How Stable is the Multiproduct Translog Cost Function? Evidence from the Dutch Banking Industry*

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I. Introduction

As is well-known, the competitive viability of loan and deposit markets is conditional on the existence of scale and scope (dis)economies in banking [cf. *Baumol* (1977)]. Knowledge of bank production characteristics is also essential for assessing the cost (dis)advantages of bank mergers, which are a frequent phenomenon in many countries these days. Moreover, as is evident from *Elyasiani* (1983) and *Swank* (1994a), the resource cost structure of banks bears on the effectiveness of certain instruments of monetary policy. These considerations may explain why most empirical studies of bank behaviour have been devoted to cost issues.

Econometric research on banking costs is usually restricted to a particular group of banks. A well-known example for the US is the group of (small) banks participating in the Functional Cost Analysis (FCA) program. Other examples are Savings & Loans, unit-state banks, large banks, and credit unions. Obviously, the typical (translog) cost function estimated is suspected not to be so flexible that it can adequately capture the structure of production and cost of a wide range of banks [see *Le Compte* and *Smith* (1990, p. 1339)]. *Lawrence* and *Shay* (1986) and *Lawrence* (1989) find that even parameter estimates from pooled FCA data suffer from instability across bank size. It is rather striking, therefore, that a recent study by *Berger* and *Humphrey* (1991), analysing inefficiency in banking on the basis of an estimated translog cost function, includes both small and large US banks in the sample.

Another common feature of the bulk of econometric bank cost studies is that they apply to financial institutions located in the United States.

* This paper, which is a revised version of chapter 5 of my (unpublished) Ph.D. thesis, has greatly benefitted from the comments by *Lex Hoogduin, Gerard Korteweg* and an anonymous referee. All errors and opinions are mine.

Notable exceptions are *Murray* and *White* (1983) and *H. Y. Kim* (1986), dealing with British Columbia credit unions, and *M. Kim* (1986) and *Kim* and *Ben-Zion* (1989), focusing on Israeli banks. In Europe, research into the structure of bank production on the basis of econometric cost equations is rare. Recently, however, a change seems to have set in, judging by the work of *Kolari* and *Zardkoohi* (1990) on Finnish banks, time-series analyses of a single Greek bank and a single Irish bank by *Pavlopoulos* and *Kouzelis* (1989) and *Glass* and *McKillop* (1992) respectively, and an international comparison of bank production characteristics in France, Germany, Italy, Canada, Japan and the US by *Hunter* and *Timme* (1992). A natural reason for the near absence of econometric bank cost studies in Europe is that the banking industry in most European countries is much more concentrated than in the US due to past and present differences in regulation [see *Bröker* (1989, pp. 199 - 202)]. Then, the inherent scarcity of cross-section data may render the estimation of bank cost functions rather futile, unless various types of financial institutions are included in the sample.[1]

The main question addressed in this paper is how far such a pooling of different bank types is legitimate on statistical grounds. This is investigated by estimating a multiproduct translog cost function using data on a variety of banks in the Netherlands: commercial banks, savings banks, mortgage banks, government banks[2], domestic banks and foreign banks. The heterogeneity of the sample is further reflected in that the observed banks range in total asset size from 23 million guilders to 180 billion guilders (1989 figures). Moreover, the four largest banks account for more than 70% of total bank credit, and more than 40% of Dutch savings deposits is held at only one bank. A second question raised in this paper is whether the structure of cost and production in the Dutch banking industry has remained stable over the past decade, in which regulation diminished and bank mergers changed the playing field. Finally, the paper presents some estimates of economies of scale and scope in the Dutch banking industry and compares them with recent findings for other countries.

The rest of this paper is organized as follows. Section II elaborates on some conceptual issues and develops the specification of the translog

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1 As an alternative, data pertaining to different time periods can be pooled. This option was chosen by *M. Kim* (1986) and *Kim* and *Ben-Zion* (1989), who had only 17 Israeli banks in the sample.

2 Government banks in this paper are defined as banks registered as a commercial bank but with public responsibilities.

cost function estimated. Data and estimation results are discussed in section III. Section IV comments on the stability analysis and section V contains estimates of economies of scale and scope. Conclusions are drawn in the final section.

II. Conceptual Issues and Model Specification[3]

1. The Methodology

Econometric studies of banking costs are quite numerous.[4] The basic methodology starts from the assumption that the technology of an individual bank can be described by a production function, relating the output of a bank to the available production factors. All banks in the sample are assumed to use the same technology. It is further assumed that banks are efficient, implying that a bank's output is produced at minimum cost no matter how the output was chosen [*Berger* et al. (1987, p. 511, fn. 13)].[5] Under these assumptions, a dual cost function can be derived from the bank's decision problem, including as arguments the bank's output levels and factor prices.

As shown by *Diewert* (1971), the estimation of a dual cost function does not require that certain *a priori* restrictions are imposed on the underlying production frontier (Cobb-Douglas, CES, etc.), provided that certain regularity conditions are met. In fact, the researcher can directly start from a general specification of the cost function and infer global characteristics of the production structure from the estimation results. Most authors of recent bank cost studies have used the translog multiproduct cost function, proposed by *Christensen* et al. (1973), which can be considered a local second-order approximation to any production and price frontier. The specification adopted in the present paper is a hybrid form of this function in that a Box-Cox transformation is applied to output variables with zero values in the sample, thereby begging the

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[3] Conceptual issues are treated only briefly in this paper. A more detailed discussion is contained in *Humphrey* (1990).

[4] For surveys, see *Gilbert* (1984) and *Clark* (1988).

[5] In a few studies, the efficiency assumption is weakened. *Berger* and *Humphrey* (1991), for example, infer inefficiencies from comparisons between cost functions estimated over different average cost quartiles of their sample. An alternative approach is followed by *Ferrier* and *Lovell* (1990), who allow inefficiencies to be incorporated in the stochastic error term of the cost function. See *Evanoff* and *Israilevich* (1991) for a methodological digression on measuring inefficiency in banking and for a survey of recent empirical studies in the field.

problem that the standard translog form does not permit zero output levels [cf. *Caves* et al. (1980)].[6]

While it is common practice to infer bank production characteristics from an estimated translog cost function or a related form, some caveats are in order. As *De Vany* (1984, p. 605) puts it, "a bank is an entity of monstrous complexity"; it is highly unlikely, therefore, that its technology can be exactly represented by a classical production function or the corresponding cost function implied by duality. Specifically, despite their alleged flexibility, both the translog form and its generalizations are at most descriptive tools for amassing superficial empirical knowledge of sectoral production processes, a complete econometric study of which "... would require a body of data which is rarely available. It would be necessary to have data for individual enterprises over time, or, in other words, a time series of cross sections. By suitable stratifications, or more refined techniques, it might then be possible to estimate both the ex ante and the ex post production functions at the micro level as well as the various types of technological progress" [*Johansen* (1972, p. 185)]. In addition, a number of arbitrary choices have to be made before a sectoral cost function can be estimated. For example, owing to data limitations and so that multicollinearity is avoided, the typical regression only includes a few output variables, which are unlikely to capture the influence of the omitted outputs with great precision. Finally, the premise that all banks in the sample use the same technology and produce at minimum costs may be invalid due to regulatory peculiarities, market imperfections and so on. Hence, the ambition of this paper is not to estimate a bank production function but rather to present evidence on scale and scope economies in the Dutch banking sector as far as the (hybrid) translog form can adequately explain the resource costs of the various types of banks constituting the industry.

2. *Defining Output and Costs*

There has been much discussion on the appropriate definition of output in banking. In broad outline, there are two views, labelled the intermediation approach and the production approach. The intermediation approach regards banks as firms that attract deposits and other funds and transform these into loans and other assets using labour and

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6 For more general applications of the Box-Cox transformation in bank cost studies, see *Clark* (1984), *Kilbride* et al. (1986), *Lawrence* (1989), *Cebenoyan* (1990) and *Mester* (1992).

physical capital. In this view, interest payments are part of a bank's costs, and the dual cost function should not include deposits itself (being considered an input) but the interest rate on deposits. Also typical of the intermediation approach is that money amounts of assets serve as the output measure. The production approach regards banks as producers of services connected with individual loan and deposit accounts. Under this approach, interest payments are not counted as banking costs. Most studies using the production approach take numbers of loan and deposit accounts as the output measure while allowing for interbank differences in average account size.

This paper basically follows the production approach. In line with the oligopolistic structure of banking markets in the Netherlands [cf. *Swank* (1994b, 1995)], interest payments are considered a control variable of banks and, hence, do not belong in a dual cost function: "... costs that are incurred to shift the demand curve, such as interest payments and advertising, are not included as operating costs" [*Benston* (1972, p. 317)]. Three categories of output are distinguished: (1) loans, (2) demand deposits and (3) savings deposits. Forced by the data, only savings deposits are measured in numbers of accounts, while the other outputs are measured in money amounts (thousands of guilders).[7]

3. *The Number of Branches*

Following *Benston* et al. (1982), many recent bank cost studies have included the number of branches in the specification. The role of this variable is somewhat obscure, however. For, if the number of branches were a control variable of the banking firm, branches would not belong in a truly dual cost function. *Nelson* (1985), however, argues that branches offer convenience to clients and, hence, are a "characteristic of the banking product" (p. 178). So, according to this conception, branches may be considered part of a bank's output.[8] It is natural, then, to allow the number of branches to interact with all output variables as in *M. Kim* (1986), *Berger* et al. (1987), *Mester* (1987), *Kim* and *Ben-Zion* (1989), *Kolari* and *Zardkoohi* (1990), *Noulas* et al. (1990) and *Berger* and *Humphrey* (1991). This course is also pursued in the present paper.

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[7] Measuring savings deposits in money amounts rather than in numbers of accounts appeared inessential to the conclusions, which is consistent with observations made by *Clark* (1988, p. 24) and *Humphrey* (1990). Average account size of savings deposits was not significant.

[8] For a similar reasoning, see *Berger* et al. (1987, p. 506).

4. *Factor Prices*

In addition to outputs and the number of branches, a real dual cost function also includes factor prices as arguments, such as the wage rate and the price of physical capital. Unfortunately, these variables are hardly observed for Dutch banks. Though a wage rate can be computed for each bank by dividing total wages by the number of employees, it is not possible to allow for interbank differences in labour productivity and average working time. As a result, the researcher is left with a series implying that some banks pay over four times as much for the same type of full-time worker than other banks. This is certainly not realistic. Following *Gilligan* and *Smirlock* (1984) and *Kolari* and *Zardkoohi* (1990), it is assumed, therefore, that efficiency wages (as well as other factor prices) are equal for all banks. Consequently, there is no sense in extending the estimation problem by factor demand equations [derived from *Shephard*'s (1953) Lemma] to obtain more efficient parameter estimates.[9]

5. *Model Specification*

The translog cost function can now be specified as:

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\begin{aligned}
(1)\quad \ln \mathrm{TC} = {} & \alpha_0 + \alpha_1 \ln \mathrm{LOANS} + \alpha_2 (\ln \mathrm{LOANS})^2 + \alpha_3 (\ln \mathrm{LOANS})(\ln \mathrm{DD}) \\
& + \alpha_4 (\ln \mathrm{LOANS})\mathrm{SA\widetilde{V}AC} + \alpha_5 (\ln \mathrm{LOANS})(\ln \mathrm{Br}) + \alpha_6 \ln \mathrm{DD} + \alpha_7 (\ln \mathrm{DD})^2 \\
& + \alpha_8 (\ln \mathrm{DD})\,\mathrm{SA\widetilde{V}AC} + \alpha_9 (\ln \mathrm{DD})(\ln \mathrm{Br}) + \alpha_{10}\, \mathrm{SA\widetilde{V}AC} + \alpha_{11}\, \mathrm{SA\widetilde{V}AC}^2 \\
& + \alpha_{12}\, \mathrm{SA\widetilde{V}AC}(\ln \mathrm{Br}) + \alpha_{13} \ln \mathrm{Br} + \alpha_{14} (\ln \mathrm{Br})^2 + \epsilon
\end{aligned}
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where

TC	=	total operating expenses (thousands of guilders)
LOANS	=	loans (thousands of guilders)
DD	=	demand deposits (thousands of guilders)
SAVAC	=	number of savings accounts
$\mathrm{SA\widetilde{V}AC}$	=	Box-Cox transformation: $\mathrm{SA\widetilde{V}AC} = (\mathrm{SAVAC}^{\lambda} - 1)/\lambda$
Br	=	number of branches
ϵ	=	stochastic error term

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[9] *Guilkey* and *Lovell* (1980) conclude from Monte-Carlo experiments that the simultaneous estimation of a translog cost function and the implied equations for the cost minimizing input shares should be avoided anyhow if the translog form is suspected not to be an exact representation of the true technology, a view which is taken throughout this paper.

III. Data and Estimation Results

The sample consists of two subsamples, one pertaining to 1982 and one pertaining to 1989. With a few minor exceptions, both subsamples include all commercial banks, savings banks, government banks and mortgage banks located in the Netherlands. Due to mergers and entrants, banks included in the 1982 sample do not necessarily appear (as a single bank) in the 1989 sample and vice versa. Data were taken from the banks' annual reports and from reportings to the central bank.

As for the precise definition of variables, the following remarks are in order. Major costs included in total operating expenses are wages, pensions, social security taxes, depreciation of premises and equipment, rent and maintenance of office buildings. Loans comprise commercial loans, mortgages and consumer credit. Demand deposits include current accounts (transfer accounts, etc.) of all clients. Savings accounts refer to time and savings deposits of households. Branches are defined as full-servicing offices; mobile suboffices (of savings banks) are disregarded.

Using OLS[10], equation (1) was estimated for each of the two subsamples. The results are presented in the first two columns of table 1. While the overall fit of the equation is quite acceptable in both cases, a number of coefficients turn out to be insignificant. Insofar as this reflects multicollinearity among the regressors, which is not an exceptional problem in the estimation of multiproduct cost functions, more precise parameter estimates might be obtained from a pooled sample, containing observations for both 1982 and 1989. The third column of table 1 reports this regression.[11] Judging by the relatively high t-ratios, pooling really does seem to reduce multicollinearity. There are, however, problems of heteroscedasticity and functional form, suggesting that the hybrid translog form is not flexible enough to capture the whole range of bank cost structures appearing in the sample. This issue is elaborated in the next section.

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10 In theory, instrumental variable estimation would have been preferable to OLS, since outputs and the number of branches are probably not exogenous to the individual bank. As *Kim* (1985, p. 99) correctly argues: "In order to avoid biased parameter estimates (·), one must generate behavioural equations that explain the endogenous output choice made by the bank when it maximizes its profits". Poor knowledge of the banking firm's true exogenous variables led me (and practically all researchers in the field) to refrain from such an approach.

11 In order to adjust for inflation, all money amounts have been deflated by the consumer price index.

Table 1

Estimation Results for the Translog Cost Function, 1982 and 1989 (T-Ratios in Parentheses)

Variables and Statistics	1982	1989	1982/1989 Pooled
Variables[a])			
Constant Term	0.216	4.101	1.521
	(0.1)	(1.9)	(1.1)
ln LOANS	0.999	0.124	0.920
	(3.4)	(0.2)	(3.2)
$(\ln \text{LOANS})^2$	– 0.061	– 0.091	– 0.072
	(1.3)	(2.2)	(2.9)
(ln LOANS) (ln DD)	0.036	0.178	0.076
	(0.4)	(2.1)	(1.7)
(ln LOANS) $\text{SA}\tilde{\text{V}}\text{AC}$	0.031	0.005	0.019
	(5.1)	(1.0)	(4.9)
(ln LOANS) (ln Br)	– 0.007	0.134	0.173
	(0.1)	(1.8)	(4.0)
ln DD	– 0.212	0.060	– 0.351
	(0.3)	(0.1)	(1.0)
$(\ln \text{DD})^2$	0.026	– 0.066	0.004
	(0.7)	(1.2)	(0.2)
(ln DD) $\text{SA}\tilde{\text{V}}\text{AC}$	– 0.022	0.006	– 0.005
	(3.6)	(1.5)	(1.4)
(ln DD) (ln Br)	– 0.025	– 0.150	– 0.167
	(0.4)	(2.3)	(4.7)
$\text{SA}\tilde{\text{V}}\text{AC}$	– 0.143	– 0.092	– 0.167
	(2.7)	(2.3)	(5.8)
$\text{SA}\tilde{\text{V}}\text{AC}^2$	0.000	0.001	0.001
	(1.0)	(1.6)	(1.5)
$\text{SA}\tilde{\text{V}}\text{AC}$ (ln Br)	– 0.018	– 0.015	– 0.017
	(2.7)	(3.0)	(4.0)
ln Br	0.489	0.128	– 0.127
	(0.7)	(0.3)	(0.4)
$(\ln \text{Br})^2$	0.091	0.025	0.015
	(1.6)	(0.7)	(0.5)
Statistics[b])			
$\bar{R}^2$	0.97	0.95	0.95
$\bar{S}_e$	0.34	0.44	0.40

(Continued table 1)

Variables and Statistics	1982	1989	1982/1989 Pooled
Heteroscedasticity	2.53**	1.16	2.55**
Normality	4.81	0.91	2.81
Functional Form	1.47	1.64	4.40**
Sample Size	68	65	133

[a]) The parameter λ of the Box-Cox transformation $\widetilde{\text{SAVAC}} = (\text{SAVAC}^{\lambda} - 1)/\lambda$ was determined on the basis of a grid search ($\lambda \simeq 0.1$).

[b]) $\bar{R}^2$ is the coefficient of determination and $\bar{S}_e$ is the standard error of estimate, both adjusted for degrees of freedom. The test for heteroscedasticity is an F-test developed by *Pagan* et al. (1983), which involves regressing the squared residuals of the estimated equation on the explanatory variables of that equation. Normality is tested by *Jarque* and *Bera*'s (1980) statistic for normal residuals, which is distributed $\chi^2(2)$. The test for functional form is *Ramsey*'s (1969) Reset test, relying on an F-ratio, and was carried out by expanding the original equation to include (2nd, 3rd and 4th) powers of the fitted values of the dependent variable. Significance at the 5%-level and at the 1%-level is denoted by one asterisk (*) and two asterisks (**) respectively.

IV. Stability Analysis

The results of the stability analysis are recorded in table 2. Clearly, the presence of various types of banks in the sample poses serious problems. This is especially evident from the Chow-tests applied to the pooled regression, indicating that it may be dangerous to draw statistical inferences from cost functions estimated over small samples.

Why does the specified cost function perform so badly beyond simple goodness-of-fit statistics? One reason might be that the set of regressors is too poor to identify the production characteristics of special types of banks. For example, unlike commercial banks and savings banks, mortgage banks do not settle all sorts of payment transactions for the benefit of their clients. Hence, the average costs of servicing loan and deposit accounts incurred by mortgage banks are likely to be substantially lower than those incurred by other banks and, sure enough, a closer look at the residuals of the 1982 equation shows that operating expenses of mortgage banks are on average overestimated by the model. A possible solution to this problem is to include so-called "hedonic" terms in the estimating form so as to allow for differences in bank idiosyncrasies that are not expressed in variables typically found in dual cost functions.[12]

[12] In effect, the number of branches is also an hedonic variable.

Recently, this approach has been successfully adopted by *Shaffer* and *David* (1991).

Table 2

Chow-Tests for the Stability of the Translog Cost Function: F-Ratios (Degrees of Freedom in Parentheses)

Type and Object of Chow Test[a])	1982	1989	1982/1989 Pooled
Chow-1 for Large Banks[b])	0.66 (3,50)	0.94 (4,46)	0.80 (7,111)
Chow-1 for Small Banks[c])	1.98 (31,22)	1.13 (26,24)	1.84** (57,61)
Chow-1 for Savings Banks	0.38 (23,30)	0.95 (16,34)	0.55 (39,79)
Chow-1 for Mortgage Banks	3.42* (4,49)	1.15 (4,46)	1.44 (8,110)
Chow-1 for Government Banks[d])	–	4.72* (2,48)	3.26* (2,116)
Chow-1 for Banks Controlled Abroad[e])	1.04 (16,37)	1.01 (20,30)	1.89** (36,82)
Chow-1 for Unit-Branch Banks	3.96** (17,36)	7.62** (26,24)	6.85** (43,75)
Chow-1 for Banks without Savings Accounts	6.74** (17,36)	1.78 (20,30)	3.38** (37,81)
Chow-2 for 1982/1989	–	–	1.26 (15,103)

[a]) Chow-1 refers to *Chow*'s (1960) first test for parameter instability, testing the whole sample against a shortened sample. The first figure in parentheses corresponds with the number of banks in the test group. Chow-2 refers to the standard Chow-test, dividing a sample into subsamples over which separate regressions are run. The latter test was carried out by pooling the observations for 1982 and 1989 and estimating the translog over both the pooled sample and the two subsamples. Significance at the 5%-level and at the 1%-level is denoted by one asterisk (*) and two asterisks (**) respectively.

[b]) Large banks are commercial banks having a balance sheet total of over 100 billion guilders.

[c]) Small banks are banks having a balance sheet total of less than 1 billion guilders.

[d]) Government banks are banks registered as a commercial bank but with public responsibilities. There were no such banks in 1982.

[e]) Including banks with parent company outside the Netherlands.

However, the apparent instability of the estimated equations across bank size and bank type may also be due to a lack of flexibility of the (hybrid) translog form to capture the production structures of banks on edges of the cost surface. The relatively high F-ratios for unit-branch banks and banks without savings accounts suggest that there is a case in point here. In an attempt to confirm this, I have re-estimated equation (1) over the pooled sample after excluding the observations for these banks. The equation thus obtained proved to be stable with regard to all remaining types of banks. Moreover, the test statistics for functional form and heteroscedasticity both came out below the usual significance levels.[13] These results imply that the Box-Cox transformation is merely a bogus solution to the problem of zero output levels inherent in the translog form and that estimates of scale and scope economies based on reference solutions at lower extremes of the cost function are of questionable value, even when no extrapolation beyond the sample is required. At any rate, it seems worthwhile to perform appropriate stability tests before such calculations are made.

The Chow-test for structural break does not reveal a major shift in banking technology during the past decade, despite the fact that some significant regressors in the 1982 equation are insignificant in the 1989 equation and the other way around. Obviously, and in contrast with findings by *Gropper* (1991) for US banks, deregulation and increased competition have not changed existing production frontiers. Incidentally, this may serve as a justification for pooling the 1982 and 1989 samples.

V. Economies of Scale and Scope

Economies of scale and scope are calculated for four size classes on the basis of the pooled regression with unit-branch banks and banks without savings accounts removed from the sample (leaving 77 observations). Before going into this, it is important to check that marginal resource costs are positive at all average output levels in each size class. Otherwise, the estimates would not make sense from the angle of economic theory [see, e.g., *Caves* et al. (1980, p. 477)]. The results are presented in table 3.

[13] Detailed outcomes are available from the author on request.

Table 3

Marginal Costs, Economies of Scale and Cost Complementarities

	Size Class (Balance Sheet Total in Billions of Guilders)			
	< 1	1 - 5	5 - 100	> 100
Number of Banks	31	27	12	7
Marginal Costs (Guilders)				
– Loans	0.014	0.016	0.017	0.019
– Demand Deposits	0.069	0.055	0.051	0.049
– Savings Accounts	0.004	0.004	0.004	0.005
Overall Economies of Scale[a])				
– Constant Number of Branches	0.873*	0.896	0.937	0.979
– Variable Number of Branches	0.983	1.008	1.019	0.980
*Product Specific Economies of Scale (Guilders * 10^6)*[b])				
– Loans	0.001	– 0.000	– 0.000	– 0.000
– Demand Deposits	– 0.395*	– 0.026*	– 0.003*	– 0.000*
– Savings Accounts	– 0.496**	– 0.091*	– 0.055	– 0.006
*Cost Complementarities (Guilders * 10^6)*[c])				
– Loans, Demand Deposits	– 0.042	– 0.001	0.000	0.000
– Loans, Savings Accounts	0.157**	0.025**	0.010**	0.001*
– Demand Deposits, Savings Accounts	– 0.447	– 0.070*	– 0.033*	– 0.003

[a]) A figure < 1 corresponds with overall economies of scale, a figure > 1 with overall diseconomies of scale. Significant deviations **from 1** at the 5%-level and at the 1%-level is denoted by one asterisk (*) and two asterisks (**) respectively.

[b]) A figure < 0 corresponds with product specific economies of scale, a figure > 0 with product specific diseconomies of scale. Significance at the 5%-level and at the 1%-level is denoted by one asterisk (*) and two asterisks (**) respectively.

[c]) A figure < 0 corresponds with product specific economies of scope, a figure > 0 with product specific diseconomies of scope. Significance at the 5%-level and at the 1%-level is denoted by one asterisk (*) and two asterisks (**) respectively.

1. *Marginal Costs*

Marginal resource costs are indeed positive at each point of scale and scope evaluation. Apparently, servicing demand deposits is fairly expensive. This is especially true for small banks, which spend almost 7 cents on every additional guilder of demand deposits. Large banks manage to operate at lower costs on this point, but their marginal expenses on loans and savings accounts are relatively high.

2. *Overall Scale Economies*

Overall economies of scale are said to exist if a proportionate increase in all output levels (Y_i) raises costs less than proportionally. This leads to the following measure of overall scale economies (SE):

$$\text{SE} = \sum_i \frac{\partial \text{TC}/\text{TC}}{\partial \text{Y}_i/\text{Y}_i} \tag{2}$$

SE < 1 corresponds with economies of scale, whereas SE > 1 points to diseconomies of scale. *Benston* et al. (1982) have proposed a measure of augmented scale economies (ASE), which allows for alterations in the number of branches associated with an expansion of output levels:

$$\text{ASE} = \text{SE} + \frac{\partial \text{TC}/\text{TC}}{\partial \text{Br}/\text{Br}} \sum_i \frac{\partial \text{Br}/\text{Br}}{\partial \text{Y}_i/\text{Y}_i} \tag{3}$$

The expression after the summation sign measures the percentage change in the number of offices due to a 1% increase in loans, demand deposits and the number of savings accounts. Following *Hunter* and *Timme* (1986, p. 163, fn. 14), this term is computed on the basis of an auxiliary regression, relating the number of branches to the output variables.[14]

At the plant level, with branches held constant, significant overall economies of scale are only found for the smallest banks.[15] As banks become larger, overall scale economies tend to disappear. Similar results have been obtained by *Berger* et al. (1987) and *Berger* and *Humphrey* (1991) for US (branching state) banks and by *Kolari* and *Zardkoohi* (1990) for Finnish banks. At the firm level, where branches can vary

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[14] The estimated equation reads: $\ln \text{Br} = 3.69 - 1.90 \ln \text{LOANS} + 0.17 (\ln \text{LOANS})^2 - 0.21 (\ln \text{LOANS})(\ln \text{DD}) - 0.02 (\ln \text{LOANS})\, \text{SA}\tilde{\text{V}}\text{AC} + 1.33 \ln \text{DD} + 0.07 (\ln \text{DD})^2 - 0.004 (\ln \text{DD})\, \text{SA}\tilde{\text{V}}\text{AC} - 0.16\, \text{SA}\tilde{\text{V}}\text{AC} + 0.05\, \text{SA}\tilde{\text{V}}\text{AC}^2$.

[15] Significance has been examined on the basis of a Wald test.

with output levels, returns to scale are constant in all size classes. So, the U-shaped average cost curve emerging from numerous studies of US banks[16] is not supported by the Dutch data. This is quite remarkable, since the range of bank sizes in the present sample is much broader than in most American bank cost studies, which tend to focus on small banks exclusively.[17] The results also imply that, except for the smallest banks, there are no significant diseconomies involved in expanding output through increased branching rather than sticking at the same network of offices. Hence, the recent tendency of certain larger Dutch banks towards rationalizing domestic branch networks might be less cost-reducing than is sometimes suggested.

3. Product-Specific Economies of Scale

Following *Bothwell* and *Cooley* (1982), product-specific economies of scale are measured according to:

$$\text{PSE}\,(Y_i) = \frac{\partial^2 \text{TC}}{\partial Y_i^2} \tag{4}$$

PSE < 0 corresponds with declining marginal resource costs, implying product-specific economies of scale. For PSE > 0, marginal resource costs are increasing, implying product-specific diseconomies of scale. Table 3 shows that such production economies exist for all output activities, though only to a significant degree for savings deposits at smaller banks and for demand deposits in all size classes. The latter outcome, which contradicts findings by *Gilligan* et al. (1984) for US banks, suggests that even the largest banks in the Netherlands have not reached the point where the provision of payments services is most cost-effective.[18]

16 For major references, see *Gilbert* (1984), *Clark* (1988) and *Humphrey* (1990).

17 Interestingly, *Hunter* and *Timme* (1986) and *Shaffer* and *David* (1991), who have included only large US banks in their samples, find no (strong) evidence of decreasing returns to scale. See, however, *Hunter* et al. (1990) for a counterexample.

18 For what it's worth, calculations based on extrapolation reveal that this conclusion does not hold for the *combination* of the two largest banks in the sample, which have actually merged in 1990.

4. *Cost Complementarities*

A cost complementarity is defined as the change in marginal cost due to a joint expansion of two outputs (Y_i and Y_j):

$$\mathrm{COM}\,(Y_i, Y_j) = \frac{\partial^2 \mathrm{TC}}{\partial Y_i \, \partial Y_j} \tag{5}$$

$\mathrm{COM}\,(Y_i, Y_j) < 0$ is indicative of interproduct economies of scope, implying that it is cheaper to produce Y_i and Y_j jointly rather than in two specialized firms.[19] As demonstrated by *Baumol* (1977), the existence of scope economies is necessary for multiproduct cost subadditivity, which entails a natural monopoly. Specifically, "... a claim of natural monopoly asserts that production by a single firm is cheaper than it would be in the hands of *any and every* possible combination of smaller firms" (p. 815/816). This case does not seem to be very relevant to the Dutch banking industry, since loans and savings accounts show significant diseconomies of scope (i.e., specialization economies) throughout the sample. Consequently, there are significant cost disadvantages involved in expanding loans which are funded with time and savings deposits. This imposes a natural limit on the size of the traditional savings bank, for example, whose main business is (or rather was) to attract household savings and to transform these into mortgages and government loans. However, as it turns out, joint expansion of demand deposits and savings accounts enables medium-sized banks to increase cost-effectiveness, probably because these outputs share fixed inputs in the relevant size ranges. So, at the margin, and up to a point, these banks have an incentive to diversify their deposit funding and, hence, to evolve towards the "financial supermarkets" that constitute the largest size class, where all economies of scope have been exhausted or are even negative.[20] The

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[19] There are several ways of measuring scope economies, none of which is fully undisputed. For elaborations, see *Mester* (1987, pp. 439 - 442) and the references cited there. Mester's advice is to evaluate cost complementarities at different output levels (and input prices) across the surface. This course is pursued in the present paper.

[20] Estimates of production complementarity vary widely across existing bank cost studies, partly because of differences in the applied concepts and methodology. Dominance of scope diseconomies is reported in *Berger* et al. (1987), *Cebenoyan* (1990) and *Berger* and *Humphrey* (1991) for US banks, in *Kolari* and *Zardkoohi* (1990) for Finnish banks and in *Glass* and *McKillop* (1992) for the Bank of Ireland. *Gilligan* and *Smirlock* (1984), *Gilligan* et al. (1984) and *Pulley* and *Braunstein* (1992), on the other hand, find significant scope economies for US banks, whereas *Lawrence* and *Shay* (1986) and *Le Compte* and *Smith* (1990) present

latter observation implies that the recent mergers between some of the largest banks in the sample cannot be explained from cost subadditivity. Presumably, strengthening of market positions and the wish to reduce risk and vulnerability are the leading factors behind recent concentration tendencies in the Dutch financial sector, but this is beyond the scope of the present study.

VI. Conclusions

This paper presents evidence on the stability of the multiproduct translog cost function from a heterogeneous sample of Dutch banks. It is found that a hybrid form of this function is unable to capture the production structures of banks on edges of the cost surface. Hence, generally speaking, it may be sensible to exclude highly specialized banks and unit-branch banks from the sample and, *ipso facto*, to avoid using ("direct") measures of scale and scope economies taking such banks as points of comparison. A suitable alternative, not examined in this paper, might be to adopt a more flexible functional form, such as the minflex Laurent specification, applied by *Le Compte* and *Smith* (1990) and *Hunter* et al. (1990), or the composite cost function proposed by *Pulley* and *Braunstein* (1992). However, as noted by the latter authors, increased flexibility may easily lead to violation of regularity conditions, which would be problematic from a theoretical point of view. The stability analysis performed in this paper also reveals that the hypothesis of a structural break in banking technology between 1982 and 1989 has to be rejected, in spite of deregulation and increased competition during the period.

Overall economies of scale are only proved to exist at small banks with branches held constant. While this is in line with prior studies of US banks, there is no evidence of a U-shaped average cost curve. Hence, even the largest banks in the Netherlands can expand along a ray in output space without having to worry about cost disadvantages. Moreover, there are scale economies specific to demand deposits in all size classes. The competitive viability of the Dutch banking sector does not seem to be at risk, however, as loans and savings accounts show significant diseconomies of scope throughout the sample.

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mixed evidence. *Mester* (1987) concludes that there is no jointness at all in the production of Savings & Loans. According to studies by *Murray* and *White* (1983) and *H. Y. Kim* (1986), British Columbia credit unions enjoy scope economies. Significant scope economies are also reported in *M. Kim* (1986) and *Kim* and *Ben-Zion* (1989) for Israeli banks.

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Summary

How Stable is the Multiproduct Translog Cost Function? Evidence from the Dutch Banking Industry

This paper presents evidence on the stability of the multiproduct translog cost function from a sample of Dutch banks. It is concluded that a hybrid form of this function is unable to capture the production structures of banks on edges of the cost surface. It is advisable, therefore, to exclude highly specialized banks and unit-branch banks from the sample. Unlike most other bank cost studies, the average cost curve is found to be L-shaped rather than U-shaped. Significant scope diseconomies between loans and savings accounts suggest that there is no natural monopoly in the Dutch banking sector.

Zusammenfassung

Wie stabil ist die Translog-Kostenfunktion bei mehreren Produkten? Eine Dokumentation des niederländischen Bankensektors

Dieser Beitrag untersucht auf der Grundlage einer heterogenen Stichprobe niederländischer Banken die Stabilität der Translog-Kostenfunktion bei mehreren Leistungen im Banksortiment. Es wird gezeigt, daß die zugrunde gelegte hybride Form dieser Kostenfunktion sich zur Abbildung der Produktions- und Kostenstruktur von Mehrproduktbanken nicht eignet. (Dies könnte nahelegen, Ein-Produkt-Banken und filiallose Institute aus der Stichprobe herauszunehmen.) Im Gegensatz zu den meisten anderen Bankkostenuntersuchungen erweist der vorliegende Beitrag, daß die Durchschnittskostenkurve der Banken in der Stichprobe L-förmig und nicht U-förmig verläuft. Es ergeben sich im Zuge der vorliegenden Untersuchung signifikante Wirtschaftlichkeitsnachteile (diseconomies of scope) bei der Verbindung von Kreditgeschäft und Einlagengeschäft in einem Banksortiment. Dies deutet darauf hin, daß der niederländische Bankensektor kein natürliches Monopol kennt.

Résumé

Quelle est la stabilité de la fonction de coûts translog de plusieurs produits? Résultats pour les banques hollandaises

Cet article présente le preuve de la stabilité de la fonction de coûts translog de plusieurs produits pour un échantillon de banques hollandaises. L'auteur conclut qu'une forme hybride de cette fonction est incapable de capturer les structures de production des banques qui n'exercent pas certaines activités ou qui n'ont pas de succursales. C'est pourquoi, il est conseillé d'exclure de l'échantillon les banques hautement spécialisées et les banques à branche unitaire. A la différence de la plupart des études de coûts d'autres banques, la courbe de coûts moyens est en forme de L plutôt que de U. D'importants désavantages de production globale entre les prêts et les comptes d'épargne donnent à penser qu'il n'y a pas de monopole naturel dans le secteur bancaire hollandais.