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Jerry G. Thursby

Marie C. Thursby

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Jerry G. Thursby

and

Marie C. Thursby

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the authors.

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1. INTRODUCTION

The empirical literature on the determinants of bilateral trade flows has largely focused on (i) the gravity model, (ii) the Linder hypothesis, and (iii) the effect of exchange rate variability. Although specifications vary by study, the value of trade between two countries in a gravity model is a positive function of incomes of the countries and a negative function of the distance between them. This model has a long history of empirical success (See Deardorff (1984) for a survey of Tinbergen (1962), Poyhonen (1963a and b), Linnemann (1966) and other studies) and has been justified theoretically by Leamer and Stern (1970), Anderson (1979), and Bergstrand (1985). The bilateral version[1] of the Linder hypothesis is that trade of manufactured goods between two countries will be inversely related to the difference in their per capita incomes. Tests of this hypothesis have produced mixed results (See Deardorff (1984)). While researchers generally find a high proportion of bilateral trade occurring between countries with similar levels of per capita income, attempts to control for the role of transport costs (i.e. close proximity of countries with similar incomes) have tended not to support Linder's hypothesis (See Gruber and Vernon (1970), Hirsch and Lev (1973), Kennedy and McHugh (1980); Abrams (1980) is an exception). Finally, Hooper and Kohlhagen (1978), Abrams (1980), Cushman (1983), and Thursby and Thursby (1985) have found support for the hypothesis that exchange rate variability affects the pattern of bilateral trade.

This paper examines the Linder hypothesis and the effect of exchange rate variability in a gravity-type trade model derived from an underlying

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1 For studies of alternative variants of Linder's hypothesis see Blejer (1978), Hunter and Markusen (1985) and Markusen (1985).

demand and supply model. Previous studies have tended to address the three issues separately,[1] and with the exception of Linnemann (1966), Bergstrand (1985), Hooper and Kohlhagen (1978), and Cushman (1983), the equations estimated in the empirical studies have been ad hoc specifications. Our purpose is to show that a behavioral model can be used to justify examining these issues jointly, and that, in fact, such a model performs well empirically. In Section 2 we present a demand and supply model general enough to allow for the effects of exporters and importers hedging through the forward exchange market. In Section 3 it is shown that this system leads to a reduced form equation similar to a gravity model capable of examining the Linder hypothesis and the effects of exchange rate variability when commonly used proxies are substituted for unobtainable data.

The model is estimated for a sample of 17 countries for the period 1973-1982. Estimation procedure and results are given in Sections 4 and 5. The results are interesting in that we find overwhelming support for the Linder hypothesis and this version of the gravity model. Although results are not uniform across countries, we also find strong support for the hypothesis that increased exchange rate variability affects bilateral trade flows. Several distinquishing features of our approach make these results particularly interesting: (i) to our knowledge this sample size (both in terms of countries and time period) is larger than others; (ii) rather than arbitrarily deciding to pool data across countries, we test for the appropriateness of the common practice of estimating a single equation for all countries and find that such a pooling would be inappropriate; (iii) we

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1 The gravity model has been used in several studies of the Linder hypothesis (Gruber and Vernon (1970), Hirsch and Lev (1973)) and exchange rate variability (Abrams (1980)).

estimate equations using both real and nominal measures of exchange rates, and finally (iii) we use a non-nested test procedure to test which of our equations, if any, are correctly specified. This last procedure applied to our estimates suggests that for most countries our specifications are appropriate and that the effects of real and nominal exchange rate variability are largely indistinquishable.

2. THE MODEL

The model is a static demand and supply model explaining the pattern of aggregate exports from some country i to a set of countries j (j=1,...,16). The underlying model of demand is a standard one in which the quantity of i's aggregate export good demanded by the jth importing country is a function of the import price of that good, the price to importers in country j of other goods, and j's income and tastes. The underlying supply model is one in which the ith exporting country's supply of its good to country j is a function of the price in its own currency of selling to j, the price of selling the good elsewhere, and production possibility (proxied by income).

We express the import price of i's export good as $PD_j^i = P_j^i \cdot R_j^i \cdot T_j^i \cdot C_j^i \cdot HI_j^i$ where P_j^i denotes the export price in i's currency, R_j^i is the spot price i's currency in terms of j, T_j^i is one plus any tariff j places on i's good, C_j^i is a transport cost factor(c.i.f./f.o.b.), and HI_j^i is a factor to reflect any hedging done by importers in j. If importers in j do not hedge in the forward market, $HI_j^i=1$, and our expression for P_j^i is the commonly assumed one in studies abstracting from exchange risk. However, to the extent that importers hedge against foreign exchange risk, their cost of foreign exchange is not R_j^i but a weighted average of the forward and spot exchange rate with the weights depending on the portion of contracts hedged through the forward market (See Ethier (1973) and Hooper and Kohlhagen (1978) for examples). In that case R_j^i is not the correct rate of conversion between the currencies, and HI_j^i is included to reflect the extent to which the true cost of foreign exchange to importers differs.

If a portion of the contracts between exporters and importers in i and j are denominated in j's currency, then exporters may hedge through the forward market. To the extent that this occurs, the own currency receipts of exporters in i will be affected by differences between the forward rate and the relevant future spot rate of exchange. Following Hooper and Kohlhagen, we express the per unit own currency receipt of exporters in i as $PS_j^i = P_j^i \cdot HE_j^i$, where HE_j^i is a factor reflecting the extent to which hedging in the forward market alters the own currency receipts of exporters in i selling to importers in j.

The price of other goods in j's demand for i's exports can be represented by country j's CPI and an index of other import prices. Similarly, the prices to exporter i of selling in markets other than the j'th can be represented by i's CPI and an index of export prices to other countries.

In log form demand and supply are given by

$$\text{Demand:}\quad \ln Q_{jt}^i = \alpha_0 + \alpha_1 \ln P_{jt}^i + \alpha_2 \ln R_{jt}^i + \alpha_3 \ln T_j^i + \alpha_4 \ln C_{jt}^i + \alpha_5 \ln HI_{jt}^i + \alpha_6 \ln PD_{jt}^o + \alpha_7 \ln CPI_{jt} + \alpha_8 \ln G_{jt} + \alpha_9 \ln Z_{jt}^i + \varepsilon_{1t} \tag{1}$$

$$\text{Supply:}\quad \ln Q_{jt}^i = \beta_0 + \beta_1 \ln P_{jt}^i + \beta_2 \ln HE_{jt}^i + \beta_3 \ln PS_{ot}^i + \beta_4 \ln CPI_i + \beta_5 \ln G_{it} + \varepsilon_{2t} \tag{2}$$

where t refers to the time period;

Q^i_{jt} = quantity of exports from i to j;

PD^i_{jt} = import price of i's exports to j;

PD^o_{jt} = index of import prices of exports of other countries;

$CPI_{\tau t}$ = consumer price index in country τ (τ=i,j);

$G_{\tau t}$ = GNP of country τ (τ=i,j);

P^i_{jt} = export price of i's exports to j;

PS^i_{ot} = index of net export prices of i's exports to other countries; and

Z^i_{jt} = variable reflecting tastes in j for i's export good.

The reduced form equations for $\ln Q^i_{jt}$ and $\ln P^i_{jt}$ are

$$\begin{aligned}\ln P^i_{jt} &= \pi_0 + \pi_1 \ln R^i_{jt} + \pi_2 \ln T^i_{jt} + \pi_3 \ln C^i_{jt} + \pi_4 \ln HI^i_{jt} \\ &\quad + \pi_5 \ln PD^o_{jt} + \pi_6 \ln CPI_{jt} + \pi_7 \ln G_{jt} + \pi_8 \ln Z^i_{jt} + \pi_9 \ln HE^i_{jt} \\ &\quad + \pi_{10} \ln PS^i_{ot} + \pi_{11} \ln CPI_{it} + \pi_{12} \ln G_{it} + v_{1t} \\ &\equiv \pi_0 + \Sigma^{12}_{k=1} \pi_k X_{kt} + v_{1t} \end{aligned} \tag{3}$$

$$\begin{aligned}\ln Q^i_{jt} &= \gamma_0 + \gamma_1 \ln R^i_{jt} + \gamma_2 \ln T^i_{jt} + \gamma_3 \ln C^i_{jt} + \gamma_4 \ln HI^i_{jt} \\ &\quad + \gamma_5 \ln PD^o_{jt} + \gamma_6 \ln CPI_{jt} + \gamma_7 \ln G_{jt} + \gamma_8 \ln Z^i_{jt} + \gamma_9 \ln HE^i_{jt} \\ &\quad + \gamma_{10} \ln PS^i_{ot} + \gamma_{11} \ln CPI_{it} + \gamma_{12} \ln G_{it} + v_{2t} \\ &\equiv \gamma_0 + \Sigma^{12}_{k=1} \gamma_k X_{kt} + v_{2t}. \end{aligned} \tag{4}$$

where

$\pi_0 = (\alpha_0 - \beta_0)/D$ $\qquad$ $\gamma_0 = (\alpha_0\beta_1 - \alpha_1\beta_0)/D$

$\pi_k = \alpha_{k+1}/D \quad (k=1,\ldots,8)$ $\qquad$ $\gamma_k = \beta_1\alpha_{k+1}/D \quad (k=1,\ldots,8)$

$\pi_k = -\beta_{k-7}/D \quad (k=9,\ldots,12)$ $\qquad$ $\gamma_k = -\beta_{k-7}\alpha_1/D \quad (k=9,\ldots,12)$

$v_{1t} = (\varepsilon_{1t} - \varepsilon_{2t})/D$ $\qquad$ $v_{2t} = (\beta_1\varepsilon_{1t} - \alpha_1\varepsilon_{2t})/D$

and $D = \beta_1 - \alpha_1$.

3. EMPIRICAL IMPLEMENTATION

Ideally, one would estimate equations (3) and (4); however, data for P^i_{jt} and Q^i_{jt} are not generally available (particularly for a large sample of countries). On the other hand, data for their product ,

$$PQ^i_{jt} = \exp(\pi_0 + \Sigma^{12}_{k=1} \pi_k X_{kt} + v_{1t}) \cdot \exp(\gamma_0 + \Sigma^{12}_{k=1} \gamma_k X_{kt} + v_{1t}) ,$$

is easily obtained for IMF countries from The Direction of Trade, so that the following equation can be estimated

$$\ln PQ^i_{jt} = \delta_0 + \Sigma^{12}_{k=1} \delta_k X_{kt} + u_t \qquad (5)$$

where $\delta_\tau = \pi_\tau + \gamma_\tau$ ($\tau=0,\ldots,12$) and $u_t = v_{1t} + v_{2t}$.

To see how this equation relates to the gravity model and hypotheses of interest, consider the data available for variables 1 through 12. As was the case for price and quantity of bilateral trade, direct data for several of these variables are not available for a large sample of countries. In fact, only the exchange rate, CPI, and income are easily available. Once we substitute commonly used proxies for the others, our estimating equation is similar to the gravity model, with the exception that it allows for the Linder hypothesis and a proxy for exchange risk.

For the c.i.f./f.o.b. factor we substitute distance and a dummy for adjacency. Following Aitken (1973), we substitute dummies for EEC and EFTA membership in place of T^i_j. A simple version of the gravity model would include these variables plus the incomes of the exporting and importing countries. Bergstrand (1985) has shown that this simple version of the gravity model can be derived in an optimizing framework with perfect arbitrage if all goods are perfectly substitutable internationally in consumption and production. There is, however, considerable evidence that in general neither of these assumptions holds (Isard (1977), Marvel and Ray

(1985), Ray (1986), Richardson (1978), and Kravis and Lipsey (1984)). For that reason Bergstrand estimates a generalized gravity equation which includes the exchange rate, domestic price indices for both the exporter and importer, the exporter's unit value of exports, and the importer's unit value of imports. Our inclusion of R_j^i, CPI_i, CPI_j, PD_j^o, and PS_o^i makes equation (5) similar to his estimating equation. As a measure of PD_j^o we follow Bergstrand in using j's unit value of imports, and for PS_o^i we use i's unit value of exports. If import and export price indices are calculated in a comparable fashion across countries, these are reasonable approximations of indices computed from import and export price data for bilateral trade (data for the latter two being unavailable).

Z_j^i is included to reflect differences in importer j's tastes regarding the exports of different countries. Since our specification (by including price variables) is consistent with product differentiation across countries, it is reasonable to assume that tastes regarding these differentiated products will vary. But notice that this argument is a part of Linder's argument as to why trade in manufactured goods will tend to be concentrated among countries with similar levels of per capita income. Linder (1961) hypothesized that suppliers of differentiated products would tailor their products to the tastes of domestic purchasers, and that to the extent that tastes abroad were similar, one would tend to observe intra-industry trade between regions.[1] He went on to recommend per capita income as a measure of demand structure or tastes, so that trade between two

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1 Although this explanation pertains to consumer goods, one could easily argue that intra-industry trade in intermediate goods would tend to occur between countries which produced similar types of manufactured goods. Empirically, in fact, such trade may be more important that intra-industry trade of consumer goods (Ethier (1982),Marvel and Ray (1985), Ray (1986)).

regions would be a negative function of the absolute difference in per capita income in the two regions. Substituting this difference for Z_j^i in estimating (5) allows us to test Linder's hypothesis.

Just as most studies of the gravity model have omitted price variables, they have also abstracted from issues of foreign exchange risk. A number of theoretical studies (Clark (1973), Ethier (1973), Baron (1976), Hooper and Kohlhagen (1978)) have shown conditions under which exchange rate uncertainty will affect the volume and price of exports. While empirical evidence based on total trade of countries fails to show any significant affect of exchange risk on trade (Clark and Haulk (1972), Makin (1976), and Kenen (1980)), there is limited evidence (Hooper and Kohlhagen (1978), Abrams (1980), Cushman (1983), and Thursby and Thursby (1985)) that bilateral trade flows are significantly related to various measures of exchange-rate variability as proxies for exchange risk. For that reason, our underlying demand and supply equations are specified in a manner which allows us to test for such an effect. That is, we would expect HI_j^i and HE_j^i to be significantly related to the value of i's trade with j only when exchange risk affects the demand and/or supply functions. Since direct measures of HE_j^i and HI_j^i do not exist for trade aggregated over goods, we follow other studies in using variability in the exchange rate as a proxy measure.

Lacking a single theoretically correct measure of variability, previous studies have used a number of measures. These are surveyed in Akhtar and Hilton (1984) and Thursby and Thursby (1985). The measure we use is the variance of the spot exchange rate around its predicted trend, where trend is estimated from

$$R_{jt}^i = \phi_0 + \phi_1 t + \phi_2 t^2 + \varepsilon_{jt}^i \quad . \tag{6}$$

The rationale for this measure is that since variability is a proxy for exchange risk, we are interested in capturing the portion of exchange rate variation which is unexpected or unpredicted. The quadratic form of (6) allows for the possibility that trend may not be linear.

Two final issues deserve attention. First, our exchange rate data are monthly and trade flow data are yearly (See Data Appendix), so that the exchange-rate variable entered in the regression must be some aggregate over time. In particular, we compute the mean percentage change in the predicted rate (from (6)) within the year as a measure of R_j^i. Second, there has been discussion in the literature as to whether variability in the real or the nominal exchange rate is the appropriate proxy for exchange risk. As argued by Cushman (1983), if firms maximize the real value of profits in a world where prices as well as exchange rates vary, then it is variability in the real exchange rate which affects firm behavior. For that reason, we estimate two versions of (5), one which incorporates variance around predicted trend in the nominal exchange rate and one which measures variance around the predicted trend in $R_j^i CPI_i / CPI_j$.

In summary, the equation we actually estimate is equation (5) with the following changes. $X_{2t}^i = T_j^i$ is proxied by a dummy for preferential trading. $X_{3t} = C_j^i$ is proxied by two variables, distance (D_j^i) and an adjacency dummy(A_J^i). Both $X_{4t} = HI_j^i$ and $X_{9t} = HE_j^i$ are proxied by a single variable, VAR_j^i, the variance of predicted trend in R_j^i.

4. ESTIMATION PROCEDURE

Seventeen regression equations are estimated. Each equation explains the export pattern for some country i (i=1,...,17). We have 16 cross-sectional observations over a ten year period for a total of 160 observations for each equation. That is, at some time period t (t=1,...,10) we observe the value of exports, as well as regressors, from some country i to 16 other countries. For simplicity we write the system to be estimated as

$$y_{jt}^{1} = X_{jt}^{1\prime}\delta^{1} + u_{it}^{1} \qquad j=2,\ldots,17; \quad t=1,\ldots,10$$

$$y_{jt}^{2} = X_{jt}^{2\prime}\delta^{2} + u_{jt}^{2} \qquad j=1,3,\ldots,17; \quad t=1,\ldots,10 \tag{7}$$

$$\ldots$$

$$y_{jt}^{17} = X_{jt}^{17\prime}\delta^{17} + u_{jt}^{17} \qquad j=1,\ldots,16; \quad t=1,\ldots,10$$

where $y_{jt}^{i} \equiv \ln PQ_{jt}^{i}$, X_{jt}^{i} is a vector of regressors. Recall that δ^{i} is a vector of unknown coefficients, superscripts refer to the exporting country, and subscripts refer to the importing country and the time period. The u_{jt}^{i} are assumed to be jointly normal and independent across equations. Further aspects of their distributions are discussed below.

We use the log-log specification for the demand and supply equations, in part, because of its popularity in empirical trade models and, in part, because of two difficulties with estimating a linear model. First, linear demand and supply equations imply that the value equations are quadratic in the exogenous variables and that each model has 66 or more regressors. Second, linear demand and supply equations suggest disturbances with a very complicated heteroscedastic structure.

It is common in cross-section work to observe (or presume) heteroscedasticity, particularly when the dependent variable varies substantially across cross-sectional units as it does here. That is, exports from country i to country j vary little through time compared to variation in exports to different countries at a point in time. A reasonable model of the disturbances allows for a variance which varies across j but is constant across t; that is, $\text{var}(u^i_{jt}) = (\sigma^i_j)^2$. Unfortunately, without additional restrictions the disturbance variances are not identified because of only ten years of data. Rather than try to create a story to justify further restrictions on the form of heteroscedasticity we follow the estimation procedure suggested by White (1982) and modified by MacKinnon and White (1985). Their method retains the least squares coefficients but uses a covariance matrix estimator that is consistent. In matrix notation, an equation from (7) is $y = X\delta + u$ where the row dimension of y is n, so that the suggested covariance estimator for the OLS estimator of δ is

$$\left(\frac{n-1}{n}\right)(X'X)^{-1}[X'\Omega X - (X'\hat{u}\hat{u}'X)/n](X'X)^{-1}$$

where $\hat{u}$ is the vector of OLS residuals and $\Omega = \text{diag}(\hat{u}_1^2, \hat{u}_2^2, \ldots, \hat{u}_n^2)$.

The virtue of the procedure is that it does not require specification of a model of heteroscedasticity and thus avoids the potentially deleterious effects of an incorrect specification. Though the coefficient estimates are inefficient, t and F tests are valid. MacKinnon and White do not recommend tests for heteroscedasticy based on their procedure because of low power and because the procedure works well even in the absence of heteroscedasticity. We compared the least squares t statistics with those based on the heteroscedastic-consistent covariance matrix and found that the latter t statistics are generally smaller, though the differences are typically not great. All reported t statistics are based on the MacKinnon-White covariance matrix.

We did not address the issue of autocorrelation for several reasons. It is not reasonable in a setting such as this to postulate a particular autoregressive process for each equation. The more common aproach is to assume a different autoregressive process for each cross-sectional unit.

That is, if we postulate AR(1) processes, then $u^i_{jt} = \rho^i_j u^i_{jt-1} + e^i_{jt}$. Estimates of each ρ^i_j would be based on only 9 observations, with attendent problems of efficiency of estimators and power of tests for $\rho^i_j=0$. In addition, with annual observations one does not typically find highly autocorrelated disturbances.

It is not uncommon in studies such as this to pool data from all countries (see, for example, Linneman (1966), Aitken (1973), Abrams (1980), and Bergstrand (1985)). In that case, the implied restrictions for the system (7) are $\delta^1=\delta^2=\ldots=\delta^{17}$. These restrictions are testable. Rather than consider a joint test that all seventeen coefficient vectors δ^i are equal, we test the equality of coefficient vectors for every pair of equations. That is, we test 136 null hypotheses $\delta^i=\delta^j$ (i,j=1,2,...,17; i≠j). The familiar Chow test for equality of coefficient vectors across equations is appropriate only if there is a common disturbance for all observations (see, for example, Toyoda (1974)), an assumption that appears to be untenable. Instead, a series of Wald tests are used. Watt (1979) shows the superiority of Wald tests over several other procedures in this setting, though the size of the test tends to be too large. Kobayashi (1985) suggests bounds for the critical value of the Wald test.

Let d^i and d^j be the OLS estimates of δ^i and δ^j from (7). The Wald statistic for the null hypothesis $\delta^i=\delta^j$ is

$$w = (d^i-d^j)'(\mathrm{cov}(d^i)+\mathrm{cov}(d^j))^{-1}(d^i-d^j)$$

where $\mathrm{cov}(d^\tau)$ is the estimated covariance matrix for d^τ. the tests are performed using both the OLS covariance matrix and the heteroscedastic-consistent covariance matrix of MacKinnon and White (see above). Let $F(\alpha;p,n)$ be the critical point from the F distribution with p and n degrees of freedom in a test with size α. Kobayashi's bounds on the critical point for an α level Wald test of $\delta^i = \delta^j$ are $F(\alpha;p,\min(n_i-p,n_j-p))$ and $F(\alpha;p,n_i+n_j-2p)$ where n_τ is the sample size used to estimate δ^τ and p is the number of coefficients compared. Since the number of coefficients is not the same for all countries (see the above definitions of regressors A_j^i and T_j^i), we compare only the coefficients of those regressors that appear in all models in the system (7). Since in every case the Wald statistics are greater than the upper bounds given by Kobayashi, we decisively reject the restrictions necessary for pooling any of the data.

As noted in Section 3, a distinquishing feature of this study is that we estimate (5) using measures of both nominal and real exchange rate variability. To distinquish which, if either, of these competing and non-nested models is appropriate, we use the JA test procedure described as follows (see, for example, McAleer (1984)). Consider the two competing models

$$y = Z_1\Theta_1 + u_1$$

and $$y = Z_2\Theta_2 + u_2$$

used to explain the dependent variable y. The regressor matrix Z_1 is not nested in Z_2 nor is Z_2 nested in Z_1. Consider also the augmented regressions

$$y = Z_1\Theta_1 + \Psi_1 B_2 B_1 y + u_1$$

and $$y = Z_2\Theta_2 + \Psi_2 B_1 B_2 y + u_2$$

where $$B_i = Z_i(Z_i'Z_i)^{-1}Z_i \quad .$$

For our models, Z_1 and Z_2 are identical except that regressors VAR_j^i and R_j^i are measured using nominal rates in one of the models and real rates in the other. The JA test procedure consists of t-tests of the two null hypotheses $\Psi_1=0$ and $\Psi_2=0$. If $\Psi_i=0$ is rejected, then we reject the model $y = Z_i\Theta_i + u_i$. It is possible to accept both models or to reject both models as well as to accept one and reject the other. A rejection of both models implies that both models are incorrectly specified and a third (and unspecified) model is correct. Acceptance of both models simply means that the data is unable to distinguish between the models.

5. EMPIRICAL RESULTS

Table 1 presents the coefficient estimates and associated t statistics for each country. In interpreting these results recall that equation (5) is a reduced form equation for the value of bilateral trade. Without data for P_j^i or Q_j^i the structural parameters of the model cannot be recovered, so that care needs to be taken in interpreting the coefficients. The coefficient for any variable which appears only on the demand side of the underlying model will have the same sign as the structural parameter in the demand equation. Hence we expect the coefficient of Z_j^i to be negative according to the Linder hypothesis. Likewise, R_j^i should have a negative coefficient reflecting a decrease in the value of exports (denominated in the exporter's currency) in response to an appreciation of exporter i's currency. Distance should have a negative coefficient; and adjacency (A_j^i), the preferential dummy (E_j^i) and G_j should all have positive coefficients. Depending on the substitutability among goods, the coefficients of CPI_j and PD_j^o may be negative or positive. Any variable entering the supply equation or both equations will have an ambiguous sign, so that the coefficients for VAR_j^i, G_i, CPI_i, PS_o^i are ambiguous in sign.

Perhaps the most striking result is the overwhelming support for the Linder hypothesis. For all countries except Canada and South Africa, the coefficient for Z_j^i is negative and significant at the 5% level. Similarly, our results support the gravity model, the coefficients for the gravity variables, D_j^i and A_j^i, all being significant and having the expected sign. The preferential dummy appears to be more important for EFTA countries than for those in the EEC since it is significant and positive only for Austria, Denmark, Finland, and Italy (the latter significant at 10%; all others at 5%).

We also obtain substantial support for the hypothesis that exchange rate risk affects the pattern of bilateral trade among countries. The coefficient for VAR_j^i is significant at the 5% level for twelve of the seventeen countries when the real exchange rate is used, and it is significant at the 5% level for eleven (with an additional one significant at the 20% level) countries when the nominal exchange rate is used. For six of the countries the coefficient is positive and for six it is negative. To interpret these results, recall that not having data for P_j^i prevents us from isolating the price and volume effects of variability. To the extent that import demand shifts back in response to increased variability, we would expect both the volume of exports and the value of exports in the exporter's currency to decline. To the extent that export supply declines, the volume of exports should decline (the amount depending on the elasticity of demand), and the value of exports will decline, as well, if demand is elastic. Hence for those countries with significant positive coefficients (Belgium, Canada, Denmark, Germany, Switzerland, and the United States), the results are consistent with supply shifting back where demand is inelastic. The only sensible economic interpretation of this case is that export price rises. The negative significant coefficients for Austria, Finland, France, Greece, Norway, and the United Kingdom are consistent either with demand shifting back or a backward supply shift and elastic demand. In either event, the negative coefficient implies that volume declines.[1] What we cannot determine in this case is whether the export price rises or declines. Finally, the only case in which we can say nothing is where the coefficient is insignificant. That result is consistent with price and volume effects of a supply shift offsetting each other or insignificant shifts in either demand or supply.

As we would expect, the importing country's GNP is significant and positive in all cases. The results for the exporter's GNP vary. For eight countries the coefficient is negative and significant at least at the 20% level. From equations (3) and (4), it can be seen that the coefficient of exporter's GNP (i.e. G_i) is $[-\beta_5(\alpha_1+1)]/D$. Since we expect D and β_5 to be positive,a negative coefficient implies that the elasticity of demand,$\alpha_1<1$. These results combined with those for VAR_j^i for Belgium, Germany, and Switzerland are consistent with the argument given above of a backward shift in supply and inelastic demand.

Finally, the results of the JA test procedure suggest two things. First equation (5) is an appropriate specification (based on a 5% significance level) for the trade of all countries except Canada, Denmark, France, and South Africa. That is, for all other countries, at least one of the real or nominal equations is accepted. Second, for eleven of the remaining countries, we are unable to distinquish between the real and nominal equations. For the United States, only the real equation is accepted, and for Austria and Italy only the nominal equation is accepted.

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1 This volume effect could be insignificant if demand were to shift back with sufficiently inelastic supply. This appears to be this case for the U.S. and German flows studied by Hooper and Kohlhagen.

6. CONCLUDING REMARKS

In this paper we derive and estimate a model to explain a country's bilateral trade pattern. It is shown that an estimating equation similar to a generalized gravity equation can be derived from fairly standard assumptions about demand and supply. If the importer's demand function includes a term to reflect tastes and if, in addition, we allow for the possibility that risk averse exporters and importers may hedge their foreign exchange transactions through the forward market, the estimating equation will include terms which allow tests of the Linder hypothesis and the effects of exchange risk on the pattern of trade. This is the first paper to show that a complete specification of a gravity equation would include these terms.

The model is estimated for a sample of 17 countries for the period 1973-1982. Based on the JA test procedure, this version of the gravity model is an acceptable specification of bilateral trade in the case of all but four countries. Moreover, Wald tests support our having estimated separate equations for each country's trade. Not only would pooling data into one equation be inappropriate for this sample, but also we reject the pooling of data for exports of any two countries.

We find overwhelming support for the Linder hypothesis. The coefficient of the Linder term is significant and negative for all countries but two, and these two (Canada and South Africa) are countries whose equations are rejected as misspecified. These results are interesting since previous empirical tests of the hypothesis using a gravity model have tended to reject the hypothesis.[1]

There is also strong support for the hypothesis that exchange risk affects the pattern of bilateral trade. Of the countries which have acceptable specifications, four of the VAR coefficients are positive and significant and five are negative and significant (i.e. nine of the thirteen countries with acceptable specifications show significant effects). One virtue of relating equation (5) to the underlying demand and supply equations is that it aids in interpreting these results. Results for countries with positive coefficients are consistent with supply shifting back with demand inelastic. Negative coefficients imply either a backward shift in demand or a backward supply shift and elastic demand.

Finally, this is the only study to present these results for both real and nominal measures of exchange risk. Accordingly, we are able to statistically test for whether real and nominal exchange rate variability affect trade flows differently. At least for this sample the results are indistinquishable.

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1 In this regard, our results are consistent with those of Abrams (1980) who finds support for the Linder hypothesis in a gravity equation which also includes a term for exchange risk. His analysis differs from ours in that he pools data into a single equation, and he uses different measures of exchange risk and only examines nominal exchange rate variability. Moreover, his specification is ad hoc so that it does not include the other price terms that our underlying model implies should be included in the equation.

TABLE 1

Country / Variable	Z^i_j	VAR^i_j	G_j	G_i	R^i_j	CPI_j	CPI_i	D^i_j	PS^i_o	PD^o_j	A^i_j	E_j	RSQ
Austria Real	-.288	-.093	.226	.110	3.791	1.002	-2.660	-.448	2.874	-.659	2.032	.000	.847
(t)	-11.518	7.297	8.332	.171	.731	3.442	-2.972	-8.897	2.353	-2.743	18.944	3.419	
Nominal	.291	-.071	.225	.264	2.537	1.159	-2.912	-.437	2.838	-.703	2.039	.000	.851
(t)	-11.796	7.612	8.482	.415	.477	3.946	-3.247	-8.640	2.373	-2.812	19.733	3.700	
Belgium Real	-.274	.045	.551	-1.393	1.607	.730	-.985	-.912	1.708	-.487	.882	-.000	.826
(t)	-6.527	3.978	11.964	-1.489	.234	1.548	-1.186	-16.131	1.665	-1.484	4.416	-.485	
Nominal	-.275	.041	.547	-1.445	2.563	.633	-1.043	-.912	1.909	-.490	.878	-.000	.825
(t)	-6.516	3.804	11.718	-1.540	.374	1.308	-1.259	-15.509	1.861	-1.420	4.369	-.452	
Canada Real	.073	.104	.670	-.167	-3.603	1.168	-2.505	-8.389	2.574	-1.387	2.247	na	.817
(t)	1.049	6.208	12.162	-.215	-.432	2.383	-1.842	-10.308	2.728	-2.722	7.680		
Nominal	.064	.094	.663	-.348	.586	.997	-1.729	-8.291	2.150	-1.499	2.338	na	.811
(t)	.919	5.433	11.618	-.454	.075	1.939	-1.223	-10.094	2.283	-2.835	7.573		
Denmark Real	-.437	.026	.334	.140	1.757	2.615	-1.581	-.774	1.675	-1.923	1.284	.005	.735
(t)	-11.704	2.029	7.660	.250	.233	8.318	-.893	-11.805	.741	-6.725	4.541	9.667	
Nominal	-.441	.032	.340	.047	9.216	2.419	-1.217	-.776	1.404	-1.759	1.299	.467	.741
(t)	-12.067	2.677	7.986	.086	1.220	7.162	-.681	-12.393	.621	-5.875	4.641	9.718	
Finland Real	-.404	-.053	.437	-.549	2.018	1.187	.412	-1.113	-.019	-.825	.519	.004	.805
(t)	-12.286	-4.700	12.894	-1.894	.309	3.960	.447	-14.947	-.023	-3.451	3.819	3.091	
Nominal	-.405	-.051	.444	-.540	4.599	1.183	.450	-1.115	-.182	-.731	.524	.004	.805
(t)	-12.310	-4.638	13.144	-1.855	.692	3.663	.495	-15.070	-.219	-2.755	3.823	3.102	
France Real	-.305	-.014	.533	-.765	-.827	1.990	-2.370	-.720	2.452	-1.105	1.607	.000	.803
(t)	-5.748	-1.046	10.737	-2.047	-.155	5.597	-1.606	-9.552	1.549	-3.589	10.675	.435	
Nominal	-.308	-.019	.527	-.712	2.010	2.040	-2.427	-.702	2.427	-1.090	1.645	.000	.805
(t)	-5.791	-1.472	10.751	-1.908	.364	5.507	-1.650	-9.117	1.531	-3.389	10.731	.516	
Germany Real	-.203	.061	.551	-1.881	1.442	-.598	4.365	-.937	-2.687	.765	.507	-.000	.736
(t)	-5.650	8.104	13.425	-2.011	.265	-1.121	2.464	-17.787	-1.942	1.969	3.013	-.144	
Nominal	-.260	.059	.543	-1.943	.047	-.682	4.419	-.929	-2.482	.715	.544	-.000	.732
(t)	-5.571	7.733	13.250	-2.049	.009	-1.269	2.468	-17.472	-1.793	1.859	3.348	-.264	
Greece Real	-1.142	-.089	1.041	-.253	9.645	-1.523	.553	-1.144	-.197	1.256	na	-.000	.792
(t)	-22.775	-7.103	21.205	-.633	1.279	-3.635	.442	-13.459	-.144	3.399		-.344	
Nominal	-1.146	-.090	1.047	-.192	-2.671	-1.319	.268	-1.135	-.095	1.177	na	-.000	.791
(t)	-22.763	-7.312	21.113	-.501	-.392	-3.012	.218	-13.203	-.072	3.167		-.088	

	Z^i_j	VAR^i_j	G_j	G_i	R^i_j	CPI_j	CPI_i	D^i_j	PS^i_o	PD^o_j	A^i_j	E_j	RSQ
Italy Real	-.816	-.003	1.067	-.556	3.878	.111	-.385	-1.351	.971	-.148	.157	.000	.928
(t)	-27.878	-.261	40.502	-4.704	1.040	.471	-.456	-23.663	1.137	-.584	2.463	1.875	
Nominal	-.816	-.005	1.067	-.578	-.287	.117	-.537	-1.354	1.170	-.189	.153	.000	.928
(t)	-27.944	-.428	41.505	-5.037	-.089	.488	-.643	-23.720	1.385	-.713	2.509	1.937	
Japan Real	-.241	-.020	.463	-.206	2.099	-.339	.157	-1.211	.552	.123	na	na	.498
(t)	-2.594	-.818	6.949	-.287	.363	-.633	.175	-4.591	.577	.252			
Nominal	-.240	-.026	.461	-.241	.252	-.255	.177	-1.221	.495	.077	na	na	.499
(t)	-3.607	-1.093	7.004	-.334	.044	-.463	.198	-4.597	.527	.160			
Nether- Real	-.259	.014	.481	-1.052	-1.961	1.508	-1.966	-.925	1.707	-.786	1.119	.000	.808
lands (t)	-6.811	1.062	13.227	-1.317	-2.88	3.531	-1.870	-16.709	1.758	-2.680	4.296	1.243	
Nominal	-.259	.012	.479	-1.093	-1.159	1.502	-1.960	-.924	1.747	-.792	1.121	.000	.807
(t)	-6.681	.924	13.108	-1.359	-.173	3.349	-1.864	-16.429	1.791	-2.473	4.330	1.198	
Norway Real	-.377	-.032	.349	.262	1.338	2.463	-2.965	-1.024	2.272	-2.064	.442	.006	.619
(t)	-9.842	-1.987	5.680	.329	.124	3.504	-2.552	-9.615	2.423	-4.193	2.340	4.690	
Nominal	-.379	-.033	.351	.264	7.630	2.400	-2.803	-1.012	2.134	-1.934	.438	.006	.622
(t)	-9.771	-2.154	5.765	.332	.741	3.239	-2.303	-9.523	2.226	-3.809	2.329	4.697	
South Real	-8.806	.021	1.154	8.137	-5.296	-1.813	-.408	-5.453	-.697	.936	na	na	.693
Africa (t)	-.449	1.225	18.470	.390	-.563	-2.219	-.061	-5.166	-.263	1.851			
Nominal	-7.925	.016	1.153	7.435	-.551	-1.808	-.815	-5.440	2.293	.933	na	na	.691
(t)	-.407	1.016	18.048	.358	-.059	-2.213	-.121	-5.122	-.110	1.785			
Sweden Real	-.377	.003	.419	.585	2.358	.864	-3.063	-1.014	1.993	-.447	.402	.001	.763
(t)	-12.246	.291	13.331	1.866	.449	2.869	-2.558	-16.590	1.916	-1.561	2.439	3.140	
Nominal	-.377	-.000	.416	.602	3.840	.814	-2.979	-1.004	1.940	-.414	.400	.001	.764
(t)	-12.058	-.014	13.349	1.975	.867	2.557	-2.459	-16.523	1.859	-1.413	2.441	3.097	
Switzer- Real	-.392	.020	.466	-1.642	1.504	-.015	.338	-.361	-.366	.474	.963	.001	.819
land (t)	-11.395	2.243	16.257	-2.218	.333	-.015	.251	-7.772	-.254	2.022	10.699	2.211	
Nominal	-.392	.018	.464	-1.630	2.418	-.065	.430	-.357	-.448	.488	.973	.001	.819
(t)	-11.349	2.073	16.088	-2.219	.587	-.204	.314	-7.574	-.306	2.012	10.699	2.200	
United Real	-.370	-.056	.515	-.521	.390	1.256	-.806	-.692	1.039	-.960	.003	na	.677
Kingdom (t)	-7.208	-3.935	14.554	-1.702	.105	2.858	-.578	-13.666	.843	-2.939	3.750		
Nominal	-.370	-.056	.516	-.541	-1.099	1.369	-.955	-.697	1.069	-.928	.003	na	.679
(t)	-7.265	-4.078	14.533	-1.806	-.272	3.063	-.676	-13.795	.861	-2.792	3.753		
United Real	-.192	.108	.720	-.411	-9.674	-.511	-.397	-3.208	1.559	-.093	1.862	na	.648
States (t)	-2.998	5.853	14.206	-.426	-1.040	-.939	-.156	-5.817	.800	-.177	7.692		
Nominal	-.186	.092	.684	-.320	-6.759	-.560	-.060	-3.032	1.373	-.325	1.859		.629
(t)	-2.825	4.811	12.100	-.326	-.794	-.976	-.022	-5.109	.666	-.588	7.482		

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