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Measuring the Quality of Imported Tobacco

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ABSTRACT

Domestic tobacco producers have faced increasing competition from imported tobacco since the late 1970s. Much of the debate has centered on the unknown quality of imported tobacco. This study provides a discussion and clarification of the concept of quality, and demonstrates a method of measuring the average quality of imported tobacco. The results show that since 1977, imported tobacco has been steadily decreasing in average quality and moving toward lower quality producing countries and types of tobacco. The reasons for this decline are discussed along with the policy implications.

Key Words: index numbers, quality, tobacco.

Domestic tobacco producers have faced increasing competition from imported tobacco since the late 1970s. U.S. Department of Agriculture (USDA) statistics (from its September 1994 *Tobacco Situation and Outlook Report*) show that between the late 1970s and 1993, imports steadily increased from 24% to 41% of domestic cigarette tobacco disappearance. The two most frequently cited reasons for this increasing demand are lower foreign prices and increasing foreign quality, relative to the United States. Clearly, a consensus can be established for lower foreign prices, as this phenomenon is easily documented (e.g., Grise; Snell, Palmer, and Duncan). However, there is no consensus with regard to the changing quality of imported tobacco. In fact, the term "quality" is seldom defined.

Several authors (e.g., Babcock and Johnson; Johnson; Pompelli and Pick; Snell, Palmer, and Duncan) imply that the increase in imported tobacco is due in part to increases in this enigmatic quality of imported tobacco relative to domestic tobacco. Alternatively, some researchers (e.g., Grise; Grise and Griffin; Snell, Palmer, and Duncan) suggest that the increase in imported tobacco is driven in part by two significant changes in cigarette manufacturing, discussed below.

First, the distribution of cigarettes being produced has changed. Most cigarette manufacturers produce a wide variety of cigarettes, ranging from discount or "price-valued" cigarettes to premium cigarettes. In 1988, discount cigarettes represented only 10% of the total market, but by 1993, their market share had increased to 37% (Bickers). A greater portion of lower quality leaf is used for discount cigarettes than for premium cigarettes (Doolittle); therefore, when the demand for discount cigarettes increases relative to premium cigarettes, the demand for lower quality leaf relative to higher quality leaf increases, *ceteris paribus.* Second, cigarette manufacturing technology has changed. Foreign tobacco generally is recognized as being of lower quality in aggregate than U.S. tobacco, but because of technological developments such as puffing, freeze drying, and use of tobacco sheets, the quantity and quality of tobacco required per cigarette has decreased over time (Grise, p. 3).

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These changes in the cigarette manufacturing process allow more low-quality tobacco to be used per cigarette, thereby creating an increased demand for lower quality imported tobacco.

The first conjecture, i.e., that the quality of imported tobacco has been increasing over time, would seem to be at odds with the second conjecture, i.e., that demand has increased for lower quality tobaccos. Yet both conjectures are theoretically compatible for three reasons. First, without explicitly defining what is meant by the term "quality," the actual effect that changing quality will have on demand is indeterminate. Second, even when quality is explicitly defined, how quality affects demand is still indeterminate, *a priori*. Stated more formally, the partial derivative of demand with respect to quality is sign indeterminate in general (Hanemann). Third, the first conjecture implicitly holds technology constant, while the second conjecture implicitly holds quality constant. As is well known, seemingly incompatible results are easily explained when *ceteris paribus* clauses are violated. So, at the theoretical level, it is entirely possible that not only has the quality of imported tobacco been increasing, but the demand for lower quality tobacco also has been increasing. Thus, how the quality of imported tobacco has changed cannot be determined by considering demand changes; it must be determined empirically.

The purpose of this article is threefold. Because the term "quality" is often an enigma, the first objective is to discuss and clarify the term. The second objective is to demonstrate a procedure for measuring changes in quality due to changing the mix of countries and products in the tobacco import bundle. The final objective of the study is to implement the procedure to determine how the quality of imported tobacco used in cigarette manufacturing has changed over time and to determine if these changes are statistically significant over time.

Defining Quality and the Change in Quality

Although the term "quality" is often used, it is rarely defined. This definitional ambiguity leads to inferential ambiguity. The first step in obtaining a quantitative measure of quality is to define quality and what is meant by quality change. Lancaster states:

> . . . quality is an ordinal concept with no inherent cardinality, and the terms 'measuring quality' or 'measuring quality change' refer to the construction of some numerical index with the following properties: (1) that it correctly *ranks* goods varieties in terms of quality whenever an unambiguous ranking exists, (2) that it *measures* something well-defined and useful in the context to which the index applies. From these considerations it is clear that there may be many indexes which rank quality, each of which measures something different and is applicable to its own special use (p. 82).

Quality is therefore inherently a subjective term. But quality is also a relative term because it implicitly invokes some type of comparison over space, time, or between goods. However, with regard to an aggregate commodity such as foreign tobacco, perhaps the most important aspect of defining quality is to distinguish between the quality of a single good and the quality of an aggregate commodity that is composed of several goods. In this section, we examine the two prominent definitions of quality of an aggregate commodity and discuss what these definitions imply about measuring the change in quality of an aggregate commodity such as foreign tobacco.

The two prominent definitions of quality are the Lancaster definition and the Theil-Houthakker definition. According to Lancaster, the quality of a single good refers to an ordinal index of the characteristics possessed by one good relative to another. By the Lancaster definition, the quality of an aggregate commodity must refer to some measure of "average quality." Average quality is therefore some aggregate index of characteristics possessed by all the goods within the aggregate. Because the aggregate quality index (i.e., average quality) is merely an ordinal index that aggregates characteristics, and the utility function defined in characteristics space is such an index, the utility function defined in characteristics space can be considered an average quality index. Furthermore, as Lancaster discusses, utility can be defined in characteristics space (C-space) or goods space (G-space)—but regardless of the space in which utility is defined, the level of utility (i.e., an ordinal quality index) is the same. This is analogous to standard duality concepts of defining the utility function in quantity space (i.e., the direct utility function) or price space (i.e., the indirect utility function).

The Theil-Houthakker definition of quality is expressed in G-space and refers to the composition of goods composing an aggregate commodity. Thus, the Theil-Houthakker definition refers to an average quality. According to the Theil-Houthakker definition of quality, an aggregate commodity is of low average quality if the distribution of component goods is skewed toward lower quality goods, and an aggregate commodity is of high average quality if the distribution of component goods is skewed toward higher quality goods. Note this definition implies that nothing can be said about the quality of an aggregate commodity by considering only the total quantity of the aggregate commodity purchased. However, Theil and Houthakker assume that higher quality implies a higher price, *ceteris paribus,* so the unit-value price is a measure of average quality of the aggregate commodity. Because the Theil-Houthakker definition of quality is represented in G-space, it entails the Lancaster definition of quality, and vice versa. This is because optimality in G-space implies optimality in C-space, so the optimal composition of goods implies the optimal composition of characteristics. Thus, the Lancaster definition of average quality is reflected in the corresponding Theil-Houthakker definition, and vice versa.

While the Lancaster and Theil-Houthakker definitions of average quality are related by duality, they are not dual with respect to *changes* in average quality. The Theil-Houthakker definition implies that the quality of the aggregate commodity changes as the mix of goods composing the aggregate commodity changes (i.e., as the distribution of component goods changes). Alternatively, the Lancaster definition of average quality implies that average quality of the aggregate commodity changes as the level of characteristics in the aggregate commodity changes. However, the mix of goods composing the aggregate can change (i.e., a change in the Theil-Houthakker measure of quality) because of several factors, in addition to changes in characteristics. For example, a change in relative prices, a change in the distribution of outputs produced from the goods, or a change in technology could lead to changes in average quality as defined by Theil and Houthakker. Thus, a Theil-Houthakker average quality change entails a Lancaster average quality change but does not identify a Lancaster average quality change. Stated alternatively, a Lancaster average quality change is sufficient for a Theil-Houthakker quality change, but not necessary.

Because of the difference in the Lancaster and Theil-Houthakker definitions of average quality change, it is possible to have an increase in average quality according to Lancaster, but a decrease in average quality according to Theil-Houthakker. For example, suppose that Brazilian tobacco increased in quality (Pompelli and Pick) by Lancaster's definition, but was still viewed as lower quality than U.S. tobacco. Further suppose that more Brazilian tobacco was then consumed relative to U.S. tobacco, so that the distribution of tobaccos composing the aggregate shifted. This would represent a decrease in average quality according to Theil-Houthakker, but would denote an increase in average quality according to Lancaster.

The major disadvantage of a Lancaster measure of average quality change is that it requires detailed time-series characteristics data on imported tobacco, which are unavailable. Circumventially, a Theil-Houthakker measure of average quality change can be constructed with disaggregate price and quantity data. Because, as Lancaster argues, there is no unique measure of quality change, the Theil-Houthakker definition of average quality is a viable measure of average quality change of an aggregate commodity such as imported tobacco. Furthermore, because the Theil-Houthakker definition of quality is concerned with aggregates, it is accessible to the economic theory of index numbers.[1]

Method of Analysis

Chinloy has shown that average quality can be measured by exploiting developments in the economic theory of index numbers. Aw and Roberts used the technique to measure the change in the average quality of imported footwear into the United States.

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[1] It should be noted that the Theil-Houthakker and Lancaster measures of average quality change will coincide if and only if all consumers have the same preference structure (i.e., vertical product differentiation) and the aggregator function is separable in the characteristics vector (Hanemann).

Because neither Chinloy nor Aw and Roberts explicitly define the term "quality," their analyses are ambiguous. In this section, it will be shown that their notion of average quality is a Theil-Houthakker measure. Once this is clarified, the index number techniques of Aw and Roberts are used to measure the changing average quality of imported tobacco.

Chinloy defines average quality of an aggregate commodity to be $q_t = X_t^*/X_t$, where q_t is average quality, X_t^* is the value of the theoretically consistent aggregate commodity, and X_t is the total amount of the aggregate commodity. The growth rate or change in average quality at time t is then shown by Chinloy to be

$$\frac{\partial \ln(q_t)}{\partial t} = \sum_{i=1}^{I} (s_{it} - b_{it}) \frac{\partial \ln(x_{it})}{\partial t}, \tag{1}$$

where s_{it} is the expenditure share of the ith input, b_{it} is the quantity share of the ith input, and x_{it} is the ith component of the aggregate commodity. This measure of average quality change is related to the Theil-Houthakker measure of average quality, as follows. Let $P_t = \sum_i p_{it}x_{it}/X_t$ be the unit-value price of the aggregate commodity, where p_{it} is the price of the ith good. Simple algebraic manipulations show that if s_{it} is greater (less) than b_{it} in (1), it is implied that p_{it} is greater (less) than P_t.[2] Therefore, if the log differential of x_{it} is positive, the contribution to the change in the average quality index will be positive (negative), as p_{it} is greater (less) than P_t. Because Theil considers using some average price to measure quality, the change in the average price (and hence average quality) will be positive (negative) if there is a shift toward higher (lower) priced goods. Chinloy's method therefore provides a measure of the change in a Theil-Houthakker measure of average quality.

The change in average quality defined by Chinloy in equation (1) can equivalently be written as

$$\frac{\partial \ln(P_t)}{\partial t} - \frac{\partial \ln(P_t^*)}{\partial t} = \frac{\partial \ln(q_t)}{\partial t} = \sum_{i=1}^{I} (s_{it} - b_{it}) \frac{\partial \ln(x_{it})}{\partial t}, \tag{2}$$

and this is the form of (1) used by Aw and Roberts.[3] The first term on the left-hand side of (2) is the continuous log differential of the unit value index, and the second left-hand-side term is a continuous-time superlative price index, such as the Divisia index.

Aw and Roberts note that in an international trade context, the average price of an aggregate imported commodity can change as the mix of countries changes, as the mix of goods or products composing the aggregate changes, or some combination thereof. However, by exploiting the Chinloy derivations, these effects can be decomposed. Let $g = 1, \ldots, G$ denote the number of goods or product categories, and $c = 1, \ldots, C$ denote the number of supply countries. The aggregate unit-value price at time t is then

$$P_t = \frac{\sum_g \sum_c V_{gct}}{\sum_g \sum_c x_{gct}}, \tag{3}$$

where V_{gct} is the value of imports of product g from country c at time t, and x_{gct} is the quantity of imports of product g from country c at time t. The discrete form of (2) is expressed as

$$\Delta P_t - \Delta P_t^* = \Delta q_t, \tag{4}$$

where $\Delta P_t = \ln(P_t) - \ln(P_{t-1})$, and ΔP_t^* is the Tornqvist price index, defined to be

$$\Delta P_t^* = \sum_g \sum_c .5\Big((s_{gct} + s_{gct-1}) \cdot [\ln(P_{gct}) - \ln(P_{gct-1})]\Big), \tag{5}$$

where s_{gct} is the expenditure share of product g from country c in time t, and P_{gct} is the unit value

[2] By definition, $s_{it} = p_{it}x_{it}/E_t$, where E_t denotes total expenditures on the aggregate commodity and $b_{it} = x_{it}/X_t$. Also, by definition, $X_tP_t = E_t$. Thus, substituting $X_t = E_t/P_t$ into b_{it}, and then substituting the definitions of s_{it} and b_{it} into $s_{it} > b_{it}$ and rearranging terms, yields $p_{it} > P_t$. Of course, the same procedure applies for $s_{it} < b_{it}$.

[3] Average quality is defined to be $q_t = X_t^*/X_t$ and, therefore, $\ln(q_t) = \ln(X_t^*) - \ln(X_t)$. Now, by the rules of product aggregation theory, if E_t is total expenditures, then $X_tP_t = E_t = X_t^*P_t^*$ must hold. From this, it follows that $\ln(q_t) = \ln(X_t^*) - \ln(X_t) = \ln(P_t) - \ln(P_t^*)$, and partially differentiating this equality with respect to time yields the relationship between (1) and (2).

of product g from country c in time t. If there is a shift toward more expensive supplying countries and products, then Δq_t is positive and average quality has increased. If Δq_t is negative, the reverse is true.

While equation (3) is informative, it does not allow us to determine whether the average quality change is due more to a changing country mix or to a changing product mix. Aw and Roberts show that equation (4) can be decomposed into a changing country effect, a changing product effect, and a changing interaction effect by using a partial Tornqvist price index. The partial Tornqvist price index for characteristic i is

$$(6)\quad \Delta P^*_{it} = \Sigma_t\ .5\Big((s_{it} + s_{it-1}) \cdot [\ln(P_{it}) - \ln(P_{it-1})]\Big), \quad i, j = g, c,$$

where s_{it} is the ith expenditure share over all j characteristics in time t, and P_{it} is the unit-value price over all characteristics j. For example, suppose the $i = c$ (country) partial Tornqvist index is desired. In this case, for each country, all products are treated as the same or identical (i.e., homogeneous). The s_{ct} is then the c country's share of expenditures over all countries, treating all products as homogeneous in time t. The P_{ct} is the unit-value price over all products for country c in time t. Thus, ΔP^*_{ct} is a partial-country Tornqvist index treating all products as homogeneous, while ΔP^*_{gt} is a partial-product Tornqvist index treating all countries as homogeneous.

The two main quality effects are:

$$(7)\quad \Delta P_t - \Delta P^*_{ct} = \Delta q_{ct}$$

and

$$(8)\quad \Delta P_t - \Delta P^*_{gt} = \Delta q_{gt}.$$

Equation (7) measures the changing mix of countries assuming all products are the same (i.e., homogeneous), and will be termed the country effect. Equation (8) measures the changing mix of products assuming all countries are homogeneous, and will be termed the product effect. If Δq_{ct} (Δq_{gt}) is positive, then the import bundle has shifted to more expensive (i.e., higher average quality) countries (products). If Δq_{ct} (Δq_{gt}) is negative, the reverse is true.

The sum of equations (7) and (8) will overestimate the change in average quality because these equations ignore interaction effects. From (4), (7), and (8), an interaction effect can also be defined as the difference between the total effect and the sum of the main effects, i.e.,

$$(9)\quad \Delta q_{cgt} = \Delta q_t - \Delta q_{ct} - \Delta q_{gt}.$$

The interaction effect is much like a covariance; if Δq_{cgt} is positive, then the change in average quality in terms of countries is moving in the same direction as that of products. If Δq_{cgt} is negative, then the change in average quality in terms of countries is moving opposite to that of products. Substituting equation (4) into equation (9) and rearranging terms yields

$$(10)\quad \Delta P_t = \Delta P^*_t + \Delta q_{ct} + \Delta q_{gt} + \Delta q_{gct}.$$

Equation (10) shows that the change in the unit-value price index can be decomposed into the growth in the theoretically correct aggregate price index and the three average quality terms as defined earlier.

Data and Empirical Analysis

The data used in the analysis consist of the quantities and values of the five major types of cigarette tobacco imported from 14 countries, where the values include cost, insurance, and freight (CIF). The annual U.S. tobacco imports for consumption data for 1977–93 were obtained from *U.S. Imports for Consumption and General Imports: FT246 and FT247*, annual reports published by the U.S. Bureau of the Census. Cigarette tobacco imports were chosen because they compete most directly with domestic tobacco; approximately 85% of domestic tobacco is used in cigarette manufacturing (Grise and Griffin). The five types of cigarette tobacco considered are unstemmed Oriental, unstemmed flue-cured, unstemmed burley, stemmed tobacco except cigar leaf, and scrap except cigar leaf.

The 14 countries considered for this study are Argentina, Brazil, Bulgaria, Canada, Greece, Guatemala, Italy, Korea, Malawi, Mexico, the Philippines, Turkey, Yugoslavia (former), and Zimbabwe (formerly Rhodesia). The remaining countries are treated as a rest-of-the-world category (ROW). The selection of the types of tobacco, countries, and years was dictated both by the desire to obtain, in a manner as consistent as possible, a time series of disaggregate data by type and country, and by the importance of these types and countries in the aggregate tobacco import bundle. Because international time-series data are often inconsistent, the construction of the data set is discussed in detail in the appendix.

The empirical analysis proceeds as follows. The mean unit-value prices are presented first by country and type of tobacco, and a simple analysis of variance (ANOVA) is conducted to detect if there are significant statistical differences in the mean prices. The changes in total average quality indices are then constructed and decomposed into the change caused by altering the country mix (i.e., country effect) and the change caused by altering the product mix (i.e., product effect). Next, regression analysis is conducted to first determine if the changes in these indices over time are statistically significant, and then to determine which is greater—the country effect or the product effect. Because the U.S. does not produce Oriental tobacco and competes more directly with imported flue-cured and burley tobacco, all of the analysis is performed by both including and excluding Oriental tobacco in the aggregate commodity (i.e., imported cigarette tobacco).

Results presented in table 1 show the average unit-value price per pound for each country for the sample when all tobacco types are assumed to be identical or the same (i.e., homogeneous). When Oriental tobacco is *included,* Greece has the highest price of tobacco per pound, followed by Yugoslavia, Bulgaria, Turkey, Korea, Malawi, Canada, Brazil, Argentina, ROW, Guatemala, Mexico, Italy, Zimbabwe, and the Philippines. The F-test strongly rejects the null hypothesis that the means are equal at the 1% level, and the Bartlett test rejects the null hypothesis of a homogeneous variance at the 1% level. When Oriental tobacco is *excluded,* Korea has the highest price of tobacco per pound, followed by Malawi, Canada, Brazil, Argentina, Guatemala, Mexico, ROW, Italy, Bulgaria, Zimbabwe, the Philippines, Greece, Yugoslavia, and Turkey. The F-test again strongly rejects the null hypothesis that the means are equal at the 1% level, and the Bartlett test rejects the null hypothesis of a homogeneous variance at the 1% level.

Table 1. Average Unit-Value Prices, ANOVA and Bartlett Tests

Countries (across types)	Including Oriental	Excluding Oriental
Argentina	1.36	1.36
Brazil	1.39	1.39
Bulgaria	1.68	.98
Canada	1.42	1.42
Greece	1.75	.73
Guatemala	1.30	1.29
Italy	1.09	1.04
Korea	1.55	1.55
Malawi	1.45	1.45
Mexico	1.28	1.27
Philippines	.79	.79
Turkey	1.59	.27
Yugoslavia	1.68	.58
Zimbabwe	.90	.90
ROW	1.32	1.16
ANOVA-F	10.10	9.80
Bartlett	51.73	121.63

When all countries are assumed identical or homogeneous, the average unit-value price ($/lb.) for each type of tobacco is $1.69 for Oriental, followed by stemmed ($1.65), unstemmed flue-cured ($1.04), unstemmed burley ($.94), and scrap ($.64). The F-test of the null hypothesis of equal means shows a value of 56.70, and clearly rejects the null of equal means at the 1% level; however, the Bartlett test of a homogeneous variance produces a value of 7.40, and does not reject the null of equal variances at the 1% level. (These results are not shown in table 1.)

The general theme reflected by the data in table 1 is not new, but it does bear repeating. To consider an average unit-value price across countries treating the types of products as homogeneous is, in general, incorrect (i.e., table 1). To consider an average unit-value price across types of products treating all countries as homogeneous is also, in general, incorrect. To implicitly assume heterogeneous products and countries are homogeneous is incorrect—and for this reason, a unit-value price by product type or country is biased.

Results presented in table 2 show the decompo-

Table 2. Quality Change in U.S. Tobacco Imports Including Oriental (average annual rates)

Year	Unit-Value Price Index ΔP	Fisher Ideal Index ΔP^*	Total Quality Δq	Country Effect Δq_c	Product Effect Δq_g	Interaction Effect Δq_{cg}
1977–78	.095	.066	.029	.020	.004	.005
1978–79	−.014	.083	−.097	−.089	−.119	.111
1979–80	.003	.099	−.096	−.076	−.089	.069
1980–81	.034	.054	−.020	−.046	−.034	.060
1981–82	.106	.167	−.061	−.077	−.045	.061
1982–83	.095	.266	−.171	−.167	−.125	.121
1983–84	.013	.301	−.288	−.287	−.231	.230
1984–85	−.025	.303	−.328	−.284	−.245	.201
1985–86	−.007	.298	−.305	−.273	−.211	.179
1986–87	−.016	.250	−.266	−.262	−.186	.182
1987–88	−.010	.262	−.272	−.250	−.169	.147
1988–89	.043	.270	−.227	−.229	−.128	.130
1989–90	.046	.327	−.281	−.274	−.181	.174
1990–91	.087	.421	−.334	−.320	−.235	.221
1991–92	.144	.550	−.406	−.419	−.291	.304
1992–93	−.149	.489	−.638	−.644	−.513	.519
Average 1980–90	.028	.210	−.182	−.176	−.135	.129
Average 1990–93	.028	.486	−.458	−.461	−.346	.349

sition of the change in the unit-value price index for tobacco imports between 1977 and 1993 *including* Oriental tobacco. The results are consistent and clear. The decomposition of the change in the unit-value price index into price and quality effects reveals that the slow change in the unit-value price index is due mainly to decreasing quality over time. Between 1980 and 1990, the quality-adjusted price index grew at 21% on average, while quality decreased by 18.2%; thus, the unit-value price index grew by only 2.8%.[4] Between 1990 and 1993, the quality-adjusted price index grew by 48.6% on average; but because quality decreased by 45.8%, the unit-value price index again grew by only 2.8%.

The decomposition of the quality effect shows that the continuous trend has been toward lower quality supplying countries and lower quality types of tobacco. On average, between 1980 and 1990, the changing mix of countries had a negative impact on quality of 17.6%, while the changing mix of tobacco types had a smaller negative impact on quality of 13.5%. The average interaction effect between 1980 and 1990 suggests that 12.9% of the quality change is due to a simultaneous move toward lower quality producing countries and lower quality types. Between 1990 and 1993, this trend continued, producing an average interaction effect of 34.9%.

Results presented in table 3 show the decomposition of the change in the unit-value price index for tobacco imports between 1977 and 1993 *excluding*

[4] When using international trade data disaggregated at this level, missing data are often problematic. If there are no values and quantities in a given year, then from a theoretical standpoint, the price is above the reservation price in that given year (i.e., a corner solution). However, if there are zero values in year $t - 1$, followed by positive values in year t, then the Tornqvist index cannot be used, because the log of zero is infinity. There are basically two alternatives that can be pursued. The price can be estimated, as was done by Aw and Roberts, which introduces bias into the index. The other alternative is that advocated by Diewert. It exploits the tenets that (*a*) the Fisher ideal index is also a superlative price index, and (*b*) the Fisher ideal index does not require any logarithms in its calculation. The Fisher ideal index is used and economic theory further exploited to handle the problem. That is, if there is a corner solution, then quantities are implicitly zero, and so the relevant choice set is the reduced choice set. In this case, when there are zero quantities, these are just dropped from the index calculation. Diewert shows that while this approach may result in some upward bias, other alternatives can produce greater upward bias.

Table 3. Quality Change in U.S. Tobacco Imports Excluding Oriental (average annual rates)

Year	Unit-Value Price Index ΔP	Fisher Ideal Index ΔP^*	Total Quality Δq	Country Effect Δq_c	Product Effect Δq_g	Interaction Effect Δq_{cg}
1977–78	.142	.116	.026	−.002	.017	.011
1978–79	.063	.179	−.116	−.151	−.111	.146
1979–80	−.043	.266	−.309	−.260	−.209	.160
1980–81	−.074	.262	−.336	−.315	−.146	.125
1981–82	.068	.318	−.250	−.256	−.183	.189
1982–83	.271	.521	−.250	−.090	.062	−.098
1983–84	.157	.542	−.385	−.317	−.048	−.020
1984–85	−.043	.576	−.619	−.511	−.211	.103
1985–86	.042	.575	−.533	−.479	−.105	.051
1986–87	−.024	.493	−.517	−.514	−.110	.107
1987–88	−.029	.502	−.531	−.498	−.085	.052
1988–89	−.014	.475	−.489	−.464	−.036	.011
1989–90	.005	.527	−.522	−.511	−.079	.068
1990–91	.164	.678	−.514	−.509	−.070	.065
1991–92	.122	.780	−.658	−.652	−.203	.170
1992–93	−.143	.639	−.782	−.775	−.312	.305
Average 1980–90	.040	.411	−.371	−.336	−.095	.060
Average 1990–93	.047	.699	−.652	−.645	−.195	.188

Oriental tobacco. As can be seen, the results are similar to those in table 2. In general, the slow change in the unit-value price index is due mainly to decreasing quality over time. Furthermore, the decomposition of the quality effect in table 3 reveals that the changing mix of countries had a larger negative impact on quality than did the changing mix of tobacco types, and that there was a simultaneous move toward lower quality producing countries and lower quality types.

Tables 2 and 3 would seem to provide compelling support of two hypotheses. First, the imports of cigarette tobacco have been shifting toward lower quality tobacco over time. Second, this shift has been more toward lower quality countries than lower quality types. However, these conclusions would be premature, because tables 2 and 3 provide no evidence of statistical significance for these two hypotheses.

To test the hypothesis that the decrease in cigarette import tobacco quality over time is statistically significant, the following equation was estimated using the data in tables 2 and 3:

$$(11) \quad \Delta q = a_0 + a_1 T + a_2 D83 + a_3 HS.$$

The dependent variable Δq is the change in total quality, T is a linear time trend, $D83$ is a dummy variable that is zero prior to 1983 and one after 1982, and HS is a dummy variable that is zero prior to 1989 and one after 1988. The dummy variable $D83$ is designed to test if there is any significant break in the change in quality after 1982, as indicated by visual inspection of table 2. The dummy variable HS is designed to capture possible differences due to changing from the Tariff Schedule of the U.S.A. (TSUSA) codes to the Harmonized System in 1989.

To test the hypothesis that the country effect and product effect are statistically significant over time in tables 2 and 3, the following two equations were estimated:

$$(12) \quad \Delta q_c = b_0 + b_1 T + b_2 D83 + b_3 HS$$

and

$$(13) \quad \Delta q_g = c_0 + c_1 T + c_2 D83 + c_3 HS,$$

where the variables are as defined earlier. Though equations (12) and (13) are informative, they do not

Table 4. Statistical Significance of Quality Change in U.S. Imports of Tobacco

	Including Oriental				Excluding Oriental			
Variable	Δq	Δq_c	Δq_g	Diff	Δq	Δq_c	Δq_g	Diff
Constant	.098	.114*	.041	.073**	.060	.094	.035	.058*
	(.062)	(.058)	(.066)	(.022)	(.069)	(.061)	(.057)	(.035)
Time	−.035**	−.040**	−.025	−.015**	−.064**	−.073**	−.040**	−.032**
	(.012)	(.012)	(.013)	(.004)	(.014)	(.012)	(.011)	(.007)
*D*83	−.011	.023	−.002	.026	.078	.196**	.267**	−.070*
	(.085)	(.079)	(.091)	(.030)	(.095)	(.084)	(.078)	(.049)
HS	.075	.063	.059	.004	.239**	.220**	.166**	.054
	(.085)	(.079)	(.091)	(.030)	(.095)	(.084)	(.078)	(.049)
$\bar{R}^2$	.77	.82	.52	.83	.82	.85	.41	.92
F-test	.64	.32	.31	.45	3.36*	4.00**	5.87**	3.57*

Notes: Standard errors are reported in parentheses. Single and double asterisks (*) indicate significance at the 10% and 5% level, respectively.

provide a test of the hypothesis that the shift has been more toward lower quality countries than lower quality types over time (i.e., $b_1 < c_1$). To test this hypothesis, subtract (13) from (12) to form

(14) $\text{Diff} = d_0 + d_1T + d_2D83 + d_3HS,$

where $\text{Diff} = \Delta q_c - \Delta q_g$, $d_0 = (b_0 - c_0)$, $d_1 = (b_1 - c_1)$, $d_2 = (b_2 - c_2)$, and $d_3 = (b_3 - c_3)$. The one-sided *t*-test of d_1 will, therefore, test the hypothesis that tobacco imports have shifted more toward lower quality countries than types of tobacco (i.e., $b_1 < c_1$). As with equations (11)–(13), equation (14) can be applied to the data in tables 2 and 3.

Table 4 shows the regression results for equations (11), (12), (13), and (14) *including* and *excluding* Oriental tobacco in the aggregate. When Oriental tobacco is included in the analysis, the decrease in total quality over time is statistically different from zero at the 5% level (i.e., $\hat{a}_1 = -.035$). The results also indicate that the move to lower quality exporting countries over time is significant (i.e., $\hat{b}_1 = -.040$). However, the move to lower quality types of tobacco over time is not significant (i.e., $\hat{c}_1 = -.025$). While the results for equation (14) show that the difference in the country effect and the product effect is significantly different from zero at the 5% level (i.e., $\hat{d}_1 = -.015$), this test statistic does not actually identify which effect is greater because it is a two-tailed test. In table 4, the country effect appears to dominate the product effect; to test this, the appropriate alternative hypothesis is H_a: $d_1 = (b_1 - c_1) < 0$. The test statistic for this lower tailed test is −3.75, and the 5% *t*-value is −1.76. Thus, the null hypothesis is rejected; the country effect dominates the product effect. This result has an intuitive appeal because cigarette manufacturers have more flexibility across countries than across tobaccos. The *F*-test statistics in the last row of table 4 represent tests of the null hypothesis that the *D*83 and *HS* dummy variables are not different from zero. As can be seen, in the models that include Oriental tobacco, this hypothesis is not rejected.

When Oriental tobacco is excluded from the analysis, the results are somewhat different. In addition to the parameters significant in the models where Oriental tobacco was included, the move to lower quality types of tobacco over time is also significant when Oriental tobacco is excluded (i.e., $\hat{c}_1 = -.040$). In general, the dummy variables *D*83 and *HS* are also significant when Oriental tobacco is excluded in the analysis, as indicated by the *t*-statistics and the *F*-tests. However, as their namesake implies, no inferential conclusions can be drawn from this significance. Perhaps the most important point is that the country effect again dominates the product effect, because the *t*-statistic is −4.75 for the null hypothesis. This again may imply that cigarette manufacturers have more flexibility across countries than across tobaccos.

Conclusions

Once the term "quality" is explicitly defined and discussed, the conclusion to be drawn is that quality refers to an ordinal index with no inherent cardinality—and is therefore a subjective term. Because it is ordinal and subjective, there is no unique measure of quality, and the appropriate measure depends on the problem at hand. If interest is on the changing quality of an aggregate, such as foreign tobacco, then a viable measure is that of Chinloy or of Aw and Roberts, which is shown to be a Theil-Houthakker measure of average quality change. We have used the Aw and Roberts method in this study to measure the average quality change of imported cigarette tobacco.

The results of this investigation show that the quality of imported cigarette tobacco has been steadily decreasing since 1977, and that this decrease is statistically different from zero. These results hold when Oriental tobacco is both included and excluded from the analysis, though the results are tempered when Oriental tobacco is included. Our findings are consistent with the claim that in addition to lower foreign prices, technological changes in the cigarette industry are driving the increased demand for foreign tobacco, especially non-Oriental tobacco.

The results also reveal that there has been a statistically significant and steady move toward lower quality producing countries and lower quality types of tobacco. The move toward lower quality producing countries has been more rapid than the move toward lower quality types of tobacco. Again, these results hold when Oriental tobacco is both included and excluded from the analysis, and the results are again tempered when Oriental tobacco is included.

These findings indicate that while technological changes have been occurring in the cigarette industry that allow for greater use of lower quality tobacco (especially non-Oriental tobacco), the fundamental constraint for the cigarette producer is still blending technology. Because the changing-country mix treats all tobaccos as homogeneous, the results suggest that cigarette manufacturers are more indifferent to countries than they are to tobacco types. Stated alternatively, cigarette manufacturers attempt to minimize the cost of a given blend of tobaccos rather than the cost of a given blend of countries. The implication of this finding for policy analysis is that if the U.S. is intent on imposing barriers to trade to improve the competitive position of U.S. tobacco domestically, then the most effective policy will be one that restricts trade by tobacco type—especially non-Oriental tobacco—and not by country source.

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Appendix

Based on the manner in which the U.S. Bureau of the Census has classified import data over time, the general pattern is that classification codes become more disaggregated over time. Prior to 1977, flue-cured and burley cigarette leaf not stemmed were classified together under the TSUSA code 1703020, and all scrap (cigarette and all other) was classified under 170600. Furthermore, stemmed tobacco was not separated by cigarette leaf and other (1704500). In 1977, the main cigarette leaf categories were disaggregated into the classifications used here: unstemmed Oriental cigarette leaf (1702800), unstemmed flue-cured cigarette leaf (1703210), other unstemmed (mainly burley) cigarette leaf (1703230), stemmed cigarette leaf (1703500), and scrap except cigar leaf (1706040). In 1985, the stemmed cigarette leaf was further disaggregated into stemmed cigarette leaf (1703510) and stemmed cigarette leaf not specifically provided for (1703520). To retain consistency in the stemmed series, these two categories (1703510 and 1703520) were combined from 1985–93. In 1989, the classification system was changed from the TSUSA codes to the Harmonized System, and the quantities were no longer reported in pounds but in kilograms. The concordance between the TSUSA codes and the Harmonized System was obtained from the Foreign Agricultural Service; the series was then completed and the kilograms converted to pounds. As indicated here, both unstemmed and stemmed are now disaggregated by flue-cured and burley.