $S = 0$, average costs would halve when output doubles, if S=1, then average costs would remain the same with doubled output.

Fig. 2. Predicted average cost curves in a single output translog model



Note: Open boxes indicate predicted average costs for 1990-1999, plusses indicate predicted average costs for 2000-2005. The left panel a) shows central bank owned processors ($DPRIVATE = 0$), panel b) privately owned processors ($DPRIVATE = 1$). The curves are fitted trends to the predicted values (cubic splines).

man TAI, provides a nice illustration of our finding. The merged ACH–called Equens–will double its payment volume from 3 billion each to 6 billion total processed payments per year. Given our average scale measure $S = 0.24$, this implies that average costs could fall as much as with 38 percent (for simplicity ignoring possible extra investments necessary for additional processing capacity over one platform).[10] Using the individual estimates (column 2, table 5) of 0.18, this implies a similar cost reduction of about 41 percent.[11] Our estimated (upper) curve in Figure 2 indicates a decrease from around 4 eurocent to lower than 2.5 eurocent per transaction. Hence, the new payment processor Equens will be much more competitive in the intra-European payments market. Ultimately, end-users may benefit from these cost reductions in the form of lower prices.

4.3.2 A double output translog model

A major drawback of the single output model is that it does not allow for different scale effects across different "produced" activities. However, in general,

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[10] Given $AC_0 = OC_0/VOL_0$, as a first approximation the merger would imply a new average cost of $AC_1 = OC_1/VOL_1 = ((1 + EoS)OC_0)/2V_0$. That is, $AC_1 = (1 + EoS)/2\ AC_0 = 0.62\ AC_0$, implying a 38 percent decrease.

[11] In a recent press release (January 23, 2007), Equens announced that the volume growth from their merger will generate large scale benefits and, by 2010, they could "realize cost savings of approximately 25 percent, which include a reduction of around 400 full-time positions and plan to increase the yearly processed payments transactions to 10 billion."

payment processors are involved in producing a variety of payment services, ranging from processing paper-based checks to straight-through-processed direct debits. Naturally, these types of activities require their own labour and capital intensities, implying different scale elasticities. The sum of these separate scale elasticities yield the total economies of scale.

The most obvious split-up of activities would be electronic payments versus paper-based payments. One would expect that the positive scale effects of electronic payment processing are larger than paper-based processing. However, the quality of our data is insufficient to allow such a separation of activities. Instead we focus on bill payments $VOL1$ (i.e. credit transfers and direct debits) versus point-of-sale payments $VOL2$ (i.e. credit and debit cards, ATM withdrawals and checks). To execute POS payments, ACHs need to hook up with retailers through a connected POS terminal network to retrieve payment information, which is costly. Payment terminals are not needed in executing bill payments which lowers the unit cost of such a payment. Therefore, it is expected that POS payments show less scale effects.[12] Table 4 presents the estimation results for two specifications.

Model 3a) is the loglinear specification with two outputs and two inputs. Although most parameters are significant, in terms of log likelihoods model 3a) performs less than model 2b) which has only one output. Apparently, in a simple loglinear specification, the split of payment volume into bill payments and POS payments decreases the ability to explain the variation in total operating costs. In model 3a), the total scale economy measure points to a value of around 0.20. Model 3b) is the fully specified translog model with two outputs and two inputs. The log-likelihood of model 3b) increases versus model 2b), but uses five extra parameters. A simple likelihood ratio test produces $2(41.4 - 38.9) = 5 < 11.1 = X_5^2$ on a 5-percent level, indicating that model 2b) cannot be rejected in favor of model 3b). Model 3b) yields a (statistically significant) total scale measure of 0.26, which is in line with the scale measures of model 2b). As expected, the scale elasticity of bill payments (0.11) is smaller than POS payments (0.15). Both elasticities are small and significantly different from 1 (no scale effects), which seems plausible since both payment types heavily depend on electronic networks. Again, the ownership dummy DPRIVATE is significant, and the effect of technical progress is similar to that of model 2b) in terms of significance and magnitude.

As shown in table 5, the various scale estimates compare well to those of model 2), confirming robustness across the various translog models. Figure 3 shows the estimated average cost curves of both outputs (all data pooled together),

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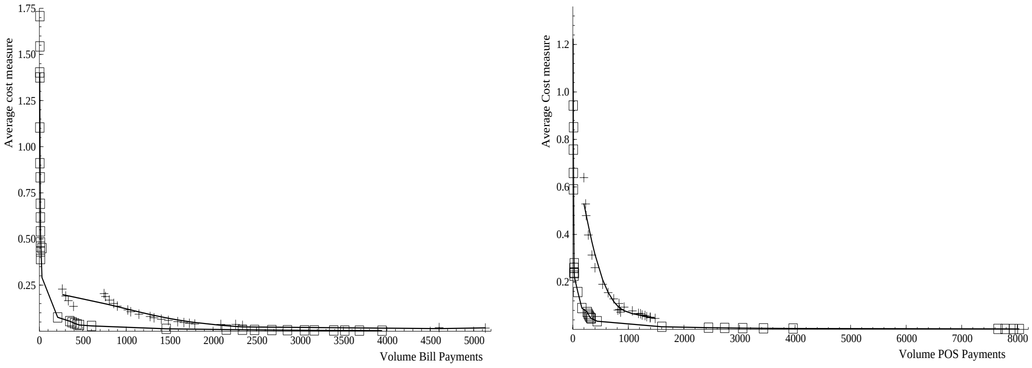
[12] It must be noted that not all payment processors produced both activities in every year. In order to carry out the translog estimation we set the volume level to a small value (0.0001) in those periods. This was done six times out of 134 observations.

Fig. 3. Predicted average cost curves in a double output translog model



Note: Panel a) Predicted average cost (measure) versus bill payment volume; open boxes indicate banks' owned processors and plusses indicate privately owned processors; panel b) predicted average cost measure versus point-of-sale payment volume. Lines are fitted trends (cubic splines) to the predicted observations.

depending on ownership structure, and based on the estimation results of model 3b). Note that in a double output translog model the level of average costs cannot be obtained for individual outputs. This is because predicted payment operating costs are obtained by holding the volume of the other output constant at its mean level. However, the slope of the curves are a fair reflection of how payment average costs change with the volume of individual outputs.[13]

5 Conclusion

Using heretofore unavailable payment processing cost data, our analysis provides a first step in assessing the potential benefits of SEPA. Two important conclusions stand out. First, large scale effects are possible when European payment processors would merge and consolidate their operations. Being cost-effective might prove to be the only viable business strategy in a competitive, intra-European payment processing market when SEPA has arrived. On average, based on our estimations, doubling payment volume would raise total operating cost with only approximately 25 to 30 percent. Moreover, these scale estimates are statistically significant. As a consequence, average costs should fall strongly. To illustrate, we estimated that the merger of Interpay and TAI could effectively lead to a 35-40 percent reduction in average costs. A further tendency to merge may therefore be expected with the advent of SEPA.

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[13] The inability to obtain average costs for a subset of outputs was already noted in Baumol, Panzar, and Willig (1982).

Second, ownership structure of payment processors is a significant factor to explain cost differences across payment processors. Grosso modo, central bank owned processors show much lower average costs. It is likely that this finding is explained by differences in the degree of cross-subsidization or outsourcing of payment activities.

Finally, in an econometric sense, we found that the double output translog model did not add much to the single output model in terms of goodness-of-fit and explanatory power. It did however allow a more detailed analysis of scale elasticities across different payment activities and scale economies across different European payment processors.

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Appendix

Table 1. Data, institutions, and descriptive stats

Processor	Country	Volume (mln, 2005)	Period	Obs	Ownership (dummy)
SIT	France	11982	1991-2005	15	0, NCB
Voca/BACS	U.K.	5134	2004-2005	2	1, banks
Interpay	Netherlands	3272	1990-2005	16	1, banks
TAI	Germany	3200	2003-2005	3	1, banks
SIBS	Portugal	1785	2002-2005	4	1, banks
CEC	Belgium	952	1990-1994	5	0, NCB
DIAS	Greece	29	1995-2005	11	0, NCB
LIPS-net	Luxemburg	14	1995-2005	11	0, NCB
Total		26368		67	4

Data	Variable	Mean	Median	Min	Max
Operating Cost	OC (euro, in mln)	68.08	23.64	1.76	384.89
Payment Volume	VOL (trx, in mln)	2176.17	1136.10	6.01	11982.00
Average Cost	AC=OC/VOL (euro/trx)	0.13	0.10	0.002	0.46
Labour Cost	WAGE (euro, in mln)	0.08	0.07	0.04	0.21
Capital Cost	INTRATE (perc.)	14.95	14.19	7.49	24.24
Ownership	DPRIVATE	=0 if owned by NCB, =1 else			
Technology	TIME	Time=1,…,16 for year=1990,…,2005			

Table 2. Simple loglinear regressions, no input prices

Regressor	Coefficient	Estimation Model 1a	 Model 1b	 Model 1c
$CONSTANT$	α_0	-0.01	0.39**	0.32***
VOL	α_1	0.51***	0.31***	0.31***
$DPRIVATE$	γ_1		2.10***	2.09***
$TIME$	γ_2			0.01
S		0.51(0.04)	0.31 (0.02)	0.31 (0.02)
Adj. R^2		0.59	0.87	0.87
Log Likelihood		-98.67	-58.85	-58.70
LM-stat		16.82	3.31	3.45
N		67	67	67

Note: Dependent variable is log of operating cost (OC). Payment volume VOL is logged. Standard errors of parameters are corrected for heteroskedasticity and autorcorrelation using Newey-West. Superscripts *,**,*** indicate significance levels of 10,5,1 percent respectively. Standard error of S in parentheses.

Table 3. Translog regressions: single output

Regressor	Coefficient	Estimation Model 2a	Model 2b
$CONSTANT$	α_0	3.07***	-2.00
VOL	α_1	0.28***	1.19**
VOL^2	α_{11}		-0.06
$WAGE$	β_1	0.91***	-0.77
$WAGE^2$	β_{11}		-0.25
$INTRATE$	$1-\beta_1$	0.09***	1.77
$INTRATE^2$	β_{11}		-0.25
$VOL*WAGE$	δ_1		0.14***
$VOL*INTRATE$	$-\delta_1$		-0.14***
$WAGE*INTRATE$	$-\beta_{11}$		0.25
$DPRIVATE$	γ_1	2.00***	1.84***
$TIME$	γ_2	-0.02	-0.05**
S		0.28 (0.03)	0.23 (0.03)
Adj. R^2		0.91	0.95
Log Likelihood		-46.93	-41.35
LM-stat		0.64	0.87
N		67	67

Note: Dependent variable is log of operating cost (OC). All regressors, except for dummies, are logged. S is averaged for model 2b). Standard errors of parameters are corrected for heteroskedasticity and autorcorrelation using Newey-West. Superscripts *,**,*** indicate significance levels of 10,5,1 percent respectively. Standard error of S in parentheses.

Table 4. Translog regressions: double outputs

Regressor	Coefficient	Estimation	
		Model 3a	model 3b
$CONSTANT$	α_0	1.85*	1.46
$VOL1$	α_1	0.08***	0.08
$VOL1^2$	α_{11}		0.03*
$VOL2$	α_2	0.11***	0.44*
$VOL2^2$	α_{22}		0.01
$WAGE$	β_1	0.58***	-0.34
$WAGE^2$	β_{11}		-0.33*
$CAPC$	$1-\beta_1$	0.42***	1.34
$CAPC^2$	β_{11}		-0.33*
$VOL1 * VOL2$	β_{12}		0.00
$VOL1 * WAGE$	δ_{11}		-0.00
$VOL1 * CAPC$	$-\delta_{11}$		0.00
$VOL2 * WAGE$	δ_{21}		0.05
$VOL2 * CAPC$	$-\delta_{21}$		-0.05
$WAGE * CAPC$	$-\beta_{11}$		0.33*
$DPRIVATE$	γ_1	2.31***	1.94***
$TIME$	γ_2	0.03	-0.06*
ϵ_1		0.08 (0.02)	0.11 (0.08)
ϵ_2		0.11 (0.03)	0.15 (0.07)
S		0.19 (0.02)	0.26 (0.03)
Adj. R^2		0.88	0.92
Log Likelihood		-57.21	-38.92
LM-stat		0.04	1.24
N		67	67

Note: Dependent variable is log of operating cost (OC). All regressors, except for dummies, are logged. S is averaged for model 3b. Standard errors of parameters are corrected using Newey-West. Superscripts *,**,*** indicate significance levels of 10,5,1 percent respectively. Standard error of S in parentheses.

Table 5. Total scale elasticities

Country	Model 2a	Model 2b	Model 3a	Model 3b
France	0.28	0.11	0.19	0.23
U.K.	0.28	0.11	0.19	0.52
Netherlands	0.28	0.18	0.19	0.26
Germany	0.28	0.18	0.19	0.26
Portugal	0.28	0.21	0.19	0.24
Belgium	0.28	0.06	0.19	0.19
Greece	0.28	0.49	0.19	0.34
Luxembourg	0.28	0.36	0.19	0.21
Average	0.28	0.23	0.19	0.26

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