IMPORT DEMAND FOR THE UNITED STATES: A TRANSLOG COST FUNCTION ANALYSIS

ABD EKONOMİSİNDE İTHALAT MALLARI TALEBİ: TRANSLOG MALİYET FONKSİYONU ANALİZİ

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ABSTRACT

This paper examines the role of imports as an alternative input to domestically supplied capital and labor in the U. S. economy for the period 1970-1993. We use the aggregate translog cost function, which permits us to obtain econometric measures of the pair-wise elasticities of substitution between inputs for each year, the annual own- and cross-price elasticities of demand for inputs. Our results imply conventionally downward sloping demand curves for inputs but they are inelastic. The demand for labor is most inelastic, followed by imports and capital, respectively. Regression results also show that inputs are gross substitutes, the partial elasticity of substitution between capital and imports is higher than the partial elasticity of substitution between labor and imports.

Keywords: *Import demand, translog cost function*

ÖZET

Bu çalışma 1970 ve 1993 yılları arasında ölçülen ABD ekonomisi için alternatif bir üretim faktörü olarak ithalatın, ulusal çapta arz edilen sermaye ve emek girdileri ile arasındaki ilişkiyi ampirik olarak analiz etmektedir. Çalışmada her yıl için, üretim faktörleri arasındaki ikili ikame esneklik katsayılarını ve her yıl, tüm girdiler için hem normal hem de talebin çapraz fiyat esneklik katsayılarını ölçmemize olanak veren toplam translog maliyet fonksiyonu kullanılmıştır. Sonuçlarımız her bir girdi için esnek olmayan fakat beklenildiği gibi negatif eğimli talep eğrilerinin varlığını göstermiştir. İşgücüne olan talep diğer ikisine göre daha az esnektir ve onu sırasıyla ithalat ve sermayeye olan talep takip etmektedir. Sonuçlarımız ayrıca girdilerin birbirleriyle genel olarak ikame olduklarını, sermaye ve ithalat arasındaki kısmi ikame katsayısının ise işgücü ile ithalat arasındaki aynı katsayıdan daha büyük olduğunu göstermektedir.

Anahtar Sözcükler: *İthalat malları talebi, translog maliyet fonksiyonu*

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INTRODUCTION

The purpose of this paper is to examine the role of imports in the U. S. economy for the period 1970-1993, by using aggregate translog cost function. In addition to the domestically supplied capital and labor, it includes imports as a factor of production. Translog cost function permits us to obtain econometric measures of the pair-wise elasticities of substitution between inputs for each year, the annual own- and cross-price elasticities of demand for inputs, economies of scale for each year coupled with estimates of technical change.

The significance of the treatment of imports as an input is that if imports are a substitute input for one or more domestic inputs, then international trade and trade policies may directly affect the level of domestic factor income and as well as its distribution within a country. However, the assumption that imports are final goods with no close domestic substitutes, rules out any income distribution effects of change in input prices. This study assumes that imports are purchased by firms attempting to minimize the cost of delivering a single output to final demand. Whether or not the returns to primary factors rise or fall as a result of a change in import prices depends upon the signs of certain second partial derivation of the production function for final output. The changes in the share of labor income, for example, depend upon whether Allen-Uzawa partial elasticity of substitution between labor is less than or greater than the partial elasticity of substitution between capital and imports. The advantage of using translog specifications that it permits us to obtain the Allen-Uzawa elasticities of substitution to differ between pairs of factors, without the imposition of a priori restrictions. It therefore enables us to test the hypothesis regarding the effects of trade barriers on real income and income distribution.

Section 2 reviews some of the previous empirical studies. Section 3 discusses briefly the translog functional form and estimation procedure. The regression results using annual data on capital, labor, imports, and their prices for the period 1970-1993 are presented in Section 4. Section 5 concludes the paper.

EMPIRICAL STUDIES

In early studies of import demand, the foreign sector was generally modeled such that imports were generally taken as either final goods or intermediate goods, rather than an input. These models have concerned the aggregate-producing sector as employing primary factors, labor and capital, to produce a single final output, which is used for domestic and foreign uses. In these specifications, the quantity demanded of imports was frequently considered to be a function of national income and the ratio of the price of imports relative to the price of domestic value added. For example of import demand estimates where imports are treated as final goods (Houthakker and Magee, 1969, and Leamer and Stern, 1970). However, recent studies have argued that it would be more appropriate to treat import as a factor input (Burgess, 1974a, 1974b, Mohabbat and Dalal, 1983, Mohabbat et al., 1984, and Truett et al., 1994).

In a seminal paper, Chenery and Strout (1966) stated that " the inflow of external resources has become virtually a separate factor of production, whose productivity and allocation provides one of the central problems for a modern theory of development". This idea was later adopted and tested by Burgess (1974a), who argued that the majority of international trade occurred in intermediate goods requiring further domestic processing.

Much of the studies involving aggregate cost functions support the hypothesis that domestic capital and labor are substitutes. However, the findings of the various studies have mixed results about the relationships between domestic inputs and imports. For example, Burgess (1974a) using the U.S. data, and Kohli (1978) using Canadian data have obtained the results that imports and capital are complements. However, using a one-output model, Burgess (1974b) showed that capital, labor, and imports are substitutes for the United States. These mixed results might be attributed to the models that they utilized.

Mohabbat and Dalal (1983) have shown that for South Korea, imports are net substitutes for labor and capital, whereas Mohabbat et al. (1984) have shown that imports and capital are substitutes, but imports and labor do not exhibit a significant degree of substitutability or complementarity by using Indian data. Finally, Truett et al. (1994) using Mexican data, have found that labor and imports are complements, but capital and imports are substitutes. These mixed results may be attributed to the differences in relative factor endowments across countries.

METHODOLOGY AND DATA

We use a one-output and three-input model. Imports (M), labor (L), and capital (K) are used to produce a single output (Y) for domestic and foreign demands. The output measure is the value of final sales net of indirect taxes and subsidies (i.e., gross value added plus value of imports). It is linked to the total cost of production by the following accounting identity;

$$P_y\, Y \equiv W_l\, L + W_m\, M + W_k\, K \equiv TC,$$

where P_y is the price of the final good, W_j is the price of the j^{th} factor, and TC is the total cost.

This study assumes that the cost minimizing level of producing the single output can be represented by the translog cost function:

$$\ln C = a_0 + a_y \ln Y + \sum a_i \ln W_i + \tfrac{1}{2} b_{yy} (\ln Y)^2 + \tfrac{1}{2} \sum \sum b_{ij} \ln W_i \ln W_j + \sum b_{iy} \ln W_i \ln Y + \sum b_{it} \ln W_i T + b_{yt} \ln Y T + b_t T + \tfrac{1}{2} b_{tt} T^2 \quad (1)$$

where i, j = K, L, M; t is an indicator of the level of technology, and the symmetry requirement implies $b_{ij} = b_{ji}$. The cost function is constrained to be homogeneous of degree one in input prices, implying the restrictions;

$$\sum a_i = 1; \quad \sum b_{ij} = 0; \qquad (j = K, L, M)$$

$$\sum b_{iy} = 0; \quad \sum b_{it} = 0; \qquad (2)$$

Essentially, the same set of restrictions on parameters follows from the "adding up" requirement of the factor shares. The set of cost-share equations associated with the translog cost function, as implied by the duality theory, is obtained via Shephard's Lemma as;

$$S_i = a_i + \sum b_{ij} \ln W_j + b_{iy} \ln Y + b_{it} T \qquad (i = K, L, M) \qquad (3)$$

where $S_i = \partial \ln C / \partial \ln W_i$. Since $\sum S_i = 1$, this requires the same restrictions as given above (2) and implies that only two of the three cost-share equations in (3) are linearly independent.

The Allen-Uzawa partial elasticities of substitution between inputs i and j are given by;

$$\sigma ij = [(bij / SiSj)] + 1 \quad (i \neq j) \qquad (4)$$

and the own-price (e_{ii}) and cross-price elasticities (e_{ij}) of input demand are given by

$$e_{ii} = (b_{ii} / S_i) + S_i + 1$$

and

$$e_{ij} = (b_{ij} / S_j) + S_j + 1 \qquad (5)$$

Scale economies are measured by the relation between total variable cost and output along the expansion path. Hence, the elasticity of scale (ε) is measured by the reciprocal of the elasticity of cost with respect to output (ε_{cy}), and is given by;

$$\varepsilon = (\varepsilon_{cy})^{-1} = (\partial \ln C / \partial \ln Y)^{-1} = R^{-1} \qquad (6)$$

with $\varepsilon > 1$ ($\varepsilon < 1$) implying increasing (decreasing) returns to scale in the underlying aggregate production function, $\varepsilon = 1$ implying constant returns to scale.

The cost function (1) allows us to estimate technical change, with the rate of technical change (which measures the cost reduction resulting from technical change) being defined as

$$\varepsilon_t = -(\partial \ln C / \partial \ln t) = -[\, b_t + b_{tt} T + b_{yt} \ln Y + \sum b_{it} \ln W_i] \qquad (7)$$

Equation (7) implies that scale and technical change interact to create efficiency gains. If for example, the b_{yt} in equation (7) is negative, then larger scale has the effect of increasing ε_t over what it would have been in the absence of this larger scale. In such case, larger scale is necessary to realize the additional cost savings from technical change.

The system of equations consisting of the cost function (1) and two of the three cost-share equations (3) is estimated as a simultaneous system (with the import cost-share equation being dropped). The iterative Zellner's seemingly unrelated regression (ITSUR) estimation procedure (see, Greene, 1997) is applied to estimate the parameters of the system of equations, yielding estimates which are asymptotically equivalent to maximum likelihood estimates and invariant to the cost-share equation dropped.

The data needed for estimations are the total cost of production, the cost shares of labor and capital, and the ratios of the price of labor and the price of capital to the price of imports. The labor input price (w_l) is measured by total compensation of employees divided by total employees. W_m is unit value index numbers for imports with 1990 as a base year. The capital input price (w_k) is represented by following formula;

$$w_{kt} = r_t q_{t-1} + d q_t - g_t, \qquad (8)$$

where r is government bond yield, q is the implicit deflator for gross domestic capital formation, d is the 7% average rate of depreciation, g_t = 5-year trailing average of (q_t-q_{t-1}). The expression for the price of capital is taken from Christensen and Jorgenson (1969). The total cost of production, the cost shares of labor and capital and the relevant price ratios were calculated for each year from 1970 to 1993 and quantity and price ratios were scaled to one in the base year 1990. Appendix presents the data used in the empirical part of the paper.

EMPIRICAL RESULTS

The cost function model consisting of equations (1), and (3), with restrictions of homogeneity in input prices, symmetry, and adding up property, was estimated using time series data for the period 1970-1993. As noted above, in the estimation of the model, the cost-share equation for import was deleted. The parameter estimates and the associated asymptotic t-values are presented in Table 1.

The model fits the data quite well; the R^2's are 0.96 for the cost function (1); 0.53, and 0.33 respectively for the cost shares of capital and labor. To be an adequate representation of the underlying technology, the estimated cost function must be concave in input prices and monotonically non-decreasing in input prices. In this case, monotonicity and concavity are satisfied for all observations since the fitted cost shares are positive at all sample points and determinantel test and the test used iegenvalues imply the concavity of cost function with respect to input prices. Furthermore, the appropriate way of testing whether the technology can be characterized by a Cobb-Douglas production function requires the simultaneous imposition of zero restrictions on the parameter b's. We have used the Log-Likelihood Ratio test to test the hypothesis that the technology can be adequately represented by a Cobb-Douglas production function. The calculated Chi-square

Table 1

Estimated Coefficients of the Translog Cost Function

a_0	14.91	b_{kk}	0.025	b_{ly}	0.01
	(1.27)		(1.33)		(0.26)
a_k	0.22	b_{kl}	-0.02	b_{lt}	-0.0011
	(1.64)		(-0.96)		(-1.49)
a_l	0.64	b_{ky}	0.007	b_{yy}	1.66
	(4.23)		(0.2)		(0.92)
a_y	-0.619	b_{kt}	-0.001	b_{yt}	0.04
	(-0.94)		(-2.79)		(1.99)
a_t	-0.13	b_{ll}	0.042	b_{tt}	-0.003
	(-1.53)		(1.68)		(-1.58)

statistic with ten degrees of freedom is 102.33, while the critical value is 25.18 at the 0.5 percent level, which indicates that we can reject the Cobb-Douglas specification.

Partial Elasticities of Substitution between Inputs and Own- and Cross-Price Elasticities of Input Demand

Table 2 presents the Allen-Uzawa partial elasticity of substitution between each pair of inputs and the own price elasticities of derived demand based upon the ITSUR estimates in Table 1. All the own-price elasticities have the theoretically correct negative sign, and all are inelastic. Our findings indicate that e_k varies between -0.64 and -0.67; e_l varies between -0.24 and -0.28; e_m varies between -0.52 and -0.66.

Table 2

Allen-Uzawa partial elasticities of substitution and own price elasticities of derived demand based on the ITSUR estimates.

YEAR	σ_{kl}	σ_{km}	σ_{lm}	e_k	e_l	e_m
1970	0.87865	0.67231	0.52094	-0.64998	-0.24931	-0.52417
1971	0.87594	0.66805	0.52998	-0.65374	-0.24618	-0.52911
1972	0.87484	0.68516	0.55719	-0.65464	-0.24683	-0.54871
1973	0.87394	0.71158	0.58933	-0.65431	-0.25294	-0.57356
1974	0.87018	0.77855	0.67925	-0.65509	-0.26727	-0.63277
1975	0.86905	0.75506	0.64779	-0.65609	-0.26769	-0.61566
1976	0.86798	0.76781	0.67065	-0.65742	-0.26611	-0.62786
1977	0.86681	0.77622	0.68447	-0.65831	-0.26691	-0.63537
1978	0.86729	0.78026	0.68569	-0.65723	-0.27013	-0.63684
1979	0.86622	0.79277	0.70013	-0.65701	-0.27602	-0.64523
1980	0.86503	0.81129	0.72131	-0.65631	-0.28466	-0.65595
1981	0.86595	0.80682	0.71034	-0.65493	-0.28711	-0.65207
1982	0.86418	0.79358	0.69829	-0.65732	-0.28347	-0.64611
1983	0.86169	0.78395	0.70042	-0.66137	-0.27322	-0.64472
1984	0.86215	0.80074	0.72135	-0.66073	-0.27475	-0.65413
1985	0.85977	0.79166	0.71791	-0.66335	-0.27021	-0.65183
1986	0.85517	0.791111	0.73241	-0.66752	-0.26302	-0.65643
1987	0.85423	0.799663	0.74279	-0.66769	-0.26579	-0.66074
1988	0.85321	0.79869	0.74241	-0.66812	0.26695	-0.66078
1989	0.85114	0.79825	0.74589	-0.66935	-0.26641	-0.66189
1990	0.85078	0.80528	0.74649	-0.66809	-0.27711	-0.66355
1991	0.84599	0.79216	0.74961	-0.67224	-0.26319	-0.66269
1992	0.84201	0.78576	0.75144	-0.67419	-0.25947	-0.66281
1993	0.83738	0.78029	0.75571	-0.67601	-0,25524	-0.66364
1970-1993 Averages	0,86165	0,77196	0,68757	-0,66129	-0,24442	-0,63194

Using time series data from 1929-1969 for the United States, Burgess (1974a) obtained the estimate of the price elasticity of demand for capital ranging from -0.61 to -0.64. The corresponding figures for the other two inputs were -0.48 to -0.52 for labor and -0.51 to -0.66 for imports. Burgess (1974b) obtained similar (but slightly higher in absolute value) estimates of these price elasticities of demand, using U.S. data from 1947-1968.

Furthermore, the corresponding cross-price elasticities of demand for the inputs are calculated, which are consistent with the hypothesis that all pairs of inputs are substitutes because they are all positive for the whole period. We have considerable evidence to support the hypothesis that inputs are gross substitutes, and that capital and imports are closer substitute than labor and imports probably due to the development level of the United States. The fact that Allen-Uzawa partial elasticity of substitution between capital and imports is higher than the partial elasticity of substitution between labor and imports suggests that trade barriers which raise the price of imports will alter income distribution in favor of capital. Therefore, for the United States, the relaxation of trade barriers can be expected to make both capital and labor better off, but raise the share of national income going to labor. However these inferences must be regarded as tentative since our results are based on one-sector model. Changes in the composition of output between consumption and investment, for example, affect the aggregate factor demands at given input prices. These results are consistent with the findings of Burgess (1974b). When comparing our results with those of Burgess, we are restricting comparison to those results found in Burgess (1974b), since the methodology employed is much more similar to that of the present paper than that of the other article by Burgess (1974a).

Note that the Morishima and Shadow elasticities of substitution are also calculated based on the ITSUR estimates. Blackorrby and Russell (1989) show that the Allen-Uzawa elasticity of substitution does not explain factor substitution explicitly[*]. Since it does not provide information about the comparative statics of factor shares, it cannot be interpreted as the marginal rate of substitution. An alternative measure of factor substitution is the Morishima elasticity of substitution ($\sigma_{ij}^{M} = e_{ij} - e_{jj}$). Morishima elasticity of substitution measures the percentage change in the ratio of a pair of factors with respect to a change in the ratio of their respective prices. As Table 3 reports, all of the Morishima elasticities of substitution coefficients are positive, implying that each pairs of inputs are Morishima substitutes. Note that as table indicates even though Allen - Uzawa partial elasticity of

[*] I especially thank to one of the anonymous referees for pointing out this issue.

substitution is symmetric, Morishima elasticity of substitution does not need to be symmetric.

Morishima Elasticity of Substitution based on the ITSUR Estimates						
5 - year Averages	σ_{kl}^{M}	σ_{lk}^{M}	σ_{km}^{M}	σ_{mk}^{M}	σ_{lm}^{M}	σ_{ml}^{M}
1970-1974	0.852796	0.862244	0.615292	0.821220	0.605844	0.646868
1975-1979	0.848578	0.858246	0.709940	0.836674	0.700272	0.721844
1980-1984	0.846612	0.856702	0.741352	0.841898	0.731260	0.746068
1985-1989	0.839882	0.847108	0.755262	0.834694	0.748036	0.760448
1990-1993	0.832490	0.837625	0.764520	0.827275	0.759385	0.769735
1970-1993	0.844554	0.853000	0.715305	0.832564	0.706858	0.727295

Scale Elasticities and Technical Change

Turning to the regression results it appears that underlying aggregate production function has been characterized by economies of scale until the year, 1984, with $\varepsilon > 1$ all observations except two years, whereas after 1984, statistically significant diseconomies of scale are found, with $\varepsilon < 1$ all observations and declining remarkably in value from 0.97 to 0.52. The average scale elasticity value of $\varepsilon = 1.26$ indicates that the average elasticity of cost is $\varepsilon^{-1} = 0.79$ which, in turn, suggests that a 1% increase in output would lead to a 0.79% increase in total variable cost.

The average annual rate of technical change for the whole period is with ε_t=0.0008 and suggests that technology has not made any remarkable contribution to the whole economy. However, an examination of the two sub-periods indicates that the contribution of technical change has been negative (but decreasing in absolute value) in the first period 1970-1978, while the second period 1978-1993 indicates that the contribution of technical change has increased from 0.001 to 0.02.

CONCLUSIONS

In this paper we have assumed that a single homogeneous imported good is purchased by cost minimizing firms as an alternative input to domestically supplied capital and labor in order to produce a single output.

Regression results show that the demand curves for inputs are downward sloping and are inelastic. The demand for labor is most inelastic, followed by imports and capital, respectively. Regression results also show that inputs are gross substitutes, the partial elasticity of substitution between capital and imports is higher than the partial elasticity of substitution between labor and imports.

Although the average annual rate of technical change for the period estimated as 0.0008% is statistically insignificant, we have concluded that technical change over the period has increased significantly from -0.04 to 0.23. The average scale elasticity value is estimated as 1.26%. The computation of elasticities of scale indicates that the U.S. economy has been characterized by scale economies until the year 1984, then overall economies of disscale is found during the sub-period 1984-1993.

APPENDIX SUMMARY STATISTICS

Year	Total Cost of Production Index (1990 = 100)	Capital Input Price Index (1990 = 100)	Labor Input Price Index (1990 = 100)	İmport Price Index (1990 = 100)	Gross value added plus value of imports) (Billion Dolar)	Capital Share	Labor Share	Import Share
1970	16.8	30.2	32.9	22.5	1035.6	0.22	0.72	0.07
1971	18.3	26.6	35.2	23.7	1125.4	0.24	0.70	0.07
1972	20.3	28.5	37.8	25.4	1237.3	0.25	0.68	0.07
1973	22.8	35.0	40.6	30.1	1382.6	0.25	0.68	0.08
1974	25.2	43.6	42.3	44.6	1496.9	0.23	0.67	0.10
1975	27.2	48.7	47.4	48.6	1630.6	0.21	0.70	0.09
1976	30.6	50.0	51.4	50.2	1819	0.23	0.67	0.10
1977	34.4	53.8	55.3	54.3	2026.9	0.25	0.65	0.10
1978	39.2	66.9	59.6	58.6	2291.4	0.26	0.64	0.10
1979	44.2	82.6	64.8	69.9	2557.5	0.26	0.63	0.11
1980	48.3	109.9	70.9	87.6	2784.2	0.23	0.65	0.12
1981	53.6	140.2	77.9	92.4	3115.9	0.24	0.65	0.11
1982	55.4	131.2	83.4	90.9	3242.1	0.21	0.68	0.11
1983	60.2	113.9	99.4	87.2	3514.5	0.22	0.67	0.11
1984	67.5	130.7	103.7	88.8	3902.4	0.24	0.64	0.12
1985	72.0	113.9	108.1	86.5	4180.7	0.23	0.66	0.11
1986	76.5	84.0	111.0	83.6	4422.2	0.22	0.66	0.12
1987	81.7	94.4	116.8	89.7	4692.3	0.21	0.67	0.12
1988	88.1	101.9	122.9	94	5049.6	0.21	0.66	0.12
1989	94.7	99.4	127.3	96.9	5438.7	0.20	0.67	0.13
1990	100.0	100.0	100.0	100	5743.8	0.19	0.68	0.13
1991	102.2	91.1	140.5	100	5916.7	0.17	0.70	0.13
1992	108.1	79.6	147.8	100.8	6244.4	0.18	0.69	0.13
1993	114.0	66.8	153.1	100.1	6553	0.20	0.68	0.13

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