GLOBAL END-USE DEMAND FOR COTTON: A TIME-VARYING PARAMETER MODEL

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Abstract

A Cooley-Prescott model is used to estimate trends in income and price response of end-use demand for cotton in developed countries. By comparing trends in parameter variation between different groups of developed countries it is possible to develop hypotheses regarding the varying impact of product prmotion and structural change between regions.

Introduction

Forecasting cotton consumption has been a trying exercise during the last few years. Economic upheaval has toppled Russia--once the world's largest importer--to nearly unprecedented lows. Also, China, the world's largest consumer, has been mired at nearly the same level of mill use for a decade despite a doubling of domestic income. And after a long period of increasing fiber share for cotton in mill use, global polyester capacity now seems to be inexorably increasing.

The outlook for mill consumption in any given country is further clouded by long-standing dynamics of labor costs, investment, and textile trade policy. Since mill use is ultimately dependent on consumer demand, and many countries either export a significant portion of their mill consumption or import a significant proportion of their final consumption, some degree of aggregation is a necessary first step in approaching the issue.

In past years, USDA baseline estimates for future world cotton use have been consistent with two general observations about trends in cotton's share of world fiber consumption. One is that cotton has lost about 1 percentage point of its share of total fiber end-use in developing countries each year as long as per capita incomes grow. Other fibers play a larger role in industrial applications, which grow particularly rapidly in countries only just building their industrial base. Also, during the 1970s and early 1980s, manmade fibers retained for a longer period of time the novelty value that appeared and retreated earlier in industrialized countries. Cotton's extremely high share--75 percent in 1974--represented in some sense "traditional" modes of consumption, extremely vulnerable to economic change and growth.

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The other observation is that cotton has at least maintained its share in industrialized countries. During the 1980's, cotton's share in this group of countries grew, and it seemed plausible that the factors behind this shift would remain in place in future years, rendering the shift permanent. However, in Western Europe cotton's share of fiber end-use has fallen. An interesting dichotomy has developed where North America continues to turn toward cotton, but the rest of the developed world is less enthusiastic. The global nature of world cotton markets means that anyone interested in cotton demand ignores this at their own peril. This has been driven home by several years of relatively sluggish global demand for cotton.

This paper explores the use of a Cooley-Prescott model to estimate the changing relationships between cotton demand and income and prices during 1974-95. The Cooley-Prescott model allows the relationship between cotton demand and other variables to change during every year of the study. A simple forecasting model is used to search for structural shifts and compare between groups of developed countries. By observing the most recent shifts in the relationships, better forecasts of the near future should be possible. In agricultural economics in general, the possibility of varying relationships among economic variables is particularly important at this time. Interest in exploring parameter variation has been heightened by the passage of new farm legislation during 1996 that promises to significantly revise longstanding relationships between markets, the government, and agricultural producers.

The variation in the relationships between dependent variables--such as cotton end-use--and independent variables--such as price and income--are difficult to measure with the standard tools available to economists. Since multiple observations are necessary to quantitatively examine economic behavior, a fixed relationship must generally be assumed. However, as the earlier discussion indicates, the behavior of consumers is widely believed to have shifted. The International Cotton Advisory Committee (ICAC) has periodically noted the varying "non-price competitiveness" of cotton. The cotton check-off program and foreign promotion appropriations through USDA have resulted in large research and promotion efforts aimed at promoting cotton use by industry and consumers. New products and technologies have been developed over the years, and changes in consumer attitudes toward cotton have been widely documented.

There is also evidence that the income responsiveness of textile demand varies with the business cycle. Textile demand is often described as a leading indicator of economic activity: consumers' textile purchases respond strongly to changes in income, and the change in sales is information that becomes available before the change in GDP has been confirmed elsewhere. Thus, consumer response to a given level or rate of change in income depends on preceding levels or growth rates, and is not constant.

By estimating models for textile demand with varying parameters this study will attempt to investigate the varying impacts of factors such as promotion, taste, and the business cycle on cotton in the developed countries. The ICAC has noted that promotion expenditures outside of North America have dwindled since 1990, and a time-varying model should allow the impact of changing promotion and other factors to show in the estimated model, even without their specific inclusion as variables. Including promotion and other factors shifting "taste" would also serve this purpose, but this study should at least provide some insights into building such, more complex, models, while illustrating the usefulness of the Cooley-Prescott model.

Econometric models can be tested for parameter variation by estimating over varying time periods. However, the use of such tests is limited by the availability of data. Traditional tests are also sensitive to model misspecification (Alston and Chalfant.), and approach of division into discrete time periods is also vulnerable to incorrect assumptions in separating the time periods. The Cooley-Prescott model is more flexible. Since there are parameter estimates for every year it is possible to search for appropriate points of structural shift.

The study concentrates on developed countries, and in particular, differences between Western Europe and North America. While the level of global end-use demand will depend heavily on events in developing countries, there is little likelihood that cotton can stem its relative decline in fiber usage there. Trends in developing countries have been more stable and the behavior of the developed countries has raised more questions during the relatively recent past.

Discussion

In a fixed coefficient model (fixed through time, e.g. the classic ordinary least squares, OLS, model), each time period has an associated error term. The error term varies across time and, while ideally it solely encompasses random events such as weather variations, the error term also reflects missing variables, incorrect functional form, other mis-specifications, poor data, and aggregation.

The non-price components of demand, such as taste, promotion, and business cycles have been excluded from the models, suggesting the parameter estimates might be biased. Relaxing the OLS requirement of fixed parameters over time means that the changing impact of these missing variables can be discerned over time.

The Cooley-Prescott model assumes that each coefficient varies around a non-stationary mean--alternative formulations include models that assume the coefficients vary around a stationary mean (return-to-normality models) and those that assume coefficients are a stochastic function of time.

The Cooley-Prescott model assumes that each coefficient is subjected to both permanent and transitory changes in the following manner:

$$y_t = x_t \beta_t$$

$$\beta_t = \beta^p{}_t + u_t$$

$$\beta^p{}_t = \beta^p{}_{t-1} + v_t$$

$$cov(u_t) = (1-\gamma)\sigma^2 \Sigma_u$$

$$cov(v_t) = \gamma \sigma^2 \Sigma_v$$

Cooley and Prescott have shown that the likelihood function of the model conditional on the value of the parameter process at some point in time is well defined. This permits estimation of specific realizations of the nonstationary parameter process. They illustrate their procedure by focusing on the parameter process one period past the sample, i.e. at time T+1 when estimating with a sample t=1,2,...T. Following their notation, β is written below in β_{T+1} form. See Cooley and Prescott (1976) for details.

$$y_t = x_t\, \beta + \mu_t$$

$$\beta = \beta^p{}_{T+1}$$

$$\mu_t = x_t u_t - x_t \sum v$$

The v's are summed from t+1 to T+1.

$$cov(\mu_t) = \sigma^2[(1-\gamma)R + \gamma Q] = \sigma^2 \Omega(\gamma)$$

$$R = diag[x \Sigma_u x']$$

$$q_{ij} = \min(t-i,\ t-j)\ x_i \Sigma_v x_j$$

Different Q matrices can be arranged for each time period, and serve to weight the permanent parameter changes--early permanent changes have increasing weights in later years, but later changes have zero weight in preceding years. Different coefficient values are calculated through Generalized Least Squares (GLS) for a given γ. The appropriate $\Omega(\gamma)$ matrix is derived by searching across γ for the highest log likelihood value. Given an $\Omega(\gamma)$, a standard GLS procedure is performed to obtain parameter estimates.

In this study, several forecasting models for cotton and other fiber end-use are estimated as Cooley-Prescott models. End-use is based on the Food and Agriculture Organization's (FAO) definition of apparent consumption derived from mill-use of fiber and net trade in textile products:

End-use = mill-use + (imports - exports)

End-use demand is assumed to be a function of the price of cotton and competing fibers and income:

$$EU = f(P_{cotton}, P_{other\ fibers}, \text{Private Domestic Demand})$$

The price of cotton is Cotlook's A-index, and the price of other fibers is the ICAC's index of other fiber prices. Prices are lagged one year in the models. Consumption data for cotton and other fibers are from the ICAC. Rather than Gross Domestic Product (GDP), the activity variable is Private Domestic Demand (PDD). GDP includes investment, which is a less important a determinant of consumer demand for apparel and other goods than PDD. Prices and demand were all in local currency, adjusted by real exchange rates. Price and income were deflated using each consuming region's GDP deflator. The deflators and PDD data were from DRI-McGraw Hill, and the real exchange rates from the International Monetary Fund (IMF). The models were estimated in log form, so the estimated parameters were in elasticity form, using data from 1974-95.

Results

Models were estimated with ordinary least squares (OLS)--which assumes fixed coefficient values--and with a Cooley-Prescott model--which permits the parameter estimates to vary through time.

The models for Western Europe and Other Developed Countries are shown here with two different treatments of the exchange rate. While the income elasticities for these regions are smaller than North America's regardless of the treatment of exchange rates, separating the exchange rate as an independent variable tends to give larger income elasticities and smaller price elasticities. While separating the exchange rate as a separate variable allows direct observation of its impact in the model, it also has the effect of imposing the same impact of exchange rates across the other variables. Using the exchange rate to adjust the price and income variables to local currency can be interpreted as estimating the joint impact of variations in these variables and the exchange rate. Each variable can respond differently to changing exchange rates, but exchange rate impacts cannot be distinguished from other factors. In the Cooley-Prescott estimates, the treatment of the exchange rate has a notable impact on the time trend for the income elasticity.

Generally, price elasticities are less likely to be significant in these models than income (only the first Western Europe model has significant price variables). The models perform reasonably well in specification testing, although allowing for differing income elasticities during the business cycle improves the models. The ICAC makes an adjustment of this nature through its "structural" income and price variables. The Cooley-Prescott model allows more general parameter variation, and provides some guidelines to separating transient business-cycle effects and permanent shifts in economic behavior.

The Cooley-Prescott results are similar to the OLS results in some respects. North America has the largest income elasticity in most years. North America also has the largest estimates for γ in most years. One the one hand, the high income elasticity for North America may be a result of domestic production of raw cotton. A worldwide trend during the last 30 years has been the increasing concentration of cotton textile production in cotton-producing countries. Marketing is more efficient when producers are close to their markets, a characteristic that has led U.S. processed foods producers to locate production facilities in different markets, rather than exporting from a central location. North American consumers probably see quicker feedback from their large domestic textile industry, possibly enhancing their willingness to consume at a given income level.

Another possibility is the role of promotion and research in the United States. The United States has been the world leader in generic cotton promotion since the 1960's. The larger γ estimates for North America indicate a fairly consistently larger role for permanent change compared with other developed regions. The timing and nature of the impacts of promotion is a complex question that simple models like these are ill-equipped to handle. Ideally, the results of this study may assist in research along these lines. Using such a model, Capps, et al, found a significant impact for promotion and research expenditures in the United States, but confined their study to 1986-95.

Generally across regions, the γ's tend to be larger in later years, suggesting that permanent change was more important later. All three developed regions had peak gamma values during 1990-92, coinciding with the appearance of Central Asian cotton on world markets following the collapse of the Soviet Union.

Parrott and McIntosh also found larger γ estimates in the later years of a study of cotton production in the United States. Their estimates for Georgia showed 1983, 1987-90 to have the highest estimates of a study covering 1950-90. Similarly, Zhang, et. al, found lower γ estimates during the 1970s and early 1980s compared with 1986-90 in a study of cotton demand covering 1962-90. This coincides with the implementation of the 1985 U.S. farm legislation, which reduced the role of U.S. government stockholding in balancing world cotton markets.

For Western Europe, the model results with the exchange rate as a separate variable are better at highlighting a period of structural change rather than providing much intuitive insight into it. Around 1983, cotton use in Western Europe took off, and continued rising during the rest of the 1980's. The gamma coefficient shifts from .1 to .9 then and remains there afterwards. The parameter estimates, which had been stable (and in line with theoretical expectations) become erratic. The income elasticity plunges to zero for a few years, and the exchange rate parameter increases in magnitude.

Possibly, this reveals a misspecification in fixing the exchange rate impact to one value for income and prices. Adjusting income and prices to local currency stabilizes the Cooley-Prescott income parameters, and leads to a more gradual shift in the estimated γ's. For the price variables, the pattern of the parameter shift across time in the Cooley-Prescott model is not altered by the different use of exchange rates, but the OLS parameter estimates become significant when prices are adjusted to local currency.

The behavior of the price parameters over time provides the clearest difference between Western Europe and the other developed regions. All the regions share a general trend towards lower income elasticities during the later part of the study period. The constant terms for the models generally rise as well. This is consistent with a growing share of inputs other than raw materials in the final goods purchased by consumers. While North America reaches its peak income elasticity in the middle of the study period, the constant term for the model reaches its lowest point at that time. The parameters for the Other Developed Countries show the least variation of the 3 regions on average, just as cotton's share of fiber consumption in the region has shown the least variation.

Western Europe's price elasticities during the study period exhibited two trends: first, during 1980s and early 1990s, falling cotton price elasticity and rising cross-price elasticity with other fibers. Then, after 1991, a plunge in the cross-price elasticity with other fibers. The change in other fiber price elasticity is the only differential behavior for Western Europe correlated with the change in fiber share. While there is no a priori reason why a decline in this elasticity should lead to a reduced share for cotton, it does indicate a change with respect to competitive fibers. As with the North America model, the Western Europe model does not include information allowing interpretation of the cause of this change, but only highlights the timing of the change in the competitive position of cotton versus other fibers in Western Europe. Changes in “taste” are not easily explained with aggregate economic variables, but these results may help narrow the scope of future research with respect to the timing and nature of these shifts.

Finally, the estimates provide little insight into the possible role of the business cycle. The variations in the income elasticities are not obviously correlated with economic activity. The timing of the declines in income elasticity might be correlated with deceleration in income, but Western Europe during the mid-1980's is an exception.

Summary

Allowing parameter estimates to vary through time for simple consumption models for the end-use of cotton confirmed some results from models with fixed parameters, and gave some insight to changes in North America and Western Europe. As in the fixed parameter model, North America has a generally higher income elasticity for cotton than the rest of the developed world. For all the developed world, both income and price elasticities tended to decline during 1974-95, although this was least pronounced for the income elasticity of the Other Developed Countries. And the variation in income elasticity was--at best--only slightly correlated with changes in the business cycle.

The divergence in cotton share trends between North America and Western Europe seemed unrelated to changes in the estimates for income elasticity. North America’s income elasticity grew most rapidly during the middle of the study period, possibily reflecting the time when cotton promotion expenditures were initiated. However, the divergence between the two regions after 1990 in cotton consumption was not reflected in the relative performance of their income elasticities during the same time. The change in relative elasticities most closely paralleling the relative differences in cotton consumption came in the price elasticity for other fibers.

References

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Table 1. OLS Fixed Coefficient Estimates, 1974-95 (standard errors in parentheses)

Region	Cotton	Other Fibers	Domestic Demand	Constant	Exchange Rate	R^2
North America	-0.11 (0.19)	-0.50 (0.32)	1.01 (0.40)	-4.10 (4.83)		.86
Western Europe	-0.23 (0.09)	0.42 (0.11)	0.41 (0.09)	-2.91 (0.56)		.92
Other Developed	-0.16 (0.11)	0.03 (0.19)	0.47 (0.09)	-1.58 (0.70)		.84
(non-U.S. models with Exchange Rate separate)						
Western Europe	-.016 (0.10)	0.10 (0.16)	0.92 (0.25)	-4.89 (2.85)	-0.23 (0.10)	.94
Other Developed	-0.06 (0.11)	-0.02 (0.18)	0.74 (0.14)	-3.57 (1.77)	-0.18 (0.12)	.88

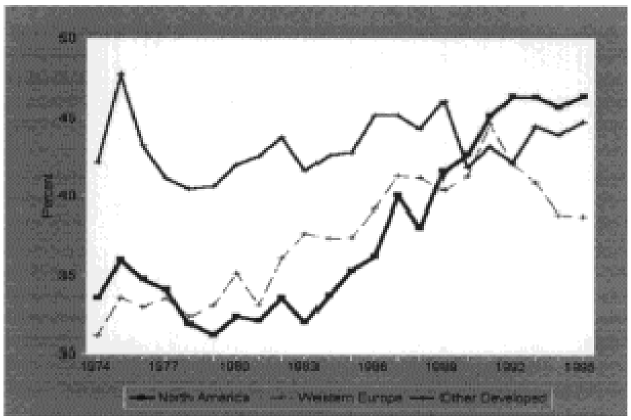

Figure 1. Cotton Share of Fiber End-Use.

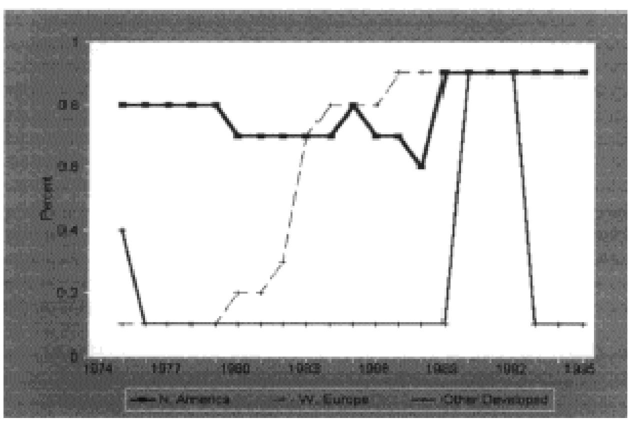

Figure 2. Permanenceof Change (Gamma)

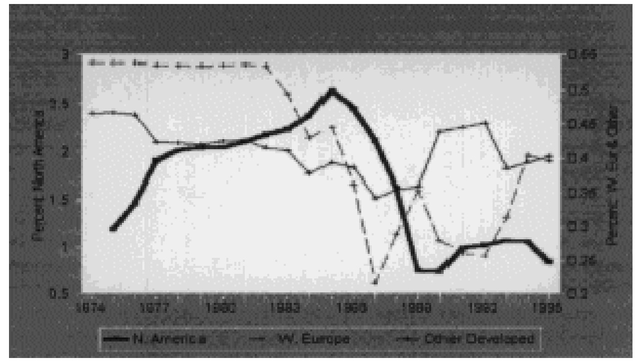

Figure3. Income Elasticity: Estimated in Local Currency.

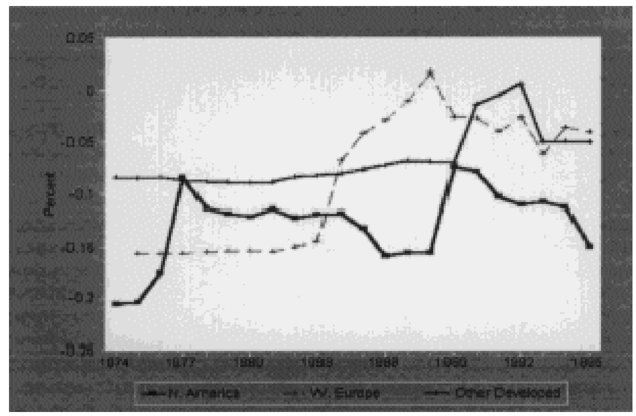

Figure 4. Cotton Price Elasticity.

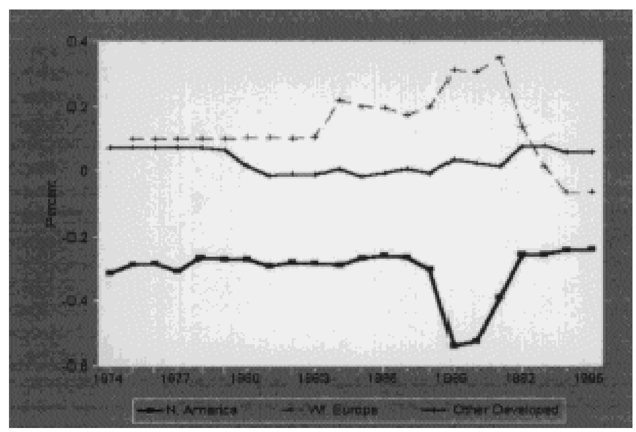

Figure 5. Other Fiber Price Elasticity.