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ABSTRACT

While the German economy may currently be a bright spot in Europe, it has faced substantial challenges in recent years. Moreover, tensions are rising regarding Germany's responsibilities and opportunities as a member of the European Monetary Union. Other studies have documented the difficulties that Germany has encountered as a result of the unification and the further integration of Europe. This paper adds to that literature by using an aggregate translog cost function approach to examine the relationships among inputs of domestic capital and labor and imports. Our findings indicate that the input pairs of capital-labor and labor-imports are substitutes. The substitutes relationship between labor and imports, which has become stronger over time, suggests that increasing globalization will add to Germany's unemployment woes. Capital and imports appear to be weak complements, but that relationship is not statistically significant. The results also suggest that imports are playing an increasingly important role in Germany's aggregate production, accentuating the role of the international environment.

I. INTRODUCTION

For a long time, Germany had been considered to be a prime example of prudent macroeconomic policymaking with fiscal and monetary stability, even deemed "Model Germany" (Hein and Truger, 2005, p. 3). However, the unification of Germany in July 1990 presented a new set of economic challenges that were probably far greater than most Germans anticipated, including a loss of industrial employment and a reduction in manufacturing profitability (Carlin and Soskice, 1997; Lechner, Miquel and Wunsch, 1990; and Sinn, 2002). The unification of Germany was followed in 1992 by the Treaty on European Union signed in Maastricht and the Stability and Growth Pact in 1997. The former treaty paved the way for a common currency, the euro, for the members of the European Monetary Union, and the latter had the goal of maintaining fiscal stability and budget discipline among the countries of the euro zone. While the Stability and Growth Pact restricts the policy flexibility of member countries, Germany was in favor of such an agreement to facilitate price stability with the introduction of the euro (Hoekstra, Horstmann, Knabl, Kruse, and Wiedemann, 2008).

As the 20th century turned to the 21st, Germany found itself beset by stagnation problems, with one source asserting that "From 2001 until present the German economy has been facing its most serious crisis in post-war history" (Hein and Truger, 2005, p. 4). While it improved briefly in 2006, the situation soon began to deteriorate once again. Long relying on exports to promote growth, Germany found itself caught in the international economic collapse. There was an export "meltdown"; January 2009 exports were 20% lower than a year earlier and industrial output decreased 19% (Bartha, 2008, p. A6; Benoit, 2009, p. 2; Landler, 2006, p. 1; and Walker, 2009, p. A8). The former model country was characterized as the eurozone's "sick man" and Europe's "faltering giant" (Bibow, 2005, p. 30; Hein and Truger, 2005, p. 4; and Mueller, 2007).

The German economy is particularly sensitive to international economic fluctuations since the country relies on exports for a substantial portion of aggregate demand. For example, in 2009 exports were a little over 40% of gross domestic product (GDP) (Statistisches Bundesamt, *Statistisches Jahrbuch*, 2010, p. 636).

By 2011, the Germany economy had rebounded, particularly relative to those of some of the other members of the EMU. Still, the Greek debt crisis and the difficulties of other members of the EMU such as Ireland, Portugal, and potentially even Spain, Belgium, and Italy presented challenges to the German economy. The German export-dependent economy has strong markets for its products in Asia, and the recent fall in the euro has helped to stimulate exports to countries outside the eurozone. Nevertheless, with an economy dependent on exports, significant problems in the weaker EMU countries are likely to impact Germany as well, both in terms of its exports and in any international assistance efforts (in addition to that for Greece) in which it may need to play a major role. Moreover, while the its economy now looks robust compared with those of many of its neighbors, 2010 Germany still had a budget deficit in 2010 of over 3.5%, above the 3% limit of the EMU budget rules.[1] In addition, policies that helped to reduce the impact of the recent downturn on employment may also slow the rise in employment as the economy expands.[2]

[1]See, for example, Jonathan Cheng and Marcus Walker, "German Economy Steams Ahead," *The Wall Street Journal*, January 13, 2011, p. A8; and Simon Kennedy, "Germany Reaps The Euro's Reward," *Bloomberg Businessweek*, July 19-July 25, 2010, pp. 13-14.

[2] These policies include the *Kurzarbeit*, or short work week plan, as well as the work-time account, which enables companies to reduce work hours during periods of slack demand, then to not have to pay overtime as employees work the lost hours as demand expands. See Christopher Power, "The Price of Saving Jobs in Germany," *Bloomberg Businessweek*, August 2-August 10, 2010, pp. 12-13.

Blame for Germany's past problems has been assigned to a variety of possible sources, including aid to the former East Germany after unification that included generous unemployment benefits; the trade unions for maintaining too high of wage rates and other structural rigidities in the labor market; and overly strict monetary and fiscal policies (Benoit, 2006, p. 2; Bibow, 2005, pp.29-30; Hein and Truger, 2005, pp. 3-4; and Snower and Merkl, 2006). However, the goal of this paper is not to directly discern which of these possible factors contributed the most to Germany's difficulties. Rather, it investigates the relationships between Germany's domestic inputs of capital and labor and imports, where imports are also considered a factor of production, and the implications of these findings for Germany's future. Specifically, the results here will allow us to infer some things about the behavior of the German input markets, including the labor market, and how these markets will impact the German economy in the international environment. As far as we know, these particular aspects of the German economy have not been addressed in any similar recent research.

Through this approach to the production process, one can develop information regarding how demands for the domestic inputs and imports affect one another and, therefore, some insight into how the increasing internationalization of Europe and the world has affected Germany in the past and is likely to do so in the future. The view of imports as an input in the production process has been used by many other researchers (for example, Aw and Roberts, 1985; Burgess, 1974a and b; Chenery and Strout, 1966, p. 679; and Kohli, 1993). We use a translog cost function, which gives a local second-order approximation to any economically appropriate cost function, to infer information regarding the production relationships in the German economy. From translog cost function parameter estimates one can obtain estimates of the input direct and cross price elasticities of demand, price and quantity elasticities of inverse output supply, and quantity elasticities of input demand. The next section of this paper discusses the specific version of an aggregate translog cost function used for this research.

II. THE TRANSLOG COST FUNCTION

The model utilized in this study assumes that aggregate output can be divided into two types of goods, consumption goods and investment goods, and that inputs can be divided into three classes: capital, labor, and imports. In early studies of import demand, imports were considered to be part of the final goods group, rather than an input. In these specifications, the quantity demanded of imports was frequently hypothesized to be a function of national income, the price of imports, and the price of domestic goods, with an adjustment for the exchange rate [for example, Houthakker and Magee (1969)].

However, Chenery and Strout (1966, p. 679) argued that imports were external resources that should be considered a separate input of production, and Burgess (1974a, p. 225) also followed this approach. They pointed out that even imported final goods require domestic handling and marketing before reaching the ultimate consumer and, therefore, enter the production process as well. The significance of the treatment of imports as an input is that if imports are a substitute input for or have a complementary relationship with one or more domestic inputs, then trade and trade policies may directly affect domestic factor prices and, therefore, the level and distribution of domestic factor incomes.[1]

Consistent with the view of imports as an input, it is assumed that on an aggregate level imports are combined with domestic capital and labor by producers who seek to minimize the

[1]Other research that has used this approach to imports include Kohli (1994 and 1978) for Canada, (1983) for Australia, and (1982) for Switzerland; Diewert and Morrison (1986) for the United States; Mohabbat, Dalal, and Williams (1984) for India, and Mohabbat and Dalal (1983) for South Korea.

cost of producing an output that includes investment goods and consumption goods that are sold domestically or exported. We employ a transcendental logarithmic (translog) cost function and its corresponding input and revenue share equations to estimate the cross price elasticities of demand between the various input pairs as well as the direct price elasticities of demand for these inputs. In addition, the question of the separability of the outputs of consumption goods and investment goods is investigated and, specifically, the issue of whether Germany's demand for imports is affected by the *composition* of domestic output.[2] The hypothesis of imports as a separable factor of production from domestic capital and labor is also tested.

A general production possibility frontier for the case of two outputs (consumption goods and investment goods), and three inputs (labor, capital, and imports), can be expressed in the following form:

$$F(Y_C,Y_I,X_K,X_L,X_M,T) = 0, \qquad (1)$$

where Y_C is consumption goods, Y_I is investment goods, X_K is capital, X_L is labor, X_M is imports, and T represents time-related components, including technological change.[3] If the

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[2]See Kohli (1991); Berndt and Christensen (1973a and b); Brown, Caves, and Christensen (1979, p. 258); Caves, Christensen, and Tretheway (1980); and Christensen, Jorgenson, and Lau (1973) for more detailed discussions of translogarithmic production and cost functions. An advantage of the translog cost function is that it contains fewer parameters than some other flexible functional forms, such as the extended generalized Cobb-Douglas. See Guilkey, Lovell, and Sickles (1983, p. 615); and Caves, Christensen, and Tretheway (1980, p. 478).

[3]See Binswanger (1974a, p.380; and 1974b, pp. 967-969); Caves, Christensen, and Tretheway (1984, footnote 5, p. 473); and Kohli (1991, pp.103-106) for a discussion of the technological change variable. The time trend variable can be included in the original cost function as either a set of exponential expressions with e^T as an argument or as a set of expressions containing *T* not exponentiated. In the first case, the time trend variable will appear in the *logarithmic* total cost function in terms containing *T*. In the latter case, the logarithmic total cost function will have terms containing *ln T*. In the first case, $\partial ln\ TC/\partial T$ indicates the rate of change of the *log* of total cost with respect to *T*. In the latter case, $\partial ln\ TC/\partial ln\ T$ gives the *elasticity* of total cost with respect to *T*. Either version of the time trend variable can be and has been used in the literature. In this study, *T* was used in the final version of the estimated cost

transformation function has a strictly convex input structure, then there exists a unique multiproduct cost function,

$$TC = f(Y_C, Y_I, W_K, W_L, W_M, T), \qquad (2)$$

where W_K is the price of capital, W_L is the price of labor, and W_M is the price of imports (Brown, Caves and Christensen, 1979, pp 257-258).

The exact cost function (2) can be approximated with the translog cost function

$$\ln(TC) = \alpha_0 + \alpha_T T + \sum_i \alpha_i \ln Y_i + \sum_j \beta_j \ln W_j + 1/2 \sum_i \sum_r \delta_{ir} \ln Y_i \ln Y_r \qquad (3)$$
$$+ 1/2 \sum_j \sum_s \gamma_{js} \ln W_j \ln W_s + \sum_i \sum_j \rho_{ij} \ln Y_i \ln W_j + \sum_j \gamma_{jT} \ln W_j T + \sum_i \rho_{iT} \ln Y_i T$$
$$+ 1/2 \alpha_{TT} T^2,$$

where *i*, *r* = *C*, *I*; and *j*, *s* = *K*, *L*, and *M*.[4] The minimum requirements for the cost function to

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function because it resulted in fewer violations of the regularity conditions.

[4]The principal advantages of using a translog cost function such as equation (3) over a translog production function include the following four features of the cost function: (1) the partial derivatives of a cost function with respect to input prices yield the corresponding input demand functions (Shephard's Lemma); (2) it follows from (1) and the definition of elasticity that the derivative of the cost function in logarithmic form with respect to log factor prices yields the cost shares; (3) the partial derivative of the joint cost function with respect to an output yields the marginal cost of that output; and (4) it follows from (3) and the additional assumptions of perfect competition in the output markets (for the equality of output price and marginal cost) and constant returns to scale that the derivative of the cost function in logarithmic form with respect to the quantities of the various outputs yields expressions for the revenue shares (Binswanger 1974a, p. 377).

Kohli (1991, p. 14) has argued that a revenue or variable profit function is preferable in the context of international trade because those functions imply that the quantity of domestic inputs and output prices are exogenous, whereas the cost function approach implicitly assumes that the output mix and input prices are exogenous. Thus, in the context of a revenue or profit function approach, changes in import prices would affect the domestic economy through their effects on domestic factor prices rather than on the quantities of domestic inputs employed. This approach is appropriate in a neoclassical framework where domestic inputs are fully employed but their prices are endogenous. The cost function approach could be considered appropriate in a Keynesian context where input usage is determined by the level of aggregate demand and input prices are rigid or at least exogenously determined.

While reported German aggregate unemployment rates were a low 1.2 percent in 1973, they describe a "well-behaved" technology are that it be (1) linearly homogeneous in input prices, (2) positive and monotonically increasing in input prices and outputs, (3) concave in input prices and (4) convex in output quantities.[5]

The transformation function is homogeneous of degree $(\Sigma \alpha_i)^{-1}$, ($i = C, I$), and it follows that

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quickly rose to 4.7 percent in 1975, then to 7.5 percent by 1982 and remained above that level throughout the 1980s. In 1991, the official aggregate unemployment rate was only 4.9 percent, but it rose steadily to over 10 percent in early 2005. (See Statistisches Bundesamt, *Statistisches Jahrbuch*, 1984, p. 110; 1990, p. 111; and 2005, p. 79.) Snower and Merkl (2006, p. 375) argue that the unemployment rate in the former East Germany was considerably higher--rising from about 10 percent in 1991 to 20 percent in 2004. The lower figure for 1991 is reported in *Statistisches Jahrbuch*, 2005, p. 79, based on International Labour Organization data. However, *Statistisches Jahrbuch* (1996, pp. 123-124) states that the unemployment rate for the former West Germany was 6.3% in 1991 and 6.6% in 1992. The reported unemployment rate for the former East Germany was 14.8% in 1992. Regardless of which data are correct, it is clear that during much of the study period, additional workers were available for employment in productive activities. In addition, extensive government and trade union involvement in the economy allows the assumption that both the output mix and input prices are exogenous variables to be plausible. Nevertheless, this limitation of the cost function approach is recognized.

[5]These regularity conditions require the following restrictions on the translog parameters:

(1) linearly homogeneous in input prices:

$\sum_j \beta_j = 1$, $\sum_j \rho_{jr} = 0$, $\sum_j \gamma_{jT} = 0$ and $\sum_j \gamma_{js} = 0$, ($r = C, I$) and ($j, s = K, L, M$); and

(2) monotonically increasing in input prices and outputs:

$$\partial \ln TC / \partial \ln W_j \text{ and } \partial \ln TC / \partial \ln Y_i > 0.$$

A convex input structure for the transformation function is equivalent to the cost function being homogeneous of degree one, nondecreasing, and concave in input prices. A necessary and sufficient condition for concavity of the cost function in input prices is that the Hessian matrix of second partial derivatives with respect to factor prices is negative semidefinite. Concavity will be assured if the principal minors of successive order alternate in sign beginning with a negative sign. A necessary and sufficient condition for convexity of the cost function in output quantities is that the Hessian matrix of second partial derivatives with respect to output quantities is positive semidefinite. Moreover, the equality of the cross partial derivatives requires the symmetry constraints that $\delta_{ir} = \delta_{ri}$ and $\gamma_{js} = \gamma_{sj}$. See Ryan and Wales (2000, pp. 254-256) and the maintained assumption of aggregate constant returns to scale requires $\sum_i \alpha_i = 1$. In addition, the maintained assumption of a linearly homogeneous transformation function requires that the joint cost function be homogeneous in outputs, so that

$$\sum_i \delta_{ir} = 0,\ \sum_i \rho_{iT} = 0, \text{ and } \sum_i \rho_{ij} = 0,\ (i, r = C, I) \text{ and } (j = K, L, M).$$

Given perfect competition in the input and product markets, the parameters of the translog cost function can be estimated indirectly by estimating the coefficients of the cost and revenue share equations.[6] The cost share equations $S_j = \partial \ln TC/\partial \ln W_J$ (where $j = K, L, M$) are as follows:

$$S_j = \beta_j + \sum_i \rho_{ij} \ln Y_i + \sum_s \gamma_{sj} \ln W_s + \gamma_{jT} \ln T,$$

($i = C, I$) and ($s = K, L, M$).

Given the restriction of linear homogeneity in factor prices on the cost function and the additional assumption of a homogeneous transformation function, the input cost share equations become

$$S_L = \beta_L + \gamma_{LL} [\ln (W_L/W_M)] + \gamma_{KL} [\ln (W_K/W_M)] + \rho_{CL} [\ln (Y_C/Y_I] + \gamma_{LT} \ln T, \qquad (4)$$

$$S_K = \beta_K + \gamma_{KK} [\ln (W_K/W_M)] + \gamma_{KL} [\ln (W_L/W_M)] + \rho_{CK} [\ln (Y_C/Y_I] + \gamma_{KT} \ln T, \qquad (5)$$

and $S_M = 1 - S_L - S_K$.

Only two of the factor share equations are linearly independent, since their sum must be equal to

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Brown, Caves, and Christensen (1979, p. 257).

[6]To some extent, the assumption of perfect competition is out of place in Germany. However, the historical system of extensive government involvement in the economy and labor union influence have resulted in characteristics of perfect competition in the sense that certain prices would appear fixed from an individual firm point of view.

unity.

Similarly, with constant scale returns the revenue shares ($R_i = \partial \ln TC/\partial \ln Y_i$, $i = C, I$) are given by

$$R_C = \alpha_C - \delta_{CI} [\ln (Y_C/Y_I)] + \rho_{CL} [\ln (W_L/W_M)] + \rho_{CK} [\ln (W_K/ W_M)] + \rho_{CT} \ln T \qquad (6)$$

and $R_I = 1 - R_C$. Only one of the revenue share equations is linearly independent, since constant returns to scale and perfect competition imply that the revenue shares also sum to unity.

The labor and capital factor share equations, S_L and S_K, and the consumption goods revenue share equation, R_C, have twelve free parameters. Inclusion of the translog cost function in the model to be estimated would add three more parameters, α_0, α_T, and α_{TT}.[7] Two dummy variables were also added to the aggregate cost function. Dummy U (1 beginning in 1991) reflects the effect of German unification on aggregate cost. Dummy E (1 beginning in 2002) reflects the effects of the implementation of the common currency (euro) on aggregate cost. Separate stochastic error terms, assumed to reflect errors in optimizing behavior, are implicitly added to equations (4), (5), and (6) and the cost function. Annual time series data from 1968-2005 were utilized in the study.[8] The cost function, cost share, and revenue share equations are

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[7]The data are normalized using the variable means as the base period. See Burgess (1975, p. 110); and Caves, Christensen, and Tretheway (1984, p. 477) for a discussion of normalization of variables.

[8]The following data were used in estimating the total cost function. The price of labor was given by the index of labor hourly earnings [*Index der durchscnittlichen bezahlten Wochenstunden und Bruttoverdienste der Arbeiter und Arbeiterinnen im produzierenden Gewerbe: Bruttostundenverdienste* (*insgesamt*)]. The data series utilized for the price of capital was given by the government bond yield. The price of imports was given by I*ndex der Einfuhrpreise* (2000 = 100). The data for nominal output and the producer price indices (2000 = 100) of the gross output (I*ndex der Erzeugerpreise gewerblicher Produkte*) in each respective category (domestic and exported consumption goods and investment goods, respectively) were used to calculate the real value of output. Wages paid to labor was given by A*rbeitnehmerentgelte*. Total profit was calculated as *Bruttoinlandsprodukt* less net indirect taxes

estimated by using the Zellner-efficient method (ZEF) and iterating on the estimated covariance matrix until convergence is achieved.[9]

As noted earlier in this paper, Kohli (1991) has argued that in the context of international trade it is preferable to assume that the quantities of domestic inputs are given rather than that the output quantities and input prices are exogenous.[10] While this limitation of the cost function approach is noted, Germany had extensive government and trade union involvement as well as significant excess capacity during most years covered by this study (Snower and Merkl, 2006; Mueller, 2007; Carlin and Soskice, 1997), so the assumption of exogenous input prices is reasonable. Accordingly, the presence of government involvement can also emulate perfect competition in the sense that an individual firm would not be able to control prices.

One hypothesis of interest in this study is input-output separability, because it is related to the impact, if any, of a change in the *composition* of output on the demand for each respective

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and wages. Total cost was equal to total wages plus total profit plus I*mporte* in current prices, in billions of euros. Data utilized prior to 1991 were for the former West Germany (Früheres Bundesgebiet), while that for 1991 and later years were for the unified Germany (Deutschland). The data sources, Statistisches Bundesamt, *Statistisches Jahrbuch Für die Bundesrepublik Deutschland*, and the International Monetary Fund, *International Financial Statistics Yearbook*, are listed in the bibliography.

[9]Barten (1969, pp. 24-25) has shown that maximum-likelihood estimates of a set of share equations less one are invariant to which equation is omitted. Kmenta and Gilbert (1968) and Oberhofer and Kmenta (1974) have demonstrated that iteration of the Zellner (1962) procedure (IZEF) until convergence yields maximum-likelihood estimates. Ruble (1968, pp. 279-286) has also shown that the IZEF and maximum likelihood methods are computationally equivalent.

[10]As a result, one could argue that it is more appropriate to use an iterative three-stage least squares (I3SLS) procedure with instrumental variables. However, this method presents the problem that the results may vary with the set of instrumental variables employed, and there are no straightforward decision criteria to determine which variables to include. Therefore, the choice of instrumental variables is somewhat arbitrary. Moreover, Applebaum (1978, p. 94) compared the I3SLS results of Berndt and Christensen (1973a) with those of his model using the maximum likelihood method and found they were quite close. Burgess (1976, p. 32) also obtained point estimates and standard errors using I3SLS similar to those achieved with the IZEF procedure.

input.[11] A transformation process that is separable with respect to a partitioning between inputs and outputs implies that the various outputs can be combined into a single aggregate output measure, a procedure that requires the *relative* marginal costs of the different products to be independent of the input prices. Accordingly, input-output separability requires the marginal rate of transformation between the different products to be independent of the input composition, and the marginal rate of substitution between factor pairs to be independent of the composition of output. A sufficient condition for input-output separability is that the interaction terms between outputs and input prices are all zero: $\rho_{CK} = \rho_{CL} = 0$.[12] It follows that if input-output separability exists, changes in the output mix will not affect the cost-minimizing input mix, given a set of factor prices.

The question of the separability of domestic labor and capital from imports is also examined, since the existence of this type of separability has implications for the impact of a change in import prices on the demand for domestic inputs and the factor shares. To test the hypothesis of domestic input separability from imports, linear restrictions that $\gamma_{KK} = \gamma_{LL} = -\gamma_{KL}$ are imposed.[13]

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[11]Since the results of the IZEF procedure are maximum likelihood estimates, we can test hypotheses based on various restrictions imposed on the above equations by using a test-statistic based on the likelihood ratio, λ (Theil, 1971, p. 397).

[12]The requirement that the values of these two terms are equal to zero is sufficient to require all of the other output-input price interaction terms to be equal to zero because of the regularity conditions. If some $\rho_{ij} \neq 0$, input-output separability requires that the ratios of the cost elasticities with respect to each output are independent of all output levels and factor prices. See Brown, Caves, and Christensen (1979, p. 259).

[13]Separability between the domestic inputs requires that the partial elasticity of substitution between capital and imports is equal to that between labor and imports ($\sigma_{KM} = \sigma_{LM}$). For this cost function, the equality of these elasticities of substitution implies that $S_L \gamma_{KM} = S_K \gamma_{LM}$, where S_L and S_K are the input cost shares for labor and capital, respectively. A cost function that is monotonically increasing in factor prices requires that the input shares be positive. After substituting the expressions in the share equations, one finds that separability holds if either

The results additionally provide estimates of the cross and direct price elasticities of demand for the inputs, the quantity elasticities of inverse output supply, the elasticity of output prices with respect to input prices, and the elasticity of the demand for inputs with respect to a change in the output mix. These elasticities can be expressed in terms of the estimated parameters and cost and/or revenue shares.[14]

III. ESTIMATION RESULTS

The IZEF estimates of the translog cost function parameters are given in Table 1.[15] The

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$\$_K/\$_L = (_{KK}/(_{KL} = (_{KL}/(_{LL}$ or that $(_{KM} = (_{LM} = 0$. The latter condition requires that $(_{KK} = (_{LL} = -(_{KL}$. It follows that the translog cost function will also be separable with respect to the inputs if it reduces to the three-factor Cobb-Douglas form, which requires all $(_{ij}$ terms to be equal to zero. The nonlinear separability terms were not tested. See Berndt and Christensen (1973a, p. 86; and 1973b); Berndt and Wood (1975, p. 266); and Burgess (1975, footnote 23, p. 119).

[14]The cross price elasticity of demand $,_{js} = (\mathrm{Mln}\ X_j)/(\mathrm{Mln}\ W_s)$ is
FUNC { epsilon sub{js} ~= ~ S sub {s} ~ +~ {{ gamma sub {js}} over {S sub j}}`.}
The direct price elasticity of demand for input *j* is given by

FUNC { epsilon sub {j}~ = ~ {{ gamma sub {jj} ~ + ~ S sub {j} sup 2 ~-~ S sub {j}} over {S sub {j}}}.}
The other elasticity coefficients are similarly derived (Kohli, 1991, p. 34). The quantity elasticities of inverse output supply can also be called the inverse price elasticities of output supply.

[15]The concavity of the cost function conditions were violated at only two data points, a result that does not preclude translog estimates of the relevant elasticities from being acceptable. See Wales (1977) and Caves and Christensen (1980) for discussions of the implications of violations of the these conditions.

Two tests were conducted on the residuals to test for the presence of serial correlation. First, the conventional single-equation Durbin-Watson statistic for the total cost equation was 2.29, which was in the uncertain region for positive and negative serial correlation at the 5 percent level of significance. See Durbin (1957), Malinvaud (1970, p. 509), and Berndt and Christensen (1973a, p. 95) for a discussion regarding use of the Durbin-Watson statistic to check for serial correlation in the case of simultaneous equations.

Second, a Lagrange multiplier test for serial correlation was conducted on the total cost equation using lagged values of the error term ranging from one to eight periods (see Godfrey, 1988, pp. 112-117). In all cases, the value of the LM statistic was such that the null hypothesis that D was equal to zero could not be rejected at the 5 percent level of significance.

estimates in the first column are for the original model with the maintained hypotheses of linear homogeneity in input prices and a linearly homogeneous transformation function. The second and third column estimates were derived when the additional restrictions for linear input-output separability and the restrictions for linear separability of capital and labor from imports were imposed, respectively, on the original model. The values of the logs of the likelihoods are such that the null hypothesis that the additional restrictions required for either of these two types of separability are valid could be rejected at the 5 percent level of significance. Thus, the initial model without the separability restrictions was used as the final model.[16] These findings imply that the transformation process is not separable with respect to a partitioning between inputs and outputs, and therefore combining consumption goods and investment goods into one aggregate output is not appropriate for Germany. Also, the domestic inputs of capital and labor cannot be isolated from imports in the production process.

While the majority of the estimated coefficient values in the final model were significantly greater or less than zero at the five percent level of significance, a few, including the dummy variable coefficients, were not. The findings with respect to the dummy variables suggest that neither German unification nor the establishment of the single currency had a statistically significant impact on aggregate costs. Omitting the dummy variables, however, resulted in a greater number of violations of the regularity conditions.

The coefficient estimates in Table 1 are not generally of interest in and of themselves, but the

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The Regression Specification Error Test (RESET) test was also used to test for model misspecification. Tests were conducted using squared, cubed, and fourth power terms containing the predicted values of the dependent variable. The F-value in each of these cases was such that no model misspecification was indicated.

[16]Two restrictions were added in each case ($D_{CK} = D_{CL} = 0$ for the second model and $(_{KM} = (_{LM} = 0$ for the third model). See Aizcorbe (1992) for a discussion of the limitations of empirical

elasticity estimates calculated from these estimated parameter values and input shares are important. A summary of the these elasticity values for the model with only the initial restrictions is given in Table 2. The direct price elasticities of demand for the three inputs are shown at the top of the table. These calculated price elasticities of demand are negative as would be expected, but inelastic.[17]

Using a bootstrap technique [Eakin, McMillen, and Buono, 1990], we were able to derive means and standard deviations for the difference between the calculated elasticities in 1968 and 2005 as well as statistics to test whether the mean elasticity estimates were significantly different from zero. In the case of the direct elasticities, the mean values of the estimated direct price elasticities of demand for capital and labor (E_{KK} and E_{LL}, respectively), were significantly less than zero at the 1 percent level of significance, but the mean estimated direct price elasticity of demand for imports (E_{MM}) was not significant even at the 15 percent level, because of the relatively high standard deviation of those values. The values of E_{KK} and E_{LL} did not change significantly over time. However, the value of E_{MM} did decrease (*increase* in absolute value) significantly over time, suggesting that the quantity demanded of German imports has become more price sensitive over time.

The estimated input cross price elasticities are also summarized in Table 2, and the bootstrap

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tests of separability with functional forms.

[17]Other studies have estimated inelastic price elasticities of demand for inputs using a translog cost function and, on an aggregate basis using time series data, such a result is not surprising. For example, see Griffin and Gregory (1976, p. 852); Berndt and Wood (1975, p. 265); Burgess (1974a, p. 231, and 1975, p. 118); Kohli (1978, p. 176, and 1982); and Mohabbat, Dalal, and Williams (1984, p. 598). Mohabbat and Dalal (1983, p. 718) obtained inelastic price elasticity of demand estimates for domestic Korean inputs, but their estimates were consistent with an elastic price elasticity of demand for imports. Using a different methodology, Legendre and Le Maitre (1998, p. 13) obtain an even lower estimate of the relative-cost elasticity of employment. They find that a 1% decrease in labor costs, *given the output level*, would increase employment by only between 0.4 and 0.18 percent. However, the output effects of a decline in

procedure was again used to check for their significance. These results indicate that the input pairs of capital-labor and labor-imports were substitutes, but that capital and imports were complements. The mean estimated values of both E_{KL} and E_{LK} were significantly greater than zero at the 1 percent level, and those for E_{LM} and E_{ML} were significant at the 10 percent and 15 percent levels, respectively. The values of E_{LM} and E_{ML} increased significantly over time, indicating that the substitutes relationship between labor and imports has become stronger. However, the mean estimated values of E_{KM} and E_{MK} were not significant at any reasonable level, suggesting that the complementary relationship, if it exists, is weak, and it did not become stronger (increase in absolute value) significantly over the study period. The results for labor and imports suggest that a reduction in the price of imports will have a negative and larger (in absolute value) effect than in previous years on the quantity demanded of domestic labor, a situation that does not bode well for the German labor market as global economic integration continues. A complementary relationship between domestic capital and imports suggests that a decrease in the price of imports would increase the demand for capital, but this effect is too weak to be significant.

The second section of Table 2 shows the effect of changes in the mix of outputs on output prices. With positive marginal costs, one would expect that an increase in the output of either type of good (consumption or investment) would be associated with an increase in its own price.[18] Thus, E_{CC} and E_{II} would be expected to be positive, as is the case in Table 2, and their mean estimated values were significantly greater than zero. The estimated values for quantity elasticities of inverse output supply increased over time at the 5% significance level for E_{II} and at

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labor costs may be significant.

[18]The convexity of the cost function in outputs implies that the inverse output supply functions are nondecreasing in their respective quantities.

the 7.5% level for E_{CC}, suggesting increasing output price flexibility may be developing in the German market.

The third part of Table 2 gives the effect on output price of a change in input prices. The price of labor appears to be the most important input price affecting the price of both consumption and investment goods. The smallest values for the price elasticities of inverse output supply were those for E_{IM}, and they were the only ones whose mean estimated values were not significantly greater than zero at the 1 percent significance level (they were positive at the 10 percent level). Thus, import prices, compared with the prices of other inputs and consumption goods, apparently have the smallest effect on the price of investment goods. This result suggests that a decrease in import prices would have a greater effect on consumption goods prices than on investment goods prices. This finding may be unsettling to German policymakers concerned that a decrease in import prices would encourage consumption spending at the expense of investment spending. They may well prefer to see relatively more investment spending and less consumption spending to promote long-term economic growth.

The values of E_{CK} and E_{IK} *decreased* (5 percent significance level), while the values of E_{CM} and E_{IM} *increased* (at the 1 and 10 percent significance levels, respectively) between 1968 and 2005. These results may reflect the fact that the cost share of imports was increasing while that of capital was declining during the study period. So, imports are becoming a more important influence on domestic goods prices. Thus, a decrease in import prices would have a more substantial negative effect on the prices of German consumption and investment goods than previously. Of course, the effect of an *increase* in the price of imports would be greater as well.

The last section of Table 2 shows the quantity elasticities of input demand--the effect that a change in the quantities demanded of the final products will have on the quantities demanded of the inputs. The mean estimated values of these variables were all greater than zero at the 1 percent significance level except for those of E_{MI}, which were greater than zero at the 10 percent level. Only the values of E_{LC} and E_{LI} changed significantly over time (6% significance level), with E_{LC} increasing and E_{LI} decreasing. Thus, the quantity demanded of labor is apparently becoming more sensitive to an increase in the production of consumption goods, but less so to investment goods production.

IV. CONCLUSIONS

The results of this study suggest that it is not appropriate to combine the outputs of consumption and investment into one aggregate output in estimating an aggregate cost function for Germany, nor are the inputs of capital and labor separable from imports. While only the mean estimated values of the direct price elasticities of demand for capital and labor were significantly less than zero, the estimated value of the price elasticity of demand for imports did become significantly larger in absolute value over the study period. The estimated cross price elasticities of demand for the input pairs of capital-labor and labor-imports indicated that the inputs in both pairs were substitutes for one another. However, capital and imports appeared to have a weak complementary relationship that did not get stronger over time. On the other hand, the substitutes relationship between labor and imports has grown significantly stronger over time. Thus, if imports become cheaper as globalization progresses, those price decreases will have a larger negative effect on the quantity demanded of labor, and further integration of the international markets is likely to present greater problems in terms of unemployment for Germany.[19] A complementary relationship between capital and imports would bode well for

[19]It is worth noting that Germany has laws that significantly restrict the ability to lay off workers, including a requirement to give up to seven months notice and two weeks' pay for each

capital goods suppliers if import prices fall, but it was too weak to be statistically significant.

As would be expected when marginal costs are positive, the own quantity elasticities of inverse output supply were positive. Moreover, they increased significantly over the period of study, consistent with increasing output price flexibility and perhaps reflecting the increasing role of international markets in Germany. The price elasticities of inverse output supply suggest that a drop in import prices would have a greater effect on the prices of consumption goods than investment goods, encouraging more consumption spending at the expense of investment goods. The latter result could be frustrating for German policymakers who are concerned about promoting long-term growth. The findings also indicated that import prices had a proportionally greater effect on the prices of domestic goods in 2005 than in earlier years. Finally, the results suggested that the quantity demanded of labor is apparently becoming more sensitive to a change in consumption goods output, but less sensitive to changes in the production of investment goods. This last finding may reflect an increasing capital intensity in the production of investment goods.

These results all suggest that further economic integration will present difficulties for Germany, particularly in the area of domestic employment. Moreover, the effects of globalization appear to be generally greater in recent years than they were previously. Recently, Germany (and some other European nations) have used a government-subsidized reduction in worker hours, the *kurzarbeit* program, in an attempt to limit the increase in unemployment.[20] However, such programs do not address potential needs for structural changes such as the array of domestic outputs produced or the methods by which they are produced. In addition, a recent

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year of employment (Thornton, 2009, p. 53).

[20]Workers can apparently participate in the *kurzarbeit* plan for as long as two years ("The Price of Saving Jobs in Germany," *Bloomberg Businessweek,* August 2-August 8, 2010, pp. 12-

decision to make a balanced budget a provision in the German constitution will further limit the options of policymakers (Münchau, 2009). Moreover, the economic problems of many of the other countries of the EMU may cause difficulties for Germany as well. While she benefitted from the falling euro in the summer of 2010, it still appears clear that Germany will face substantial challenges in the economic realm in the years ahead.[21]

13; and "You're Not Fired," *Financial Times*, June 18, 2009, p. 14).

[21] Simon Kennedy, "Germany Reaps the Euro's Reward," *Bloomberg Businessweek*, July 19-July 25, 2010, pp. 13-14.

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Table 1: Estimates of Cost Function Parameters (t-values)

	Initial Restrictions	Output Separability	[(K,L),M] Separability
α_0	-0.12271 (-8.385)	-0.13129 (-9.333)	-0.12581 (-8.630)
α_T	0.00829 (4.726)	0.01040 (6.741)	0.01298 (7.154)
α_{TT}	-0.00035 (-2.489)	-0.00049 (-4.292)	-0.00080 (-5.705)
α_C	0.78409 (36.971)	0.77116 (121.070)	0.76114 (39.722)
β_K	0.27268 33.602)	0.26329 (36.133)	0.25104 (28.344)
β_L	0.54006 (31.532)	0.53996 (42.362)	0.55705 (61.392)
γ_{KK}	0.05194 (6.844)	0.06149 (9.024)	0.03935 (5.820)
γ_{LL}	0.06769 (2.748)	0.05564 (3.421)	0.03935 (5.820)
γ_{KL}	0.01134 (1.318)	0.00204 (0.321)	-0.03935 (-5.820)
δ_{CI}	-0.35039 (-9.694)	-0.37623 (-12.313)	-0.32850 (-8.992)
ρ_{CK}	-0.02871 (-2.052)		-0.00619 (-0.418)
ρ_{CL}	-0.00708 (-0.289)		-0.01403 (-0.739)
γ_{KT}	-0.00222 (-2.827)	-0.00227 (-3.902)	-0.00327 (-7.682)
γ_{LT}	0.00015 (0.380)	0.00061 (1.771)	0.00103 (2.423)
ρ_{CT}	-0.00256 (-2.560)	-0.00183 (-6.442)	-0.00142 (-1.546)
Dummy U	-0.01162 (-0.897)	-0.01436 (-1.077)	0.02554 (1.690)
Dummy E	-0.01388 (-0.989)	-0.00674 (-0.473)	0.00448 (0.274)
Log Likelihood	430.46	426.79	409.22

Table 2: German Aggregate Elasticities Estimates

	1968	1980	1990	2000	2005
Direct and Cross Price Elasticities of Input Demand:					
$E_{js} = M(\ln X_j)/M(\ln W_s)$					
E_{KK}	-0.529	-0.542	-0.544	-0.532	-0.492
E_{LL}	-0.364	-0.349	-0.329	-0.320	-0.321
E_{MM}	- 0.098	-0.150	-0.134	-0.194	-0.226
E_{KL}	0.539	0.566	0.596	0.621	0.638
E_{LK}	0.318	0.272	0.253	0.201	0.162
E_{KM}	-0.010	-0.024	-0.052	-0.090	-0.146
E_{MK}	-0.015	-0.026	-0.054	-0.062	-0.069
E_{LM}	0.046	0.077	0.076	0.119	0.159
E_{ML}	0.113	0.175	0.188	0.256	0.295
Quantity Elasticities of Inverse Output Supply:					
$E_{ir} = M(\ln P_i)/M(\ln Y_r)$					
E_{CC}	0.204	0.208	0.201	0.202	0.210
E_{CI}	-0.204	-0.208	-0.201	-0.202	-0.210
E_{IC}	- 0.501	-0.541	-0.476	-0.482	-0.569
E_{II}	0.501	0.541	0.476	0.482	0.569
Price Elasticities of Inverse Output Supply:					
$E_{ij} = M(\ln P_i)/M(\ln W_j)$					
E_{CK}	0.255	0.211	0.192	0.140	0.102
E_{CL}	0.491	0.511	0.537	0.548	0.548
E_{CM}	0.254	0.279	0.271	0.312	0.349
E_{IK}	0.395	0.354	0.329	0.278	0.248
E_{IL}	0.525	0.546	0.571	0.582	0.584
E_{IM}	0.080	0.100	0.100	0.140	0.168
Quantity Elasticities of Input Demand:					
$E_{ji} = M(\ln X_j)/M(\ln Y_i)$					
E_{KC}	0.614	0.608	0.579	0.546	0.527
E_{KI}	0.386	0.392	0.421	0.454	0.473
E_{LC}	0.697	0.709	0.690	0.692	0.718
E_{LI}	0.303	0.291	0.310	0.308	0.282
E_{MC}	0.887	0.879	0.865	0.842	0.849
E_{MI}	0.113	0.121	0.135	0.158	0.151