Substitution Between Imports and Primary Inputs in the Netherlands, 1953–1977

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1. Prologue

Recent renewed emphasis in the analysis of input substitutability/complementarity in the production process has been undertaken by new flexible econometric techniques which have rendered conventional single-output two-input functions obsolete. In general equilibrium models, firms choose a bundle of available inputs to minimize the cost of producing a certain output level, derived demand for these inputs is determined by their relative prices, the output level, and any substitution possibilities permitted by the existing technology and factor endowment. Using this analytical framework this paper examines the contribution made by imports to the Dutch production process. The traditional assumptions of perfect competition in commodity and factor markets and constant returns to scale (CRRTS) are, in fact, uniquely relevant to this economy because of the structure of Dutch technology. The Dutch economy is “open” by virtue of its association with various organizations such as Benelux, ECSC, OEEC (OECD), EAEU, and EEC. Balassa (1976) justifies the assumption of perfect competition as follows: "In most industries there has been no conflict between the exploitation of economies of scale and increased competition as the integration of national markets has permitted both to occur simultaneously in the EEC. Thus, the predictions of those who feared the strengthening of monopolies have not been realized." Furthermore, "the larger the market, the fewer will be the industries where monopoly positions may emerge."

The CRRTS assumption a) enables the acquisition of linear equation shares, b) implies consistent prices (value of output is equal to value of inputs), and c) allows simplification. According to R. G. D. Allen (1965) "the choice between the two (production) formulations or any variations of them, is not a question of choosing between right and wrong, nor can it be made solely by reference to the facts of life. Technical conditions in the real world are so complex that any formulation of them for analysis involves simplification. Which simplified ‘production function’ is to be adopted is a matter of economic convenience and of mathematical approximation." The estimating procedure employed in this paper is thus a joint translogarithmic cost function using aggregate annual Dutch time-series data, 1953–77. Departing from traditional practice we partition total output into consumption goods (C) and investment goods (I) produced by capital (K), labor (L) and im-

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ports (M) which are treated as a factor input akin to primary factors. The rationale for output disaggregation is to determine whether or not the composition of output has any effect on the cost minimization bundle of input mix.

The findings of this study may have significant policy implications for the Dutch balance of payments, factor utilization, and income distribution. This paper thus supplements and extends the work undertaken by Magnus (1979). The paper is organized as follows: in section 2 we briefly describe the translog production and cost functions along with the related concepts of duality, aggregation, and separability. In section 3 we report the empirical results, in section 4 we state the conclusions, while in the Appendix we indicate the sources of the data and explain the arithmetic manipulations and data-normalizations.

2. The Translog Specification

Shephard (1953), Uzawa (1964), and McFadden (1973) have shown that a well-behaved cost-minimizing technology may be described sufficiently by a joint cost function in lieu of a production function. A systematic analysis of the properties of price derivatives of the cost function was first performed by Hotelling (1932), and Samuelson (1947) identified the properties of cost functions. Ease of implementation dictates use of the cost approach thereby bypassing the multicollinearity problems inherent in production functions. We focus on the following two relationships: a) the partial derivatives of the joint cost function with respect to input prices and output yields the input demand functions and marginal costs respectively; b) logarithmic differentiation with respect to factor prices and output quantities yields the cost and revenue shares respectively (Shephard's Lemma).

The joint cost function is represented as

\[ TC = \mu(Y_i, Y_j, W_k, W_l, W_m) \]  

where \( TC \) = total cost, \( Y_i(i = C, I) \) and \( W_j(j = K, L, M) \) are vectors of output and input prices respectively. For our estimation procedure, we use the following translog function:

\[
\ln(\frac{TC}{Y_i}) = \alpha_0 + \sum_j \alpha_j \ln Y_j + \sum_j \beta_j \ln W_j + \frac{1}{2} \sum_j \sum_k \gamma_{jk} \ln Y_j \ln W_k + \sum_j \rho_j \ln Y_j + \ln W_j 
\]

where \( i, r = C, I; j, s = K, L, M \).

The parameters of (2) are estimated from the cost and revenue shares obtained by Shephard's Lemma:

\[ S_C = \frac{\partial \ln (TC)}{\partial \ln W_C} = \beta_C + \gamma_{Ck} \ln W_k \frac{W_C}{W_k} + \gamma_{Cl} \ln W_l + \gamma_{Cm} \ln W_m \frac{W_C}{W_m} + \rho_C \ln W_C \]

\[ S_K = \frac{\partial \ln (TC)}{\partial \ln W_K} = \beta_K + \gamma_{Kk} \ln W_k + \gamma_{Kl} \ln W_l + \gamma_{Km} \ln W_m \frac{W_K}{W_m} + \rho_K \ln W_K \]

\[ S_L = \frac{\partial \ln (TC)}{\partial \ln W_L} = 1 - S_C - S_K, \]  

and

\[ R_C = \frac{\partial \ln (TC)}{\partial \ln Y_C} = \alpha_C + \beta_C \ln Y_C \frac{Y_C}{Y_l} + \rho_C \ln W_C \frac{W_C}{W_C} \]

The technology is represented by the cost function, which is "well-behaved" according to neoclassical postulates:

a) Linear homogeneity in factor prices:

\[ \sum_j \beta_j = 1; \sum_j \gamma_{jk} = \sum_j \gamma_{jm} = 0; \sum \rho_j = 0. \]

b) Monotonicity with respect to input prices (first-order condition):

\[ \frac{\partial \ln (TC)}{\partial \ln W_i} > 0. \]

\[ S_C = \frac{\partial \ln (TC)}{\partial \ln W_C} = \beta_C + \gamma_{Ck} \ln W_k \frac{W_C}{W_k} + \gamma_{Cl} \ln W_l + \gamma_{Cm} \ln W_m \frac{W_C}{W_m} + \rho_C \ln W_C \]

\[ S_K = \frac{\partial \ln (TC)}{\partial \ln W_K} = \beta_K + \gamma_{Kk} \ln W_k + \gamma_{Kl} \ln W_l + \gamma_{Km} \ln W_m \frac{W_K}{W_m} + \rho_K \ln W_K \]

\[ S_L = \frac{\partial \ln (TC)}{\partial \ln W_L} = 1 - S_C - S_K, \]  

and

\[ R_C = \frac{\partial \ln (TC)}{\partial \ln Y_C} = \alpha_C + \beta_C \ln Y_C \frac{Y_C}{Y_l} + \rho_C \ln W_C \frac{W_C}{W_C} \]

The superiority of the translog function over the traditional Cobb-Douglas and CES forms is that separability is tested rather than assumed. Moreover, the translog does not dictate that the partial Allen-Uzawa elasticities of substitution (AUES) be unitary or constant, but permits them to vary from period to period.

Linear separability exists if \( \alpha_C = \alpha_I = 1 \) implying a partial Cobb-Douglas structure: complete global separability requires \( \alpha_C = \alpha_I = 1 \) in which the translog reduces to a complete Cobb-Douglas function. Moreover, non-linear separability exists if \( \alpha_C = \alpha_I = 1 \). Rejection of linear and non-linear hypotheses indicates that no consistent aggregate indices of (K, L), (K, M), or (L, M) exists for the aggregate Dutch data. This is equivalent to assuming that the conventional multi-factor Cobb-Douglas and CES functions are rejected.

3. Results

Alternative tests on separability are laid-out below. All tests and estimations are based on the \( x^2 \) distribution calculated by \( \lambda = L_2 / L_0 \), where \( L_2 \) and \( L_0 \) respectively show the values of the constrained and unconstrained likelihood functions. Thus, \( \lambda = L_2 / L_0 \) and \( \chi^2 = 2 \ln (L_2 / L_1) \) with degrees of freedom (df) determined by the
number of imposed restrictions.

Table 1 presents estimates of the nine free
g parameters with imposed restrictions required
by symmetry, CRTS, and a well-behaved cost
function.

First, we test the hypothesis that the Dutch
technology is separable between inputs and
outputs. The parameter estimates are shown in
Table 2.

The calculated $\chi^2$-statistic with $2df$ ($\sigma =
\sigma_{\omega}$ = 0) is 5.89 being below the 5% critical
level of 5.991 so that the null hypothesis that
the Dutch technology is separable between
inputs and outputs cannot be rejected. Hence-
forth, changes in the composition of output
do not have any effect on the cost minimizing
input mix at given factor prices. The present
results are in disagreement with Burgess' (1974)
who concluded that input-output separa-
tibility for the U.S. economy is rejected.

In the next step we test whether the Cobb-
Douglas or CES functions are appropriate in
representing the Dutch technology. To this
end, we test linear and non-linear separabilities.
With three inputs the possibilities for separability are:

\[
\begin{align*}
\{K, L, M\} & : \sigma_{KL} = \sigma_{LM} \\
\{K, M, L\} & : \sigma_{KM} = \sigma_{ML} \\
\{L, M, K\} & : \sigma_{LM} = \sigma_{MK}
\end{align*}
\]

Only two of the above are independent since
any two of these restrictions imply the third. If
linear and non-linear functional separabil-
ities are rejected, it is concluded that the tra-
tional Cobb-Douglas and CES functions are
inappropriate. The successive tests are sum-
marized in Table 3.

All null hypotheses of functional separabil-
ity are rejected even at the 1% (9.21) criti-
cal level of statistical significance. Hence,
we conclude that Cobb-Douglas and CES
specifications cannot appropriately explain the
Dutch technology. Of special importance is
the rejection of the specification \(YIC = I =\)
\(\Phi(h, K, L, M)\) which implies that the Dutch
value-added (VA) is not produced exclusively
by the primary factors. This conclusion sup-
ports the incorporation of imports as a factor
input in the production process; thus VA =
\(K, L\) is a misspecification.

Next, we evaluate the AUES (\(\eta_w\)) among
the three factor inputs and the own-price
elasticity of demand (\(\eta_d\)) and report selected
estimates in Table 4.

Characteristically, the elasticity of substi-
tution between capital and imports is above
unity throughout the sample period, while the
remaining two pair-elasticities remain below
unity with \(\sigma_{KL}\) approaching unity. Based on
the Stolper-Samuelson theorem, imposition of
import tariffs will improve both primary
factors of production, but as long as \(\sigma_{KL} <
\sigma_{MK}\) income is redistributed from capital-
ists to laborers. Production techniques which
encourage the substitution of machinery and
equipment for relatively expensive imports
may improve the BOP status.

In Table 3 we also observe that the own-
price elasticities of demand are negative and

\[\eta_d = \frac{S + s}{S} \]

where \(\eta = \left(\begin{array}{c} n \\ s \end{array}\right)\)

\(\eta = \left(\begin{array}{c} -s \\ n \end{array}\right) + \frac{S}{s}\)

\(\) Specific tables are available on request.
inelastic indicating that the demand curve for each factor is downward sloping. Since the demand for labor appears to be inelastic with a declining tendency, labor unions may have a strong bargaining position in wage negotiations.

Throughout the 25-year period, the revenue share of investment has increased substantially against the consumption share. On the other hand, the cost share of labor has increased from 31% in 1953 to 43% in 1977, generating decreases in both import and capital cost shares. Comparisons of the actual and fitted cost and revenue shares indicate that divergences are minor which suggests the model represents the data adequately.

For added information Table 5 reports the own-elasticities of substitution ($\eta_0$) and cross-price elasticities of input demand ($\eta_m$) for selected years.3 The positive signs of $\eta_0$ verify the aforementioned results with respect to input substitutability. In accordance with microeconomic foundations, the sum of the own-price elasticities of input demand to absolute terms is equal to the sum of the cross-price elasticities:

$$\sum_{j=1}^{K} \eta_0 = \sum_{j=1}^{L} \eta_m$$

where $K = L = M$.

The present results are comparable to those of Burgess (1974) for the US, Denny and Pinto (1978) for Canada, and Magnus (1979) for The Netherlands.

4. Conclusions

We have hypothesized that imports are akin to primary factors in the Dutch aggregate economy. The two-output, three-input translog cost model has generated a number of important conclusions about the total product. Since input-output separability was not rejected, it is concluded that changes in the composition of output do not affect the cost minimizing input-mix. Moreover, the rejection of the specification $\gamma_{12}$ implies rejection of the Dutch value-added concept. Hence, imports cannot be deleted from the production function. The rejection of linear and non-linear separability hypotheses means that the Cobb-Douglas and CES specifications cannot adequately represent the Dutch technology.

All elasticity estimates satisfy theoretical expectations. Labor capital and imports are substitute inputs for each other, and display a stability throughout the sample period. The observed substitution possibilities are especially important for BOP improvements and for avoiding such economic rigidities as aggressive labor unions. Provided $\sigma_{mX} > \sigma_{mK}$, a gradual further reduction in tariffs, as suggested by EEC, will benefit labor. Intensive investment in human capital, especially in the blue-collar production sector, is suggested to diminish certain costly imports. Imports demand curves are all downward sloping and inelastic. Finally, the divergences observed between actual and fitted cost and revenue shares are small which attests to the goodness of fit of the model and its specification.

Appendix

Data

Assuming function (2) is linear homogeneous, the sum of the value shares is unity so that the value of output is equal to the value of inputs:

$$P_X + P_Y = W_K + W_L + W_M.$$  (A-1)

Since output is expressed as final sales, imports of consumption and investment goods must be added to gross domestic product (GDP) and non-factor costs must be excluded:

$$TC = P_X + P_Y - W_M.$$  (A-2)

where $\text{indirect taxes, } S$ = subsidies, and $mM$ = value of imports.

All information needed for the right-hand side of (A-2) is provided by the OECD, National Accounts (NA), for the entire period.9 The total value of consumption goods is the sum of the expenses on non-durables and services undertaken by households (H), government (G), and exports (X):

$$P_X Y_X + P_Y Y_X + P_X Y_X + P_Y Y_X = (A-5)$$

where $P_X$, $Y_i$ ($i = H, G, X$) are the unit value and quantities respectively. The value of non-durable exports was calculated from the UN, Yearbook of International Trade Statistics. Exports of services were calculated as the difference between the value of exports of goods and services (OECD, NA) minus the value of merchandise exports (UN, Yearbook of International Trade Statistics). Investment figures were treated as a residual:

$$P_Y = TC - P_X.$$  (A-4)

Thus, $R_Y = P_X Y_X/TX$ and $R_Y = P_X Y_X/TX = 1 - R_Y$ are the consumption and investment revenue shares respectively. For estimation purposes the ratio $P_X Y_X/TX$ was calculated and scaled to 1.00 in 1953, the base year.

The data for the factors of production were obtained as follows. The wage bill was provided by The Netherlands, National Accounts. The labor force was readily available by OECD, Labor Force Statistics. Thus, the wage index $W_K$ was calculated by the average wage level $W_L$ and scaled to 1.00 in 1953. With respect to imports, the unit value index $W_M$ was obtained from the UN, Yearbook of International Trade Statistics. Both labor and imports cost shares were obtained by dividing the respective bills by TC. Also, the unit value index for the services of capital $W_Y$ is 4 all data are in current prices. Detailed information accompanied by tables with data are available upon request.
Capital Markets, Output, and the Demand for Inputs Under Uncertainty

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I. Introduction

The Sharpe (1964)-Lintner (1965)-Mossin (1966) capital-asset-pricing-model has motivated considerable contributions to the theory of finance and to the empirical verification of financial propositions. This model provides a capital market equilibrium approach to the valuation of risky claims and its various applications include studies of corporate financial policies, investment (capital budgeting) decisions, and examinations of the efficiency of capital markets. The above studies culminate in a financial theory of the firm which sheds light on the valuation of securities under uncertainty while neglecting the classical problems of the firm, concerning the choice of factor-proportions and the determination of its output. Moreover, the financial literature is curiously silent with respect to the equilibrium of the industry in terms of price-output and inputs adjustments and the associated entry (exit) of firms.

Meanwhile, the incorporation of uncertainty into the neoclassical theory of the firm took place within a class of "entrepreneurial" models in which the firm is assumed to maximize the expected utility of random profits. These models focus on production under uncertainty, where the firm is a participant in the product and factor markets, without any reference to the role of financial markets as a mechanism for the valuation of uncertain profit claims and allocation of resources. This class of models indicates that production decisions are sensitive to the preferences of the entrepreneur and that, consequently, the results of the deterministic theory of the firm do not in general prevail. Since capital markets are absent within this class of models, one is still left with the task of separating the impacts of uncertainty and risk aversion, as well as those which are due to the assumed incomplete market setting where risky prospects are valued subjectively through managerial preferences.

This paper integrates the financial literature, of valuation of securities under uncertainty, with the standard neoclassical theory of the firm dealing with a production plan and with the equilibrium adjustments of the industry in terms of inputs, price-output determination.

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1Examples of the application of the capital-asset-pricing-model include: Fama (1970), Stiglitz (1972), Fama (1972), Jensen and Lang (1972), Rubinstein (1973), and Merton and Sufi (1974).

2The literature of the utility-maximizing firm under uncertainty received a considerable impetus with the publications of Sandmo (1971) and Leland (1973). Earlier studies of this subject include McCall (1947) and Stigler (1967). Extensions of this approach to the study of the demand for inputs under uncertainty include: Kall and Ulbrich (1974), Hartman (1975), Holthausen (1976) and Epstein (1974).