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Economic Growth and Food Imports: Evidence from Saudi Arabia

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Abstract

Saudi Arabia has experienced rapid economic growth since the 1960s. The sustained income growth, supported primarily by oil revenues, has brought about profound socioeconomic change and has linked Saudi consumers to other affluent nations in the global market place. This study examines the impact of economic growth on consumption patterns and food imports. The Almost Ideal Demand System is used to study the patterns of substitution and complementarity in consumption. Monte Carlo sampling is used to generate confidence intervals for the estimated elasticities and conduct policy simulation. The analysis indicates that economic growth combined with food subsidies have resulted in a shift in consumption away from grains (the traditional diet) to meats and dairy products. This rise in demand is driven by high income elasticities for luxury food items and is further fueled by the income effect of subsidized grain prices. The study provides evidence that well-intentioned policies that distort relative prices lead to undesirable outcomes in terms of

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increasing demand for food imports and induce shifts in consumption, both with important long run economic implications.

I. Introduction

Much of the discussion surrounding the petroleum price shocks during 1970s and 80s has been concerned with the effect of wealth transfers on the developed economies ⟨Griffin & Teece [1982]⟩. In contrast, little interest has centered on the impacts of such transfers on the Organization of Petroleum Exporting Countries (OPEC). Among OPEC's member countries, Saudi Arabia has been subjected to the largest number of income shocks for the longest duration ⟨Amuzegar [1983]⟩. These economic shocks have profoundly affected the nation's economy in terms of major gains in productivity, shifts in the pattern of international trade, and have resulted in shifts in tastes leading to changes in consumption patters ⟨Looney [1990], El Mallakh [1982], Quandt [1981]⟩.

Since the formation of OPEC in the 1960s and through the 1980s, Saudi Arabia has been the "archetype" of an upper income petroleum based economy that could not domestically absorb the income generated through trade in primary commodities. Massive increases in oil revenues over this period meant the average consumer in Saudi Arabia experienced an unprecedented income growth. Living standards were drastically improved as government expenditures on infrastructure, industry, services, education, and imported goods, increased several fold. Moreover, increased foreign trade strengthened the economic links between Saudi Arabia and the rest of the world, effectively integrating Saudi consumers with other affluent consumers in the global market place.

These development are in many ways representative of the situation in other petroleum based economies in North Africa and the Middle East, where three forces – income growth, population explosion, and cultural change – have changed the food balance equation creating a "food gap," primarily caused by rapid growth in demand rather than a fall in agricultural production. The population growth rate in these countries is among the highest in the world providing a major challenge to domestic food producers. The persistent growth of income since 1960s and other socioeconomic developments such as changes in the composition of the population have further compounded this task. Government food policies – primarily subsidies to producers and urban dwellers – has also significantly enhanced food demand, both directly and indirectly. These development have lead to a politically undesirable setting where a large portion of total food demand is imported ⟨Richard & Waterbury [1990]⟩. Because of these developments and the fact that the socioeconomic causes of the current situation are expected to persist for the foreseeable future, understanding the dynamic of this problem is of paramount importance.

This study examines the effects of persistent income and population growth on Saudi Arabia's food consumption patterns as reflected in the nation's food imports. The developments in Saudi Arabia represents an extreme case of similar developments in other petroleum based economies. The focus of this study on food imports reflects the fact that relative to demand, domestic production of the commodities considered has been quite small since 1960s. In fact food imports have exceeded 60 percent of total demand since 1965 ⟨Looney [1990], p. 54⟩. For Saudi Arabia as with other oil based economies, food imports are crucial in meeting the gap between the rising demand and domestic production of most food items. Furthermore, according to the United Nations' Food and Agriculture organization (FAO), this gap is expected to persist for the foreseeable future. A comprehensive analysis of the country's demand for food imports is, however, nonexistent. This study aims to fill this gap.

The Almost Ideal demand model ⟨Deaton & Muellbauer [1980a]⟩, which possess desirable theoretical properties, is used for analyzing consumer preferences for six broad categories of imported foods – meats, oils, dairy, wheat, rice and grains, and sugar. The use of such framework is critical for understanding the evolving patterns of complementarity (substitutability) among goods. Monte Carlo simulation techniques are used to generate confidence intervals for the estimated elasticities. The elasticity estimates are then used to explore issues related to food security concerns, health and nutrition policy, and to forecast future demand conditions.

The plan of the paper is as follows:The demand model, its underlying assumptions, the estimation procedure, and the Monte Carlo methods are discussed in section II. The data on which this study is based are described in section III. The empirical findings and their implications are discussed in section IV. Policy implications and conclusions appear in the final sections of the paper.

II. The Demand Model

Several functional specifications may be utilized to estimate a system of commodity demand equations. However, only two demand systems consistently aggregate over individual consumers without imposing overly stringent assumptions. These are the Linear Expenditure System (LES) of Stone [1954] and the Almost Ideal (AI) Demand System of Deaton & Muellbauer [1980a]. This study utilizes the latter since LES requires positive compensated cross-price elasticities and rules out inferior goods ⟨Deaton & Muellbauer [1980b]⟩. In contrast, the AI has a flexible functional form and imposes no *a priori* restrictions on demand elasticities. Recent applications of AI to various data have given interesting and sensible results ⟨Green & Alston [1990]⟩.[1]

Before discussing the details of AI model, it will be useful to explicitly discuss the types of assumptions that would justify its use for the analysis of food imports. The standard models of import demand ⟨Jones & Kenen [1984]⟩ – typically single equations rather than a system – include measures of prices, output, and purchasing power of domestic economy relative to the rest of the world. Hence, exchange rates, real domestic income, real domestic prices, and a variety of socioeconomic factors may enter the demand model. This study controls for the majority of these factors. The size of the data, however, limits the number of explanatory variables that could enter the analysis without significantly reducing the available degrees of freedom. So, for example, although a variety of data on domestic economic indicators are available, one can only include a small number of such variables. The approach adopted here is to select variables that are consistent with theory and serve as a good proxy for other measures.

1. Since the AI has been applied in many studies it is not possible to provide an exhaustive reference. Green & Alston [1990] provide a relatively complete recent reference to other applications.

Exchange rate effects are absent from this analysis because the Saudi Monetary Authorities have maintained fixed exchange rates throughout the period under consideration. This policy has insured that changes in relative prices of domestic and imported goods has not been driven by fluctuation in exchange rates. Indeed the commodities considered were purchased in U.S. Dollars – the currency in which oil is sold – and their values had been converted to Saudi Rials (SR) using a fixed exchange rate ⟨Kingdom of Saudi Arabia [1964-1990]⟩.

Using a representative demand model to study food imports imposes theoretical assumptions that underlay the 'rational behavior' model – *i.e.*, decisions are based on expenditure minimization or utility maximization. Whether the context and the data used here are consistent with optimization assumptions is subject to debate and empirical examination. Certainly, assumptions such as homogeneity in prices and expenditures are appropriate for import demand functions as well ⟨Jones & Kennen [1984]⟩. In the present study, the benefits of estimating a system of demand rather than a single equation is the ability to account for complementarity and substitution effects in consumption, an important consideration given the focus of this study.[2] Imposing the restrictions implied by demand theory also reduces the number of estimated parameters and improves the statistical significance of the estimated model.

Throughout this analysis it is assumed that the demand for imported foods as a group is 'separable' from other imports and domestic goods. This assumption is necessitated by data limitations rather than a specific theoretical justification. A more comprehensive analysis would integrate prices and quantities of domestically produced foods and non-food imports. Recent analysis by Looney [1990, p. 59] suggest that the value of food imports – consistently below 15% of total imports – is generally independent of non-food imports providing some justification for separability assumption. As for the inclusion of domestic foods, such data are generally non-existent for Saudi Arabia. Furthermore, the commodities considered are either not pro-

2. Looney [1990, p. 60] report expenditure elasticities for food imports based on single-equation double-logarithmic specification. These elasticities are considerably larger than those reported below, precisely because complementarity and substitution effects are absent from his analysis.

duced domestically (*e.g.*, rice) or are produced in negligible quantities (*e.g.* oils, meats).[3] The exclusion, therefore, is likely to be a minor limitation as the value of the commodities considered in this analysis is on average 78% of total domestic agricultural production, which includes non-food items such as animal feed. In the absence of domestic food consumption data the estimated demand model includes the value of agricultural output (deflated by the agricultural CPI)to account for domestic supply conditions. In any case, the direction of the bias caused by the foregoing assumptions and data limitations is somewhat predictable and will be discussed when presenting the results. With these caveats noted, we briefly outline the specifics of the AI model.

In the AI model, the demand equations for the n goods considered are expressed as a system of equations (1), in which the budget share of the i-th commodity, w_i, depends on the prices, p_j, and real total expenditures, $[\frac{X}{P}]$:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left[\frac{X}{P}\right] + \mu_i \quad (1)$$

where P is a price index and ;

$$\log P = \alpha_0 + \sum_j \gamma_{ij} \log p_j + \frac{1}{2}\sum_j \sum_i \gamma_{ij} \log p_i \log p_j. \quad (2)$$

Equation (1) is the starting point of empirical demand studies. The added disturbance term μ_i is assumed to be normally distributed with mean of zero and a constant variance. Following the suggestion by Deaton & Muellbauer [1980a], it is customary to approximate (2) with the Stone price index. This approximation, however, has been questioned on various grounds, including misleading elasticity estimates ⟨Pashardes [1993]⟩ and is therefore not adopted here. Instead, equation (1), after substitution of (2), will be estimated using nonlinear estimation techniques. In this form, (1) suggests that the expenditure share on any commodity is related to the price of all commodities and to real expenditures. Both variables are as-

3. In the absence of foreign exchange constraints and given the cost advantage of foreign producers, there have been little or no incentives to produce these commodities domestically. Recently, however, food security concerns have resulted in high subsidies for grain production. As a result, the country has become self-sufficient in wheat and barley production since the late 1980s. The data used does not include this period.

sumed exogenous, and α_i, γ_{ij}, and β_i are parameters to be estimated.

The formulas for various elasticities for the AI demand system are as follows ⟨Green & Alston [1990]⟩. The uncompensated (Marshalian) price elasticities are given by;

$$\eta_{ij} = \frac{\partial \ln q_i}{\partial \ln p_j} = -\delta_{ij} + w_i^{-1}\left\{\gamma_{ij} - \beta_i[\alpha_j + \sum_k \gamma_{kj} \ln p_k]\right\} \tag{3}$$

where $\delta_{ij} = 1$ for $i = j$ and zero otherwise. Income elasticities are given by; $\varepsilon_i = 1 + \beta_i/w_i$. The substitution (compensated) elasticities are derived from the elasticity form of the Slutsky equation; $\sigma_{ij} = \eta_{ij} + w_j\, \varepsilon_i$ ⟨Deaton & Muellbauer [1980b]⟩. Socioeconomic variables are incorporated into the AI model through the parameters α_i:

$$\alpha_i = \alpha_{0i} + \sum_k \tau_{ik} * T_k \tag{4}$$

where T_k is the k-th socioeconomic variable and τ_{ik} measures its influence on the expenditures share of group i.[4] The various restrictions of demand theory, namely adding-up ($\Sigma_i \alpha_i = 1$), homogeneity ($\Sigma_j \gamma_{ij} = 0$), and symmetry ($\gamma_{ij} = \gamma_{ji}$), are imposed by restrictions on the parameters of equation (1). These restrictions considerably reduce the number of parameters that must be estimated and are imposed throughout the estimation procedure.

In time series studies, changes in demand specifically due to passage of time are often captured by including a trend variable in the demand model ⟨Deaton & Muellbauer [1980b]⟩. In the analysis that follows, the *real* value of domestic agricultural output is used in place of a trend variable. The substitution is appropriate since, like a trend variable, the value of agricultural output rises smoothly over time. The substitution allows calculation of import demand elasticities with respect to changes in the value of agricultural outputs (θ_{ik});

$$\theta_{ik} = \frac{\partial \ln q_i}{\partial \ln T_k} = w_i^{-1}\left\{T_k * \tau_{ik}[1 - \beta_i]\right\} \tag{5}$$

The most important attribute of the flexible demand models such as the AI is that they place few restrictions on various demand elasticities. The

4. Note that by imposing the adding up and homogeneity restrictions the parameters of the omitted equations is calculated, *i.e.*, $\sum_{i=1}^{n} \tau_{ik} = 0$.

validity of such models, however, has often been based on statistical tests of their fit rather than on the value of the estimated elasticities. In fact, researchers have often drawn the untested inference that statistically significant parameter estimates automatically lead to significant elasticity estimates. To avoid this pitfall, it seems more appropriate to ask how the precision of a given functional form influences the precision of the elasticity estimates ⟨Anderson & Thursby [1986], Green, Hahn & Rocke [1987]⟩.

Determining the precision of elasticity estimates in the AI type models is complicated by the fact that the elasticity formulas presented above are nonlinear functions of the model's estimated parameters. Using the Translog cost function, which has similar elasticity formulas, Anderson & Thursby [1986] have shown that because of this nonlinearity, the distribution of elasticity estimates cannot be derived analytically, even if the distribution of the parameters of the underlying model are known.

Three methods have been suggested to deal with this problem ⟨Krinsky & Robb [1991], provide a recent survey⟩. First, approximation techniques may be used to linearize these formulas. This approach may not provide a good approximation, given the extent of nonlinearity in the AI elasticity formulas. Second, Green et al. [1987] suggested the Bootstrap method for constructing confidence intervals. Although this suggestion offers a reasonable solution to the problem, in practice the Bootstrap method may not be computationally feasible;the AI system is highly nonlinear, and depending on the number of equations and the specific data, convergence may not be achieved for each Bootstrapped sample.[5]

A third possibility, suggested by Krinsky & Robb [1986], is to generate a simulated distribution for the elasticities by drawing many samples from the multivariate normal distribution of the model's parameters.[6] This study implements this approach by sampling ($N = 5000$) from the joint distribution of the model's estimated parameters (*i.e.*, α_i, β_i, γ_{ij}, etc.). For each draw, the elasticities are calculated at the mean predicted expenditure shares and at

5. Identifying the appropriate starting values and ensuring convergence of the model estimated here required use of a relatively fast computer. With a large sample size, Bootstrapping the model even for only a moderate number of times (say 50)could require powerful computing facilities.
6. Krinsky & Robb [1991] compared these alternative using the Translog cost function.

the mean value of the T_k variable.

III. The Data

The primary source of data for this study has been *Saudi Arabia's Statistical Year Book*, published by the Ministry of Finance and National Economy (1964-1990). The United Nation's *Year Book of International Trade Statistics* and the Food and Agricultural Organization's (1965-1990) *Year Book of Agricultural Trade Statistics* were used as cross references. Since data on the majority of goods considered were unavailable for the 1950s, the study uses the most complete set of data which covers 1963 through 1986. Data beyond 1986 is fragmented and subject to further revision.

Annual data on quantity (tons) and value (1,000 SR) for sixteen agricultural commodities are used. The overall value of the sixteen commodities is on the average 72 percent of total agricultural imports (the range is 50 to 87 percent). The difference is made up of fresh fruits, canned goods, beverages and tobacco, and other specialty goods. The value of the commodities considered on average amounted to 78% of the value of all domestic agricultural output and 8% of all imports. The share of agricultural imports in total imports has declined steadily over time ⟨Looney [1990]⟩.

The commodities considered are: cattle and beef; sheep and goats; other meats;poultry (fresh and frozen); milk (fresh, powder, etc.); butter and ghee; cheese (various forms); eggs; wheat (including flour); rice; beans (lentils, chick peas, etc.); barley; maize and millet; oils (various types); and sugar (including sugar products). These commodities were aggregated into six broad categories:meats (beef, sheep, poultry, and other meats), oils (all types), dairy (milk, butter, cheese, eggs), wheat (including flour), grains (rice, beans, maize and millet), and sugar products.

The present commodity grouping may be justified by appealing to aggregation theory, which indicates that close substitutes should be grouped together ⟨Deaton & Muellbauer [1980b]⟩. Group prices are calculated by dividing total group expenditures (SR) by quantity (Kg). The group expenditure shares (w_i) are defined as the ratio of expenditures on specific commodity groups to expenditures on all commodities considered. Population figures and data on the Gross National Products (GNP), imports, exports,

Table 1
Description of Variables

Variable	Definition	Mean	Std.Dev.	1963	1986
Expenditure					
MEATS	Expenditure Share on all Meats (%)	30.00	10.00	18.00	47.00
OILS	Expenditure Share on Oils and Fats (%)	7.00	2.00	7.00	7.00
DAIRY	Expenditure Share on Dairy Products (%)	16.00	3.00	11.00	22.00
WHEAT	Expenditure Share on Wheat and Flour (%)	15.00	7.00	20.00	3.00
GRAINS	Expenditure Share on Rice and Grains (%)	24.00	6.00	36.00	17.00
SUGAR	Expenditure Share on Sugar Products (%)	8.00	3.00	8.00	4.00
Quantities					
q_1	Per Capita Quantity of MEATS (KG)	16.20	13.00	2.33	25.00
q_2	Per Capita Quantity of OILS (KG)	5.93	4.54	2.25	14.20
q_3	Per Capita Quantity of DAIRY (KG)	9.70	6.16	2.10	13.80
q_4	Per Capita Quantity of WHEAT (KG)	40.15	16.00	25.45	8.90
q_5	Per Capita Quantity of GRAINS (KG)	56.05	33.56	30.60	59.10
q_6	Per Capita Quantity of SUGAR (KG)	18.14	11.85	3.70	13.45
Prices					
p_1	Price of MEATS (SR/KG)	5.35	1.76	4.14	7.40
p_2	Price of OILS (SR/KG)	2.70	0.98	1.70	1.90
p_3	Price of DAIRY (SR/KG)	4.42	1.53	2.80	6.30
p_4	Price of WHEAT (SR/KG)	0.80	0.33	0.40	1.25
p_5	Price of GRAINS (SR/KG)	1.05	0.32	0.65	1.10
p_6	Price of SUGAR (SR/KG)	1.34	0.86	1.15	1.30

the Consumer Price Index (CPI), and the value of agricultural outputs were obtained from World Bank ⟨World Tables [1991]⟩ and United Nations publications (1970-1990). Tables 1 and 2 provide statistics on the variables used in the model, as well data on basic economic indicators during the period under consideration.

Table 2
Broad Socioeconomic Indicators

Definition	Mean	Std.Dev.	1963	1986
Economic Indicators				
Populations (1,000)	8208.79	2883.51	5065.00	14185.00
Gross National Product (10^6 SR)	171.63	177.00	6.00	310.42
Value of Total Exports (10^6 SR)	95.85	99.80	4.43	86.00
Value of Total Imports (10^6 SR)	63.40	71.80	1.90	115.25
Value of Total Agricultural Output (10^6 SR)	3.90	4.55	0.80	15.90
Share of Domestic agriculture in GNP (%)	4.60	3.70	13.00	5.00
Value of Above Commodities as % of Agr. Output	78.00	38.00	34.00	36.00
Value of Above Commodities as % of Total Imports	8.00	4.00	14.00	5.00

Note: Computed from the *Saudi Arabia Statistical Yearbook* [1963-1990].

IV. Estimation and Results

The starting point in the estimation of the AI model is equation (1). Nonlinear Seemingly unrelated estimation technique is used to estimate this system of demand equations.[7] Adding-up, homogeneity, and symmetry, were imposed simultaneously. System estimation implies that one equation in the system is redundant and should be dropped (sugar in this case). The estimated parameters and the model are highly statistically significant. The parameters have limited economic interpretation and will not be reported to save space. Instead, the discussion focuses on the estimated elasticities and their interpretation.

Table 3 contains the estimated income, price, substitution, and agricultural output elasticities obtained. All elasticity estimates are calculated at the mean value of agricultural output, prices, and predicted share values. Standard errors for the elasticities were obtained via the Monte Carlo simulation described above. The expenditure elasticities – all statistically significant – indicate that meats, dairy, and sugar are luxuries while oils, grains, and wheat are necessities. Income elasticities are obtained by scaling food

7. Data and the SAS programs are available from the author.

Table 3

Expenditure, Price, Substitution, and Agricultural Output Elasticities

Elasticity	MEATS	OILS	DAIRY	WHEAT	GRAINS	SUGAR
Expenditure						
ε_i	1.40*	0.80*	1.05*	0.47*	0.83*	1.05*
Own-Price						
η_{ii}	–0.90*	–0.50*	–0.58*	–0.30*	–0.57*	–0.58
Substitution						
σ_{1j} MEATS	–1.68*	3.90*	–0.87	–1.55*	1.70*	2.45
σ_{2j} OILS	–	–7.27*	–0.55	–0.98	–0.98*	–2.60
σ_{3j} DAIRY	–	–	–2.52*	4.96*	–0.20	–0.10
σ_{4j} WHEAT	–	–	–	–1.58*	–0.14	0.62
σ_{5j} GRAINS	–	–	–	–	–1.52*	–0.20
σ_{6j} SUGAR	–	–	–	–	–	–5.93
Agricultural Output						
θ_{ij}	1.53*	0.10*	0.03*	–1.31*	–0.32*	–0.32*

* Significant at 5% level and less. Goods are *normal* when $\eta_{ii} < 0$, *Giffen* when $\eta_{ii} > 0$, *superior* when $\varepsilon_i > 0$, *inferior* when $\varepsilon_i < 0$, *Luxury* when $\eta_{ii} > 1$, and *necessities* when $\eta_{ii} < 1$. Commodities are *substitutes* when $\sigma_{ij} > 0$ and *complements* when $\sigma_{ij} < 0$.

expenditure elasticities with the budget share of foods in total expenditures. Estimates of food budget shares for Saudi Arabia vary considerably falling within 20 to 30% range. Income elasticities are expected to decrease as incomes increases and food budget shares decline ⟨Timmer, Falcon & Pearson [1983]⟩. This suggests a gradual decline in demand for these commodities as incomes grow in the future.

In terms of own-price effects, meats have the highest price elasticity, while wheat – a highly subsidized commodity – has the lowest. All goods considered are generally responsive to price changes. Based on the magnitudes and statistical significance of these estimates, price policies – subsidies and taxes – will be an effective means of influencing demand for these commodities.

The (compensated) substitution elasticities (the σ_{ij}s), help disentangle the income and substitution effects. As Table 3 shows, the own-substitution elasticities along the diagonal are all negative, indicating that price increases lead to reduced demand for all commodities considered. The off-diagonals indicate an interesting pattern of complementarity and substitution among the food groups, indicating that grains (primarily rice) and oils (primarily ghee) are substitutes for meats, while wheat is found, somewhat surprisingly, to be a compliment to meats. Other statistically significant substitution elasticities indicate complementarity between oils and grains and substitution between dairy and wheat. The remaining elasticities are mostly statistically insignificant and suggests consumption independence. It is worth noting that the expenditure and price elasticities reported above are larger in magnitude relative to estimates for similar commodity groups from the United States ⟨Ramezani, Rose & Murphy [1995]⟩ and other developed economies ⟨Deaton & Muellbauer [1980 p. 63]⟩. The last row of Table 3 reports the estimated demand elasticities with respect to real domestic agricultural output. This variable was added to the model for two reasons. First, it serves as a proxy for a trend variable, indirectly measuring the influence of passage of time on demand. Second, and more importantly, the variable measures domestic food supply conditions; as the domestic output of the commodities considered rise, all else being equal, demand for imported food items should decline. The opposite is also conceivable; if increases in domestic output are achieved by specializing in a specific commodity (wheat in this case), the output of other commodities will decrease given the limited labor, land and water resources. In such cases, demand for food imports whose domestic output has decreased (increased) will be expected to rise (fall). The elasticity estimates in Table 3 are consistent with this latter scenario; with each 1% increase in agricultural output – primarily wheat and grains – the demand for imported meats, oils, and dairy will rise while demand for wheat, grains, and sugar will fall. The increase in meat and the fall in wheat demand are particularly notable.

As noted above these results may be biased because data limitations leads to the exclusion of other imports and the prices and quantities of domestic foods consumed. The estimated elasticities are likely to be upwardly biased by these omissions as more of the variation in demand are attributed to prices, expenditure, and domestic output that appear in the model. The Monte Carlo simulation is likely to reduce this bias as it produces elasticity estimates from a range of the model parameters. The price elasticity estimates can also be biased if price changes overtime are reflective of changes in transportation costs, quality improvements, or other unrelated factors ⟨Timmer et al. [1983]⟩. Such biases are common to all demand analysis and their direction depends upon the direction of price movement due to these factors.

Despite such limitations, estimates of food consumption parameters are deemed to be indispensable for addressing questions such as, when per capita income rises, how much is the market demand for specific commodities *likely* to rise, and what would be the effect on the market demand for other commodities?

As Timmer et al. [1983, p. 54] observe, "Care in specifying consumption equations is an essential step in estimating sensible parameters (assuming adequate information is contained in the data in the first place). Specification – determining what variables and what functional form will best suit the regression estimated – is an art." They conclude that such "artistic endeavors" can be considered a success if the results of the analysis is at least consistent with long established empirical relationships such as the Engel's Law. It is only then that the estimated food consumption parameters will be useful in conducting a variety of policy analysis. In the preceding analysis attempts were made to control for functional specification and the results are generally consistent with established empirical relationships. The next step in this process is to consider the usefulness of the results for policy analysis, which is briefly discussed next.

V. Policy Analysis

There are a number of methods in which the elasticity estimates reported in this study can be used for policy analysis. The first is for the purpose of forecasting trends in future consumption based on a host of scenarios about the future evolution of income, prices, and other socioeconomic variables of interest. We provide the results of a simulation exercise to further illustrate this point and highlight the usefulness of the estimated elasticities.

Suppose population and expenditures growth rates are related to their last period values via a simple linear relationship of the form $x_t = \alpha + \beta x_{t-1}$, where α and β are constants. Using the sample data these parameters were estimated by the Least Square procedure. The coefficients were then used to forecast future growth rate of per capita expenditures. This simple analysis suggests that expenditures will grow at approximately 8% annually. This information in conjunction with expenditure elasticities and the last year's consumption values for each commodity provides the means for forecasting consumption for each commodity group into the future. Of course there are many other potential schemes for extrapolating the value of the exogenous variables and hence obtaining forecasts of future demand. Policy makers can experiment with a variety of scenarios so as to develop a sense for potential future outcomes.

The elasticity estimates could also be used to **A.** anticipate the consequences of price changes instituted through taxation or subsidies on specific commodities, **B.** analyze the effect of income subsidies for specific income groups, and **C.** study the consequence of changes in socioeconomic variables on consumption patterns. Policy simulation can also be carried out at a disaggregated level, where the estimated consumption parameters in conjunction with socioeconomic information about a specific target population, is used to design policies that will influence food consumption and intake of specific nutrients.

For the first two purposes – forecasting and the evaluation of income/ price policies – the magnitude and significance of price and expenditure elasticities are of paramount importance. The estimated elasticities reported above generally meet this criteria. The high expenditure elasticities suggest continued growth in demand for food imports even for modest growth in income. Indeed, the continued growth in food imports despite the recent collapse in oil prices suggests that expenditure elasticities may be downward inelastic. Government policies, therefore, should place greater emphasis on enhancing domestic supplies as a means of managing the growing 'food gap' in the short run. Price policies may be the most useful tool in demand management. Removal of consumption subsidies on grains and some form of taxation on luxury food imports can effectively reduce the growth for imports. The cross-price elasticities, which are generally insignificant, indicate limited possibilities for influencing consumption *patterns*. The elasticities with respect to domestic food supply conditions shows that the drive for self sufficiency in grain production could further backfire by redirecting resources from the domestic production of other foods to wheat, and through its powerful income effect further enhance demand for food imports.

Despite the impressive gains in the standards of living, portions of the Saudi population still faces health risks because of malnutrition ⟨The Economics Research Service [1980-1988]⟩. Concerned policy makers may use the results of this study to design policies that target specific populations. Timmer et al. [1983], Knudsen & Scandizzo [1982], and Behrman & Deolalikar [1988] show how knowledge of the aggregate demand elasticities may be used to design programs that target specific segments of the population. The methodology proposed requires knowledge of the price and income elasticities for the targeted population. Such information can be obtained by considering two 'stylized facts' ⟨Timmer et al. [1983, p. 56]⟩. First, Engel's Law implies that food expenditure shares are higher at low incomes levels. Consequently, income and price elasticities are also expected to vary by income. Using the parameters of the model estimated above and data on food expenditure shares, it is possible to obtain income and price elasticity estimates for populations at different income levels. Second, Bennett's Law ⟨Timmer et al. [1983, p. 58]⟩ indicates that the proportion of calories derived from starchy staples declines with income as consumers expand their consumption bundle to include higher-priced calories. The knowledge of price, income, and substitution elasticities for various income groups – in conjunction with the Bennett's law – provide an important tool for assessing the consequences of price and income subsidies (taxes) on nutritional intake.

The estimated elasticities reported here confirm both laws at the aggregate level; subsidies on grains in conjunction with increases in income have accelerated the shift from the the starchy staples to higher-priced calories from meats and dairy. Removal of consumption subsidies, increases in the price of meat and dairy, or fall in the growth rate of incomes are the likely forces that can curtail this trend.

VI. Summary and Conclusions

The application of the AI model to the data on agricultural imports of Saudi Arabia yields elasticity estimates with reasonable and statistically significant values. The results indicate a major shift in consumption patters that is due primarily to high income elasticity of demand for meats and dairy, significant cross-price effects from wheat and grain, and the persistent increases in incomes and grain subsidies. The net effect is a shift over time from a grain based diet to a diet composed primarily of meats, dairy, oils, and sugar. This shift – beneficial to the average Saudi consumer whose diet has improved – has important public health consequences that are reminiscent of those observed in the industrialized countries.

The 'food consumption parameters' estimated in this study and changes in their value over time are of primary importance to understanding changes in consumption patterns. The reported findings are therefore pertinent to those concerned with factors influencing consumer behavior, in particular policy makers concerned with food security and agricultural trade issues. The results also provide an indication of changes that are likely to take place in other petroleum based economies. The main lesson emerging from the analysis is that grain price subsidies introduce distortions that in addition to discouraging domestic production lead to greater demand for non-grain imports through their income effect. Hence, 'desirable' government policies could lead to undesirable outcomes in the form of increased reliance on food imports and increased consumption of high fat and cholesterol products.

Saudi Arabia's living standards have improved dramatically in the past decades but much remains to be done. According to studies conducted by the U. S. Department of Agriculture ⟨The Economics Research Service [1980-1988]⟩, in 1981 approximately 33 percent of the permanent population received an adequate diet, another third were upgrading their diets, and the bottom third were still considered undernourished. On the upper end of the scale, the wealthier families had an average daily intake of about 3000 calories per capita. Furthermore, 83 percent of the calories consumed by the average resident were imported (USDA-1984). Given such statistics, it is important to further study the forces that influence demand for food in Saudi Arabia.

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