Estimating the Effect of Prices in Some International Markets on the Demand for Sudanese (Acacia Senegal L.) Gum

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Estimating the Effect of Prices in Some International Markets on the
Demand for Sudanese Hashab (Acacia senegal L.) Gum

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Abstract: This study was designed mainly to carry out a detailed analysis of the demand of individual markets for Hashab (Acacia senegal L.) gum in order to find out the effect of Hashab gum prices on its demand in international markets. Specifically, the study attempted to develop and estimate demand models for the major importing countries as individual markets, and estimate price elasticity for Hashab gum in international markets. A demand model consisting of a group of single equations was estimated, using OLS technique, and tested using various economic, statistic and econometric criteria. The results showed that the United Kingdom, France, and the United States markets were relatively price inelastic (price elasticities of demand were 0.752, 0.3659 and 0.831, respectively). In the United Kingdom market, in particular, it was found that Talh (Acacia seyal Del.) gum has been a substitute for Hashab gum, while Nigerian Hashab gum was a complementary good for Sudanese Hashab gum. It was found that in the German market Hashab gum demand is price elastic (1.707) and that Talh gum is used as a substitute for Hashab gum. The study concludes that gum markets behaved differently, and that although price was a factor affecting demand, its effect was not substantial in many markets and that other factors which are probably playing greater roles will need to be investigated.

INTRODUCTION

Hashab gum is a natural exudate of Acacia senegal L. (Hashab tree), which stretches across Africa from Mauritania in the west to Ethiopia and Somalia in the east (FAO 1995). In the Sudan, the distribution of Acacia senegal is uniform and found in pure stands giving the Sudan the advantage of being the biggest producer and exporter of the best qualities
of the Hashab gum. Sudan used to have a near monopoly position in the world markets as it produces, on average, over 75% of the world production.

Sudan is threatened by eventually losing its prominent position in the international gum Arabic market. Quantitative, analytical studies on demand of this commodity would throw light on the factors that have effect on its demand. This will help in designing sound production and marketing policies to improve the Sudan’s position in the international market. Available studies on factors affecting demand for Hashab gum relied largely on general trend studies and logical conclusions derived from certain conditions believed to have affected demand. These kinds of investigations were mostly qualitative, and thus have little empirical value. On the other hand, there exist very few examples of research efforts that attempted quantitative econometric analysis of demand models. Mahmoud (1983) estimated a demand model confined to the U.S. market alone. Hasab Elgawi (1998) extended his model to some of the other markets, but his data were limited to the period 1990-1998. Because of the many changes that occurred in the gum Arabic business and the need for decisions that are based on empirical studies, it is important to carry out an updated and more comprehensive quantitative study on the demand for gum Arabic.

The main objective of this study was to carry out a detailed analysis of the demand for Hashab gum in order to determine the effect of gum prices on its demand in the international market. Specifically, the study attempted to (i) develop and estimate demand models for Hashab gum for the major importing countries as individual markets, and (ii) estimate price elasticity for Hashab gum in the international markets.
METHODOLOGY

Development of the theoretical model
Demand studies are generally based on the Keynesian theory of the consumption function (Griffiths and Wall 1997) expressed as
\[ C = b_0 + b_1 Y \]  
(1)
where:
- \( C \) = consumer expenditure;
- \( b_0 \) = a constant;
- \( b_1 \) = the marginal propensity to consume out of the last unit of income received; and
- \( Y \) = national income.

In some of the earlier international demand studies regarding forest products, using cross-sectional data, \( C \) was the consumption for a forest product and \( Y \) was disposable income or any other macroeconomic measure. A version of this model, using time series data, was also estimated. Later on, the model was improved by introducing supply factors (availability of forest products) and dynamization of the basic static model by introducing lagged consumption and income variables in addition to price variables (Buongiorno 1977), Riihinen (1962) and, later on, Katila and Riihinen (1990) estimated functions for newspaper print consumption in Finland by developing multi-equation models and using time series data.

Demand was estimated by Mahmoud (1983) for the Hashab gum consumed in the United States market using the following function:
\[ C_t = f(P_t, I, V, \zeta) \]  
(2)
where:
- \( C_t \) = quantity consumed in metric tons (MT) by the U.S. in year \( t \);
- \( t = 1, 2, \ldots, T \);
- \( P_t \) = price of Hashab gum in US$ in year \( t \);
- \( I \) = the food industry index in the United States;
- \( V \) = Hashab gum viscosity index; and
- \( \zeta \) = the disturbance term

Hasab Elgawi (1998) has attempted to estimate demand functions for Hashab gum in the different international markets. His model was of the form...
where:

\[ C_{tk} = f(P_k, \zeta) \]  \hspace{1cm} (3)

The present study used a similar model to that developed by Hasab Elgawi (1998). The basic model is represented by

\[ C_{tk} = f(P_{gt}, P_{st}, P_{ct}, \zeta) \]  \hspace{1cm} (4)

where:

\[ C_{tk} = \text{quantity of Hashab gum exported in MT by Sudan to market } k \text{ in year } t; \]
\[ t = 1, 2, \ldots, T; \]
\[ P_{gt} = \text{international price of Hashab gum in US$ exported by Sudan in year } t; \]
\[ P_{st} = \text{international price of Hashab gum substitute in US$}; \]
\[ P_{ct} = \text{International price of Hashab gum in US$ exported by competing country } c \text{ in year } t; \]
\[ \zeta = \text{the disturbance term} \]

Time-series data for the period 1980-2001 was used. The data were composed of Hashab gum exports and imports by different international markets and exports prices. In addition, exports by competing countries and their respective export prices were included. Most of the data were compiled from the Gum Arabic Company (GAC) records, Food and Agriculture Organization (FAO), and foreign trade statistics.

### Estimation of the model

The Hashab gum demand model is a group of single-equations where each estimated equation represents a particular market. Equations were estimated separately for Hashab gum for some markets; namely, United Kingdom, France, Germany, and United States markets.

The model (derived from equation 2) was estimated by the Ordinary Least Squares method. The time series data were transformed into different functional forms; namely, linear, log-linear and log-log functions to detect the most appropriate form of the model.
Evaluation of the estimated regression equations was based on the following criteria:

1. Economic criterion: Evaluation concerns whether variable coefficients have the right sign as postulated by economic theory.
2. Statistical criterion: Where the t-statistic of the parameter estimates measure the significance of the individual parameters, while the F-statistic measures the overall significance of the models.
3. Econometric criterion: The coefficient of determination, denoted by $R^2$ (adjusted for degrees of freedom), was used to test the goodness of fit of individual equations reflecting the explanatory power of the regressions. The first-order serial correlation in the error term was tested by the Durbin-Watson (DW) test. The subscripts in DW indicate the probability value. When the lagged observations of the dependent variable were included in the set of regressors, the Durbin-h test (Dh) was used instead (Pindyck and Rubinfeld 1981). First-order difference and First-order logarithmic difference forms were also applied to the equations to reduce the serial correlation in the error term. The parameters of the basic and difference forms have also been compared to select the appropriate equations.

When logarithmic transformation is found satisfactory, the coefficients can be interpreted directly in terms of elasticity or relative (percentage) changes (Harvey 1990). However, in cases where linear equations are more satisfactory, elasticity will be computed using the following formula:

$$\xi = \left(\frac{dy}{dx}\right) \times \left(\frac{\bar{y}}{\bar{x}}\right)$$  \hspace{1cm} (5)

where:

$\xi$ is the elasticity coefficient, $dy/dx$ is the marginal change in quantity demanded of Hashab gum as price changes,
$\bar{y}$ and $\bar{x}$ are the arithmetic means of quantity demanded of gum and gum price, respectively.
The demand will be elastic when $\xi > 1$, of unit elasticity when $\xi = 1$ and inelastic when $\xi < 1$. 

RESULTS

The estimated equations are presented in the first row of the set of presented results for each country. The second row shows the t-values reported in parentheses beneath each parameter estimate. The third row presents the significance level of the estimates, also reported in parentheses beneath the t-values. The coefficient of determination adjusted for degrees of freedom, which shows the goodness of fit, was denoted $R^2$ and reported for each estimated equation. Durbin-Watson statistic was used to test the presence of the serial correlation in the error term and denoted DW. The F is the F-statistic that shows the significance of the model as a whole. The subscripts of DW and F indicate their significance levels.

British market

The following estimated equation illustrates the demand function for Hashab gum in the United Kingdom market.

$$ CUK_t = 4022.855 - 0.601 \text{PH}_t + 4.220 \text{PT}_t - 1.979 \text{PHN}_t $$

(6)

$t$-value $= (3.091) \ (-2.535) \ (2.629) \ (-2.979)$

Significance level $= (0.000) \ (0.002) \ (0.030) \ (0.024)$

$$ R^2 = 66.9\% \quad F (0.025) = 5.39 \quad DW (0.01) = 2.29 $$

The adjusted $R^2$ shows that the coefficient of multiple regressions is 66.9, which indicates that 66.9% of the variation in Hashab gum demand in the United Kingdom market ($CUK_t$) was explained by variables included in the model. All coefficient estimates were significantly different from zero. No serial correlation in the error term was detected.

The estimated model showed that demand for Hashab gum was influenced by its price ($PH_t$), Talh gum price ($PT_t$) and Hashab price offered by the competing country, Nigeria ($PHN_t$). The $PH_t$ variable has the correct sign as expected. An increase in the Hashab price offered by Sudan by one US$ generated a 0.601 metric ton decrease in quantity demanded by the United Kingdom market, citrus paribus. The price elasticity of demand was calculated to be 0.752, meaning that as gum Hashab price increases by one percent, the quantity demanded by the United Kingdom market declines by 0.752%, which indicates that the market demand for gum Hashab was relatively price inelastic.
Talh gum price shows that increasing Talh gum price by one US$ increases the quantity demanded of Hashab gum by the United Kingdom market by 4.220 metric tons. The positive sign of the estimated coefficient indicated that Talh gum has been a substitute for Hashab gum in the United Kingdom market.

The coefficient of Nigeria price variable has a negative sign indicating that when Nigeria decreased its Hashab gum price, demand for Sudanese Hashab declined by 1.979 \textit{citrus paribus}. This shows that Nigerian Hashab gum cannot be considered a substitute for Sudanese Hashab gum, rather it can be considered as a complementary good.

**French market**

The following demand model for Hashab gum shows the selected estimated equation for French market.

$$ CHF_t = 9081.759 - 1.329 \text{PH}_t \quad (7) $$

\begin{align*}
\text{t-value} & = (7.294) \quad (-2.87) \\
\text{Significance level} & = (0.000) \quad (0.01)
\end{align*}

$$ R^2 = 30.3 \quad F (0.01) = 8.255 \quad DW (0.01) = 1.169 $$

The adjusted $R^2$ shows that the coefficient of simple regression is 30.3, which illustrates that about 30% of the variation in Hashab gum demanded in the French market (CHF) was explained by its price, which has the expected negative sign and was significantly different from zero. An increase in the price of Hashab gum by one US$ has the effect of decreasing the quantity demanded of gum by the French market by 1.3929 metric tons. The price elasticity was calculated at 0.3659, indicating that as Hashab gum price increased by one percent, the quantity demanded declined by 0.366%. This means that the French market demand for Hashab gum was relatively price inelastic.
**German market**

The following demand model for Hashab gum shows the selected estimated equation for German market:

\[
\text{Log CHG}_t = 1.988 - 1.707 \log \text{PH}_t + 2.350 \log \text{PT}_t \tag{8}
\]

<table>
<thead>
<tr>
<th>t-value</th>
<th>Significant level</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1.988)</td>
<td>(0.196)</td>
</tr>
<tr>
<td>(-3.371)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>(3.371)</td>
<td>(0.005)</td>
</tr>
</tbody>
</table>

\[ \text{R}^2 = 41.7 \]

\[ F (0.01) = 6.15 \]

\[ \text{DW} (0.01) = 2.155 \]

The adjusted \( \text{R}^2 \), reflecting a coefficient of multiple log-log regression of 41.7, reveals that 41.7% of the variation in Hashab gum demand in the German market was explained by its price (PH\(_t\)) and the price of Talh gum (PT\(_t\)). All coefficients were significantly different from zero, and no serial correlation existed.

As the model is a log-log function, the parameter coefficients are elasticities, the estimated model therefore showed that a one percent increase in the Hashab price led to a decrease in the quantity demanded of Hashab gum by the German market by 1.707% indicating that this market was relatively price elastic. The coefficient of Talh gum price shows that an increase of 1% in its price raised the demand by 2.35%. This indicates that Talh gum serves as a substitute for Hashab gum in Germany.

**American market**

The following is the demand model for Hashab gum in the United States:

\[
\text{Log CHUS}_t = 6.455 - .801 \log \text{PH}_t \tag{9}
\]

<table>
<thead>
<tr>
<th>t-value</th>
<th>Significant level</th>
</tr>
</thead>
<tbody>
<tr>
<td>(14.128)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>(-5.606)</td>
<td>(0.000)</td>
</tr>
</tbody>
</table>

\[ \text{R}^2 = 53.9 \]

\[ F (0.00) = 31.43 \]

\[ \text{DW} (0.01) = 1.273 \]

The adjusted \( \text{R}^2 \), reflecting a coefficient of simple log-log linear regression of 53.9, indicates that about 54% of the variation in Hashab gum demand in United States market was explained by its price. The coefficient of the Hashab gum price was significantly different from zero. No serial correlation was detected. The model says that a one percent increase in Hashab price will decrease United States demand for Hashab gum by 0.801% indicating an inelastic demand in this market.
DISCUSSION

In this study, demand of individual importing countries was slightly responsive to price changes in most of the cases. In the British market, Hashab gum from Sudan is being complemented by Hashab gum from Nigeria. Nigerian gum is known to be immature and of lesser quality than Sudanese gum and of high viscosity levels to be accepted by key sectors of industry. Therefore, rather than substituting it for Sudan Hashab gum it is mixed with it. This process adds considerable costs and drives up the price of the product as stated by Shirley (1999).

The behaviour of the United Kingdom and the German markets, indicated by their respective models, might be due to the Joint Experts Committee on Food Additives (JECFA) specification which considers Talh gum as a close relative to Hashab gum (FAO 1995). The French market showed price inelasticity too; this result is similar to what was found by Hasab Elgawi (1998). This is so although France imports gum from the Francophone countries of West and Central Africa (FAO 1995).

In the German market, demand for Hashab gum was relatively price elastic, and Talh gum appeared to be a readily available substitute for it. This explains the high price elasticity of Hashab gum. On the other hand, these results contradict the findings of Mahmoud (1983) and Hasab Elgawi (1998) with regard to the United States market. This difference might be due to the fact that our study used data for long and more recent periods during which many changes have occurred in the market. The inelasticity of the United States demand might be attributed to the failure of utilization of Hashab gum substitutes as ingredients in pharmaceutical, food and beverage products where taste, mouth feel, superior emulsification, low calorie value, high fibre content and extended shelf-life of product (the characteristics found in gum arabic) are demanded by the United States industries and consumers (Shirley 1999).
CONCLUSIONS

1. The demand for Hashab gum in the United Kingdom market is relatively price inelastic, and Talh gum is an important substitute for Hashab gum, but Hashab gum from Nigeria is complementary to Hashab gum of the Sudan.
2. The German demand is relatively price elastic, and Talh gum is an important substitute for Hashab gum from Sudan.
3. The demand of individual markets of the United States and France are relatively price inelastic.
4. All estimated models indicated that there are overlooked factors playing greater roles that need to be investigated; the most important factor is probably gum arabic substitutes prices for which reliable and sufficient data were not available.
5. Lowering Hashab gum prices will not help much in increasing demand. It will only hurt producers.
6. Talh gum is gaining importance at least in some markets and this fact should not be ignored when considering production policies.
REFERENCES


تقدير تأثير الأسعار في بعض الأسواق العالمية على طلب صمغ الهشاب السودانى

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موجز البحث: هدفت هذه الدراسة لإجراء تحليل كمي مفصل على طلب صمغ الهشاب في الأسواق الفردية بغرض التعرف على تأثير الأسعار على الطلب. الدراسة هي محاولة بناء وتقدير معادلات الطلب في أسواق أهم الدول المستوردة لصمغ الهشاب وتقدير مرونة الطلب السعرية عليه في تلك الأسواق العالمية.

تتكون معادلة الطلب من مجموعة من المعادلات الفردية والتي قدرت بواسطة استخدام تقنية المربعات الصغرى الاعتيادية (OLS) واختبرت باستخدام معايير مختلفة اقتصادية و إحصائية و قياسية. أوضح النتائج أن الطلب على صمغ الهشاب كان غير مرن في كل من بريطانيا و فرنسا والولايات المتحدة (مرونة الطلب السعرية 0.752 و 0.3659 و 0.831 على التوالي). كما وجد أن صمغ الطلح أصبح بديلًا لصمغ الهشاب في السوق البريطاني بينما صمغ الهشاب النيجيري أصبح سلبًا مكملاً لصمغ الهشاب السوداني، وأن السوق الألماني مرن (1.707) وصمغ الطلح يستخدم بديلاً لصمغ الهشاب.

خلاص الدراسة إلى أن أسواق الصمغ تختلف في سلوكها وأنه على الرغم من أن السعر عامل مؤثر على الطلب، لكن تأثيره ليس كبيراً في كثير من الأسواق وهناك احتمال وجود عوامل أخرى تلعب دوراً كبيراً على الطلب تجب دراستها.