The Impacts of WTO and Water Policy Changes on Saudi Arabian Agriculture: Results from an Equilibrium Displacement Model

Authors:
Mahdi M. Al - Sultan
Assistant Professor, Dept of Agricultural Economics,
King Saud University,
P.O. Box 2460, Riyadh 11451,
Saudi Arabia
alsultan@ksu.edu.sa

Stephen Davies (Corresponding Author)
Professor, Dept of Agricultural and
Resource Economics
Colorado State University
Fort Collins CO 80523
970-491-6951
Stephen.Davies@Colostate.edu

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INTRODUCTION

Saudi Arabia's food consumption has grown dramatically over time. There has been a sharp increase in food consumption and significant changes in the composition of food consumed. Therefore, it is important that the government of Saudi Arabia anticipate further effects of these changes on growth of food demand and focus on food policies that contribute to development goals. On the other hand, limited agricultural productivity and the nature of the country's climatic conditions have constrained agricultural production. This restricted growth in production, combined with population growth, has led Saudi Arabia to depend heavily on food imports to cover the gap between domestic demand and local production. The increased reliance on imports as a source of food will increase the country's import demand.

These main problems facing the Saudi agricultural sector suggest the need for an analytical framework that can evaluate effects of policy and resource change on imports, local production and local demand simultaneously. Ideally, the framework should account for substitution and income effects across products that might arise from changes in consumption and production patterns. This is the main objective of this paper.

CONTRIBUTIONS AND BENEFITS OF THE MDOEL

In this paper, a number of extensions to the PPW model are developed and applied to the setting in Saudi Arabia. First, we convert the model from an export-oriented framework to one with an ability to examine imports. Also, in contrast to the PPW approach, where prices are endogenous, this effort will analyze the effects on quantities imported, produced and demanded due to changing world prices that are assumed to be exogenous, so we invoke the small country case. While these changes are not necessarily more complex than the original PPW structure, they permit alternative assumptions to be used that extend the simulation structure of PPW. Additionally, the analysis is set up to decompose the changes in imports into variations in the domestic supply and demand responses. Thus, these simulations can be used to show the effect of change in local or international policy on quantities imported, demanded domestically and supplied domestically. Further, PPW use linear functions in their model, while we show that any function that is linear in parameters can be successfully put into this framework, For example, a CBS domestic demand function, and a log-log supply function could be accommodated. The entire framework can easily be implemented in EXCEL or other spreadsheets. Lastly, we are able separate world prices, retail prices and domestic farm prices, while PPW used just one price and ignored the various policy aspects between these relationships and they did not reflect vertical differences in their model set up.

Also, given the extensive set of elasticities used in this model, it would appear that this model has data requirements and efforts similar to an agricultural sector or computable general equilibrium model. However, we are able to develop most of the elasticities by estimating a restricted AIDS-type import demand matrix. The restrictions are based on a trade identity that relates local supply and demand elasticities to import elasticities. By manipulating this identity and assuming supply matrices, we are able to estimate domestic demand coefficients using relatively accessible trade data and typical econometric approaches. (This part of the research was presented in Al-Sultan and Davies (2003). Thus, we believe that this approach has considerable potential for the development of models that can capture a significant amount of sector effects, but can be based on an empirical base that also has moderate inputs to develop. Moreover, they do not require specialized software beyond that available in most agricultural economics departments in developing countries.

METHOD AND EXAMPLE RESULTS

To develop this framework, this paper extends an equilibrium displacement simulation model by Piggott, Piggott and Wright (American Journal of Agricultural Economics, 1995) (hereafter PPW). Their paper used a full system of demand and supply elasticities, along with several input elasticities, in order to create a simulation model that would be capable of examining the effects of advertising on the exports of lamb and wool from Australia. In our paper, a set of own and cross price elasticities for retail demand are used for eight main agricultural products imported into Saudi Arabia, in conjunction with a relatively sparse matrix of supply elasticities and for inputs, such as water and fertilizer, in order to examine several key issues in the Saudi agricultural sector. Our elasticities were derived from an AIDS-type estimation based on quarterly import data from 1990 until 2000, following Lee, Brown and Seale (1994).

Trade Elasticities Model

The objective of this model is to use the import estimates, which are often based on more reliable trade data, and non-sample domestic supply elasticities to create an analysis framework capable of doing domestic and trade policy analysis. Following McCalla and Josling (1985) and Piggott, Piggott and Wright (PPW) (1995), this model can be established. It will provide a relatively simple but effective method to evaluate many policy alternatives, as well as demand and supply shifters. To demonstrate the range of possible applications of this modeling technique, and examine issues of interest in Saudi Arabian agriculture, a number of simulations will be presented. For example, the prices of imports into Saudi Arabia, which are exogenous because of Saudi Arabia's size, will be altered to account for anticipated WTO trade liberalization impacts. Also, local supply will be affected by changes in inputs prices, water for example, which is expected to rise due to water scarcity. In addition, a reduction in input subsidies will affect these results as well.

Domestic demand for agricultural commodities in Saudi Arabia comes from two sources, domestic supply and imports. It should be clear that the summation of imports and domestic supply equals the total domestic demand in the absence of exports. This identity can be illustrated mathematically as

(1) $$Q_i^D \equiv Q_i^S + Q_i^M$$

where:

Q_i^D is total quantity demanded of commodity i,

Q_i^S is total quantity supplied of commodity i and,

Q_i^M is total quantity imported of commodity i.

This identity represents the exante market clearing equilibrium. The behavioral functions can be added by assuming that import, local supply and domestic prices are the same, and equal to world prices, because the Saudi Arabian economy is small compared to the world market. Substituting out the quantities with the right hand side expressions, the model becomes,

(2) $$Q^D(P,.....) = Q^S(P,.....) + Q^M(P,.....).$$

The sensitivity of quantities to price change can be established as

(3) $$\frac{dQ^D}{dp} = \frac{dQ^S}{dp} + \frac{dQ^M}{dp}.$$

Rearranging this equation we get,

(4) $$\frac{dQ^M}{dp} = \frac{dQ^D}{dp} - \frac{dQ^S}{dp}.$$

Then, multiplying equation (4) by P/Q^M the equation becomes

(5) $$\frac{dQ^M}{dp}\frac{P}{Q^M} = \frac{dQ^D}{dp}\frac{P}{Q^M} - \frac{dQ^S}{dp}\frac{P}{Q^M}.$$

Multiplying the first component on the right hand side by $\frac{Q^D}{Q^D}$ and second component by $\frac{Q^S}{Q^S}$ the equation (5) becomes

(6) $$\varepsilon_{import} = \varepsilon_{Demand} * \frac{Q^D}{Q^M} - \varepsilon_{Supply} * \frac{Q^S}{Q^M}$$

This identity shows the relation between demand, supply and imports elasticities for linear equations. (This is derived in McCalla and Josling, pp 40).

This relation can be changed to the CBS form by substituting the CBS elasticities, which equal $\frac{\beta_{ij}}{\omega_i}$, so the following identity can be obtained,

(7) $$\frac{\beta_{ij}^{m}}{w_i^m} = \frac{\beta_{ij}^{D}}{w_i^D} * \frac{Q^D}{Q^m} - \varepsilon_{Supply} * \frac{Q^s}{Q^m}.$$

Multiplying through by w_i^m , the expression becomes

(8) $$\beta_{ij}^{m} = \beta_{ij}^{D} * \frac{Q^D}{Q^m} * \frac{w_i^m}{w_i^D} - \varepsilon_{Supply} * \frac{Q^s}{Q^m} * w_i^m,$$

where:

β_{ij}^{m} is the price coefficient of commodity i, when imported.

β_{ij}^{D} is the price coefficient of commodity i, which demanded domestically.

w_{ij}^{D} is the share of commodity i demanded.

w_{ij}^{M} is the share of commodity i imported.

The equation (8) can be rearranged and displayed as

(9) $$\beta_{ij}^{m} = \beta_{ij}^{D} * B^{\bullet} - A^{\bullet}$$

where:

$$B^{\bullet} = \frac{Q^D}{Q^m} \cdot \frac{w_i^m}{w_i^D} = \frac{Q^D}{w_i^D} \cdot \frac{w_i^m}{Q^m}$$

and

$$A^{\bullet} = \varepsilon_{Supply} * \frac{Q^s}{Q^m} * w_i^m.$$

Substituting equation (9) into the CBS import demand model, we can estimate the domestic demand coefficients using the import data as

(10) $$w_{it}^{m}(\Delta \ln q_{it} - \Delta \ln Q) = \beta_i \Delta \ln Q + \sum_j (\beta_{ij}^{D} * B^{\bullet} - A^{\bullet}) \Delta \ln p_j$$

Rearranging equation (10), the following model can be defined as

(11) $$w_{it}^{m}(\Delta \ln q_{it} - \Delta \ln Q) + \sum_j A^{\bullet} \Delta \ln p_j = \beta_i \Delta \ln Q + \sum_j \beta_{ij}^{D} (B^{\bullet} \Delta \ln p_j),$$

which shows that the local demand coefficients (β_{ij}^{D}) are estimated using import data. This is a restricted estimation of the CBS that allows for calculation of local demand elasticities given assumed local supply elasticities. (In fact, any functions that are linear in the variables can be combined and analyzed with this structure. For example, a CBS domestic demand function, and a log-log supply function could be accommodated

A Framework to Analyze Import and Domestic Responses to Policy Change

Following Piggott, Piggott and Wright (1995) (PPW), the import response to a policy change can be established from the market clearing identity. (In this section, the PPW approach is revised to reflect commodities that are imported rather than exported)

(12) $$Q^M = Q^D - Q^S$$

Assuming a two-commodity case and a supply function in commodity prices, water price, and other inputs, the identity can be redefined using CBS functional forms as:

(13) Demand: $$\ln q_i^D = \frac{\beta_i}{w_i}\ln Q + \ln Q + \frac{\pi_{i1}}{w_i}\ln p_{i1} + \frac{\pi_{i2}}{w_i}\ln p_{i2}$$

(This result was developed by PPW for linear models, while we are able to show that it also works for the CBS model and other functional forms that are linear in their variables. This is another extension of the PPW approach in this research).

(14) Supply: $$\ln q_i^S = \frac{\beta_{i1}}{w_i}\ln p_{i1} + \frac{\beta_{i2}}{w_i}\ln p_{i2} + \frac{\beta_{iw}}{w_i}\ln p_{water} + \frac{\beta_{iw}}{w_i}\ln p_{input}$$

(15) Import: $$\ln q_i^M = \frac{\beta_i}{w_i}\ln Q + \frac{\pi_{i1}}{w_i}\ln p_{i1} + \frac{\pi_{i2}}{w_i}\ln p_{i2}$$

Total differentiation of equations (13) through (15) and conversion to elasticities yields

(16) $$dq_i^D = \varepsilon^{Exp}\cdot\frac{dQ}{Q}\cdot q_i^D + \varepsilon_{i1}^D\cdot\frac{dp_1}{p_1}\cdot q_i^D + \varepsilon_{i2}^D\cdot\frac{dp_2}{p_2}\cdot q_i^D$$

(17) $$dq_i^S = \varepsilon_{i1}^S\cdot\frac{dp_1}{p_1}\cdot q_i^S + \varepsilon_{i2}^S\cdot\frac{dp_2}{p_2}\cdot q_i^S + \varepsilon_i^{Water}\cdot\frac{dpw}{pw}\cdot q_i^S + \varepsilon_i^{input}\cdot\frac{dp_{input}}{p_{input}}\cdot q_i^S$$

(18) $$dq_i^m = \varepsilon^{Exp}\cdot\frac{dQ}{Q}\cdot q_i^m + \varepsilon_{i1}^m\cdot\frac{dp_1}{p_1}\cdot q_i^m + \varepsilon_{i2}^m\cdot\frac{dp_2}{p_2}\cdot q_i^m$$

substituting the equations (16) through (18) in the market clearance condition (identity) yields,

(19) $$\begin{aligned} dq_i^m &= \varepsilon^{Exp}\cdot\frac{dQ}{Q}\cdot q_i^D + \varepsilon_{i1}^D\cdot\frac{dp_1}{p_1}\cdot q_i^D + \varepsilon_{i2}^D\cdot\frac{dp_2}{p_2}\cdot q_i^D \\ &- \{\varepsilon_{i1}^S\cdot\frac{dp_1}{p_1}\cdot q_i^S + \varepsilon_{i2}^S\cdot\frac{dp_2}{p_2}\cdot q_i^S + \varepsilon_i^{Water}\cdot\frac{dpw}{pw}\cdot q_i^S + \varepsilon_i^{input}\cdot\frac{dp_{input}}{p_{input}}\cdot q_i^S\}, \end{aligned}$$

Multiplying through by q_i^m yields

(20) $$\begin{aligned} Eq_i^m &= \varepsilon^{Exp}\cdot EQ\cdot\rho_i + \varepsilon_{i1}^D\cdot Ep_1\cdot\rho_i + \varepsilon_{i2}^D\cdot Ep_2\cdot\rho_i \\ &- \{\varepsilon_{i1}^S\cdot Ep_1\cdot(\rho_i+1) + \varepsilon_{i2}^S\cdot Ep_1\cdot(\rho_i+1) + \varepsilon_{iwa}^S Ep_{wa}\cdot(\rho_i+1) + \varepsilon_{iIn}^S Ep_{In}\cdot(\rho_i+1)\}, \end{aligned}$$

where $E(.)$ is the proportional change [defined, for any variable x as $(x_1-x_0)/x_0$ with subscripts 0 and 1 denoting old and new value, respectively]; ρ_i= proportion of commodity i, equals quantity demanded divided by quantity imported.

This equation can be written in matrix form as

$$
\begin{aligned}
Eq_i^m = & [(\varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S \cdot (\rho_i + 1)) \quad (\varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S \cdot (\rho_i + 1))] \cdot \begin{bmatrix} Ep_1 \\ Ep_2 \end{bmatrix} \\
& + \left[(\varepsilon^{Exp}) \cdot \rho_i \quad - \varepsilon_{water}^S \cdot (\rho_i + 1) - \varepsilon_{iIn}^S \cdot (\rho_i + 1) \right] \cdot \begin{bmatrix} EQ \\ Ep_W \\ Ep_{In} \end{bmatrix}.
\end{aligned} \tag{21}
$$

which can be illustrated for the Saudi Arabia import model by

$$
\begin{pmatrix} Eq_1^m \\ Eq_2^m \\ Eq_3^m \\ Eq_4^m \\ Eq_5^m \\ Eq_6^m \\ Eq_7^m \\ Eq_8^m \end{pmatrix} = \begin{pmatrix} \varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S (\rho_i + 1) & \cdots & \varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S (\rho_i + 1) \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ \varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S (\rho_i + 1) & \cdots & \varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S (\rho_i + 1) \end{pmatrix} \cdot \begin{pmatrix} Ep_1 \\ Ep_2 \\ Ep_3 \\ Ep_4 \\ Ep_5 \\ Ep_6 \\ Ep_7 \\ Ep_8 \end{pmatrix} + \begin{pmatrix} (\varepsilon_1^{Exp}) \cdot \rho_1 & -\varepsilon_W^S (\rho_1 + 1) & -\varepsilon_{In}^S (\rho_1 + 1) \\ (\varepsilon_2^{Exp}) \cdot \rho_2 & -\varepsilon_W^S (\rho_2 + 1) & -\varepsilon_{In}^S (\rho_1 + 1) \\ (\varepsilon_3^{Exp}) \cdot \rho_3 & -\varepsilon_W^S (\rho_3 + 1) & -\varepsilon_{In}^S (\rho_1 + 1) \\ (\varepsilon_4^{Exp}) \cdot \rho_4 & -\varepsilon_W^S (\rho_4 + 1) & -\varepsilon_{In}^S (\rho_1 + 1) \\ (\varepsilon_5^{Exp}) \cdot \rho_5 & -\varepsilon_W^S (\rho_5 + 1) & -\varepsilon_{In}^S (\rho_1 + 1) \\ (\varepsilon_6^{Exp}) \cdot \rho_6 & -\varepsilon_W^S (\rho_6 + 1) & -\varepsilon_{In}^S (\rho_1 + 1) \\ (\varepsilon_7^{Exp}) \cdot \rho_7 & -\varepsilon_W^S (\rho_7 + 1) & -\varepsilon_{In}^S (\rho_1 + 1) \\ (\varepsilon_8^{Exp}) \cdot \rho_8 & -\varepsilon_W^S (\rho_8 + 1) & -\varepsilon_{In}^S (\rho_1 + 1) \end{pmatrix} \cdot \begin{pmatrix} EQ \\ Ep_W \\ Ep_{In} \end{pmatrix} \tag{22}
$$

In contrast to the PPW approach, where prices are endogenous, this system will analyze the effects on quantities imported, produced and demanded due to changing world prices that are assumed to be exogenous. Additionally, the analysis can decompose the changes in imports to determine variations in the domestic supply and demand responses. Thus, these simulations can be used to show the effect of change in local or international policy on quantities imported, demanded domestically and supplied domestically. When prices are exogenous, equations (21) and (22) can be used directly. In PPW, which assumes endogenous prices, a proportional change in an exogenous shifter leads to price responses in the first equation, and then those price effects cause impacts on quantities in a second equation.

Also, in PPW, there is just one price across all markets, and no policy influences are included. However, producers' prices in supply equations could be constructed as a summation of local prices and subsidies, while consumer prices in demand equations might be a summation of local prices and specific import tariffs. Other tariffs might affect both local supply and demand.

If we assume a linear function, this can be shown as the following:

(23) Import: $$Q_1^m = \beta_1 + \beta_2 p_1^m + \beta_3 p_2^m + \beta_4 z^m$$

(24) Demand: $$Q_1^d = \beta_5 + \beta_6 p_1^d + \beta_7 p_2^d + \beta_8 z^d$$

(25) Supply: $Q_1^S = \beta_8 + \beta_9 p_1^S + \beta_{10} p_2^S + \beta_{11} z^S$

These equations show the import, demand and supply functions with the differing prices and appropriate shifters. In the case of the demand function, the prices might include some tariffs and subsidies, so they could be represented as $p_1^d = p^m + TD$, where TD is a shifter, a tariff for example. Supply effects could be shown in the same way, where $p_1^s = p^m + TS$, and TS is a shifter, such as subsidies. Substituting these prices into the previous equations it becomes:

(26) Import: $Q_1^m = \beta_1 + \beta_2 p_1^m + \beta_3 p_2^m + \beta_4 z^m$

(27) Demand: $Q_1^d = \beta_5 + \beta_6 (p_1^m + TD) + \beta_7 p_2^d + \beta_8 z^d$

(28) Supply: $Q_1^S = \beta_9 + \beta_{10} (p_1^m + TS) + \beta_{11} p_2^S + \beta_{12} z^S$

The effects of tariffs and subsidies appear now in these equations as just other shifters. Because they only affect one equation, they need to be separated, rather than implemented by just shifting the price proportionally, which would induce both a supply and demand response. If an import tariff were to affect all local prices, the change could easily be simulated by making an assumed proportional change on prices (E_P) in equation (22) above. Moreover, if a tariff is assumed to be a percentage of the import price, the local demand price can be written as $p_1^d = p^m (1+T)$, where T is the percentage imposed. This can be written as $p_1^d = p^m + Tp^m$, so the change in the domestic demand price can be simulated through altering the elasticity.

Simulation Analysis

In this section, simulations looking at three issues for the Saudi Arabian agricultural economy are considered. First, changes are expected to occur in world prices because of WTO trade liberalization, which will affect the pattern of imports, local demand and exports in the economy. Also, input prices, especially water prices, will be rising due to increasing scarcity, which should affect domestic production and imports of different products. Finally, the traditional shifter examined in import demand models has been expenditure change, which will be the third simulation examined. In addition to the three issues to be examined, there will be several different scenarios reviewed for each simulation. As described in the previous section, three variations of simulations will be considered, which differ by the matrices of supply elasticities used to restrict the model to create local demand elasticities.

Changes in World Prices due to WTO Trade Liberalization

The WTO is expected to create changes in relative world prices for agricultural products because of progress made in the Uruguay Round and continued emphasis in the new Doha Round. A study done by Diao, Somwaru, and Roe projected that removing trade barriers, subsidies and other trade-distorting forms of support would increase world prices. This increase was expected to be 18 percent for wheat, 10 percent for rice, 15 percent for other grains, 8 percent for vegetables and fruits, 11 percent for oils and fats, 14 percent for sugar, 6 percent for other crops, 22 percent for livestock and 8 percent for processed food. By inspecting these relative price changes, it would appear that there is an increased incentive for production of grains and livestock, and simultaneously, a disincentive for local demand to expand due to higher prices. Thus, there are some incentives that will create greater pressures on water use in Saudi Arabia, such as better world prices for grain products, but there may be greater incentives to move towards livestock production and away from water-using grain production. The other products being imported into Saudi Arabia, such as oils and sugar, are expected to see smaller increases, so that they may in fact see larger imports from smaller relative price increases and significant substitution elasticities with products having higher increases.

To recognize the effect of these price changes on Saudi agricultural imports, local demand and local production, the expected change in exogenous world prices has been tested under the six scenarios, which are based on three different supply elasticities, and with and without imposing theoretical restrictions. Using the policy simulation framework (equation (22)), the expected changes projected by Diao, Somwaru, and Roe, are put in as proportional changes in prices. In addition, no change in local supply is assumed to occur because there are no policies directed at local production that change in this simulation, nor are there changes in expenditure levels. Thus, any changes in the pattern of local demand and supply come from changes in the exogenous world prices.

Change in Demand, Supply and Imports

The WTO trade liberalization, by changing world prices and thus the prices seen by all participants in the agricultural sector in Saudi Arabia, will have effects on quantities demanded, supplied and imported. As different scenarios were used to estimate local demand elasticities, each scenario has a different effect depending on the assumed supply elasticity and whether demand restrictions are imposed or not. Based on the results obtained in the previous section, scenario 2, which shows better consistency with economic theory as most groups show negative own price elasticities, is chosen as the one that gives the most reasonable estimation of local demand elasticities.

Scenario 2 Simulation Results

Figures 1 and 2 show the results obtained from scenario 2 without imposing restrictions on demand and then in the presence of symmetry and homogeneity restrictions. In general, based on economic theory, the quantities imported are expected to decline as a response to price increases because an import demand model was estimated. Thus with most prices rising, reduced imports should be expected. However, there are extensive cross price effects, and also significant changes in the relative prices assumed, so some products may actually see increased imports given the variations assumed in these simulations. In addition, changes in quantities imported will vary among groups

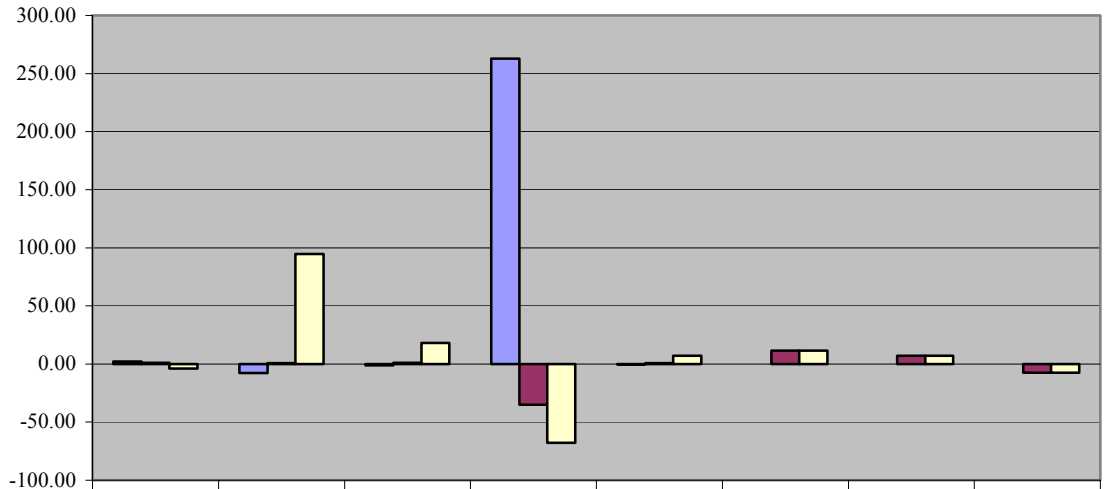
depending on the percentage change in groups' prices, local supply elasticities, local demand elasticities and the share of quantities imported in local demand.

For imported groups with some domestic supply (the first five groups), the quantities imported show different responses depending on whether restrictions are imposed or not. The results obtained without imposing restrictions, figure 6-1, show that the quantities imported of milk and dairy, vegetables and fruit, and maize and wheat will increase, which is inconsistent with expectations. These results are related to incorrect local demand own price elasticity for milk and dairy, along with significant and high cross price effects for other two product groups. The quantity imported of live animals and feed grains are consistent with expectations and decline as their world prices increase. These products are expected to experience some of the largest world price increases, so on a relative basis, they see the highest price increases.

When restrictions are imposed, figures 2, the quantities imported show completely different and more logical results. The quantities imported show a negative response from import price increases in three groups: animals; milk and dairy; and vegetables and fruit. Vegetables and fruit imply the highest decrease in quantity imported because it has the highest local demand elasticity and several significant cross price coefficients. Feed grains, and maize and wheat, show small increases in quantity imported, mostly due to their use as inputs in livestock production, whose local supply grew significantly as prices increased.

For the groups with no domestic supply and, thus, where domestic demand is supported entirely by imports (the last three groups), the results show similar effects for fats and oils, and sugar regardless of whether restrictions are imposed or not. The changes in quantities imported of these two products and sugar are inconsistent with expectations, as quantities imported increase. The change in these groups' prices is relatively low, as the world prices of other commodities are expected to grow more, and there are significant cross price effects with other groups, so a shift of imports towards fats and oils and sugars occurred. The quantity imported of beverages declines, which is consistent with expectations, and this decline is smaller when restrictions are imposed. The lack of significant cross price effects in beverages may be causing the negative impact in this group.

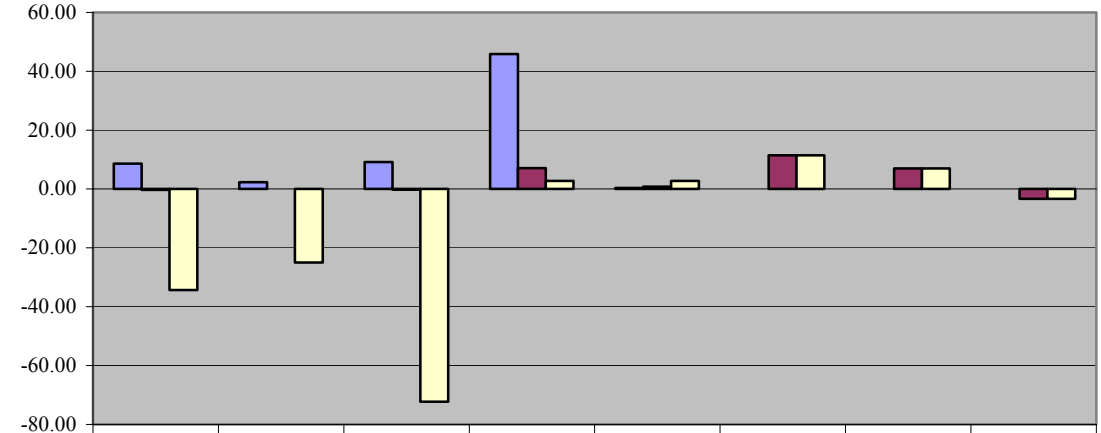
This change in quantity imported implies variations in local demand and local supply. The reactions in percentage terms are related to the proportion of domestic supply versus imports in domestic demand. For example, feed grains show the greatest decrease in domestic quantity demanded because of its high imported share (90 percent), while the quantity demanded locally of milk and dairy shows the lowest response to a change in imports due to its low import share (8 percent) in local demand. In fact, the percentage responses of quantity supplied in the first five groups is correlated directly with their shares in local demand. The quantity supplied of milk and dairy shows the lowest increase because local supply is the greatest proportion of domestic demand, while feed grains show the highest positive response because it holds the lowest share in local demand. For the last three groups, which do not have any domestic supply, the change in quantities imported is identical to the change in quantities demanded locally. That is, domestic quantity demanded is equal to 100 percent of imports, so the percentage change in imports is the same as the percentage change in domestic demand.



	LA	M&D	V&F	FG	M&W	Oils	SU	Bev
% QS	2.24	-7.80	-1.26	262.73	-0.36	0.00	0.00	0.00
%QD	0.94	0.82	0.96	-35.05	0.85	11.50	7.00	-7.40
%QM	-4.00	94.70	18.00	-67.80	7.20	11.50	7.00	-7.40

Figure 1: Percent Change in the Proportion of Quantity Imported, Demanded and Supplied Without Imposing Demand Restriction (Scenario 2)

Where: LA= Live and Frozen Animals. M &D= Milk & dairy. V &F= vegetables & fruits. FG= Feed grains. M &W= Maize, corn, rice & wheat. Oils= Oils and fats. Su= Sugar, And Bev = Beverages.



	LA	M&D	V&F	FG	M&W	Oils	SU	Bev
% QS	8.59	2.26	9.13	45.91	0.36	0.00	0.00	0.00
%QD	-0.37	-0.03	-0.24	7.04	0.74	11.46	6.96	-3.41
%QM	-34.36	-25.01	-72.29	2.76	2.72	11.46	6.96	-3.41

Figure 2: Percent Change in the Proportion of Quantity Imported, Demanded and Supplied With Imposing Demand Restriction (Scenario 2)

Changes in Input Prices

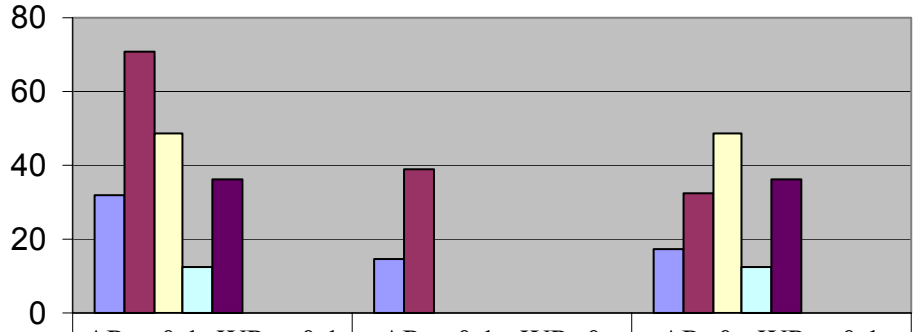
The WTO negotiations are expected to affect the Saudi Arabian agricultural economy in different ways, with a reduction of local support and reduced import subsidies being some of the expected effects. Moreover, the lack of natural water resources, combined with a limited amount of groundwater (where the estimated usable water resource is predicted to last for a maximum of 20 to 25 years) and increased water demand over time, will almost surely lead to changes in local water prices. As a result, these international and domestic issues are expected to lead policymakers to change domestic policy directed at the agricultural sector.

To forecast the expected effect of these changes, different possible scenarios have been tested. The two issues examined here are a change in water price as a result of the domestic concern about water resource availability, and a reduction of an input subsidy paid for imported live animals if Saudi Arabia would join the WTO. These simulations are quite different from those done before, in that they initially affect domestic supply, which then causes effects on import demand. Most analyses based on import demand matrices would not be able to implement this range of simulations.

Using the policy simulation framework (equation (22)) and input supply elasticities, which come from a California study on agricultural water (assuming these elasticities are appropriate for a developing country situation), multiple simulations were conducted. Different scenarios of changes in water prices and live animal prices were done in combination. Also, world prices are assumed not to change because they are exogenous, and there is no change in expenditure either because domestic demand is not affected. To capture and compare possible changes, three simulations were done. First, a change in both local (increased water prices) and international policies (reduced subsidies on imported live animals) is simulated, assuming they work at the same time. Secondly, a change in the import subsidy is made alone to show an international policy effect and a change in water price is made singly to portray the local policy impact.

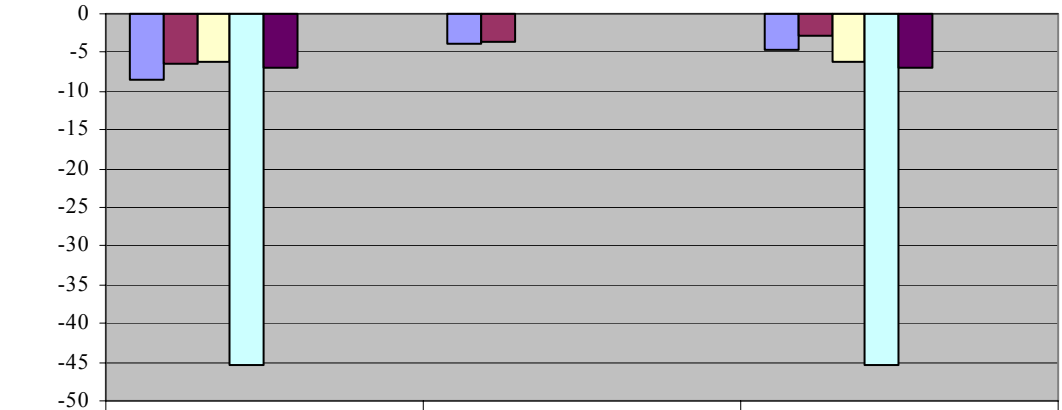
Domestic and International Policy Effect Together. In this case, an increasing water price of 10 percent and a reduction of an input subsidy on imported live animals that increases those prices by 10 percent are simulated together. The first column in figure 3 shows the expected effect on quantities imported from each group. The quantities imported from the first two groups, live animals, and milk and dairy, are expected to increase by 32 and 71 percent respectively. Vegetables and fruit, feed grains, and maize and wheat quantities imported are expected to increase by 48, 13, and 36 percentage points, respectively. The last three groups will not affected by these changes, as they are not produced locally and are not affected by input price effects. This change in imports is directly and solely related to the decline in domestic supply, which is displayed in the first column of figure 6-4. The quantity supplied of live animals, and milk and dairy, will decline by 8.4 and 6.5 percent respectively, while quantity supplied of vegetables and fruit, feed grains, and maize and wheat will decline by 6.3, 45.5 and 6.9 percent, respectively.

Because each group has different input price elasticity, assumed to be -0.3 for live animals, -0.25 for milk and dairy, and –0.5 for vegetable and fruits, feed grains, and maize and wheat, these effects vary among groups. Groups with higher input price elasticities should experience more change than other groups.



	AP=+0.1 ;WP=+0.1	AP=+0.1 ;WP=0	AP=0 ;WP=+0.1
LA	32	14	17
M&D	71	39	32
V& F	48	0	48
FG	13	0	13
M&W	36	0	36

Figure 3: Percent Increase in the Proportion of Quantity Imported Due to Increase in Water and Live Animal Prices. (AP: Animal Prices, WP: Water Prices)



	AP=+0.1 ;WP=+0.1	AP=+0.1 ;WP=0	AP=0 ;WP=+0.1
LA	-8.4	-3.8	-4.6
M&D	-6.5	-3.6	-3.0
V& F	-6.3	0.0	-6.3
FG	-45.5	0.0	-45.5
M&W	-6.9	0.0	-6.9
Oils	0.0	0.0	0.0
Su	0.0	0.0	0.0
[illegible]	0.0	0.0	0.0

Figure 4: Percent Decrease in the Proportion of Quantity Supplied Due to Increase in Water and Live Animal Prices

As long as the local supply share of domestic local demand is low, the supply response will be higher and import response will be less. For example, the share of local supply in feed grains demand is about 10 percent and the supply response from the price change is a very high 45 percent, in effect replacing the import contribution to local demand. The import response is only 13 percent because the imported proportion is nearly 90 percent, so the high growth in local supply only moderately affects the import position.

International Policy Effect (lower subsidies on imported animals). A reduction of the input subsidy assumes an increase in the imported live animal price by 10 percent. The second column in figure 3 shows the expected effect on quantities imported for each group. The quantity imported of live animals and milk and dairy are expected to increase by 14 and 39 percent respectively. Other groups will not be affected because live animals are used as inputs only in the first two groups. This increase in imports comes from a decline in local supply, which is displayed in the second column of figure 6-4. Quantities supplied from live animals, and milk and dairy, are shown to decline by 3.8 and 3.6 percent respectively. This decline is less than the previous one because there is no water policy effect. The live animals experience a smaller decline than milk and dairy as a result of a difference in input price elasticities, which were assumed to be -0.25 for live animals and –0.3 for milk and dairy.

Domestic Policy Effect (rising water prices). Increasing water price by 10 percent is used to show the effect of local policy change on local supply and imports. The

third column in figure 3 shows the expected effect on quantity imported for each group. The quantities imported of live animals, and milk and dairy, are expected to increase by 17 and 32 percent respectively. Vegetables and fruit, feed grains, and maize and wheat quantities imported are expected to increase by 48, 13, and 36 percentages respectively. The last three groups will not affected by these changes, as they are not produced locally. This increase in imports comes from the decline in local supply, which is displayed in the third column of figure 6-6. Quantities supplied of live animals, and milk and dairy, will decline by 4.6 and 3.0 percent respectively, while the quantities supplied of vegetables and fruit, feed grains, and maize and wheat will decline by 6.3, 45.5 and 6.9 percent, respectively. The difference in response between groups is associated with differences in input price elasticities. Groups with higher price elasticities experience more change than the others. Within each group, the response of imports to changes in local supply depends on import share in local demand. As long as the imported group has a high share the corresponding response will be less and visa versa. Also, it is clear that there is nearly a linear

Several policy implications are implicit in the simulations shown here. There may, in fact, be some positive aspects to the subsidy for live animals. Importing animals and feeding them locally may add value for local producers, especially as the availability of these inputs permits expansion of livestock feeding and processing industries. It is also critical that water be conserved, and agricultural policy should probably facilitate a conversion to animal production, as its water consumption may be lower than for crops. However, this is only a suggestion for research, and it needs a comprehensive study, in which simulations of all agricultural products and livestock processors operations are examined along with their water requirements to draw a conclusive policy. Conversely, water consumption could be reduced through raising water prices to save the local water resource for a longer period. However, given the modest decline in output seen with a ten percent increase in the water price, it may require such a large price effect to control water use in agriculture that outright quotas might be better.

Changes in Expenditure

Expenditures on imports are likely to increase over time. Tastes and preferences are changing because of higher education levels and, in addition, there is increased advertising for foreign goods. The unavailability of different products that are locally produced, due to the lack of a processing sector and adequate products are other factors that may affect expenditure on imports. To understand possible effects of this change, total expenditure on imports is assumed to increase by 10 percent. This expected change has been tested under the six scenarios described earlier, which are based on three different supply elasticities in combination with imposition of theoretical restrictions or not. In addition, this change in import demand is assumed to result from expected changes in expenditures alone, with no change in policy or input prices being assumed. Furthermore, it is assumed that world prices stay constant because Saudi Arabia is a small player in world demand for these products.

Using the policy simulation framework (equation (22)) and assuming no change in world or input prices, different simulations were conducted. The results are presented in figure 5. The effect of expenditure changes on quantities imported will be reflected

directly in local demand, as local supply and world prices stay unchanged. The rows in figure 5 show import groups while columns show the six implied scenarios.

As expected, the effect of increased expenditure is to increase the quantity imported from each group. However, this increase differs among groups depending on their expenditure elasticities, which vary based on the supply elasticity assumed, whether restrictions are imposed or not, and the proportion of quantity imported as a proportion of domestic quantity demanded.

The results obtained show that imposing restrictions on the estimation reduces the proportion of quantities imported for the five groups that are also produced locally, except vegetables and fruits. In contrast, imposing restrictions induces an increase in quantities imported for groups that have no local supply and are thus completely imported. Scenarios 1 and 2 show similar results, while scenario 3 shows a greater fluctuation, presumably based on effects of supply elasticity assumed.

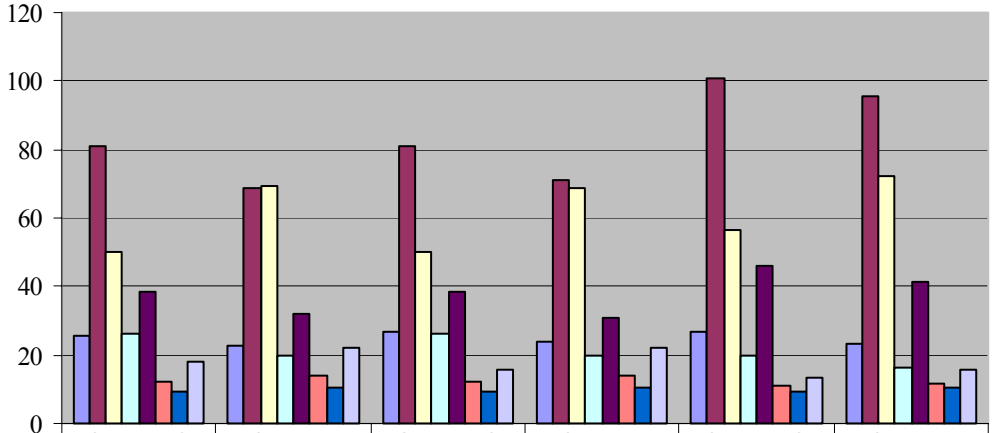
As noted in the earlier simulations, scenario 2 is chosen to evaluate in more detail because the local demand elasticities estimated using this scenario show more consistency with economic theory, as all groups have a negative own price elasticity. Scenario 2 results without restrictions in figure 6-5 show the proportional change in quantities imported as a response to expenditure change. The milk and dairy group shows the highest response, with an increase of 81 percent in imports, while sugar shows the lowest response, with a growth of nine percent in imports. Overall, as expenditure increases, the demand for imported goods will increase for all groups but the percentage increase for groups that are not totally imported, the first five groups, will be higher than for totally imported goods, the last three groups.

These results are simply because the proportion of imports in domestic disappearance varies among the groups. For milk and dairy, with over 90 percent being locally supplied, a seven percent change in domestic demand from the expenditure change leads to the 81 percent increase, in imports, while sugar, which has no domestic supply, sees a 18 percent increase in imports to match the 18 percent increase in domestic demand.

Thus the changes in domestic demand, which are shown in figure 6 give a better perceptive on the agricultural system reacts to increased expenditures. These changes are generally modest, with less than 10 percent increases in domestic demand for all but three commodities, regardless of whether they have local supply or not, and regardless of whether restrictions are imported or not. In this table, the differences in domestic demand responses depend only on expenditure elasticities; the high expenditure elasticities in fats and oils, beverages and especially feed grains result in more growth of domestic demand for the other products. Because there is no exogenous price change in the world markets, there is no change in supply, and all variation shown here arises from changes in domestic demand induced by the expenditure shift, which is then translated into changes in imports.

In viewing these results, it must be kept in mind that, to get a ten percent increase in expenditures in these food groups, it would take a thirty percent increase in income because of the two stage budgeting procedure used in this analysis. Assuming an elasticity such as 0.333 for all food), and assuming it is based on real per capita income changes, then it may well be a long time before these increases arise due to growth in income, as real per capita income has been stagnating for a decade. Thus population

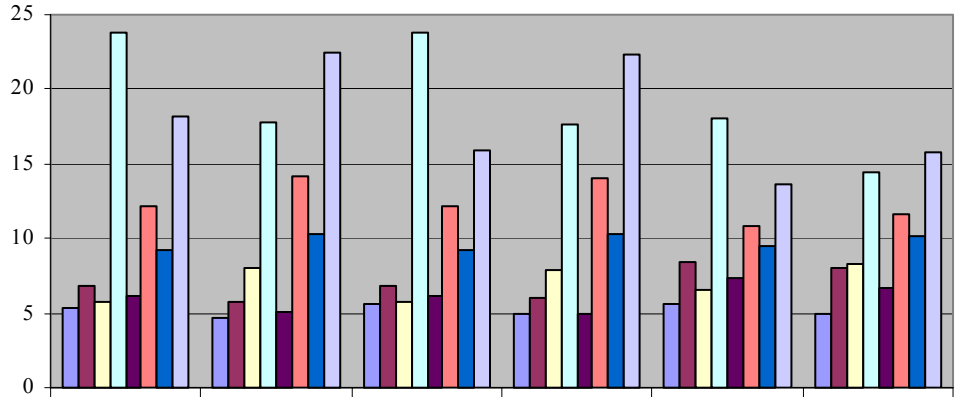
growth, for which there will be a direct increase in food consumption for each mouth added, will be a much larger factor in future import and domestic demand for food.



	SEN1-W/O	SEN1-W	SEN2-W/O	SEN2-W	SEN3-W/O	SEN3-W
LA	26	23	27	24	27	24
M&D	81	68	81	71	101	95
V&F	50	69	50	69	57	73
FG	26	20	26	20	20	16
M&Wt	38	32	38	31	46	41
Oils	12	14	12	14	11	12
Su	9	10	9	10	9	10
Bev	18	22	16	22	14	16

Figure 5: Percent Change in the Proportion of Quantity Imported for All Groups' Results from the Effect of Expenditure Change Under All Possible

Scenarios



	SEN1 - W/O	SEN1 - W	SEN2 - W/O	SEN2 - W	SEN3 - W/O	SEN3 - W
LA	5	5	6	5	6	5
M&D	7	6	7	6	8	8
V&F	6	8	6	8	7	8
FG	24	18	24	18	18	14
M&Wt	6	5	6	5	7	7
Oils	12	14	12	14	11	12
Su	9	10	9	10	9	10

Figure 6: Percent Change in the Proportion of Quantity Demanded for All Groups' Results from the Effect of a Ten Percent Increase in Expenditure

Summary and conclusion

In order to link domestic and international effects across a wide variety of alternatives, a policy analysis framework was developed. A simulation model, adapting and extending a structure given in an article by Piggott, Piggott and Wright (1995), was constructed. Three different issues in the Saudi Arabian agricultural economy were then considered in this analysis. First, changes are expected to occur in world prices because of WTO trade liberalization, which will affect the pattern of imports, local demand and local supply in the economy. Also, input prices, especially the possibility of rising water prices due to increasing scarcity, should affect domestic production and imports of different products. Finally, the traditional shifter examined with import demand models has been expenditure change, which is the third simulation examined in this analysis.

The first simulation shows the effect of changing world prices due to WTO impacts. A study done by Diao, Somwaru, and Roe projected that removing trade barriers, subsidies and other trade-distorting forms of support would increase world prices, but that relative prices would also change for certain products. It appears that there is an increased incentive for production of grains and livestock because of higher prices, but these same higher prices will reduce local demand. Thus, there are some incentives that will create greater pressures on water use in Saudi Arabia, such as better world prices for grain products, but there may be greater incentives to move towards livestock

production and away from water-using grain production. The other products imported into Saudi Arabia, such as oils and sugar, are expected to have smaller price increases; indeed, they may see increased imports, partly from these relatively smaller price increases and partly from the existence of significant substitution elasticities with products having larger price gains.

The last point above shows that are even though all prices are expected to go up, it is possible that some commodities will see greater imports because of cross price effects and lower relative prices after the WTO alters world prices. For example, quantities imported of feed grains, wheat and maize, oils, and sugar increase by 2.8, 2.7, 11.5 and 7 percent, respectively in the first simulation. Also, without imposing theoretical restrictions, several incorrect signs appear, and very large and, perhaps, incorrect cross price effects, represent surprising results. The imposition of the restrictions creates results that are more consistent. For example, milk and dairy, and vegetables and fruit, show increasing quantities imported without imposing restrictions, while their responses are negative with restrictions imposed. Moreover, local production naturally grows with these price increases, and the relative percentage responses depend on the proportion of domestic supply in local demand. For example, if this share is low, as in feed grains (10 percent) the production response will be proportionally high (46 percent).

The second set of simulations was done to look at impacts on domestic supply. To realize the expected total effect of the WTO on the Saudi agricultural sector, assuming Saudi Arabia joins the organization, a reduction of local support and reduced import subsidies are analyzed. Additionally, the increasing domestic concern about water resources suggests that some changes in the agricultural incentives could occur. The two issues examined in these areas were a change in water price and the reduction of an input subsidy paid for imported live animals. These simulations are quite different from those done before, in that they initially affect domestic supply, which then causes effects on import demand.

Multiple simulations were made using varying combinations of changes in water and live animal prices. With a reduction in subsidies on live animal imports, only live animals, and milk and dairy are affected, as the subsidy is directed at these two groups, while all products produced locally are affected by water price changes. Combining the two policy changes in one simulation just gives a sum of the two effects, implying that the effects are additive. This arises mainly because of the assumption that world prices are exogenous, so shifts in supply only change quantities and not prices. Without price changes, there are no spillover effects to other products. With endogenous prices, either of these policies would have impacts on all other products through cross prices effects. This alternative assumption will be used in later research.

Several policy implications are implicit in the second set of simulations. There may in fact be some positive aspects to the subsidy for live animals. Importing animals and feeding them locally may add value to local producers, especially as the availability of these inputs permits expansion of the livestock feeding and processing industries. It is also critical that water be conserved, and agricultural policy should promote a conversion to animal production, as its water consumption is probably lower than for crops. Moreover, there may be some enduring transportation advantages to importing feed grains and feeding livestock locally. However, this is only a suggestion for future research, and suggests need for a comprehensive study. Also, increasing water prices

could reduce water consumption. However, given the modest decline in output seen with a ten percent increase in water price, it may require such a large price effect to control water use in agriculture that outright water quotas might be better.

Thirdly, to understand the possible effect of increased expenditures on imported goods from factors affecting demand, such as changes in tastes and preferences or increased advertising for foreign goods, six scenarios were analyzed. The effects differ between groups depending on expenditure elasticities and a group's import share in local demand. Groups with low expenditure elasticities and low import shares in local demand, such as milk and dairy, experience a greater percentage response than those that have higher expenditure elasticities and higher import shares, like feed grains. For those groups that are completely imported, the import response depends directly on the expenditure elasticities. Again, these impacts could be much wider with endogenous prices, as changes in expenditures in any of the products raises prices, which would then affect all other commodities depending on their elasticities.

Comparing the three simulations, some additional perspectives can be seen. In the first simulation, relative price changes from the WTO may in fact save water due to a greater growth in animal agriculture. However, the anticipated reduction in live animal import subsidies (also related to the WTO) may offset some of the incentives for greater production of livestock products. So the movement to livestock activities may be slowed down some due to input price effects from WTO, and some of the water conservation indicated in the first result may not occur. However, the separate analysis of increased water prices might make livestock products more attractive relative to crop production. he second simulation shows some evidence in this direction, as the reduction in feed grains was 46 percent compared with 8 percent for animal products. These trends may be even clearer with endogenous prices.

The WTO simulation is also related to the expenditure simulation in that they show two effects that would influence the cost of imports. It turns out that the products likely to have the greatest increase in world prices from WTO effects, shown in the first simulation, are the same products that will have the greatest expenditure responses from added purchases of food imports. Thus, the cost of agricultural imports could be rising more than expected from the convergence of these two effects. However, higher world prices may well reduce some of the expenditure response in the third simulation, so those products with the highest expenditure elasticities may not be the ones with the greatest import response.

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