AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

378.713
D46
WP-96-1

Working Papers Series

Working Paper WP96/01 January 1996

WEAK SEPARABILITY IN COFFEE DEMAND SYSTEMS

by

Daniel Sellen
and
Ellen Goddard

UNIVERSITY of GUELPH

Department of Agricultural Economics and Business

Waite Library
Applied Economics - U of M
1994 Buford Ave - 232 ClaOff
St Paul MN 55108-6040 USA

University of Guelph
Guelph, Ontario
Canada
N1G 2W1

378.713
D46
WP-96-1

Weak Separability in

Coffee Demand Systems

by

Daniel Sellen

and

Ellen Goddard

WORKING PAPER WP96/01
Department of Agricultural Economics and Business
University of Guelph

January 25, 1996

Waite Library
Applied Economics - U of M
1994 Buford Ave - 232 ClaOff
St Paul MN 55108-6040 USA

WORKING PAPERS ARE PUBLISHED WITHOUT FORMAL REVIEW WITHIN
THE DEPARTMENT OF AGRICULTURAL ECONOMICS AND BUSINESS

Abstract

Linear versions of the Almost Ideal Demand System are estimated for U.S. and German coffee imports, with the intent of testing for weak separability and calculating elasticities. Three utility trees are tested and separability restrictions are rejected. In contrast with most econometric studies of coffee, coffee is shown to be a heterogeneous good by country of origin. Cross-price elasticities further suggest that coffee roasters, in blending, consider coffees from different countries as complements and substitutes.

Key words: consumer demand, coffee, Almost Ideal Demand System, weak separability.

Weak Separability in Coffee Demand Systems

1. Introduction

In demand analysis, weak separability implies that the marginal rate of substitution between two consumption goods in one group is independent of quantities of goods consumed from outside the group. In other words, no restrictions exist on substitutions between goods within a group, but substitution between goods in different groups occurs only through a factor of proportionality characterized by the relationship between groups in terms of expenditure. Accordingly, consumers may be viewed as allocating total expenditure to a broad category of goods and subsequently apportioning expenditure among subgroups, based on subgroup prices and expenditures. Weak separability, therefore, is a necessary and sufficient condition for multi-stage budgeting. More importantly, it makes possible use of conditional demand systems that avoid specification of the complete set of demand equations theoretically attainable from the consumer's utility maximization problem. In this way, the number of variables and parameters can be reduced to a manageable size.

The concept of separability of preferences, which originated in the work of Leontief (1947), has been widely used or implied in econometric modelling of consumer demand (Blackorby, Primont and Russell, 1978). Although many empirical studies use demand systems for agricultural commodities, most have used weak separability as a maintained (untested) hypothesis (exceptions are Pudney, 1981; Eales and Unnevehr, 1988; Nayga and Capps, 1994; Moschini and Moro, 1993; Moschini, Moro and Green, 1994). Most empirical studies reject separability restrictions when they are tested (Pudney, 1981).

Coffee, one of the world's most important traded commodities, has been the focus of dozens of econometric studies. However, coffee is rarely modelled in a demand system framework that recognizes it as a heterogeneous good (exceptions are Goddard and Akiyama, 1989; Kalenda, 1991; Sellen, 1996). In fact, roaster-buyers (and some consumers) are acutely concerned about what variety of coffee they acquire (Marshall, 1983; De Graaff, 1986). Varieties are typically divided into *robustas* (which are more acidic and higher in caffeine) and the *arabicas* (which are milder and more fragrant). Arabicas are further subdivided into *Colombian milds* (from Colombia, Kenya, and Tanzania), *unwashed arabicas* (mainly Brazilian), and *other milds* (the remainder--mainly from Central and South America). Consumers may also be concerned about the national origin of their coffee. Many, for example, express particular interest in the high quality product of Colombia or Jamaica. However, most coffees are sold as blends. These are carefully defined by roasters' recipes but are responsive to changes in consumers' tastes and relative prices.

Exploration of the relationships within coffee demand suggests the utility of a demand system that employs multi-stage budgeting. However, no study has tested for weak separability within coffee demand. The objective of this paper is to determine an appropriate commodity aggregation within coffee demand by carrying out tests for weak separability within a demand system. Results should contribute to understanding the nature of coffee demand by showing how coffee consumers allocate coffee expenditure. In doing so, the study will add to the small but growing body of empirical evidence on separability in demand for agricultural products. In addition, elasticities generated by the model will illuminate features of coffee demand.

2. Testing for Weak Separability

To characterize weak separability, the utility function $U(q)$ appears as a function of n subutility functions, such that

$$U(q) = U_0[U_1(\boldsymbol{q}_1), U_2(\boldsymbol{q}_2), \ldots, U_S(\boldsymbol{q}_S)] \quad (1)$$

where $\boldsymbol{q}$ is the vector of consumption goods. Goldman and Uzawa (1964) show that this separable structure restricts the substitution possibilities between goods in different groups, so that the Slutsky substitution terms S_{ik} between two goods in different groups are proportional to the income effects:

$$S_{ik} = \mu_{GH} \frac{\partial q_i}{\partial M} \frac{\partial q_k}{\partial M} \quad \textit{for all } i \in G,\ k \in H,\ G \neq H \tag{2}$$

where μ is a factor of proportionality, and G and H are separable commodity groupings. Assuming weak separability of the direct utility function, then

$$S_{ik} \frac{\partial q_j}{\partial M} \frac{\partial q_k}{\partial M} = S_{jk} \frac{\partial q_i}{\partial M} \frac{\partial q_k}{\partial M} \quad \textit{for all } i,j \in G,\ k \in H,\ G \neq H \tag{3}$$

From (3) it follows that testing whether commodity group H is separable from group G (and vice-versa) may be conducted with the hypothesis

$$S_{ik} \frac{\partial q_j}{\partial M} - S_{jk} \frac{\partial q_i}{\partial M} = 0 \tag{4}$$

where the test is based on a χ^2 statistic with degrees of freedom equal to the number of restrictions.

Tests for weak separability have relied on Wald Tests or Likelihood Ratio (LR) Tests. The former test, used by Eales and Unnevehr (1988) and others, is less cumbersome than the latter since it avoids estimating both restricted and unrestricted models. However, it has been demonstrated that the Wald Test is not invariant to how the nonlinear restrictions are specified (Lafontaine and White, 1986). For this reason the LR Test will be used, where the test statistic is

$$\psi = 2(LR_{ur} - LR_r) \tag{5}$$

where LR_{ur} and LR_r are the values of the restricted and unrestricted log likelihood functions, respectively. It has been shown that the LR Test tends to overreject in large demand systems so that a correction for size is appropriate. Monte Carlo simulations carried out by Moschini, Moro, and Green (1994) have shown that the following correction works well when testing for weak separability, where the corrected LR test statistic is

$$\psi^* = \frac{\psi}{KT}\left[KT - \frac{1}{2}(N_{ur}+N_r) - \frac{1}{2}K(K+1)\right] \qquad (6)$$

where K is the number of equations, T is the number of time series observations, and N_{ur} and N_r are the number of parameters in the unrestricted and restricted models, respectively.

Three possible separable structures are selected *a priori* for testing (Table 1). These "utility trees" are chosen based on quality differences described in the literature (e.g. Marshall, 1983) and variety definitions of the International Coffee Organization. Tree #1 is based on two general branches separating *arabicas* and *robustas*. Tree #2 separates the lower-quality *unwashed arabicas* from *robustas* and remaining *arabicas*. Tree #3 views *other milds*, *Colombian Milds*, *unwashed arabicas*, and *robustas* as separable groupings.

These utility trees are tested to determine whether weak separability is supported in the cases of U.S. and German (former West Germany) coffee demand. These countries are the two largest coffee importers, accounting for about 45 percent of world consumption. To simplify the model in terms of exporters of Other Milds and Robustas, only the largest four exporters of each in the sample period are singled out, with residual suppliers captured in the "Other" categories.

In formulating tests for weak separability it is helpful to establish the correct number of non-redundant restrictions, R, which is determined by the formula

$$R = \frac{1}{2}\left[m(m-1) - \sum_{s=1}^{S} m_s(m_s-1) - S(S-1)\right] \qquad (7)$$

where m is the total number of goods and m_s is the number of goods in the sth group *($s=1,2,...S$)*. Following Nayga and Capps (1994), the number of i, k, and j combinations for the three utility trees described in Table 1 is shown in Table 2. Given our interest in obtaining an appropriate commodity aggregation, homotheticity of the subutility functions is also required to be consistent with one-shot utility maximization (Green 1976). Income elasticities within groups must therefore be equivalent, requiring the restrictions that

$$\frac{\partial q_i}{\partial M}\frac{M}{q_i} = \frac{\partial q_j}{\partial M}\frac{M}{q_j} \qquad \textbf{(8)}$$

Simultaneous imposition of homotheticity restrictions entails adding $(m_s\text{-}1)$ additional restrictions. Thus there are 62, 75, and 86 restrictions for Trees 1, 2, and 3 respectively.

3. A Model of Coffee Demand

Parameters are estimated with the Almost Ideal Demand System (AIDS), which is based on the flexible expenditure function known as the price-independent generalized logarithmic (PIGLOG) form (Deaton and Muellbauer, 1980). The AIDS model is attractive because it is simple to estimate and is compatible with demand theory; it satisfies the axioms of choice, aggregates over consumers without implying linear Engel curves, and can be used to test for homogeneity and symmetry. The linear form of the AIDS model is given by:

$$w_i = a_i + \sum_j c_{ij}\ln p_j + b_i \ln\left(\frac{M}{P}\right) + d_i t \qquad \textbf{(9)}$$

where w_i is the budget share for coffee from country i, p_j is the price of coffee from country j, M is total expenditure on all coffee, and P is the expenditure-weighted price for all coffee, where $lnP=\Sigma_i w_i \ln p_i$ (the Stone index). A time trend variable, t, is included to capture steady movements of unmodelled variables. Since the system of expenditure share equations must sum to one, all but one of the equations are estimated. Restrictions from demand theory--homogeneity, adding-up, and symmetry--may be imposed on the AIDS model with the restrictions $\Sigma_i a_i=1$, $\Sigma_i b_i=\Sigma_i c_{ij}=0$, and $c_{ij}=c_{ji}$. Error terms are assumed to have a joint normal distribution with mean zero and constant covariance.

Imposition of separability restrictions globally is extremely restrictive (Moshini, Moro and Green), so that the test will be be applied at the mean only, having first scaled prices and income to equal unity at that point. In addition, the shares are replaced by the estimated values, which correspond to the constant term in the AIDS model. In equation (9), $S_{ik}=c_{ik}+w_i w_k$ and

$\partial q_i/\partial M=(b_i+w_i)/p_i$, so that with normalized prices, at the mean the weak separability restrictions in (4) take the specific form:

$$(c_{ik}+w_i w_k)(b_j+w_j) - (c_{jk}+w_j w_k)(b_i+w_i) = 0 \qquad (10)$$

With income elasticities defined as

$$\frac{\partial q_i}{\partial M}\frac{M}{q_i} = \frac{b_i}{w_i}+1 \qquad (11)$$

the homotheticity restrictions in (8) take the form

$$\frac{b_i}{w_i}-\frac{b_j}{w_j} = 0 \qquad (12)$$

5. Data

Trade data (in terms of quantities and value) are from the United Nations trade data system which uses the Standard International Trade Classification (SITC) #0.711 for green coffee. The available sample period is 1962-1993 for the U.S. and 1962-90 for Germany. Producers are classified according to the dominant variety of coffee grown. Information about the variety of coffee exported from each country comes from various years of the USDA's *World Coffee Situation*. Population, consumer price indices, exchange rates, and disposable income values for 1962-93 are from various years of the IMF's *International Financial Statistics* Yearbook. Prices used are import unit values derived from the trade data. Data limitations require that the roaster-importers of coffee are used as a proxy for the coffee consumer. For the tenets of demand theory to hold, a constant marketing margin is assumed and consumer tastes are assumed to be accurately transmitted to the roasters.

6. Empirical Results

The model is estimated with the full-information maximum likelihood procedure. For the unrestricted model, a total of 146 parameters are estimated in fourteen equations (parameters in the fifteenth equation are computed using the restriction of adding-up).

Test results for homogeneity and symmetry are found in Table 3 using standard and corrected LR test statistics. At the 95 percent level of confidence, homogeneity restrictions are rejected for both U.S. and German models. Symmetry, however, may not be rejected. To preserve tenets of demand theory, both homogeneity and symmetry restrictions are imposed in the results which follow with the caveat that homogeneity restrictions compromise estimation results. Validation of the model is presented by observing goodness-of-fit and existence of serial correlation of the error term (Table 4). R^2 values indicate satisfactory to good fit for most of the estimated equations, with the German model providing more explanatory power than the U.S. model. Durbin-Watson statistics indicate that serial correlation is a problem in many of the equations in both models.

Test results for weak separability appear in Table 5. Weak separability is rejected in both models for all utility trees tested, even when the corrected likelihood test statistic is considered. This implies that roasters--the proxy for coffee consumers--do not select among coffee varieties but instead choose among coffees based on country of origin.

Marshallian elasticities for the unrestricted U.S. and German models appear in Table 6 (only the classical restrictions from demand theory are imposed). In both models, all own-price elasticities have the correct sign and thirteen out of fifteen of these elasticities in each are statistically significant. Perhaps the most interesting result is how small these elasticities are. Econometric studies typically treat coffee as a homogeneous good, implying infinite elasticities of substitution and perfectly elastic export demand. In all cases found here elasticities are less than 3.0 and in five cases less than unity. Almost half of the cross-price elasticities are significant, and roughly half are negative, reflecting complementary relationships. A priori expectations were that substitution relationships would dominate cross-price elasticities within varieties. This generalization does not hold. Only six of the fifteen expenditure elasticities are significantly different from zero in each of the models. Coffees from different countries are viewed as both normal and inferior goods. Remaining estimation results--coefficients on trend variables and associated *t*-statistics--are presented in Table 7.

7. Conclusion

This study attempted to use weak separability tests to establish an appropriate commodity aggregation for use in a coffee demand system. Three utility trees selected *a priori* were tested, and separability restrictions were rejected. This supports Pudney's (1981) observation that separability is generally rejected. The implication for modelling of coffee markets using this data set is that all producers should be included simultaneously in the demand estimation. However, due the degrees of freedom problem (the problem that separability would have help to avoid) the data set is not long enough to avoid the practice of aggregating "like" producers together.

Although parameters estimated here are insufficient to establish export elasticities elasticities facing coffee producing countries, they suggests that these countries may not increase supply without adversely affecting export price. Conversely, they suggest the utility of supply-restricting policies such as those attempted in International Coffee Agreements.

Among the limitations of this study was the reliance on a single functional form (AIDS). Future work might consider other possible commodity aggregations within the broader coffee category, together with tests to ensure that coffee is separable from all other goods.

7. References

Blackorby, C., Primont, D., and Russell, R.R. (1978). Duality, Separability, and Functional Structure: Theory and Economic Applications. New York: North Holland.

Deaton, A. and Muellbauer, J.(1980). Economics and Consumer Behaviour. Cambridge: Cambridge University Press.

De Graaff, J. (1986). The Economics of Coffee. Wageningen: Pudoc, 1986.

Eales, J.S. and Unnevehr, L.J. (1988). Demand for Beef and Chicken Products: Separability and Structural Change. American Journal of Agricultural Economics. (70):521-32.

Goddard, E.W. and Akiyama, T. (1989). United States Demand for Coffee Imports. Agricultural Economics. (3):147-159.

Goldman, S. and Uzawa, H. (1964). A Note on Separability in Demand Analysis. Econometrica. (32):387-98.

Green, H.A.J. (1976) Consumer Theory. New York: MacMillan.

International Monetary Fund (1994). International Financial Statistics, 1993. Washington, D.C.: IMF.

Kalenda, P.K.(1991). The Demand for Coffee and Product Differentiation by Product Characteristics and Country of Origin. M.Sc. thesis. University of Guelph.

Lafontaine, F., and K.J. White (1986). Obtaining any Wald Statistic You Want. Economic Letters 21(1):35-40.

Leontief, W.(1947). Introduction to a Theory of the Internal Structure of Functional Relationships. Econometrica (15):361-73.

Marshall, C.F.(1983). The World Coffee Trade: A Guide to the Production, Trading, and Consumption of Coffee. Cambridge: Woodhead-Faulkner.

Moschini, G. and Moro, D.(1993). Food Demand System for Canada. Technical Report 1/93. Ottawa: Policy Branch, Agriculture Canada.

Moschini, G., Moro, D. and Green, R.D. (1994). Maintaining and Testing Separability in Demand Systems. American Journal of Agricultural Economics. (76):61-73.

Nayga, R. M. and Capps, Jr, O. (1994). Tests of Weak Separability in Disaggregated Meat Products. American Journal of Agricultural Economics. (76):800-808.

Pudney, S.(1981) An Empirical Method of Approximating the Separable Structure of Consumer Preferences. Review of Economic Studies. (48):561-77.

Sellen, D. (1996) Producer Returns from Research and Advertising: The Case of Colombian Milds Coffee. Unpublished Ph.D. dissertation. University of Guelph.

USDA (various years). World Coffee Situation. Washington, D.C.: United States Department of Agriculture.

Table 1. Characterization of Utility Trees Tested

Variety	Country of Origin		Index Number	Utility Trees		
	United States	Germany		1	2	3
other milds	Mexico	El Salvador	1	A	A	A
	El Salvador	Nicaragua	2	A	A	A
	Costa Rica	Honduras	3	A	A	A
	Guatemala	Guatemala	4	A	A	A
	Other	Other	5	A	A	A
Colombian milds	Kenya	Kenya	6	A	A	B
	Colombia	Colombia	7	A	A	B
	Tanzania	Tanzania	8	A	A	B
unwashed arabicas	Brazil	Brazil	9	A	B	C
	Ethiopia	Ethiopia	10	A	B	C
robustas	Cote d'Ivoire	Indonesia	11	B	C	D
	Thailand	Cameroun	12	B	C	D
	Uganda	Côte d'Ivoire	13	B	C	D
	Indonesia	Uganda	14	B	C	D
	Other	Other	15	B	C	D

Table 2. Summary of Weak Separability Tests

	i,k	j: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TREE #1	1,2											*	*	*	*	*
	2,3											*	*	*	*	*
	3,4											*	*	*	*	*
	4,5											*	*	*	*	*
	5,6											*	*	*	*	*
	6,7											*	*	*	*	*
	7,8											*	*	*	*	*
	8,9											*	*	*	*	*
	9,10											*	*	*	*	*
	10,11															
	11,12										*					
	12,13										*					
	13,14										*					
	14,15										*					
TREE #2	1,2									*	*	*	*	*	*	*
	2,3									*	*	*	*	*	*	*
	3,4									*	*	*	*	*	*	*
	4,5									*	*	*	*	*	*	*
	5,6									*	*	*	*	*	*	*
	6,7									*	*	*	*	*	*	*
	7,8									*	*	*	*	*	*	*
	8,9															
	9,10								*			*	*	*	*	*
	10,11															
	11,12								*		*					
	12,13								*		*					
	13,14								*		*					
	14,15								*		*					
TREE #3	1,2						*	*	*	*	*	*	*	*	*	*
	2,3						*	*	*	*	*	*	*	*	*	*
	3,4						*	*	*	*	*	*	*	*	*	*
	4,5						*	*	*	*	*	*	*	*	*	*
	5,6															
	6,7					*				*	*	*	*	*	*	*
	7,8					*				*	*	*	*	*	*	*
	8,9															
	9,10					*			*			*	*	*	*	*
	10,11															
	11,12					*			*		*					
	12,13					*			*		*					
	13,14					*			*		*					
	14,15					*			*		*					

Note: * represents nonredundant test for separability

Table 3. Tests for Homogeneity and Symmetry

Restriction Tested	Number of Restrictions	Critical Value ($\chi_{.05}$)	U.S. Model		German Model	
			ψ	ψ^*	ψ	ψ^*
Homogeneity	14	23.68	107.72	42.98	125.76	57.22
Symmetry	91	114.30	211.02	104.03	198.72	107.51

Table 4. Validation Statistics

Equation Number	U.S. Model R^2	U.S. Model D.W.	German Model R^2	German Model D.W.
1	0.72	1.02	0.93	2.06
2	0.57	1.89	0.58	1.28
3	0.74	1.35	0.57	1.20
4	0.60	2.01	0.79	0.86
5	0.15	1.80	0.22	1.88
6	0.75	1.35	0.73	1.68
7	0.72	0.87	0.85	1.49
8	0.33	0.51	0.54	1.25
9	0.45	1.98	0.53	2.02
10	0.40	1.13	0.89	1.47
11	0.72	1.53	0.82	2.15
12	0.43	1.58	0.79	1.58
13	0.20	1.81	0.41	1.95
14	0.12	0.58	0.55	1.34

Table 5. Results of Weak Separability Tests

Utility Tree	Number of Restrictions	Critical Value ($\chi_{.05}$)	U.S. Model		German Model	
			ψ	ψ^*	ψ	ψ^*
1	62	81.38	190.40	96.90	214.85	98.43
2	75	96.22	217.44	113.82	289.86	137.43
3	86	108.60	234.20	125.46	298.98	141.42

Table 6. Uncompensated Elasticities for Unrestricted Models

U.S. Model	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12	p13	p14	p15	M
q1	-1.06*	0.59*	0.48	-0.86*	0.61	0.53*	-0.12*	-0.18	-0.30*	-0.12	1.80*	0.70*	0.03	-0.92*	-0.93*	-0.27
q2	0.86*	-1.78*	-1.02*	3.28*	-0.21	-0.92*	-0.08	0.54*	0.36	-0.28	0.41	-0.72*	-0.22	0.43	-0.52	-0.13
q3	0.37	-1.19*	-0.94*	0.82	-1.16*	-0.88*	1.81*	-0.18	-1.35*	1.51*	-0.73*	0.17	1.17*	0.42	-0.38	0.54
q4	-0.55*	1.21*	0.25	-1.30*	0.75*	0.14	-1.04	0.41*	-0.32	-0.43*	-0.30	0.15	0.01	-0.95*	0.37	1.61*
q5	0.29	-0.13	-0.43*	0.80*	-1.81*	-0.11	-0.97	-0.11	1.75*	0.03	-0.21	0.06	-0.30	0.13	-0.43	1.44*
q6	1.53*	-1.87*	-1.55*	0.83	-0.52	-1.22*	1.04	1.59*	-1.26	-0.37	2.12*	0.29	1.22*	0.23	-2.78*	0.72
q7	-0.25*	-0.06	0.18*	-0.36*	-0.33	0.06	-1.36*	-0.05	0.30	0.42*	-0.17	0.17*	0.24*	-0.39	-0.06	1.66*
q8	-1.02	2.01*	-1.89*	2.14*	-1.03	2.99*	-1.24	-0.92	0.87	-1.15	2.24*	-0.54	-3.28*	1.54	-1.48*	0.75
q9	-0.10*	0.01	-0.13*	-0.06	0.43*	-0.07	0.29	0.02	-1.74*	-0.11	-0.08	-0.05*	-0.25*	0.22*	0.34*	1.32*
q10	-0.12	-0.20	1.05*	-0.72*	0.21	-0.12	2.96*	-0.22	-0.34	-1.55*	-0.65*	-0.26*	0.54*	0.14	-0.01	-0.70
q11	1.58*	0.23	-0.40*	-0.42	-0.27	0.65*	-0.60	0.69*	-0.38	-0.57*	-0.53*	-0.61*	0.62*	-0.11	-0.63	0.76
q12	2.90*	-2.35*	0.35	0.94	0.26	0.38	3.36*	-0.47	-2.69*	-1.21*	-1.23*	-0.62*	-1.95*	1.71*	-2.23*	2.83*
q13	0.03	-0.14	0.70*	0.12	-0.39	0.41*	1.61*	-0.57*	-1.27*	0.45*	0.71*	-0.38*	-2.41*	1.09*	0.31	-0.28
q14	-0.80*	0.29	0.26	-1.35*	0.36	0.09	-1.30*	0.26	1.98*	0.11	-0.03	0.39*	1.03*	-0.64	0.22	-0.89*
q15	-0.43*	-0.17	-0.10	0.35	-0.26	-0.45*	0.96	-0.27*	1.20*	-0.05	-0.29	-0.18*	0.10	0.03	-1.14*	0.70

German Model	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12	p13	p14	p15	M
q1	-1.91*	1.07*	0.12*	-0.48*	-1.21*	0.34*	-0.42	0.18	0.73*	-0.24	0.18*	0.11	0.01	-0.58*	-0.24	2.33*
q2	1.38*	-0.90*	0.41	-0.50*	-1.05*	-0.04	-1.24*	0.26	0.56	-1.46*	-0.06	0.35	0.86*	0.71*	-0.11	0.82
q3	0.59*	0.57	-1.76*	-1.45*	-0.82	1.76*	1.69*	0.38	0.56*	0.78	-1.29*	-0.40	0.56*	-0.34	-0.79	-0.05
q4	-0.87*	-0.69*	-0.52*	-2.70*	0.14	0.61	2.77*	0.79*	0.62	0.44	0.03	-1.08*	-0.46*	-0.23	0.26	0.89
q5	-1.90*	-2.06*	-0.22	0.31	-0.75*	0.70	3.98*	-0.30	1.82*	0.40	-0.11	0.31	-0.90*	-0.87*	1.53*	-1.94*
q6	2.24*	-0.03	0.49*	0.58	0.51	-1.47*	-2.21*	0.32	-0.80*	-0.25	-0.46*	0.73*	0.14	0.23	0.52*	-0.57
q7	-0.15	-0.53*	0.22*	0.51*	0.63*	-0.77*	-2.02*	-0.35*	-0.03	0.20*	0.18*	-0.30*	0.07	0.40*	0.09*	1.99*
q8	0.90	0.21	0.22	1.43*	-0.77	0.61	-2.66*	-0.45	1.27	-0.28	-0.04	-1.35*	0.76*	0.22	-0.95*	0.88
q9	0.76*	0.08	0.35*	0.20	0.62	-0.67*	-0.12	0.28	-3.57*	-0.36*	-0.13	0.38*	-0.12	0.39*	-0.27	2.16*
q10	-1.31	-1.92*	0.74	1.27	1.05	-1.03	3.06*	-0.45	-2.08*	-0.87*	0.59	1.66*	-0.14	-0.55	-0.96	0.93
q11	1.69*	-0.20	-2.09*	0.01	-0.88	-2.92*	3.66*	-0.17	-1.39	0.89	-0.80*	0.84*	-0.53	-0.33	-0.95	3.16*
q12	1.24*	0.46	-0.25	-2.19*	0.80	2.18*	-1.78	-1.55*	2.54*	1.36*	0.49*	-0.90	0.50*	-0.45	0.26	-2.72*
q13	0.80	1.57*	0.78*	-1.49*	-3.57*	0.83	0.15	1.71*	-0.34	-0.10	-0.35	0.84*	-0.78*	-0.02	2.79*	-2.84
q14	-2.47*	1.35*	-0.42	-0.75	-3.69*	1.22	8.62*	0.58	1.93*	-0.70	-0.21	-0.81	-0.03	-2.67*	-0.09	-1.85
q15	-0.25	-0.02	-0.35	0.49	2.23*	0.94*	1.49*	-0.66*	-0.39	-0.42	-0.23	0.12	1.01*	-0.04	-2.79*	-1.11

Asterisks indicate significance at the 95 percent confidence level.

Table 7. Coefficients on trend variables

Index Number	U.S. Model Coefficient	U.S. Model *t*-statistic	German Model Coefficient	German Model *t*-statistic
1	.003	13.57	-.010	-4.96
2	.001	5.29	-.001	-0.35
3	.001	8.36	-.001	-0.17
4	.004	9.75	-.002	-1.07
5	.002	4.62	.007	3.34
6	.001	3.52	.002	1.28
7	.006	7.43	-.005	-1.11
8	-.001	-1.67	.001	0.63
9	.004	3.23	-.008	-1.54
10	-.000	-0.94	.002	0.51
11	.000	0.51	.001	0.61
12	.002	6.18	-.038	4.22
13	.000	0.32	.003	2.23
14	.001	3.20	.003	2.39