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World Fibers Demand

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ABSTRACT

This paper analyses the world demand for fibers using the system-wide approach with three dimensions—product × space × time. We investigate to what extent differences in international consumption patterns of fibers can be explained by differences in incomes and prices faced by different consumers. A novel approach to cross-country consumption comparisons is employed to avoid the troublesome problem of what exchange rates to use when converting data into a common currency unit. We use data from the ten largest consuming countries to estimate demand systems and then examine how they perform in predicting consumption patterns in a large number of out-of-sample countries.

Key Words: *demand systems, fibers demand, international consumption comparisons.*

This paper analyses the pattern of demand for fibers for the world as a whole. Such an analysis is important for understanding fluctuations of fiber prices, which are an important part of export earnings for some countries, as well as the cost of clothing etc. which accounts for about 9 percent of total expenditure in both the OECD and emerging economies.[1] Figure 1 uses equilateral triangles to present market shares of cotton, wool and chemical fibers in the 10 most important consuming countries in the world.[2] As can be seen, there are large differences across fibers, countries and time. For example, Panel A, which refers to 1974, reveals a distinct tendency for the high-income countries to be clustered in the sub-triangle in the bottom-left, which corresponds to the share of chemical fibers exceeding 50 percent. By contrast, the low-income countries cluster in the bottom-right sub-triangle, corresponding to the cotton share exceeding 50 percent. Eighteen years later, in 1992 (Panel B), there is a tendency for countries to have moved to be closer to the middle sub-triangle, whereby no individual fiber absorbs more than 50 percent of the total.[3] In other words, the international diversity of consumption patterns has fallen over time. These differences in consumption patterns are three dimensional—product × space × time. In this paper we analyse these 3-D differences and ask to what extent they can be explained by observable differences in incomes and prices faced by different consumers.

A distinctive feature of our analysis is that

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[1] See Chen and S. Selvanathan.

[2] This diagram is interpreted as follows. For any point in the triangle, draw three lines parallel to the axes. Consider the line which is parallel to the chemical fibers axis. The intersection of this line with the cotton axis then gives the value of the share for this fiber. The values of other two shares are obtained in a similar manner.

[3] The sources of the data in Figure 1 are described in the next section.

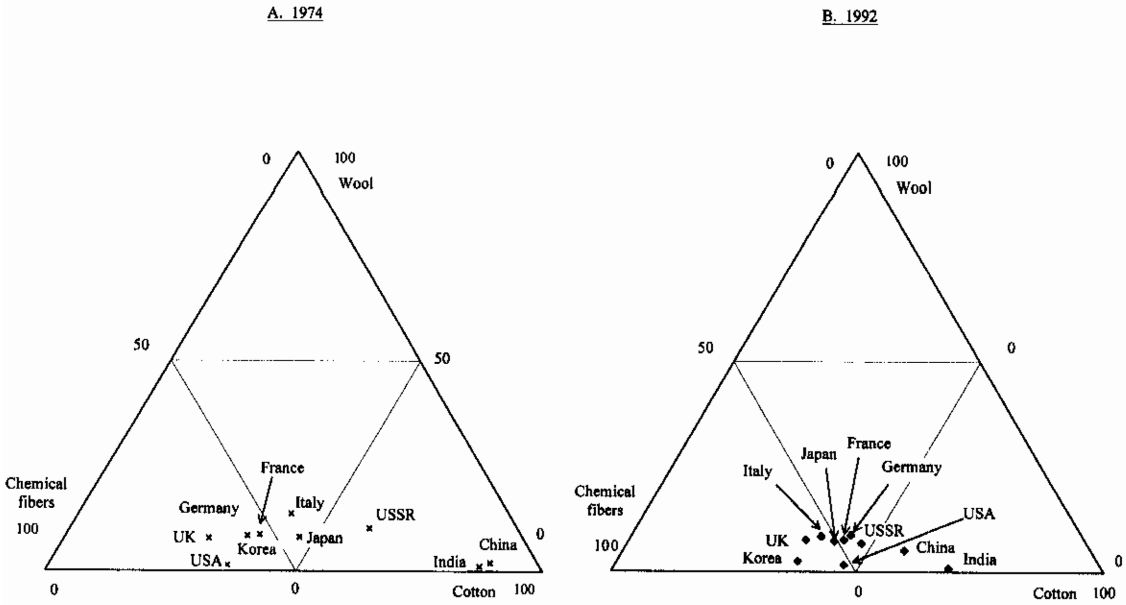

Figure 1. Market shares of three fibers

we use the system-wide approach to model jointly the demand for the three fibers; much previous research in this area uses single-equation methodology which is unable to capture the interrelationships between fibers in a theoretically satisfactory way.[4] Another novelty is the use of cross-country data to estimate demand equations. Although international data have been used in demand analysis previously by Chen, S. Selvanathan, Theil (1996), Theil and Clements, Theil, Chung and Seale and some others, this previous research has mostly dealt with the demand for broad national-accounts-type aggregates such as food, clothing, housing, etc. By contrast, we use cross-country data for more finely disaggregated goods, the three fibers. The advantage of using cross-country data is that usually they contain much greater variability than do time-series data for a single country; greater variability in the explanatory variables can lead to more precise estimates of the demand equations. On the other hand, the unavoidable "cost" of this greater variability is the assumption that, except for random factors, countries share the same demand functions, so that tastes/technology are taken to be identical internationally. Another problem with using international data is how to express them all in a common currency. As market exchange rates are subject to large fluctuations and tend to amplify the true diversity of incomes across countries, their use can obviously lead to distortion of measurement. PPP exchange rates, while better than market rates, are still not perfect as they involve assumptions—what is the base year, what index formula is used, what goods are included/excluded, etc. The approach that we use completely avoids exchange-rate conversion problems. As we use only pure numbers such as logarithmic changes over time and consumption shares, these are independent of currency units and thus directly comparable across countries. A further innovation of the paper is that it introduces a way of dealing with cross-country consumption comparisons when information on prices is limited.

The paper is structured as follows. The next two sections present consumption data for the ten largest consuming countries in the

[4] It should be noted, however, that Coleman and Thigpen employ a somewhat similar approach to ours in modeling the world demand for cotton and noncellulosic fibers. In reviewing the previous literature, Coleman and Thigpen refer to Adams and Behrman; Donald, Lowenstein and Simon; Dudley; Ecevit; Magleby and Missaien; Monke and Taylor; Meus and Simmons; Thigpen; and Thigpen and Mitchell.

world, and use these data to estimate several demand systems for fibers. Next we evaluate the performance of the demand models by investigating their comparative ability to predict the consumption shares. We then perform an out-of-sample test of the preferred model by using the shares of 82 additional countries and find that this model can still be improved upon by combining it with no-change extrapolation. Finally, some concluding comments are given in the last section.

The Ten Largest Consumers

Table 1 gives fibers data pertaining to the 10 largest consuming countries in the world, with countries listed according to GDP per-capita. These basic data refer to "apparent consumption" of fibers and represent two snapshots in time, one for 1974 and the other for 1992. It can be seen that in per-capita terms, the US has the largest consumption of cotton and chemical fibers in both years, while Germany is the largest wool consumer. Next, in Table 2 we transform the basic data into the form of shares and changes. Columns 2 to 4 present the share of each fiber in the total, averaged over the two years. That is, if we write q_{it} for the quantity consumed of fiber i (i = 1, 2, 3, indicating cotton, wool, and chemical fibers) in year t and $Q_t = \Sigma_{i=1}^{3} q_{it}$, then $w_{it} = q_{it}/Q_t$ is the consumption (or quantity) share of fiber i in t. The quantity share which is representative of the two years 1974 and 1992 is just the arithmetic average of the two shares, $\bar{w}_i = \frac{1}{2}(w_{i,1974} + w_{i,1992})$. The three average shares are given in Columns 2 to 4 of Table 2. As can be seen, in seven out of the 10 countries the largest share is for chemical fibers; in the three other countries—the USSR, China and India—cotton has the largest share, which is always more than 50 percent. Columns 5 to 7 of Table 2 present the per-capita quantity data in annual log-change form; that is, the entries in these columns are $Dq_i = (1/18)(\log q_{i,1992} - \log q_{i,1974})$, the average annual log-change in consumption of fiber i, where the divisor 18 comes from there being 18 years between the two snapshots. These log-changes represent the long-run trends in consumption. Averaging over the 10 countries, as shown in the second last row of Columns 5 to 7, per-capita consumption of chemical fibers grows the fastest (3.6 percent p.a.), then cotton (2.0 percent), while wool exhibits the slowest growth (1.6 percent). If we weight countries by population, as in the last row of these columns, the means become closer to China, the most populous country. A notable feature of the data is the pattern in the growth in chemical fibers—low for US and Germany and high for Korea, China and India.

The overall growth in fibers consumption can be measured by taking a quantity-share-weighted average of the growth in the individual components, $DQ = \Sigma_{i=1}^{3} \bar{w}_i Dq_i$. This DQ is approximately a Divisia volume index and is interpreted as the growth in the volume of per-capita fibers consumption as a whole.[5] This index is given in Column 8 of Table 2 and ranges from 8.2 percent for Korea and −1.3 percent for the USSR. This index will be used subsequently in our analysis. Information on prices for wool and cotton is readily available only at the international level, not for individual countries. Thus we convert these international prices to the currency of the country in question, but we are aware of the measurement error that this may introduce. For chemical fibers, as there is no published index of these prices, we simply use wholesale prices in most cases; see the notes to Table 2 for details. Again, although this is less than ideal, there seems to be little alternative. The resulting price data are given in Columns 9 to 12 of Table 2.

Simple Demand Systems

In this section we use the fibers data to estimate systems of demand equations. For rea-

[5] Strictly speaking, the Divisia index involves the use of budget shares as weights, not quantity shares. The budget share of i is defined as the share of total expenditure devoted to the good, $p_iq_i/\Sigma_{i=1}^{n} p_iq_i$, where p_i is the price of i and n is the number of goods. Our approximation of budget shares with their quantity counterparts is not likely to introduce serious distortions; in any event, due to absence of high-quality price data, discussed below, there is no alternative to using quantity shares.

Table 1. Cross-Country Data on Fibers Consumption

	Total (thousand tonnes)							
	Cotton		Wool		Chemical Fiber		Total Fibers	
Country	1974	1992	1974	1992	1974	1992	1974	1992
USA	1,650.3	3,330.5	63.4	121.7	2,921.6	3,664.1	4,635.3	7,116.3
Germany	383.6	766.5	89.6	152.8	588.1	803.6	1,061.3	1,722.9
Japan	743.1	1,145.0	128.2	203.1	715.1	1,385.1	1,586.4	2,733.2
France	256.9	416.1	58.2	71.2	351.8	460.6	666.9	947.9
Italy	245.5	402.5	78.6	88.5	254.3	550.1	578.4	1,041.1
UK	246.2	397.8	65.6	83.0	543.5	621.2	855.3	1,102.0
Korea	76.0	349.6	10.1	23.5	92.5	570.9	178.6	944.0
USSR	1,903.3	1,402.9	326.6	201.8	959.8	1,330.9	3,189.7	2,935.6
China	2,513.3	3,580.7	56.0	316.1	276.0	2,360.2	2,845.3	6,257.0
India	1,118.0	1,505.8	13.9	16.4	157.0	678.0	1,288.9	2,200.2
Mean-Unweighted	—	—	—	—	—	—	—	—
-Weighted	—	—	—	—	—	—	—	—

Notes: 1. The data are "apparent consumption", i.e., mill consumption minus exports plus imports. Chemical fibers comprise cellulosic and non-cellulosic fibers (polyamide, polyester, acrylic, polypropylene and other). 2. The countries are the 10 largest fiber consumers in 1992. 3. Countries are listed according to real GDP per-capita in 1992 in international dollars, except for the USSR and Korea, for which the 1989 and 1991 figures are used respectively (from the Penn World Table). 4. Population shares are used as weights to compute the weighted means.
Source: Food and Agricultural Organization of the UN, *World Apparel Fiber Consumption Survey.* Rome, Italy (various issues).

sons discussed in the previous section, the price data are imperfect and do not contain a great deal of information. Accordingly, we have to restrict ourselves to demand models that are simple in the sense that they do not contain many unknown parameters. We do this by using separability theory and invoking the assumption that the three fibers form a group which is distinct from all other goods. This leads to conditional demand equations whereby the demand for a given fiber depends on the total size of the fibers market and the prices of fibers. While this approach has the cost of reducing the scope for substitution possibilities, it does make the estimation problem tractable. For further details, see, e.g., Theil and Clements (Chap. 4).

We use three demand models which are members of the differential family (Theil, 1980), viz., the Rotterdam model (Barten, 1964; Theil, 1965), Working's model (see, e.g., Theil and Clements, Sec. 1.15) and E. A. Selvanathan's model.[6] Recall that $\bar{w}_i$ is the arithmetic average of the quantity share of fiber i, Dq_i is the log-change in consumption of i and DQ the Divisia volume index of the growth in total consumption of fibers. Adding a country subscript c (c = 1, . . . , 10), the i[th] equation of the Rotterdam model is then

$$(1) \quad \bar{w}_{ic}Dq_{ic} = \alpha_i + \theta_i DQ_c + \phi\theta_i\left[Dp_{ic} - \sum_{j=1}^{3} \theta_j Dp_{jc}\right] + \epsilon_{ic},$$

where Dp_{ic} is the log-change in the i[th] price for country c; α_i is an intercept for fiber i ; θ_i is the i[th] marginal share; ϕ is the own-price elasticity of demand for fibers as a whole; and ϵ_{ic} is a zero-mean disturbance term. Dividing both sides of equation (1) by $\bar{w}_{ic}$, we find that $\alpha_i/\bar{w}_{ic}$ is the autonomous trend in consumption of i and that $\theta_i/\bar{w}_{ic}$ is the i[th] income elasticity. Holding total consumption of fibers constant, the elasticity of consumption of fiber i with respect to the price of j is $\phi(\theta_i/\bar{w}_{ic})(\delta_{ij} - \theta_j)$, where δ_{ij} is the Kronecker delta ($\delta_{ij} = 1$ if i =

[6] Note that Working's model is also known as the CBS model (Keller and van Driel).

Table 1. (Extended)

Population (millions)		Per-Capita (kilograms)							
		Cotton		Wool		Chemical Fibers		Total Fibers	
1974	1992	1974	1992	1974	1992	1974	1992	1974	1992
213.9	255.5	7.72	13.04	.30	.48	13.66	14.34	21.67	27.85
62.1	80.6	6.18	9.51	1.44	1.90	9.47	9.97	17.09	21.38
110.2	124.3	6.74	9.21	1.16	1.63	6.49	11.14	14.40	21.99
52.5	57.3	4.89	7.26	1.11	1.24	6.70	8.04	12.70	16.54
55.4	57.1	4.43	7.05	1.42	1.55	4.59	9.63	10.44	18.23
56.2	58.0	4.38	6.86	1.17	1.43	9.67	10.71	15.22	19.00
34.6	41.9	2.20	8.34	.29	.56	2.67	13.63	5.16	22.53
252.1	291.2	7.55	4.82	1.30	.69	3.81	4.57	12.65	10.08
909.1	1,183.6	2.76	3.03	.06	.27	.30	1.99	3.13	5.29
604.9	798.2	1.85	1.89	.02	.02	.26	.85	2.13	2.76
—	—	4.87	7.10	.83	.98	5.76	8.49	11.46	16.56
—	—	3.89	4.51	.38	.43	2.92	4.22	7.18	9.16

j, 0 otherwise).[7] We estimate equation (1) for io = 1, 2, 3 by maximum likelihood under the assumption that the disturbances ϵ_{ic} are normally distributed and have a constant covariance matrix. As we have concerns regarding the quality of the data for the former USSR, we estimate the model with that country included and excluded. The top panel of Table 3 contains the results. It can be seen that when the USSR is included all but the two estimated coefficients for wool are significantly different from zero, while when that country is excluded two more intercept terms become insignificant.

Next, we use Working's model, the i[th] equation of which takes the form

[7] As (1) holds constant total consumption of fibers, as measured by the Divisia index DQ_c, this is a conditional demand equation. Accordingly, the income and price elasticities are also to be interpreted as conditional versions. This comment applies also to the other two models to be discussed; for brevity, however, we shall omit the adjective "conditional" when referring to the demand equations and the elasticities. It should also be noted that (1) is a special case of the Rotterdam model as it is based on the assumption of preference independence. See Theil and Clements (Sec. 1.14) for details. Note that one could question the reasonableness of the assumption of preference independence when applied to fibers as a case could be made that they interact in production technology and/ or consumer preferences. In view of the quality of our price data, however, it would be difficult if not impossible to relax this assumption.

$$(2) \quad y_{ic} = \alpha_i + \beta_i DQ_c + \phi(\beta_i + \bar{w}_{ic})\left[Dp_{ic} - \sum_{j=1}^{3} (\beta_j + \bar{w}_{jc})Dp_{jc}\right] + \epsilon_{ic},$$

where $y_{ic} = \bar{w}_{ic}(Dq_{ic} - DQ_c)$; β_i is the i[th] "income" coefficient and the other notation is as before. The ML estimates of this model are given in Panel B of Table 3. It is to be noted that most of the income coefficients β_i are insignificant. As the income elasticity implied by (2) takes the form $1 + \beta_i/\bar{w}_{ic}$, an insignificant β_i means that the corresponding income elasticity is not significantly different from unity. We shall come back to this issue. The final model we consider is Selvanathan's, which for fiber i is

$$(3) \quad y_{ic} = \alpha_i + \beta_i DQ_c + \gamma\bar{w}_{ic}\left[Dp_{ic} - \sum_{j=1}^{3} \bar{w}_{jc}Dp_{jc}\right] + \epsilon_{ic},$$

where γ is the common elasticity of substitution between the fibers. The estimates of this model are contained in Panel C of Table 3. As most of the estimates of β_i in equation (2) are insignificantly different from zero, we re-estimate with $\beta_i = 0$; this model then coincides with (3) with $\beta_i = 0$. Panel D of Table 3 contains the results, while Panel E adds the ad-

Table 2. Cross-Country Data on Quantity Shares, Log Changes of Quantities and Prices of Fibers

	Quantity Shares			Per-Capita Quantity Log-Change			Divisia Quantity Index	Price Log-Change			Divisia Price Index
Country	Cotton	Wool	Chemical Fibers	Cotton	Wool	Chemical Fibers		Cotton	Wool	Chemical Fibers	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
USA	41.20	1.54	57.26	2.91	2.64	.27	1.40	−.57	1.02	4.36	2.28
Germany	40.32	8.66	51.03	2.40	1.52	.29	1.24	−2.80	−1.21	2.71	.15
Japan	44.37	7.76	47.88	1.73	1.89	3.00	2.35	−5.49	−3.90	1.06	−2.23
France	41.21	8.12	50.67	2.19	.63	1.01	1.47	−.04	1.55	7.09	3.70
Italy	40.55	11.04	48.40	2.58	.49	4.12	3.09	3.66	5.25	9.14	6.49
UK	32.44	7.60	59.96	2.49	1.13	.57	1.23	1.87	3.47	8.00	5.67
Korea	39.79	4.07	56.13	7.41	3.63	9.05	8.18	1.82	3.41	7.98	5.34
USSR	53.73	8.56	37.71	−2.50	−3.48	1.02	−1.26	−.57	1.02	4.36	1.42
China	72.78	3.51	23.71	.50	8.15	10.46	3.13	5.77	7.36	5.40	5.73
India	77.59	.91	21.50	.11	−.62	6.59	1.50	5.91	7.50	7.26	6.21
Mean-Unweighted	48.40	6.18	45.43	1.98	1.60	3.64	2.23	.96	2.55	5.73	3.48
-Weighted	64.44	3.85	31.71	.63	3.15	6.38	2.00	3.55	5.14	5.63	4.57

Notes: 1. The quantity shares given in columns 2–4 are arithmetic averages of the corresponding shares in 1974 and 1992. 2. For all variables except those in columns 2–4, the data are expressed in terms of annual averages. 3. All entries are to be divided by 100.

Sources: For quantities, Table 1. For the prices of cotton and wool in terms of $US, International Cotton Advisory Committee, *World Textile Demand,* 1997. These $US prices are then converted to local-currency terms using prevailing exchange rates, obtained from the International Monetary Fund *International Financial Statistics* (various issues). Due to the unavailability of exchange-rate data for the USSR, for this country we use prices of cotton and wool expressed in terms of $US. As there is no readily-available index of the prices of chemical fibers, as a proxy we use wholesale price indexes for all countries except China and the USSR. For China, in the absence of any other data we use the consumer price index; and for a similar reason in the USSR, we use the WPI in the US. The WPI and CPI data are from the International Monetary Fund *International Financial Statistics* (various issues).

Table 3. Estimates of Demand Equations for Fibers[a]

Coefficient	Cotton	Wool	Chemical Fibers	Cotton	Wool	Chemical Fibers
	USSR INCLUDED			USSR EXCLUDED		
	A. *Rotterdam Model*					
Intercept $\alpha_i \times 100$	−.853 (.323)	−.017 (.065)	.870 (.363)	−.395 (.230)	.084 (.050)	.311 (.222)
Marginal share θ_i	.352 (.056)	.024 (.016)	.624 (.067)	.296 (.042)	.005 (.011)	.698 (.044)
	$\phi = -.792$ (.248) Log-likelihood value = 95.34			$\phi = -.637$ (.213) Log-likelihood value = 92.37		
	B. *Working's Model*					
Intercept $\alpha_i \times 100$	−1.387 (.324)	−.060 (.078)	1.447 (.345)	−1.158 (.361)	.020 (.093)	1.138 (.368)
Income coefficient $\beta_i \times 10$	−.015 (.515)	−.264 (.175)	.280 (.551)	−.497 (.654)	−.437 (.198)	.934 (.696)
	$\phi = -1.049$ (.265) Log-likelihood value = 90.34			$\phi = -1.028$ (.370) Log-likelihood value = 82.54		
	C. *Selvanathan's Model*					
Intercept $\alpha_i \times 100$	−1.179 (.316)	−.116 (.078)	1.295 (.339)	−.929 (.278)	−.070 (.094)	.999 (.290)
Income coefficient $\beta_i \times 10$	−.609 (.586)	−.095 (.235)	.704 (.624)	−1.241 (.585)	−.214 (.275)	1.456 (.577)
	$\gamma = -1.009$ (.254) Log-likelihood value = 89.98			$\gamma = -.997$ (.205) Log-likelihood value = 82.57		
	D. *Working's and Selvanathan's Model with income coefficients suppressed*					
Intercept $\alpha_i \times 100$	−1.258 (.314)	−.133 (.057)	1.391 (.337)	−1.152 (.316)	−.118 (.061)	1.270 (.337)
	$\phi, \gamma = -.954$ (.269) Log-likelihood value = 89.39			$\phi, \gamma = -.898$ (.266) Log-likelihood value = 80.16		
	E. *Working's and Selvanathan's Model with intercepts only*					
Intercept $\alpha_i \times 100$	−.264 (.250)	−.057 (.042)	.322 (.244)	−.220 (.275)	−.043 (.044)	.263 (.265)
	Log-likelihood value = 87.59			Log-likelihood value = 78.85		

[a] Asymptotic standard errors in parentheses.

ditional constraint that ϕ (and γ) equals zero, which amounts to all price elasticities vanishing. On the basis of the log-likelihood values in Table 3, we are unable to reject the restricted versions of the models given in Panels D and E.[8]

Predicting the Quantity Shares

Table 4 contains the quantity shares for the three fibers in 1974 and 1992, as well as their

[8] Using a likelihood ratio test to test the model in Panel D against that in Panel B yields a chi-square value of 1.90 with the USSR included, and 4.76 when that country is excluded. Both values are insignificant

Table 4. Quantity Shares in 1974 and 1992

	Cotton			Wool			Chemical Fibers		
Country	1974	1992	Change	1974	1992	Change	1974	1992	Change
USA	35.60	46.80	11.20	1.37	1.71	.34	63.03	51.49	−11.54
Germany	36.14	44.49	8.34	8.44	8.87	.43	55.41	46.64	−8.77
Japan	46.84	41.89	−4.95	8.08	7.43	−.65	45.08	50.68	5.60
France	38.52	43.90	5.38	8.73	7.51	−1.22	52.75	48.59	−4.16
Italy	42.44	38.66	−3.78	13.59	8.50	−5.09	43.97	52.84	8.87
UK	28.79	36.10	7.31	7.67	7.53	−.14	63.54	56.37	−7.17
Korea	42.55	37.03	−5.52	5.66	2.49	−3.17	51.79	60.48	8.68
USSR	59.67	47.79	−11.88	10.24	6.87	−3.36	30.09	45.34	15.25
China	88.33	57.23	−31.10	1.97	5.05	3.08	9.70	37.72	28.02
India	86.74	68.44	−18.30	1.08	.75	−.33	12.18	30.82	18.63
Mean	50.56	46.23	−4.33	6.68	5.67	−1.01	42.75	48.10	5.34

Note: All entries are to be divided by 100.
Source: Derived from Table 1.

changes. It is clear that the shares have changed substantially for some countries, and that the changes display some important characteristics. For example, the share for cotton in China dropped by more than 30 percentage points, a reduction that is almost offset completely by the increased share of chemical fibers. The changes in India and the USSR follow a similar pattern, but the magnitude of the changes is smaller for these two countries. In the developed countries, there is a tendency for the pattern to be reversed—cotton rises and chemical fibers falls. The wool share is more stable for both developed and developing countries. In this section we evaluate the performance of the demand models in predicting the changes in the shares. We start with the share of each fiber in 1974 and use the observed changes in prices and the total size of the market, together with the estimated coefficients, to predict the share in 1992. Given the large changes that have taken place over this 18-year period, an analysis of the quality of the predictions is a "stress test" of the models.

at the 5-percent level. Using the same approach to test Panel E against Panel D, yields chi-square values of 3.60 (USSR included) and 2.62 (USSR excluded), again both insignificant. In the next section, we discuss the economic significance of assuming that (i) the income coefficients are zero; and (ii) relative prices can be ignored as determinants of fiber consumption patterns.

Recall that the quantity share of fiber i is defined as $w_i = q_i/Q$, where q_i is per-capita consumption of fiber i and $Q = \Sigma_{i=1}^{3} q_i$ is the total size of the market.[9] The differential of this share is

$$dw_i = w_i[d(\log q_i) - d(\log Q)].$$

A finite-change approximation to this is

$$(4) \quad w_{i,1992} - w_{i,1974} = \bar{w}_i[\log(q_{i,1992}/q_{i,1974}) - \log(Q_{1992}/Q_{1974})],$$

where $\bar{w}_i = ½(w_{i,1992} + w_{i,1974})$. As Dq_i is the average annual log-change in q_i, we have that $\log(q_{i,1992}/q_{i,1974}) = 18 \times Dq_i$, where 18 is the number of years between 1974 and 1992; and similarly $\log(q_{1992}/Q_{1974}) = 18 \times DQ$. Thus, equation (4) can be expressed as

$$(5) \quad w_{i,1992} = w_{i,1974} + 18 \times \bar{w}_i Dq_i - 18 \times \bar{w}_i DQ.$$

We use the right-hand side of equation (5) to predict the quantity share in 1992. For the first term on the right of this equation, $w_{i,1974}$, we use the observed value. Regarding the second term, $18 \times \bar{w}_i Dq_i$, we use the relevant demand model to predict this. For the Rotterdam model, equation (1), as $\bar{w}_i Dq_i$ is the de-

[9] For convenience, wherever possible we suppress the country subscript.

Table 5. Actual and Predicted Quantity Shares in 1992, USSR Included

Country	Cotton	Wool	Chemical Fibers	Cotton	Wool	Chemical Fibers	Cotton	Wool	Chemical Fibers
	Actual			Rotterdam Model			Working's Model		
USA	46.80	1.71	51.49	35.75	1.80	62.45	31.91	−1.24	69.33
Germany	44.49	8.87	46.64	37.82	7.54	54.64	33.11	8.78	58.11
Japan	41.89	7.43	50.68	47.18	6.56	46.26	50.39	7.35	42.26
France	43.90	7.51	48.59	44.07	7.86	48.07	43.19	9.79	47.03
Italy	38.66	8.50	52.84	40.84	8.97	50.18	39.06	13.60	47.34
UK	36.10	7.53	56.37	33.71	7.04	59.24	25.28	8.77	65.95
Korea	37.03	2.49	60.48	37.88	2.64	59.49	45.75	.91	53.34
USSR	47.79	6.87	45.34	66.19	12.49	21.32	54.82	10.15	35.03
China	57.23	5.05	37.72	52.19	1.45	46.36	61.49	−.06	38.56
India	68.44	.75	30.82	64.85	.92	34.24	66.25	−.19	33.94
Mean	46.23	5.67	48.10	46.05	5.73	48.22	45.13	5.79	49.09
	Selvanathan's Model			Working's and Selvanathan's Model with Income Coefficients Suppressed			Working's and Selvanathan's Model with Intercepts Only		
USA	32.96	−.89	67.92	31.84	−.97	69.13	30.84	.33	68.82
Germany	34.22	8.70	57.08	32.91	8.50	58.58	31.38	7.41	61.21
Japan	49.32	7.62	43.06	49.06	7.62	43.32	42.08	7.05	50.87
France	43.13	9.98	46.90	41.76	9.78	48.46	33.76	7.69	58.55
Italy	37.84	13.85	48.31	38.76	13.87	47.38	37.68	12.55	49.76
UK	26.62	9.10	64.28	25.18	8.82	66.00	24.02	6.64	69.34
Korea	37.65	3.78	58.57	44.10	4.75	51.15	37.79	4.62	57.59
USSR	58.13	8.58	33.29	54.73	8.19	37.09	54.91	9.20	35.89
China	62.59	−.83	38.24	64.72	−.62	35.90	83.57	.93	15.50
India	68.15	−1.25	33.10	68.14	−1.29	33.15	81.98	.04	17.98
Mean	45.06	5.86	49.07	45.12	5.87	49.02	45.80	5.65	48.55

Note: All entries are to be divided by 100.

pendent variable, we just use the fitted value. The third term, $18 \times \bar{w}_i DQ$, involves the arithmetic average share $\bar{w}_i$ and the Divisia volume index DQ. We can take DQ as given, but not $\bar{w}_i$ as this contains $w_{i,1992}$ which is the object of the prediction. We adopt a simple iterative scheme (Theil, 1971, p. 647) of first using $w_{i,1974}$ for $\bar{w}_i$ in the last term on the right of equation (5). This yields an initial prediction of $w_{i,1992}$, $\hat{w}'_{i,1992}$, which we then normalize so that the predicted shares of the three fibers sum to unity. Next, with the normalized $\hat{w}'_{i,1992}$ we form $\bar{w}'_i = \frac{1}{2}(w_{i,1974} + \hat{w}'_{i,1992})$. Using this $\bar{w}'_i$ in (5) as before yields a second-round prediction $\hat{w}''_{i,1992}$, and this process continues until convergence is obtained. In practice, this algorithm converges quickly. The other two demand models, (2) and (3), both have as dependent variable $y_i = \bar{w}_i(Dq_i - DQ)$, so that $\bar{w}_i Dq_i = y_i + \bar{w}_i DQ$ and equation (5) becomes

$$w_{i,1992} = w_{i,1974} + 18 \times y_i.$$

We evaluate this equation by using the observed value of $w_{i,1974}$ as before. As the right-hand sides of equations (2) and (3) both involve $\bar{w}_i$, it follows that y_i depends on this share and we need to use the above iterative scheme with appropriate modifications.

Table 5 contains the predicted shares corresponding to the five estimated demand models for the case when the USSR is included;

Table 6. Actual and Predicted Quantity Shares in 1992, USSR Excluded

Country	Cotton	Wool	Chemical Fibers	Cotton	Wool	Chemical Fibers	Cotton	Wool	Chemical Fibers
	Actual			Rotterdam Model			Working's Model		
USA	46.80	1.71	51.49	38.36	2.61	59.02	33.21	−.93	67.72
Germany	44.49	8.87	46.64	40.21	8.32	51.47	34.75	9.59	55.66
Japan	41.89	7.43	50.68	47.80	6.82	45.38	52.36	7.82	39.82
France	43.90	7.51	48.59	45.13	8.32	46.55	45.07	10.47	44.45
Italy	38.66	8.50	52.84	41.49	9.17	49.34	39.73	14.23	46.04
UK	36.10	7.53	56.37	35.68	7.74	56.58	25.74	9.33	64.93
Korea	37.03	2.49	60.48	34.48	1.50	64.01	41.68	−1.40	59.72
China	57.23	5.05	37.72	56.29	2.42	41.29	62.50	.83	36.66
India	68.44	.75	30.82	69.78	2.24	27.98	69.35	1.02	29.63
Mean	46.06	5.54	48.40	45.47	5.46	49.07	44.93	5.66	49.40
	Selvanathan's Model			Working's and Selvanathan's Model with Income Coefficients Suppressed			Working's and Selvanathan's Model with Intercepts Only		
USA	35.96	−.28	64.32	32.73	−.66	67.94	31.66	.60	67.74
Germany	37.33	9.15	53.52	33.76	8.60	57.63	32.20	7.67	60.13
Japan	50.73	7.87	41.40	49.47	7.77	42.76	42.89	7.31	49.80
France	45.70	10.34	43.96	42.17	9.83	48.00	34.58	7.96	57.47
Italy	38.58	13.93	47.49	39.58	13.93	46.50	38.50	12.82	48.68
UK	30.12	9.53	60.35	26.16	8.84	65.00	24.84	6.90	68.26
Korea	32.05	2.82	65.13	44.58	4.94	50.48	38.61	4.88	56.51
China	63.54	−.69	37.15	66.75	−.37	33.63	84.38	1.20	14.42
India	70.71	−.79	30.09	69.71	−1.05	31.34	82.79	.31	16.90
Mean	44.97	5.77	49.27	44.99	5.76	49.25	45.60	5.52	48.88

Note: All entries are to be divided by 100.

for convenience, the table also reproduces the actual shares. Although all models perform adequately in predicting the cross-country means of the three shares, three out of the five models predict negative shares for wool in the richest (the USA) and poorest (China and India) countries. The three models yielding negative shares are (i) Working's; (ii) Selvanathan's; and (iii) Working's and Selvanathan's model with income coefficients suppressed. In this sense then, only the two remaining models pass the stress test—the Rotterdam and Working's and Selvanathan's with intercepts only. When the USSR is excluded (Table 6), the results are somewhat similar.

Let $\hat{w}_{1c}$, $\hat{w}_{2c}$, $\hat{w}_{3c}$ be the predicted shares of the three fibers in country c and w_{1c}, w_{2c}, w_{3c} be the corresponding observed shares. Both the predicted and observed shares are positive fractions and have a unit sum. One way to measure the quality of the predictions as a whole which takes into account these special features is the information inaccuracy (Strobel; Theil and Clements, Secs. 3.17 and 3.18). The Strobel measure has the attraction of providing a simple decomposition of the information inaccuracy over its constituent goods, i.e., if $I_{ic} = \hat{w}_{ic} - w_{ic} + w_{ic}\log(w_{ic}/\hat{w}_{ic})$, then the information inaccuracy is $I_c = \Sigma_{i=1}^{3} I_{ic}$. This I_c measures the poorness of fit of the model, with I_{ic}, $I_c \geq 0$ and $I_{ic} = 0$ only if the prediction of i in c is perfect (i.e., $\hat{w}_{ic} = w_{ic}$). Panel A of Table 7 contains the information inaccuracies for the predictions based on the Rotterdam model; as the other models yield some negative shares, they are not considered any further. Consider first the left-hand part of this panel, which deals with the situation when the USSR is included. Column 2 shows that the cross-country mean of the inaccuracies is 234 $\times 10^{-4}$ and that the USSR appears to be an outlier as its I_c is about six times the mean. The means of the components I_{ic} imply that chemical fibers account for 132/234 = 56 percent of the lack of fit of the model, while the reminder is split roughly equally between cotton and wool. The right-hand side of Panel A reveals that when the USSR is excluded, the mean inaccuracy falls by about 75 percent and wool contributes relatively more to the overall lack of fit of the model.

The other panels of Table 7 provide a standard of reference by giving the inaccuracies for various special cases. Panel B replaces the marginal shares θ_i in equation (1) with the corresponding (arithmetic average) quantity shares $\bar{w}_{ic}$; as the income elasticity is the ratio of the marginal share to the quantity share, this implies that these elasticities are unity.[10] The other coefficients of the model, α_i and ϕ, are left at their estimated values, as before. As can be seen, relative to Panel A, for most countries, I_c rises. Interestingly, however, the inaccuracy for the USSR falls substantially under unitary income elasticities, from 1,454 to 428 ($\times 10^{-4}$). This raises suspicions that perhaps the Soviets "estimated" their consumption data by assuming that things expand more or less proportionally. As the mean inaccuracy increases from 234 to 291 ($\times 10^{-4}$) or by almost 25 percent, this is the "cost" of assuming unitary income elasticities. Next, we use the estimated intercepts and marginal shares and specify that the income flexibility $\phi = 0$, which means that relative prices now play no role. The results, given in Panel C, reveal a further increase in the inaccuracy for most countries, but a further *decrease* in that for the USSR, which serves to reinforce suspicions about the quality of that country's data. Comparing the mean of 640 with that given in Panel A of 234 ($\times 10^{-4}$), it can be seen that the assumption that "prices do not matter" causes the fit of the predictions to deteriorate by a factor of more than 2½. This result clearly demonstrates the importance of relative prices in determining the quantity shares. Panel D gives the results under the joint assumption that $\theta_i = \bar{w}_{ic}$ and $\phi = 0$. Here the inaccuracies for both the three fibers jointly and individually for the USSR are among the lowest. Finally, we assume that each of the shares remains unchanged over the 18-year period, so that $\hat{w}_{i,1992} = w_{i,1974}$. The corresponding inaccuracies are contained in Panel E. A comparison of these results with those of Panel A shows how the naive approach of no-change extrapolation performs relative to the Rotterdam model, with the average information inaccuracy falling from 597 to 234 ($\times 10^{-4}$), or by about 60 percent. On the basis of this analysis, in what follows we exclude the USSR.[11]

Application to 91 Countries

As an out-of-sample test of the model, we now consider predictions of the three shares for 82 countries not used in estimation. These countries, together with their GDP per-capita and the shares in 1974 and 1992, are given in Table 8; for ease of comparison, this table also contains data pertaining to the nine remaining in-sample countries, so that the total number of countries here is 82 + 9 = 91. Details of the source of the data are given in Clements and Lan.

We use exactly the same methodology as before to predict the three shares in 1992 for the 82 new countries. For this purpose, we use the estimates of the Rotterdam model given in the right-hand side of Panel A of Table 3, and it turns out that 19 out of the 82 new countries have at least one negative share; the majority of these cases refer to chemical fibers in low-income countries. The result that the model breaks down in about 25 percent of cases is not surprising given that (i) all the countries involved are out of sample; (ii) there is tremendous cross-country variability in per-ca-

[10] Note that as the marginal shares are no longer constant, the model underlying Panel B is not really the Rotterdam.

[11] A similar analysis reveals that China should be included; see Clements and Lan for details.

Table 7. First Set of Information Inaccuracies

Country (1)	Information Inaccuracy I_c (2)	Strobel Component I_{ic} Cotton (3)	Strobel Component I_{ic} Wool (4)	Strobel Component I_{ic} Chemical Fibers (5)	Information Inaccuracy I_c (6)	Strobel Component I_{ic} Cotton (7)	Strobel Component I_{ic} Wool (8)	Strobel Component I_{ic} Chemical Fibers (9)
	USSR INCLUDED				USSR EXCLUDED			
	A. *Rotterdam model*							
USA	258	155	0	102	155	87	18	50
Germany	128	56	11	62	47	22	2	23
Japan	57	31	5	20	71	38	2	30
France	1	0	1	0	10	2	4	4
Italy	14	6	1	7	25	10	3	12
UK	17	8	2	7	1	0	0	0
Korea	2	1	0	1	42	9	23	10
USSR	1,454	284	151	1,019	—	—	—	—
China	380	24	271	86	124	1	107	16
India	29	10	2	18	83	1	68	14
Mean	234	57	44	132	62	19	25	18
	B. *Unitary income elasticities*							
USA	250	143	4	103	89	32	44	13
Germany	115	69	9	37	39	5	33	0
Japan	287	101	22	164	630	188	60	383
France	95	0	73	22	250	23	116	111
Italy	334	20	182	131	694	94	238	362
UK	114	61	42	10	90	1	79	10
Korea	491	116	175	200	928	220	278	430
USSR	428	104	57	268	—	—	—	—
China	710	174	313	223	1,536	393	56	1,086
India	89	25	1	64	730	114	73	542
Mean	291	81	88	122	554	119	109	326
	C. *No price effects*							
USA	1,543	1,066	5	472	799	527	15	257
Germany	1,365	869	24	472	631	386	3	243
Japan	373	204	20	150	122	65	4	53
France	979	645	2	332	426	274	3	150
Italy	311	206	0	105	123	81	2	40
UK	1,222	896	10	316	483	343	0	139
Korea	71	39	19	13	465	291	35	139
USSR	167	1	125	41	—	—	—	—
China	249	15	175	60	110	0	100	10
India	122	44	7	71	71	2	70	0
Mean	640	398	39	203	359	219	26	115
	D. *Unitary income elasticities and no price effects*							
USA	1,819	1,266	16	536	754	492	28	234
Germany	1,497	1,015	3	478	544	353	6	184
Japan	245	156	1	88	32	6	26	0
France	1,058	733	5	320	347	221	40	87
Italy	357	218	99	40	197	15	172	11
UK	1,669	1,303	0	366	541	399	16	126

Table 7. (Continued)

Country (1)	Information Inaccuracy I_c (2)	Strobel Component I_{ic} Cotton (3)	Wool (4)	Chemical Fibers (5)	Information Inaccuracy I_c (6)	Strobel Component I_{ic} Cotton (7)	Wool (8)	Chemical Fibers (9)
Korea	293	13	96	37	216	4	205	8
USSR	67	184	53	0	—	—	—	—
China	667	6	221	262	1,588	396	31	1,162
India	22	160	0	15	565	83	92	391
Mean	769	505	49	214	532	219	68	245
				E. *No-change extrapolation*				
USA	277	160	4	113	277	160	4	113
Germany	164	90	1	73	164	90	1	73
Japan	63	27	3	33	63	27	3	33
France	62	36	9	17	62	36	9	17
Italy	211	17	110	84	211	17	110	84
UK	128	86	0	42	128	86	0	42
Korea	219	37	112	69	219	37	112	69
USSR	523	127	63	334	—	—	—	—
China	3,115	626	168	2,321	3,115	626	168	2,321
India	1,211	208	6	997	1,211	208	6	997
Mean	597	142	48	408	606	143	46	417

Note: All entries are to be divided by 10^4.

pita GDP and in the levels of and changes in the three shares. The quality of the predictions is analysed in Table 9 by comparing the information inaccuracy of the Rotterdam model with that of no-change extrapolation. This table refers to the 82 − 19 = 63 remaining out-of-sample countries, as well as the 9 in-sample, giving a total of 72 countries. The median over all countries of the inaccuracies for no-change is 365, which increases to 400 (both $\times 10^{-4}$) when the Rotterdam model is used as the basis of the prediction. When we confine ourselves to the 63 out-of-sample countries, the median inaccuracy rises from 423 to 498. While this does not seem to be too encouraging, things look somewhat better when we consider the relative performance of the two models for each country. Using Column 4 of Table 9, we find that the percentage of cases in which the inaccuracy falls in moving from no-change to Rotterdam is:

All countries	57%
9 in-sample countries	89%
63 out-of-sample countries	52%.

This shows that the demand model yields better predictions in a bit more than one-half of the out-of-sample countries.

In the above analysis, we used the coefficients estimated from the nine countries to predict the shares of the 63 other countries. This raises the question of whether we might be able to improve the predictions by allowing the coefficients to be different for the out-of-sample countries. As the own-price elasticity of demand for fibers as a whole ϕ is such a key parameter in the model, we pursue this matter by varying its value away from its estimate of −.637. The results, presented in Table 10, indicate the following: (i) The number of countries for which all the predicted shares are positive falls as $|\phi|$ rises, from 90 percent for $|\phi|$ = .1 to 72 percent for $|\phi|$ = 1 (see Column 3). (ii) From Column 4, the (cross-country) mean information inaccuracy is minimised for $\phi = -.5$ and for this value the Rotterdam model beats no-change extrapolation for 51 percent of the countries (Column 6); this is essentially the same as the case for ϕ

Table 8. Cross-Country Data on GDP Per-Capita and Quantity Shares: 91 Countries

Country	Real GDP Per-Capita in 1992 ($US)	Quantity Shares								
		Cotton			Wool			Chemical Fibers		
		1974	1992	Change	1974	1992	Change	1974	1992	Change
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. USA	23,220	35.60	46.80	11.20	1.37	1.71	.34	63.03	51.49	−11.54
2. Switzerland	21,631	29.56	48.51	18.95	22.41	11.76	−10.65	48.02	39.72	−8.30
3. Hong Kong	21,034	79.88	43.95	−35.93	3.99	11.48	7.49	16.13	44.57	28.44
4. Canada	20,970	39.26	40.35	1.08	3.99	3.19	−.80	56.75	56.46	−.28
5. Germany	20,197	36.14	44.49	8.34	8.44	8.87	.43	55.41	46.64	−8.77
6. Japan	19,920	46.84	41.89	−4.95	8.08	7.43	−.65	45.08	50.68	5.60
7. Denmark	18,730	46.01	58.58	12.57	6.43	7.26	.82	47.55	34.16	−13.39
8. Australia	18,500	39.56	43.42	3.86	7.88	7.63	−.25	52.56	48.95	−3.61
9. Sweden	18,387	39.65	58.89	19.24	4.27	5.95	1.68	56.08	35.17	−20.91
10. France	18,232	38.52	43.90	5.38	8.73	7.51	−1.22	52.75	48.59	−4.16
11. Netherlands	17,373	38.07	48.93	10.85	10.11	7.39	−2.72	51.82	43.68	−8.14
12. Norway	17,094	30.35	54.86	24.51	13.15	10.23	−2.92	56.50	34.91	−21.59
13. Austria	16,989	27.94	50.46	22.52	9.18	10.31	1.12	62.88	39.23	−23.65
14. Singapore	16,736	53.32	46.79	−6.53	4.93	1.44	−3.49	41.75	51.77	10.02
15. Italy	16,724	42.44	38.66	−3.78	13.59	8.50	−5.09	43.97	52.84	8.87
16. Iceland	16,324	32.56	48.72	16.16	39.53	23.08	−16.46	27.91	28.21	.30
17. UK	16,302	28.79	36.10	7.31	7.67	7.53	−.14	63.54	56.37	−7.17
18. Finland	15,619	42.78	45.27	2.49	4.94	5.19	.25	52.28	49.53	−2.74
19. New Zealand	15,502	43.15	36.11	−7.04	23.42	16.64	−6.77	33.43	47.25	13.82
20. Belgium-Lux.	14,049	46.88	47.02	.14	5.04	11.33	6.29	48.09	41.65	−6.43
21. Spain	12,986	30.52	31.38	.86	6.64	8.05	1.42	62.84	60.56	−2.28
22. Israel	12,783	49.30	46.97	−2.32	1.41	3.29	1.88	49.30	49.74	.44
23. Ireland	12,259	33.03	41.07	8.04	14.61	12.50	−2.11	52.36	46.43	−5.93
24. Cyprus	11,742	36.49	25.00	−11.49	9.46	16.67	7.21	54.05	58.33	4.28
25. Trinidad & Tobago	9,895	47.52	29.85	−17.67	.99	1.49	.50	51.49	68.66	17.17
26. Korea	9,358	42.55	37.03	−5.52	5.66	2.49	−3.17	51.79	60.48	8.68
27. Barbados	9,173	37.50	50.00	12.50	25.00	7.14	−17.86	37.50	42.86	5.36
28. Portugal	9,005	46.91	31.09	−15.82	6.93	9.98	3.04	46.15	58.93	12.78
29. Greece	8,658	49.85	45.27	−4.58	13.13	5.79	−7.34	37.02	48.93	11.91

Table 8. (Continued)

Country	Real GDP Per-Capita in 1992 ($US)	Quantity Shares								
		Cotton			Wool			Chemical Fibers		
		1974	1992	Change	1974	1992	Change	1974	1992	Change
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
30. Venezuela	8,449	44.27	40.72	−3.55	2.27	.75	−1.52	53.47	58.53	5.07
31. Saudi Arabia	8,407	35.71	22.31	−13.41	9.46	4.27	−5.19	54.83	73.43	18.60
32. Mauritius	8,025	40.00	33.92	−6.08	7.27	8.19	.91	52.73	57.89	5.17
33. Mexico	7,867	43.83	37.72	−6.10	1.28	1.07	−.20	54.90	61.20	6.31
34. Kuwait	7,665	51.53	27.21	−24.31	18.34	16.20	−2.14	30.13	56.59	26.46
35. Malta	7,625	58.54	12.75	−45.79	7.32	11.76	4.45	34.15	75.49	41.34
36. Malaysia	7,191	17.68	44.59	26.90	1.61	2.27	.66	80.71	53.14	−27.57
37. Bulgaria	6,774	46.48	18.30	−28.17	11.77	5.86	−5.91	41.76	75.84	34.09
38. Uruguay	6,736	44.97	45.08	.11	22.82	6.44	−16.38	32.21	48.48	16.27
39. Chile	6,326	54.65	38.10	−16.55	16.86	5.99	−10.87	28.49	55.91	27.42
40. Hungary	5,780	47.18	28.88	−18.30	3.01	477	1.76	49.81	66.35	16.54
41. Argentina	5,532	56.71	52.81	−3.90	12.81	11.02	−1.79	30.47	36.17	5.69
42. Fiji	5,288	66.67	73.47	6.80	6.67	4.08	−2.59	26.67	22.45	−4.22
43. Czechoslovakia	5,066	34.99	33.74	−1.25	7.46	6.62	−.85	57.55	59.64	2.10
44. Thailand	5,018	65.67	41.47	−24.20	.16	.04	−.12	34.17	58.49	24.32
45. Brazil	4,912	61.31	69.02	7.71	1.04	.47	−.57	37.65	30.51	−7.14
46. Poland	4,907	36.97	38.39	1.42	4.70	4.93	.24	58.33	56.67	−1.66
47. Turkey	4,893	60.41	50.52	−9.89	9.14	8.38	−.76	30.45	41.10	10.65
48. Syrian Arab Rep.	4,833	66.74	48.17	−18.56	2.89	15.70	12.81	30.37	36.13	5.76
49. Costa Rica	4,522	44.35	65.52	21.17	.87	2.87	2.00	54.78	31.61	−23.17
50. Colombia	4,254	53.95	49.94	−4.01	1.13	1.63	.51	44.92	48.42	3.50
51. Iran	4,161	41.12	56.93	15.81	5.40	2.57	−2.83	53.48	40.50	−12.98
52. Panama	4,102	36.63	40.88	4.25	2.97	7.55	4.58	60.40	51.57	−8.82
53. South Africa	3,885	34.48	27.88	−6.60	7.12	3.43	−3.69	58.40	68.69	10.29
54. Tunisia	3,807	40.16	20.15	−20.02	20.08	14.08	−6.00	39.75	65.78	26.02
55. Jordan	3,774	43.48	30.03	−13.45	23.91	5.88	−18.03	32.61	64.09	31.48
56. Ecuador	3,420	43.81	43.47	−.34	5.75	1.51	−4.24	50.44	55.03	4.58
57. Algeria	3,076	35.10	38.46	3.36	12.09	30.64	18.54	52.80	30.90	−21.90
58. Jamaica	2,978	60.00	23.33	−36.67	3.48	8.33	4.86	36.52	68.33	31.81

Table 8. (Continued)

Country (1)	Real GDP Per-Capita in 1992 ($US) (2)	Quantity Shares: Cotton 1974 (3)	Cotton 1992 (4)	Cotton Change (5)	Wool 1974 (6)	Wool 1992 (7)	Wool Change (8)	Chemical Fibers 1974 (9)	Chemical Fibers 1992 (10)	Chemical Fibers Change (11)
59. Dominican Rep.	2,918	56.86	45.09	−11.78	1.96	4.62	2.66	41.18	50.29	9.11
60. Guatemala	2,888	42.72	71.68	28.97	.49	.36	−.13	56.80	27.96	−28.84
61. Sri Lanka	2,783	77.46	28.10	−49.35	.58	2.37	1.79	21.97	69.53	47.56
62. Morocco	2,777	20.69	26.67	5.98	17.04	16.46	−.58	62.27	56.87	−5.40
63. Iraq	2,775	51.93	41.42	−10.51	11.43	7.43	−4.00	36.64	51.15	14.51
64. Paraguay	2,655	66.67	54.75	−11.91	4.00	1.52	−2.48	29.33	43.73	14.39
65. Peru	2,620	56.88	30.78	−26.11	7.56	7.32	−.24	35.55	61.90	26.35
66. Indonesia	2,601	45.42	40.75	−4.66	.49	.19	−.30	54.10	59.06	4.96
67. Suriname	2,495	55.17	64.71	9.53	6.90	17.65	10.75	37.93	17.65	−20.28
68. El Salvador	2,274	64.34	58.89	−5.45	.78	.56	−.22	34.88	40.56	5.67
69. Egypt	2,274	90.44	59.24	−31.20	2.22	1.44	−.78	7.34	39.32	31.99
70. Philippines	2,172	33.77	61.62	27.85	.31	.16	−.15	65.92	38.22	−27.70
71. Romania	2,130	36.74	18.59	−18.15	7.65	7.54	−.10	55.61	73.87	18.25
72. Bolivia	2,066	63.16	32.37	−30.79	12.63	35.26	22.63	24.21	32.37	8.16
73. China	1,838	88.33	57.23	−31.10	1.97	5.05	3.08	9.70	37.72	28.02
74. Pakistan	1,793	85.19	79.19	−6.00	3.48	2.28	−1.20	11.33	18.53	7.20
75. Honduras	1,792	41.33	55.13	13.79	5.33	1.28	−4.05	53.33	43.59	−9.74
76. India	1,633	86.74	68.44	−18.30	1.08	.75	−.33	12.18	30.82	18.63
77. Zimbabwe	1,479	78.91	79.37	.46	1.56	.40	−1.17	19.53	20.24	.71
78. Nicaragua	1,441	78.74	33.33	−45.41	.9	1.52	.73	20.47	65.15	44.68
79. Kenya	1,176	44.40	46.49	2.09	7.20	3.51	−3.69	48.40	50.00	1.60
80. Nigeria	1,132	62.35	69.61	7.26	5.72	.79	−4.94	31.93	29.61	−2.32
81. Cameroon	1,122	73.05	48.94	−24.11	1.42	3.19	1.77	25.53	47.87	22.34
82. Nepal	996	79.20	66.48	−12.72	17.60	11.36	−6.24	3.20	22.16	18.96
83. Madagascar	757	80.70	62.34	−18.36	.88	1.30	.42	18.42	36.36	17.94
84. Sudan	707	88.45	62.69	−25.76	.26	25.07	24.81	11.29	12.24	.95
85. Malawi	607	58.44	51.19	−7.25	5.19	4.76	−.43	36.36	44.05	7.68
86. Tanzania	570	75.90	73.17	−2.73	6.43	9.15	2.72	17.67	17.68	.01
87. Ethiopia	325	92.21	68.75	−23.46	4.33	26.30	21.97	3.46	4.95	1.48

Table 8. (Continued)

Country	Real GDP Per-Capita in 1992 ($US)	Quantity Shares: Cotton 1974	Cotton 1992	Cotton Change	Wool 1974	Wool 1992	Wool Change	Chemical Fibers 1974	Chemical Fibers 1992	Chemical Fibers Change
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
88. Afghanistan	—	60.69	53.03	−7.66	21.38	21.52	.13	17.92	25.45	7.53
89. Albania	—	77.17	64.52	−12.66	15.22	27.42	12.20	7.61	8.06	.46
90. Cuba	—	69.06	75.36	6.29	.87	3.26	2.39	30.07	21.38	−8.68
91. Libya	—	27.96	42.71	14.75	13.60	19.10	5.49	58.44	38.19	−20.25
Mean										
9 in-sample countries	14,158	49.55	46.06	−3.49	6.29	5.54	−.75	44.16	48.40	4.24
82 out-of-sample countries	6,975	51.55	46.26	−5.25	7.96	8.05	0.09	40.54	45.69	5.15

Note: Columns 3 to 11 are to be divided by 100.

= −.637. (iii) On the basis of the median (Column 5), the optimal out-of-sample value of ϕ is −.7.[12]

A Composite Model

In the above analysis, the predicted shares from the Rotterdam model and those from no-change extrapolation are viewed as two sets of competing forecasts. Rather than considering one forecast or the other, in this section we analyse whether it is possible to combine them to yield something that is better than the component parts.[13] As the values of the coefficients of the composite model are different from the estimates for the nine countries, this methodology can be considered as an extension of the approach employed in the previous section of allowing the own-price elasticity to differ for out-of-sample countries.

Let $\hat{w}^1_{ic}$ and $\hat{w}^2_{ic}$ be the predicted share of fiber i in country c from the Rotterdam model and no-change extrapolation, respectively. Consider a weighted average of these two sets of predictions:

$$(6) \quad \hat{w}_{ic} = \lambda \hat{w}^1_{ic} + (1 - \lambda)\hat{w}^2_{ic},$$

where the weight $0 \leq \lambda \leq 1$. Note that if λ = 1 (0), the composite forecast (6) then coincides with the Rotterdam model (no-change extrapolation).

The Rotterdam model (1) is expressed in terms of relative prices. For what follows, it is more convenient to express it in absolute prices by defining the (i, j)th Slutsky coefficient as $\pi_{ij} = \phi\theta_i(\delta_{ij} - \theta_j)$, where δ_{ij} is the Kronecker delta. The Slutsky coefficients satisfy demand homogeneity $\Sigma_{j=1}^{3} \pi_{ij} = 0$, i = 1, 2, 3, and symmetry $\pi_{ij} = \pi_{ji}$, i, j = 1, 2, 3. We can then rewrite (1) as

[12] Estimating the demand models using the larger number of countries proved unsuccessful as many of the coefficients were insignificant. For details, see Clements and Lan.

[13] The approach is similar to the optimal combination of forecasts (Bates and Granger; Granger and Newbold, Chap. 8) and Barten's (1993) combination of different demand systems to yield a synthetic model.

Table 9. Second Set of Information Inaccuracies

Country (1)	Information Inaccuracies with Prediction from: Rotterdam Model (2)	No-Change Extrapolation (3)	Rotterdam Less No-Change (4) = (2) − (3)
1. USA	155	277	−122
2. Switzerland	954	890	64
3. Hong Kong	8,573	3,117	5,456
4. Canada	332	10	321
5. Germany	47	164	−117
6. Japan	71	63	7
7. Denmark	425	372	53
8. Australia	103	31	72
9. Sweden	180	885	−705
10. France	10	62	−51
11. Netherlands	60	250	−190
12. Norway	449	1,310	−861
13. Austria	548	1,252	−703
14. Singapore	395	325	69
15. Italy	25	211	−187
16. UK	1	128	−128
17. Finland	273	15	258
18. New Zealand	1,718	423	1,296
19. Belgium-Lux.	220	334	−114
20. Spain	225	20	206
21. Israel	11	97	−86
22. Ireland	93	142	−48
23. Cyprus	1,134	443	691
24. Trinidad & Tobago	4,492	649	3,843
25. Korea	42	219	−177
26. Barbados	1,117	1,116	1
27. Portugal	1,152	525	628
28. Greece	604	455	149
29. Venezuela	274	107	167
30. Saudi Arabia	404	755	−351
31. Mauritius	219	79	140
32. Mexico	68	81	−13
33. Kuwait	3,022	1,628	1,394
34. Malta	3,229	4,605	−1,376
35. Malaysia	745	1,981	−1,236
36. Bulgaria	2,108	2,412	−304
37. Uruguay	475	1,178	−703
38. Chile	536	1,775	−1,239
39. Argentina	88	77	11
40. Fiji	205	127	78
41. Czechoslovakia	1,118	11	1,107
42. Thailand	599	1,232	−632
43. Turkey	21	257	−235
44. Syrian Arab Rep.	2,482	1,712	769
45. Costa Rica	972	1,162	−190
46. Colombia	22	39	−17

Table 9. (Continued)

Country (1)	Information Inaccuracies with Prediction from: Rotterdam Model (2)	No-Change Extrapolation (3)	Rotterdam Less No-Change (4) = (2) − (3)
47. Panama	137	338	−201
48. South Africa	1,145	272	873
49. Tunisia	1,269	1,422	−153
50. Jordan	79	2,394	−2,314
51. Ecuador	278	243	35
52. Algeria	657	1,543	−886
53. Dominican Rep.	116	356	−240
54. Guatemala	1,090	1,718	−629
55. Sri Lanka	498	5,497	−4,998
56. Morocco	17	104	−87
57. Paraguay	185	521	−336
58. Peru	13,035	1,518	11,517
59. Indonesia	142	59	83
60. El Salvador	768	71	697
61. Egypt	115	4,033	−3,918
62. Philippines	1,111	1,612	−501
63. Bolivia	2,343	2,396	−53
64. China	124	3,115	−2,991
65. Pakistan	517	237	280
66. Honduras	638	526	113
67. India	83	1,211	−1,128
68. Zimbabwe	549	64	485
69. Kenya	5,031	124	4,906
70. Nigeria	996	387	609
71. Afghanistan	41	190	−149
72. Cuba	17	358	−341
Mean			
All countries	986	879	
9 in-sample countries	62	606	
63 out-of-sample countries	1,118	918	
Median			
All countries	400	365	
9 in-sample countries	47	211	
63 out-of-sample countries	498	423	

Note: All entries are to be divided by 10^4.

$$(7) \qquad \bar{w}_{ic}Dq_{ic} = \alpha_i + \theta_i DQ_c + \sum_{j=1}^{3} \pi_{ij} Dp_{jc} + \epsilon_{ic}.$$

It is to be emphasised that equation (7) contains exactly the same information as does (1), but it is expressed in a different way. Suppose now that we have two versions of (7), one with coefficients and disturbance α_i^1, θ_i^1, π_{ij}^1 and ϵ_{ij}^1 and the other with α_i^2, θ_i^2, π_{ij}^2 and ϵ_{ij}^2. A weighted average of these two versions yields

$$(8) \qquad \bar{w}_{ic}Dq_{ic} = \alpha_i^* + \theta_i^* DQ_c + \sum_{j=1}^{3} \pi_{ij}^* Dp_{jc} + \epsilon_{ic}^*,$$

where the stared coefficients are weighted averages of their unstared counterparts [e.g., α_i^*

Table 10. Out-of-Sample Analysis of the Own-Price Elasticity of Demand for Fibers

Own-Price Elasticity ϕ (1)	Countries with Shares All Positive: Number (2)	Countries with Shares All Positive: Percent (3)	Information Inaccuracy for Rotterdam Model ($\times 10^4$): Mean (4)	Information Inaccuracy for Rotterdam Model ($\times 10^4$): Median (5)	Does Rotterdam Beat No-Change? (Percentage of Countries) (6)
−.1	74	90	1,184	522	39
−.2	72	88	1,159	505	42
−.3	71	87	1,261	498	45
−.4	69	84	1,413	599	48
−.5	65	79	956	493	51
−.6	64	78	1,159	521	53
−.7	63	77	1,365	468	49
−.8	61	74	1,457	525	48
−.9	60	73	1,154	557	47
−1	59	72	1,162	571	47

Notes: 1. There are 82 out-of-sample countries. 2. Column 6 gives the percentage of countries for which the information inaccuracy of the Rotterdam model is lower than that of no-change extrapolation.

$= \lambda\alpha_i^1 + (1 - \lambda)\alpha_i^2]$; and $\epsilon_{ic}^* = \lambda\epsilon_{ic}^1 + (1 - \lambda)\epsilon_{ic}^2$. The new Slutsky coefficients also satisfy homogeneity and symmetry. Obviously, the composite model (8) also takes the form of the Rotterdam model.

The nine-country estimates of the coefficients of equation (7) for i = 1, 2, 3 are given in Panel A of Table 11. These are derived from estimates of the relative-price version of the Rotterdam model presented in the top right-hand side of Panel A of Table 3. Also included in Table 11 are the implied income and price elasticities. As both cotton and wool have income elasticities less than unity, they are con-

Table 11. Three Sets of Coefficients and Conditional Elasticities for the Rotterdam Model in Absolute Prices

Fiber	Intercept $\alpha_i \times 100$	Marginal Share θ_i	Slutsky Coefficients × 100: π_{i1}	π_{i2}	π_{i3}	Conditional Elasticity $\theta_i/\bar{w}_i$	Conditional Price Elasticities: $\pi_{i1}/\bar{w}_i$	$\pi_{i2}/\bar{w}_i$	$\pi_{i3}/\bar{w}_i$
			A. *9-Country Estimates*						
Cotton	−.395	.296	−13,274	.094	13.161	.607	−.272	.002	.270
Wool	.084	.005	.094	−.317	.222	.064	.012	−.041	.029
Chemical fibers	.311	.698	13.161	.222	−13.428	1.608	.303	.005	−.309
			B. *No-Change Extrapolation*						
Cotton	0	.488	0	0	0	1	0	0	0
Wool	0	.078	0	0	0	1	0	0	0
Chemical fibers	0	.434	0	0	0	1	0	0	0
			C. *Composite Model*						
Cotton	−.198	.392	−6.637	.047	6.580	.803	−.136	.001	.135
Wool	.042	.042	.047	−.158	.111	.532	.006	−.020	.014
Chemical fibers	.156	.566	6.580	.111	−6.714	1.304	.152	.003	−.155

Notes: 1. The elasticities are evaluated at the means over the 92 countries of the arithmetic averages of the quantity shares $\bar{w}_{ic}$—cotton 48.8, wool 7.8 and chemical fibers 43.4 (all $\times 10^{-2}$). 2. In Panels B and C, the coefficients are evaluated at sample means. 3. In Panel C, the weighted-average parameter λ = .5.

Table 12. Comparison of Three Sets of Predictions

Weight λ (1)	Information Inaccuracies of Weighted-Average Predictions ($\times 10^4$) Mean (2)	Median (3)	Does the Weighted Average Beat Rotterdam? (% of Countries) (4)	Does the Weighted Average Beat No-Change Extrapolation? (% of Countries) (5)
		A. *All 72 countries*		
0	879	365	44	—
.1	815	354	46	72
.2	770	362	47	71
.3	740	423	47	69
.4	725	420	50	67
.5	723	376	54	65
.6	736	393	56	64
.7	763	389	58	60
.8	809	350	60	58
.9	879	389	63	58
1	986	400	—	56
		B. *9 in-sample countries*		
0	606	211	11	—
.1	465	168	11	89
.2	359	134	11	89
.3	276	121	11	89
.4	210	108	11	89
.5	159	93	11	89
.6	120	75	22	89
.7	91	66	22	89
.8	72	64	22	89
.9	62	55	33	89
1	62	47	—	89
		C. *63 out-of-sample countries*		
0	918	423	49	—
.1	865	404	51	70
.2	829	429	52	68
.3	807	483	52	67
.4	798	509	56	63
.5	804	524	60	62
.6	824	521	60	60
.7	859	488	63	56
.8	915	556	65	54
.9	995	510	67	54
1	1,118	498	—	51

ditional (i.e., within fibers) necessities, while chemical fibers are a conditional luxury. The conditional own-price elasticity for cotton is −.27, wool −.04 and chemical fibers −.31. No-change extrapolation can also be represented in the form of equation (7) with $\alpha_i = 0$, $\theta_i = \bar{w}_{ic}$ and $\pi_{ij} = 0$. Panel B of Table 11 gives the corresponding coefficients and elasticities. Next, we take a weighted-average of the two sets of coefficients to yield the composite model. To determine the value of the weighted-average parameter λ, we consider the information inaccuracy of the composite forecast (6) for various values of λ. Table 12 contains the results. Panel A reveals that on the basis of the mean information inaccuracy the optimal value of λ is .5, which corresponds to an unweighted average of the Rotterdam model and no-change extrapolation. This value of λ has the effect of reducing the inaccuracy from 986 (Rotterdam, λ = 1) and 879 (no-change, λ = 0) to 723 (all $\times 10^{-4}$), or by about 20 percent. For λ = .5, the composite model beats Rotterdam and no-change in 54 and 65 percent of cases, respectively (see Columns 4 and 5). If we use the median of the inaccuracies, the optimal value of λ, $\hat{\lambda}$, is .8. Panel B shows that for the nine in-sample countries, $\hat{\lambda}$ = 1 on the basis of both mean and median. As $\hat{\lambda}$ = 1 corresponds to the Rotterdam model and as the nine countries were used to estimate this model, it is not surprising that application of this criterion to the in-sample countries delivers back this model. Finally, for the 63 out-of-sample countries (Panel C), $\hat{\lambda}$ = .4 for the mean and $\hat{\lambda}$ = .1 for the median. While the results are not completely unambiguous, taken as a whole they point to the composite model being an unweighted average of the other two models and Panel C of Table 11 gives the coefficients and elasticities corresponding to λ = .5. Accordingly, the preferred values of the elasticities are:

	Conditional income elasticity	Conditional own-price elasticity
Cotton	.8	−.14
Wool	.5	−.02
Chemical fibers	1.3	−.16

Concluding Comments

This paper has analyzed the determinants of cross-country consumption patterns of three fibers, cotton, wool and chemical fibers. We used a novel approach to cross-country comparisons of consumption patterns which avoided the troublesome problem of what exchange rates to use when converting data from different countries into a common currency unit. We used data from the 10 largest consuming countries to estimate demand systems and then examined how those models performed in predicting the consumption shares in a large number of out-of-sample countries.

The key findings of the paper are as follows: (i) The data from the former USSR have a suspicious tendency to move more or less proportionally. We conclude that these data are probably too unreliable to be used in demand analysis. (ii) A composite model, which combines a conventional demand model with no-change extrapolation of the quantity shares, gives rise to some improvements in the quality of the predictions. (iii) The conditional income elasticity of demand for cotton is .8, making it a conditional necessity; wool has an income elasticity of .5, so it is even more of a necessity; and chemical fibers is a luxury with an income elasticity of 1.3. (iv) Each of the fibers is price inelastic: The conditional own-price elasticities are −.14, −.02 and −.16 for cotton, wool and chemical fibers.

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