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PRODUCTIVITY IN THE FINNISH CUSTOMS

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This study examines the productivity of the Finnish Customs. Though the main emphasis is on the evaluation of total factor productivity, the anatomy of total factor productivity is examined as well. The results show that productivity growth in the Customs has been faster than in the other areas of the economy.

1. Introduction

Research on the productivity of Finnish government institutions is virtually nonexistent. Some evaluations have been carried out inside the institutions concerned. As a rule these studies do not pay attention to inputs other than labour and confine themselves to the evaluation of labour productivity.

The productivity of the entire government sector has also been approximated using national accounts data. According to these studies the growth of productivity has been near zero. These approximations are however, not only unreliable but also totally misleading, because it is assumed in the national accounts that the value added in the government sector is the same as the labour input.

In this study the growth of productivity is evaluated using the cost function approach. The estimation method must take into account the fact that the Finnish Customs is a typical multiservice firm, which uses mainly labour input. Input prices can be considered as given.

The problem of many products (services) has been dealt with in two ways. One alternative is to sum up the smaller basic services into one aggregate service. The weights used in this summing reflect the labour force bound up in the production of the respective basic service. The other alternative is to use two separate services: the collection of taxes and duties on the one hand and the control of international trade and traffic and customs laboratory activities on the other. The product weights are then assumed to reflect the cost elasticities of these products. Total Factor productivity can then be estimated with the standard Törnqvist index formula, letting the weights sum up to one. Evaluating total factor productivity in this way assigns relatively little weight to those services whose production is characterised by strongly increasing returns to scale.

The use of marginal costs as product-weights in the total factor productivity calculations implies marginal cost pricing. As is known, it is socially optimal that a monopoly firm sets its service prices at a level equal to its marginal costs and not at a level equal to average costs when there are increasing returns to scale.

Total factor productivity is also decomposed into changes due to scale economies and those due to technical progress. In the case of two inputs technical progress can be considered as a shift in the isoquant of technically efficient production from time t to time t + 1. In figure 1 $K(q)_t$ denotes the required in-

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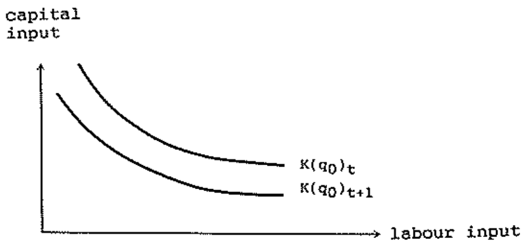

Figure 1. Technical progress.

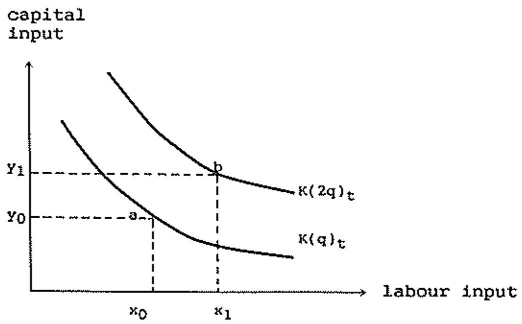

Figure 2. Increasing returns to scale.

put volume to produce output volume q at moment t.

As far as the Finnish Customs is concerned technical progress can be promoted by the rationalisation of activities, by organisational reforms or by increasing the efforts of employees.

When estimating technical progress with the index formula, the product weights are assumed to be equal to the cost elasticities as is done in Caves, Christensen and Swanson (1980) and Dodgson (1985).

The cost elasticities of this index formula are derived from the estimated total factor cost function. This function is assumed to be translog as proposed by Christensen, Jorgenson and Lau (1973). This same cost function type was later analysed by Brown, Caves and Christensen (1979) and Caves, Christensen and Thretheway (1980). In the style introduced by Caves, Christensen and Swanson (1981), the estimates of technical progress and of the changes in total factor productivity can also be derived directly from the estimated translog cost function.

Scale economies can be measured as a sum

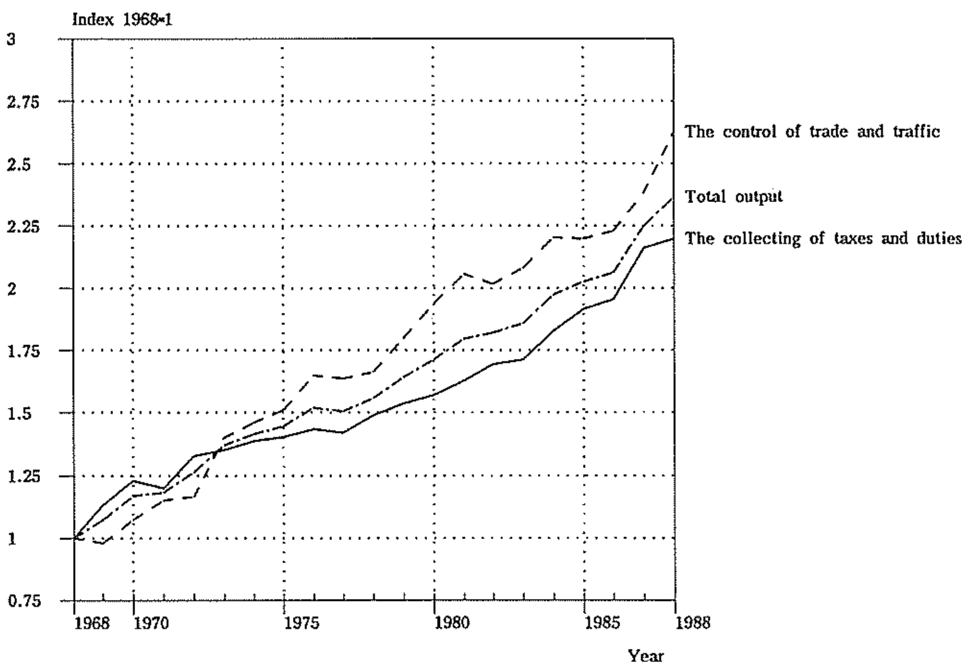

Figure 3. Service volume indexes.

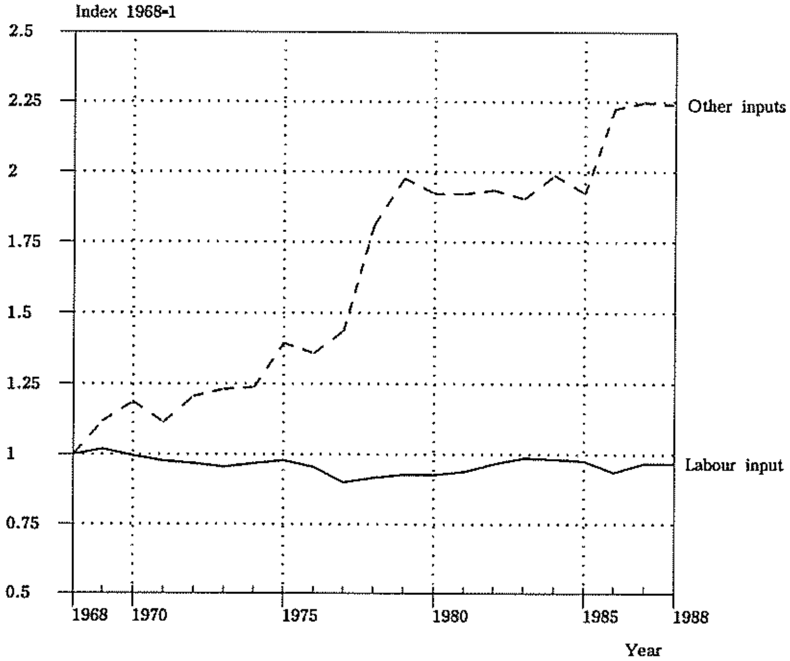

Figure 4. Input volume indexes.

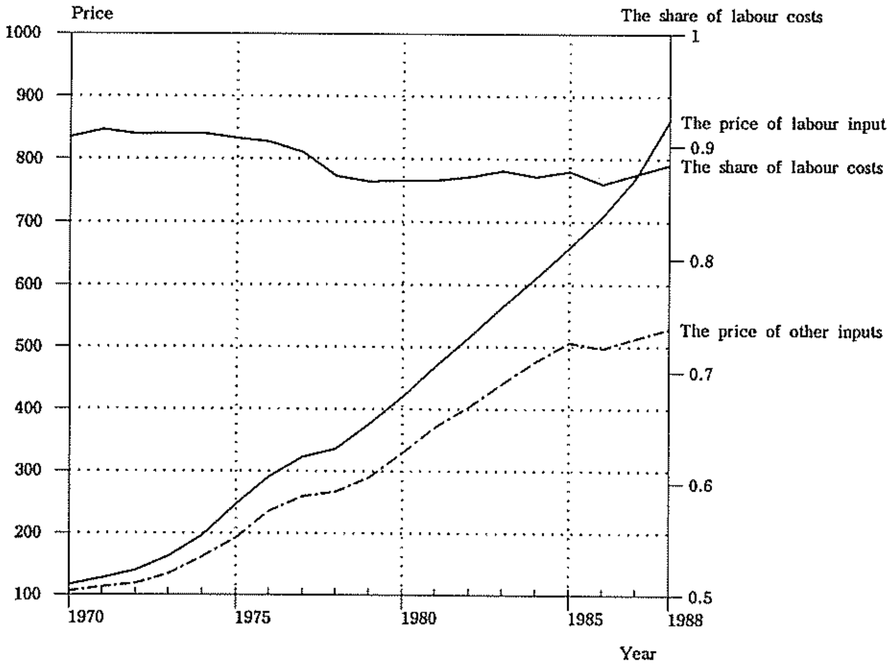

Figure 5. Input price indexes and the share of labour costs.

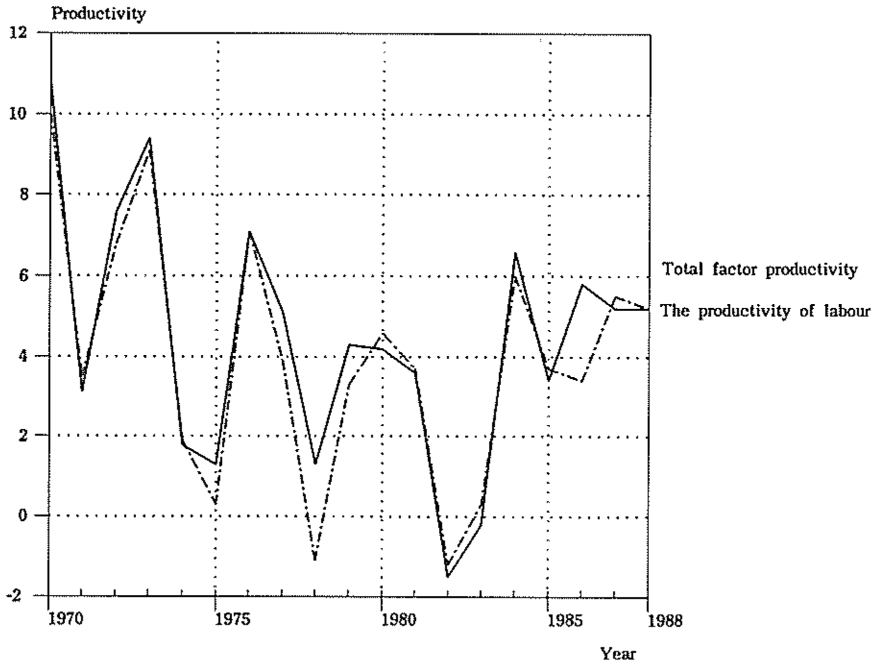

Figure 6. Growth rates of total factor productivity (TFP4) and labour productivity (LAB1).

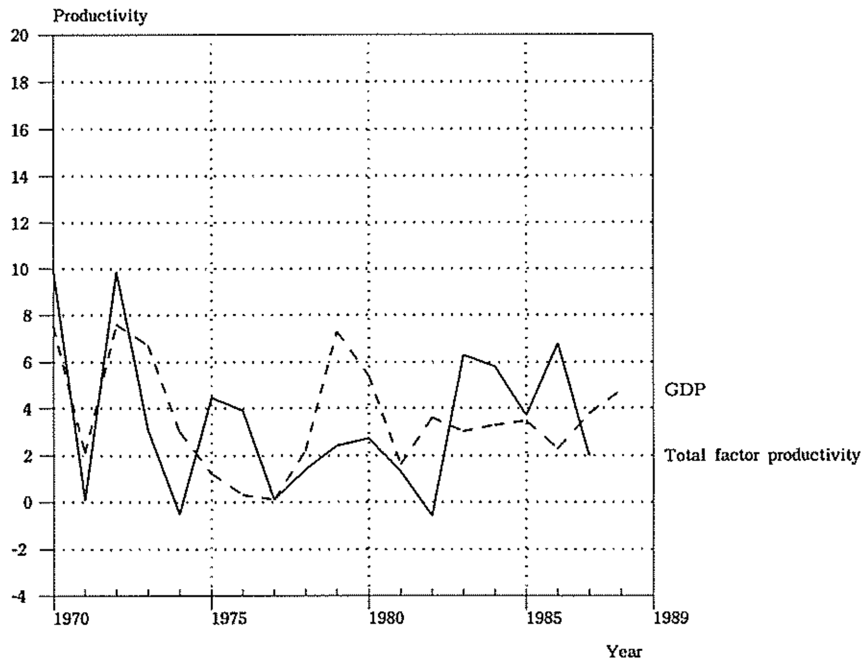

Figure 7. Growth rates of total productivity (TFP2) and the volume of GDP.

of these cost elasticities (see Brown, Caves and Christensen 1979). When there are increasing returns to scale, it is possible to increase the service volumes relatively more than the input volumes.

As a rule the empirical work done using the method described above has used cross-sectional or pooled data. The data of this study, however, describe only one firm — the Finnish Customs — and is therefore purely time series data. This restricts the number of observations and emphasizes the importance of the time parameter in the estimated total cost function.

2. *The data*

The data of this study are reported in Lehto (1989). The volume of produced services grew quite rapidly over the observed time interval.

The volume of services is determined by external factors such as the volume of foreign trade and overall traffic abroad. Hence the volume of services grew most rapidly during boom period.

The volume of labour input decreased slightly over the observed time interval. In contrast, other inputs, which consist of capital and other expenditure, grew rapidly. These inputs increased sharply especially in the years 1977 – 1979, when the Customs invested heavily in ADP and Customs laboratory equipment.

The price of labour input rose more rapidly than the price of other inputs. The share of labour costs was at the end of estimation period still almost 90 %, although it had declined continuously.

It should be noted that fixed capital has been ignored because of data deficiencies.

3. *Basic concepts and method*

3.1 *Total cost function*

The estimate of total factor productivity can be derived directly from the estimated total factor cost function. In this function total costs are explained by means of service volumes and input prices. The total factor cost

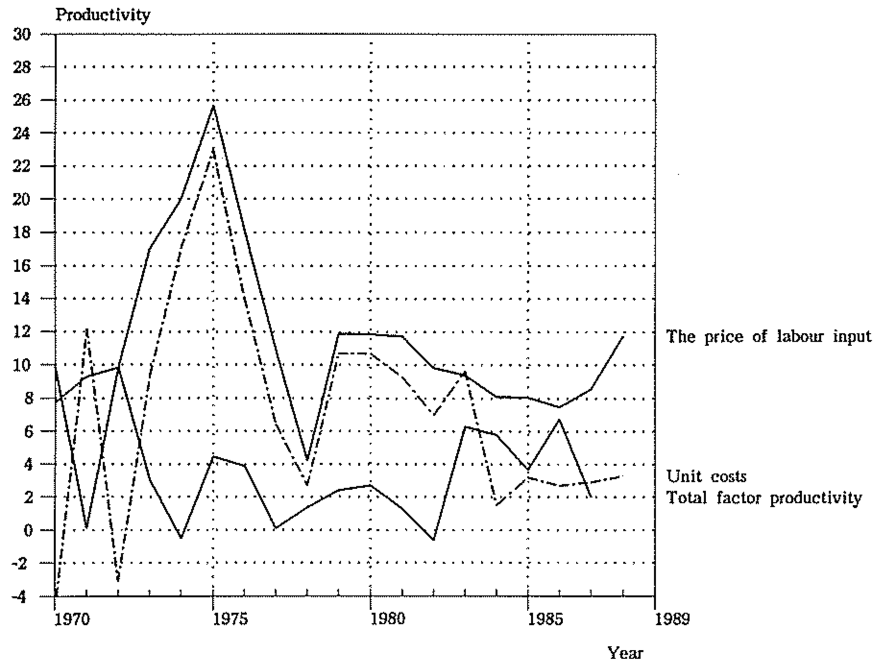

Figure 8. Percentage changes in price of labour, unit costs (UCOST1) and total factor productivity (TFP2).

function can be shown to be dual to the corresponding production function — an implicit function of service volumes and input volumes — if it has a strictly convex input structure (see Mcfadden 1978). This condition requires that the cost function is homogenous of degree plus one, nondecreasing, and concave in factor prices.

The existence of the total factor cost function also requires that costs are minimized with respect to inputs. Particularly this requirement of allocative efficiency is critical as far as public institutions are concerned. The limited data was one reason why the violation of this condition and its implications were not examined in this study.

The cost function approach is a suitable method for evaluating the productivity of the Finnish Customs for the following reasons:

* It is practical when the firm produces many products and when service volumes and factor prices are given and not determined inside the firm.

* This approach makes it possible to use a very flexible cost function structure. The corresponding production function does not necessarily have to be homogenous and homothetic.[1] Scale economies can then depend not only on product volumes but also on factor prices and the time variable. Moreover, the production function does not have to be separable with respect to input and output volumes.

The cost function used in this study is assumed to be translog.[2] The estimated total factor cost function can be written as

$$\text{(1)}\quad \begin{aligned} \ln C = {} & ao - A(t) + \sum_{i=1}^{m}(bi - ci \cdot t) \cdot \ln Qi \\ & + \sum_{i=1}^{n}(di - ei \cdot t) \cdot \ln Pi + 0.5 \cdot \sum_{i=1}^{m}\sum_{j=1}^{m} \\ & hij \cdot \ln Qi \cdot \ln Qj + 0.5 \cdot \sum_{i=1}^{n}\sum_{j=1}^{n} kij \cdot \ln Pi \cdot \\ & \ln Pj + \sum_{i=1}^{m}\sum_{j=1}^{n} mij \cdot \ln Qi \cdot \ln Pj \end{aligned}$$

where
C = total costs
t = time index
Pi = price of input i
Qi = volume of product i
A(t) = time dependent cost parameter
n = number of inputs
m = number of outputs.

The conventional symmetry restrictions require that hij = hji and kij = kji. Because the cost function is assumed to be linearly homogenous in factor prices, the parameters also have restrictions

$$\text{(2)}\quad \begin{aligned} & \sum_{i=1}^{n} di = 1,\ \sum_{i=1}^{n} ei = 0,\ \sum_{i=1}^{n} kij = 0,\ j = 1,2,\ldots n \\ & \sum_{j=1}^{n} mij = 0,\ j = 1,2,\ldots m. \end{aligned}$$

Assuming allocative efficiency we can make use of the following cost share equations implied by Shephard's lemma:

$$Si = \partial \ln C / \partial \ln Pi.$$

where Si = share of input i in total costs. So from equation (1)

$$\text{(3)}\quad Si = di - ei \cdot t + \sum_{j=1}^{m} kij \cdot \ln Qi + \sum_{j=1}^{n} mij \cdot \ln Pj,$$

The equation system (1) and (3) can be treated as a multivariate regression system. The efficient estimates of the parameters of this equation system are obtained using Zellner's Seemingly Unrelated Regressions (SURE). One share equation must be excluded to preserve non-singularity. To estimate this equation system, we have to take into account not only the parameter restrictions (2) but also the restrictions between the parameters of equation (1) and equation (3).

We experimented various specifications for the time dependent cost function term A(t). The aim was to find a specification which had good test statistics for the parameter restric-

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[1] The production function is homogenous of degree k with respect to inputs z when

$$f(\mu z) = \mu^k z,$$

where μ is a scalar.

A homothetic function is a monotone increasing transform of a homogenous function. Further discussion of the properties of these functions can be found in Nadiri (1982).

[2] The translog type was proposed by Christensen, Jorgenson and Lau (1973). It is widely applied in the analysis of the technology and productivity of multiproduct firms, especially railway companies. Talvitie and Bäckström have used it in an analysis of the technology of bus firms (1989).

tions and for the parameter estimates. A(t) was specified as

$$\alpha \cdot t + \beta \cdot \ln(t).$$

The cost function was also estimated assuming Hicks neutral technical progress. Then $A(t) = \alpha \cdot t$ and the parameters ci and ei were assumed to be zero. The estimation results obtained under these assumptions are also reported.[3]

3.2 *Derivation of estimates of changes in productivity*

Labour productivity was estimated with the formula

$$(4) \quad TY1 = \log [Qk_t/Z1_t)/(Qk_{t-1}/Z1_{t-1})],$$

where Qk_t = total volume of services (calculated by predetermined basic product weights)
$Z1_t$ = labour input

The productivity of labour was also estimated separately in the collecting of taxes and duties and in the control of international trade and traffic.

The estimate of technical progress can be derived from the total cost function (1), which can be written as

$$C = G(Q1,..., Qm, P1,..., Pn, t).$$

Totally differentiating the log of the cost function with respect to time yields

$$(5) \quad d\ln C/dt = \sum_{i=1}^{m} \partial \ln G/\partial \ln Qi \ d\ln Qi/dt + \sum_{i=1}^{n} \partial \ln G/\partial \ln Pi \ d\ln Pi/dt + \partial \ln G/\partial t$$

On the other hand, total costs can be expressed as

$$\sum_{i=1}^{m} PiZi,$$

where Z_i = input volume.

Differentiating the log of this expression with respect to time gives

$$(6) \quad d\ln C/dt = \sum_{i=1}^{n} Si \ d\ln Pi/dt + \sum_{i=1}^{n} Si \ d\ln Zi/dt.$$

Using expression (6) and Shephard's lemma, by which $\partial \ln G/\partial \ln Pi$ can be replaced by Si, we obtain from (5) an expression for technical progress

$$(7) \quad -\partial G/\partial t = \sum_{i=1}^{m} \partial \ln G/\partial \ln Qi \ d\ln Qi/dt - \sum_{i=1}^{n} Si \ d\ln Zi/dt.$$

In order to implement equation (7) in discrete time the logarithmic derivatives are approximated by first differences. The product weights are replaced by arithmetic averages. Following Caves, Christensen and Swanson (1980), the resulting index formula for technical progress (TEC1) can be expressed as

$$TEC1 = \sum_{i=1}^{m} 0.5 \cdot (C_{Qi,t} + C_{Qi,t-1}) \cdot$$
$$(8) \quad \ln(Qi_t/Qi_{t-1}) - \sum_{i=1}^{n} 0.5 \cdot (Si_t + Si_{t-1}) \cdot \ln(Zi_t/Zi_{t-1}),$$

where $C_{Qi} \equiv \partial \ln G/\partial \ln Qi$.

The index formula (8) is the Törnqvist index, which has been shown to be an exact index corresponding to the homogeneous translog production function (see Diewert (1976)).

Using (1) the partial derivative C_{Qi} can be expressed as

$$(9) \quad C_{Qi} = bi - ci \cdot t + \sum_{i=1}^{m} hij \cdot \ln Qi + \sum_{i=1}^{n} mij \cdot \ln Pi.$$

It proved difficult to approximate technical progress with formula (8), because the cost elasticity C_{Qi} also received negative values when Qi was service volume in the control of international trade and traffic. Therefore technical progress was also estimated with the estimator TEC2. The formula of TEC2 was the same as (8) except that $C_{Qi,t}$ was replaced by

$$C^{*}_{Qi} = (1/T) \cdot [C^{a}_{Qi}/\sum_{i=1}^{m} C^{a}_{Qi}] \cdot 0.5 \cdot \sum_{i=1}^{m} (C_{Qi,t} + C_{Qi,t-1})$$

where $C^{a}_{i} = (1/T) \cdot \sum_{t=1}^{T} C_{Qi,t}$.

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[3] *The specifications*

$A(t) = \alpha \cdot t + \beta \cdot t^2$
and
$A(t) = \alpha \cdot \ln(t) + \beta \cdot (\ln(t))^2$

proposed by Nadiri (1982) were also experimented with. In the latter case the time dependent parameters ci · t and ei · t were transformed into the form ci · ln(t) and ei · ln(t). These specifications did not however, fit the data. The estimation results are not reported here.

Using partial derivatives C_{Qi}, scale economies can be approximated with the following formula

(10) $SCA = 1 - \sum_{i=1}^{m} C_{Qi}$.

In the case of increasing (decreasing) returns to scale, SCA is positive (negative) and is zero when the production process is characterized by constant returns to scale.

As an estimator of total factor productivity corresponding to the estimator TEC1 we used the formula

$$TFP1 = 0.5 \cdot \sum_{i=1}^{m} (w_{i,t} + w_{i,t-1}) \cdot \ln(Qi, t/Qi, t-1) + \sum_{i=1}^{n} 0.5 \cdot (Si, t + Si, t-1) \cdot \ln(Zi, t/Zi, t-1), \quad (11)$$

where the product weights $w_{i,t}$ are

$$w_{i,t} = C_{Qi,t}/(\Sigma C_{Qi,t}).$$

The product weights are chosen so that scale economies are normalized to constant returns to scale. Using formula (8), TFP1 can also be expressed as

$$TEC1 + 0.5 \cdot \sum_{i=1}^{m} (w_{i,t}{*}SCA_t + w_{i,t-1} \cdot SCA_{t-1}) \cdot \ln(Qi, t/Qi, t-1)$$

This expression shows how the estimate of total factor productivity is divided into two components: the first representing technical progress and the second scale economies. The second component is zero, if there are constant returns to scale (SCA = 0).

Total factor productivity was also estimating using an index formula of the TEC2 type. The service volume weights used in that case were simply the time invariant proportions

$$C^a_{Qi}/(C^a_{Qi} + C^a_{Q2}).$$

The total productivity formula then becomes

$$TFP2 = \sum_{i=1}^{m} [C^a_{Qi}/(C^a_{Qi} + C^a_{Q2}] \cdot \log(Qi_t/Qi_{t-1}) - \sum_{i=1}^{n} 0.5 \cdot (Si_t + Si_{t-t}) \cdot \log(Zi_t/Zi_{t-1}), \quad (12)$$

Caves, Christensen and Swanson (1981) have shown that technical progress can also be approximated directly by differentiating the cost function with respect to a time variable. The derived estimator of technical progress is then

$$TEC3 \equiv -\partial \ln C/\partial t = \partial A(t)/\partial t + \sum_{i=1}^{m} ci \cdot \ln Qi + \sum_{i=1}^{n} ei \cdot \ln Pi. \quad (13)$$

The estimator TEC3 describes shifts in the estimated cost function as a function of time.

As an estimator of scale economies in this case can be used the expression

(14) $RTS \equiv (\sum_{i=1}^{n} C_{Qi})^{-1}$.

If RTS = 1, there are constant returns to scale. If RTS > 1 (RTS < 1), there are increasing (decreasing) returns to scale.

Total factor productivity can then be estimated with the formula

(15) $TFP = TEC3/RTS$.

The differences between the estimators TEC1 and TEC3 and between TFP1 and TFP3 are mainly due to the fact that the estimators TEC1 and TFP1 also take into account the variation in the residual of the estimated total factor cost function. Therefore the estimators TEC1 and TFP1 are prefered to estimators TEC3 and TFP3.

Total factor productivity was also estimated using the formula

$$TFP4 = \log(Qk_t/Qk_{t-1}) - 0.5 \cdot \sum_{i=1}^{m} (Si_t + Si_{t-1}) \cdot \log(Zi_t/Zi_t), \quad (16)$$

where Qk_t denotes the total volume of services calculated using predetermined basic product weights. The estimator (16) is comparable with the labour productivity estimator (4), in which the service volume weights are also predetermined.

Finally, the estimator of the changes in unit costs can be derived from equation (5) using formula (11) or (12). The percentage change in unit costs corresponding to estimators TFP1 and TFP2 are

$$UCOST1 = 0.5 \cdot \sum_{i=1}^{n} (Si_t + Si_{t-1}) \cdot \log(Pit/Pi_{t-1}) - TFP1 \quad (17)$$

$$UCOST2 = 0.5 \cdot \sum_{i=1}^{n} (Si_t + Si_{t-1}) \cdot \log(Pit/Pi_{t-1}) - TFP2. \quad (18)$$

4. *Estimation of total factor cost function*

The estimation results corresponding to five different model specifications are reported in Lehto (1989). The test statistics of the parameter restrictions included in (2) and implied by Shephard's lemma (restrictions between equations), the adjusted residual variance and t-statistics of single parameter estimates are used as the »goodness» criterion for these models.

The specified models were

Model 1: The general form (1). $A(t) = \alpha \cdot t + \beta \cdot \ln(t)$

Model 2: Separable between input prices and service volumes (mij = 0). A(t) is the same as in model 1.

Model 3: Same as model 1, except that A(t) is restricted to be $\alpha \cdot t$.

Model 4: Same as model 3, except that ci and ei are restricted to be zero.

Model 5: Same as model 1, except that there is only one aggregated service (Qk).

The test statistics for parameter restrictions between equations were

	test statistics chi-square	critical level of chi-square (5 % significance)
model 1:	7.61	12.59
model 2:	9.06	9.49
model 3:	20.93	11.07
model 4:	13.93	11.07

The validity of all restrictions at the same time (restrictions (4) and restrictions between equations) were also tested. According to the chi-square test, model 2 is the only one, in which all the parameter restrictions could be accepted at the one percent significance level.

Other test statistics

	Adjusted R^2	Adjusted SEE	DW
Model 1:			
– equation (1)	0.97	0.0210	1.90
– equation (3)	0.75	0.0093	1.11
Model 2:			
– equation (1)	0.97	0.0184	1.83
– equation (3)	0.74	0.0095	0.70
Model 3:			
– equation (1)	0.95	0.0268	1.77
– equation (3)	0.75	0.0093	1.11
Model 4:			
– equation (1)	0.96	0.0228	1.76
– equation (3)	0.71	0.0100	1.02
Model 5:			
– equation (1)	0.97	0.0210	1.90
– equation (3)	0.74	0.0095	0.80

According to the DW test there may be first order positive autocorrelation in the residual of the equation (3).

The estimated parameters corresponding to models 1 and 2 are in equation (1):

Variable	Model 1 Coef-ficient[4]	Model 1 t-value	Model 2 Coef-ficient	Model 2 t-value
constant	5.079*	2.61	4.869*	2.41
t	0.339*	5.20	0.335*	4.94
log(t)	–5.452*	5.13	–5.352*	4.84
log(Q1)	4.153*	3.70	4.091*	3.51
log(Q2)	0.020	0.03	0.023	0.03
log(P1)	0.993*	28.6	0.971*	99.8
log(P2)	0.007*	28.6	0.029*	99.8
$(\log(P1))^2$	0.023	0.92	0.045*	2.52
log(P1)*log(P2)	–0.046	0.92	–0.091*	2.52
$(\log(P2))^2$	0.023	0.92	0.045*	2.52
$(\log(Q1))^2$	–0.500	0.44	–0.379	0.32
log(Q1)*log(Q2)	5.604*	4.01	5.478*	3.78
$(\log(Q2))^2$	–0.965	1.39	–0.915	1.27
log(Q1)*log(P1)	0.101	1.65		
log(Q1)*log(P2)	–0.101	1.65		
log(Q2)*log(P1)	–0.017	0.49		
log(Q2)*log(P2)	0.017	0.49		
log(P1)*t	–0.006	2.31	–0.004*	6.26
log(P2)*t	0.006	2.31	0.004*	6.26
log(Q1)*t	–0.236*	2.95	–0.235*	2.83
log(Q2)*t	–0.057	1.01	–0.057	0.98

* significant at 5 % level

[4] *The coefficients of the symmetric variables, for example the coefficient of $\log(p1) \cdot \log(p2)$, expresses the sum $(1/2) \cdot k12 + (1/2) \cdot k21$ in equation (3). The coefficient of the quadratic variable $\log((p1))^2$ expresses the coefficient $(1/2) \cdot k11$ in equation (3).*

Equation (3):

Variable	Model 1 Coef-ficient	t-value	Model 2 Coef-ficient	t-value
constant	0.993*	28.6	0.971*	99.8
log(P1)	0.046	0.92	0.091*	2.52
log(P2)	−0.046	0.92	−0.091*	2.52
log(Q1)	0.101	1.65		
log(Q2)	−0.017	0.49		
t	−0.006*	2.31	−0.004*	6.26

* significant at 5 % level

where
Q1 = Service volume originating in collecting taxes and duties
Q2 = Service volume originating in the control of international trade and traffic
P1 = Price of labour input
P2 = Price of other inputs (including capital).
t = Time trend

In equation (1) of model 1 the explanatory power of the cross-terms log(Q1) · log(Pj) is weak. These terms are omitted from model 2. In model 1 the parameter estimates satisfy certain regularity conditions. The own-price elasticities of the inputs are negative[5]. In addition, the matrix of Allen-Uzawa elasticities of substitution is negative semidefinite.[6] These regularity conditions are slightly violated in model 2. The own-price elasticities corresponding to the parameter estimates of model 2 are on average close to zero.

5. *Estimated productivity and economies of scale*

In model 1, estimated technical progress (TEC1), scale economies (SCA) and the percentage growth of total factor productivity (TFP1) were

	TEC1	TFP1	SCA
1970	3.1	12.6	0.58
1971	0.8	−3.5	0.73
1972	4.0	12.1	0.51
1973	3.5	6.0	0.04
1974	1.0	1.2	0.06
1975	−0.9	−0.7	0.16
1976	3.0	3.1	0.03
1977	4.0	3.8	0.40
1978	−1.0	1.3	0.42
1979	−0.6	0.1	0.27
1980	0.6	0.8	0.20
1981	1.5	2.0	0.11
1982	1.4	2.3	0.29
1983	−1.1	−0.8	0.41
1984	4.3	6.3	0.21
1985	3.6	4.3	0.28
1986	2.8	3.4	0.42
1987	2.9	4.6	0.01
1988	7.2	6.8	−0.15
time-average	1.86	3.5	0.26

The growth of labour productivity and total factor productivity (according to TFP4) over the period 1970 − 1988 were on average[7]

LAB1	LAB2	LAB3	TFP4
4.4.	3.3.	5.6	4.0,

where
LAB1 = labour productivity for the total service
LAB2 = labour productivity in the collecting of taxes and duties
LAB3 = labour productivity in the control of international trade and traffic

Compared with other fields of economic activity the productivity of the Finnish Customs has grown relatively fast. In the manufacturing industry the yearly growth of total factor productivity calculated with TFP4 type of estimator was 3.3 percent over the period 1968 − 1986 on average. In the Finnish Customs the corresponding growth rate was 3.9 percent (1969 − 1986) on the basis of the estimator TFP4. Recent research (see Pekurinen and Vohlonen 1990) on productivity in Finnish hospitals shows that total factor productivity decreased on average from 4.5 to 3.6 percent a year.

A preliminary study on productivity in the Swedish public sector indicates that there also the growth of productivity in the Customs has been much faster than in other fields of the public sector.

[5] *The formula for calculating own-price elasticities is given in Nadiri (1982), p. 468.*

[6] *For a discussion of regularity conditions in the context of flexible functional forms, see Caves and Christensen (1980).*

[7] *In appendix there is a table showing yearly values of TAB1 and changes in total factor productivity according to TFP1, TFP2, TFP3 and TFP4.*

Changes in technical efficiency (technical progress) accounts for about two thirds of the growth in total factor productivity. Increasing returns to scale explain the rest. According to the results there has been great variation in scale economies. During the last two years, when service volumes were growing rapidly and input volumes remained almost unchanged, the organisation was overloaded; there were no longer increasing returns to scale.[8]

The growth rates of labour productivity and total factor productivity do not differ much from each other. This can be attributed to the labour intensity of the production process. However, in the years 1977 – 1979, when the Customs invested heavily in ADP equipment the growth rate of labour productivity exceeded that of total productivity by over one percentage point.

The total factor productivity of the Customs is correlated with fluctuations in the whole economy. This suggests the existence of increasing returns to scale. Fluctuations in the volume growth of services caused by cyclical growth in the total economy also generate cyclical movements in changes in productivity.

The estimated technical progress is very sensitive to the operationalisation of the time dependent term A(t) in the total factor cost equation (3). The time averages of technical progress (TEC2) and total factor productivity (TFP2) in different models are:

	TEC2	TFP2
model 1	2.1	3.4
model 2	2.4	3.4
model 3	0.3	4.0
model 4	0.2	4.2
model 5	1.7	4.0

The estimates of scale economies also differ from each other. The time average of scale economies (SCA) in different models over the period 1970 – 1988 is

Model	1	2	3	4	5
	0.26	0.29	0.89	0.90	0.55

There is strong evidence that increasing returns to scale have been typical of the production process in the Finnish Customs. In models 3 and 4 economies of scale are much stronger than in other models. In model 5 returns to scale increase towards the end of the time period while they decrease in models 1 and 2. The results from models 1 and 2 are more reliable than those from other models.

The changes in unit costs were heavily influenced by developments in the price of labour. So, in the years of high wage-inflation unit costs rose rapidly. In the late eighties, when the growth rate of total factor productivity accelerated and inflation slowed down, the performance of the Finnish Customs was very good, if developments in unit costs are used as a criterion.

6. *Conclusions*

The total productivity of the Finnish Customs grew on average by 3.5 – 4 % a year over the period 1970 – 1988. The growth of total factor productivity can be decomposed into two components: one generated by efforts to gain efficiency (technical progress) and the other by scale economies. Economies of scale explain about 1.0 – 1.5 percentage points of this growth.

The statistical analysis of this decomposition is associated with uncertainty. It is however important to obtain evidence on scale economies, if part of the wage is paid on the basis of productivity growth measures. An experiment is currently being conducted in the Finnish Customs to test the suitability of such wage system. The more dominant is the role of scale economies and also the role of exogenous factors of productivity, the more unsuitable is the bonus wage system.

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[8] *In appendix there is a table showing yearly values of scale economies (SCA) and technical progress according to TEC1, TEC2 and TEC3.*

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Appendix

Table 1. Percentage growth of labour productivity and total factor productivity.[9]

	LAB1	TFP1	TFP2	TFP3	TFP4
1970	10.8	12.5	9.9	8.4	10.0
1971	3.1	−3.6	0.1	5.6	3.5
1972	7.6	12.1	9.9	4.9	6.8
1973	9.4	6.0	3.1	2.5	9.1
1974	1.8	1.2	1.3	2.1	1.9
1975	1.3	−0.7	−0.5	1.6	0.3
1976	7.1	3.1	4.5	1.3	7.1
1977	5.1	3.8	3.9	0.0	3.9
1978	1.3	1.3	0.1	0.5	−1.1
1979	4.3	0.9	1.4	0.8	3.3
1980	4.2	0.8	2.4	0.9	4.6
1981	3.6	2.0	2.7	1.4	3.7
1982	−1.5	2.3	1.3	1.9	−1.2
1983	−0.2	−0.8	−0.6	2.0	0.3
1984	6.6	6.3	6.3	3.0	6.0
1985	3.4	4.3	5.8	4.2	3.7
1986	5.8	3.4	3.7	5.3	3.4
1987	5.2	4.6	6.8	5.3	5.5
1988	5.2	6.8	2.0	5.0	5.2
average	4.4	3.5	3.4	3.0	4.0

[9] *Estimates of TFP1, TFP2 and TFP3 were obtained from model 1.*

Table 2. Technical progress and percentage changes in unit costs in model no 1.

	TEC1	TEC2	TEC3	UCOST1	UCOST2
1970	3.1	3.1	3.5	−5.5	−2.8
1971	0.8	1.7	1.5	12.2	8.5
1972	4.0	3.8	2.4	−3.1	−0.9
1973	3.5	2.6	2.4	9.4	12.2
1974	1.0	1.2	2.0	17.1	17.0
1975	−0.9	−0.6	1.3	23.1	22.9
1976	3.0	4.2	1.2	14.0	12.6
1977	4.0	4.1	4.0	6.4	6.4
1978	−1.0	−1.8	0.3	2.7	3.9
1979	−0.6	0.3	0.6	10.7	9.4
1980	0.6	1.9	0.6	10.7	9.1
1981	1.5	2.2	1.2	9.3	8.5
1982	1.4	0.5	1.4	7.0	8.0
1983	−1.1	−1.0	1.2	9.7	9.5
1984	4.3	4.4	2.4	1.5	1.5
1985	3.6	4.6	3.0	3.2	1.8
1986	2.8	3.0	3.0	2.7	2.5
1987	2.9	4.8	5.3	2.9	0.7
1988	7.2	2.2	5.8	3.3	8.2
average	2.12	2.15	2.0	7.24	7.32