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| العنوان:          | COMPLETE AGGREGATED DEMAND ELASTICITIES FOR ECONOMIC SECTORS<br>IN SAUDI ARABIA                 |
| المصدر:           | مجلة جامعة الملك سعود - العلوم الإدارية   |
| الناشر:           | جامعة الملك سعود  |
| المؤلف الرئيسي:   | Kahtani, Safer H.   |
| المجلد/العدد:     | مج 6, ع 1   |
| محكمة:            | نعم   |
| التاريخ الميلادي: | 1994  |
| الصفحات:          | 15 - 22   |
| رقم MD:           | 659562  |
| نوع المحتوى:      | بحوث ومقالات  |
| قواعد المعلومات:  | EcoLink   |
| مواضيع:           | الأنشطة الاقتصادية، القطاع الصناعي، السعودية، التنمية الاقتصادية                                |
| رابط:             | <a href="http://search.mandumah.com/Record/659562">http://search.mandumah.com/Record/659562</a> |

## **Complete Aggregated Demand Elasticities for Economic Sectors in Saudi Arabia**

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(Received 15/4/1413; Accepted for publication 23/8/ 1413 A.H.)

**Abstract.** The main purpose of this paper is to estimate a complete aggregated demand elasticities for 11 sectors in Saudi Arabia. The results of the estimated complete demand system in terms of coefficient signs and magnitudes appear consistent with demand theory. Agriculture, forestry, and fishing; other manufacturing; and finance, insurance, real estate, and business services sectors have higher impact on other economic sector activities, respectively. Crude petroleum and natural gas, other mining and construction do not directly effect other sectors in the economy from the demand side. Income elasticities of other manufacturing, transport, storage, and communication; and community social and personal services are more elastic than other economic sectors. The results of price sensitivity analysis show the interdependence of the economic sectors.

### **Introduction**

Saudi Arabia is considered a one product economy, heavily dependent upon oil. After the oil embargo in 1973, the Saudi government encouraged development of other sectors (especially the private sectors) and thus began diversifying the economy. The strategies of the current Saudi development plan are to decrease dependence on the oil sector and increase reliance on other economic forces such as private investment, personal and corporate taxation, and development of bond markets.

However, the analytical and empirical research base in Saudi Arabia is generally limited to partial equilibrium analysis thus providing policy makers with an understanding of potential impacts of selected economic changes. Analysis of individual commodity markets in isolation, however, can be misleading because of interdependence of consumption, production, and government policies. The availability of a complete demand system and a general equilibrium framework for analyzing market interdependencies would be helpful in providing information to policy makers for formulating and evaluating total economic plans and government policies. This

information not only helps match total commodity supply with demand, but it also contributes to the efficient allocation of resources and increased economic development in the various economic sectors.

A complete demand system has not been estimated for the Saudi Arabia economy nor has a policy framework been established to analyze the effects of changes in government policy upon the various economic sectors. These tools need to be developed and tested in evaluating the effects of changes in the total Saudi economy.

The purpose of this paper is to estimate a complete demand system for 11 economic sectors in Saudi Arabia. The demand system includes estimation of all direct and cross price elasticities and income elasticities of demand.

### **Materials and Methods**

The data used to estimate the parameters of the entire aggregated demand system were obtained from different sources. Income elasticities and the own-price elasticity for agriculture, forestry, and fishing were obtained from Al-Ali and Jammal [1] and the expenditure weights were obtained from the 1981 Saudi Arabia National Accounts [2] as presented in Table 1.

The concept of Marshallian demand theory and separability of utility is used to estimate the complete demand system for Saudi Arabia. Several types of separability have been defined such as strong, weak, and Pearce separability and can be utilized for grouping of commodities [3,4].

A special case of strong separability is when the  $g$  groups of  $n$  commodities each contain only one commodity. This type of utility form is called pointwise strong separability. It implies that the marginal rate of substitution between any two commodities is independent of all other commodities. Thus, if the utility function is pointwise separable, then the utility function is directly additive or want independent [5, p. 53; 6, pp. 14-16].

It is important to specify the utility forms since the invariance of the want elasticities and the flexibility of money does not hold under the various transformations of utility [7, p.66; 8].

The complete demand system for the aggregated social accounts is estimated using the Frisch [9] model. The aggregated level is for the 11 commodity groups contained in the Saudi Arabia Social Accounting Matrix [2]. Frisch [9] assumed commodity groups want independent while assuming dependency within a commodity group. There are 11 commodity groups (sectors) and each group is considered to be only one commodity. Thus, the form of the utility function is pointwise separable which means the utility by group is directly additive [10].

Frisch [9] proposed that the demand relationships derived from utility theory could be used in computing all direct and cross price elasticities under an assumption

Table 1. Complete Aggregated Demand System for Saudi Arabia.

| Sectors  | Budget Shares | Income Elasticities | Budget Share Times Income Elasticity | Price Elasticities |   |   |          |          |          |          |          |          |          |          |
|--|---------------|---------------------|--------------------------------------|--------------------|---|---|----------|----------|----------|----------|----------|----------|----------|----------|
|  |               |                     |                                      | 1                  | 2 | 3 | 4        | 5        | 6        | 7        | 8        | 9        | 10       | 11       |
| 1. Agriculture, forestry, and fishing                      | 0.13816       | 0.75656             | 0.10578                              | -0.9000            | 0 | 0 | -0.00452 | 0.13160  | -0.00182 | 0        | -0.00289 | 0.00999  | -0.01628 | 0.01832  |
| 2. Crude petroleum and natural gas                         | 0             | 0                   | 0                                    | 0                  | 0 | 0 | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |
| 3. Other mining  | 0             | 0                   | 0                                    | 0                  | 0 | 0 | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |
| 4. Petroleum refining                                      | 0.04024       | 0.7355              | 0.02960                              | -0.01136           | 0 | 0 | -0.85760 | 0.12642  | -0.00175 | 0        | -0.00278 | 0.00960  | -0.01560 | 0.01760  |
| 5. Other manufacturing                                     | 0.54957       | 1.1316              | 0.62190                              | -0.01748           | 0 | 0 | -0.00668 | -1.11826 | -0.00269 | 0        | -0.00427 | 0.01477  | -0.02407 | 0.02708  |
| 6. Electricity, gas, and water                             | 0.010139      | 0.6648              | 0.00691                              | -0.01027           | 0 | 0 | -0.00393 | 0.11426  | -0.77276 | 0        | -0.00251 | 0.00868  | -0.01414 | 0.01591  |
| 7. Construction  | 0             | 0                   | 0                                    | 0                  | 0 | 0 | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |
| 8. Wholesale and retail trade, restaurants, and hotels     | 0.02073       | 0.7049              | 0.01461                              | -0.01089           | 0 | 0 | 0.12117  | -0.00168 | 0        | -0.82042 | 0.00920  | -0.01499 | 0.01687  |          |
| 9. Transport, storage, and communication                   | 0.03888       | 1.1514              | 0.04477                              | -0.01779           | 0 | 0 | -0.00416 | 0.19791  | -0.00274 | 0        | -0.00435 | -1.32071 | -0.02449 | 0.02756  |
| 10. Finance, insurance, real estate, and business services | 0.11670       | 0.7049              | 0.00823                              | -0.01089           | 0 | 0 | -0.00680 | 0.12117  | -0.00168 | 0        | -0.00266 | 0.00920  | -0.83275 | 0.01687  |
| 11. Community social and personal services                 | 0.08532       | 1.1038              | 0.09418                              | -0.01705           | 0 | 0 | -0.00652 | 0.18973  | -0.00262 | 0        | -0.00417 | 0.01441  | -0.02348 | -1.25410 |
| Frisch Parameter ( $\Phi$ ) -0.862                         |               |                     |                                      |                    |   |   |          |          |          |          |          |          |          |          |

Source: – Al-Ali and Jammal [1].

– Ministry of Finance and National Economy [2].

of want independence. Frisch [9] started with the utility maximization and budget constraint of the representative consumer as follows:

$$\text{maximize (q): } U(q_j) \quad (1)$$

$$\text{subject to : } \sum_{j=1, 2, \dots, n} p_j q_j \leq Y \quad (2)$$

where

$q_j$  = the quantity demanded of commodity  $j$ ,

$p_j$  = the price of commodity  $j$ , and

$Y$  = total consumer income or expenditure.

The consumer's choice of  $q_j$  will correspond to the quantities consistent with maximization of [11, pp. 115-118; 12, pp. 56-64]:

$$L(q_j, \pi) = U(q_j) - \pi(Y - p_j q_j) \quad (3)$$

Differentiating with respect to  $q_j$  and  $\pi$ , the following normal equations are:

$$u_j(q_j) - \pi p_j = 0 \quad (4)$$

$$Y - p_j q_j = 0 \quad (5)$$

where  $u_j$  is the marginal utility of commodity  $j$ , and  $\pi$  is the marginal utility of income.

Taking the total differential from first order conditions in equations (4) and (5), Frisch relationship can be obtained<sup>(1)</sup>. However, the Frisch relationship is the same as the Slutsky [13] equation derived from first order conditions of maximizing utility and expresses the price elasticities ( $e_{ij}$ ) as function of the want elasticities ( $\sigma_{ij}$ ), budget proportions ( $w_i$ ), income elasticities ( $e_{iy}$ ), and the flexibility of the marginal utility of income with respect to income ( $\Phi$ ):

$$e_{ij} = \sigma_{ij} - w_j e_{iy} - (1/\Phi) w_j e_{jy} e_{iy} \quad (6)$$

$$i, j = 1, 2, \dots, n$$

The Frisch statement for the homogeneity condition in terms of want elasticities and the money flexibility coefficient as defined in George and King [13] is:

(1) For a more complete mathematical manipulation, see Frisch [9], and George and King [13].

$$e_{iy} = \Phi \sum_j \sigma_{ij}. \quad (7)$$

Under want independence  $\sigma_{ij} = 0$  for all  $i \neq j$ , thus; the money flexibility, own price elasticity, and cross price elasticities can be derived from equations (6) and (7), respectively; as follows:

$$\Phi = e_{iy} - w_i e_{iy} / (e_{ii} + w_i e_{iy}) \quad (8)$$

$$e_{ii} = -e_{iy} w_i - (1 - w_i e_{iy} / \Phi) \quad (9)$$

and

$$e_{ij} = -e_{iy} w_j (1 + e_{iy} / \Phi) \quad (10)$$

Using the Frisch method the following information has to be known to construct an entire demand matrix:

- (1) all commodity income elasticities,
- (2) all commodity expenditure weights and must sum to unity, and
- (3) a single commodity own-price elasticity.

Having this information available, the Engel aggregation property can be imposed to estimate the demand matrix. The Frisch parameter is calculated from equation (8) and involves the income elasticity, direct elasticity, and budget share of any single commodity. However, estimation of the money flexibility from various commodity groups should provide similar values as long as the want independent assumption is valid [13]. The rest of the parameters are estimated using equations (9) and (10). The resulting estimates of the demand matrix automatically hold for Slutsky symmetry, homogeneity, and Cournot aggregation conditions [7, p. 68].

### Results and Discussion

The results of estimating the complete aggregated demand system are presented in Table 1. The estimated money flexibility coefficient ( $\Phi$ ) is  $-.862$  and is consistent with the Frisch categories [9]. All income elasticities have positive signs indicating normal goods. The positive relation means that as household income increases the consumption of that commodity increases. All own-price elasticities of demand are negative implying an inverse relationship between quantity consumed and its price. The demand parameters as presented in Table 1 satisfy the Engel aggregation, Cournot aggregation, homogeneity, and Slutsky symmetry conditions.

The budget share for crude petroleum and natural gas, other mining, and construction are zero thus implying no direct effect from income and thus sectors do not directly effect other sectors in the economy from the demand side. Agriculture, forestry, and fishing; petroleum refining; electricity, gas, and water; wholesale and

retail trade, restaurants, and hotels; and finance, insurance, real estate, and business services appear to be income inelastic sectors, while other manufacturing, transport, storage, and communication, and community social and personal services are income elastic sectors.

The quantity demanded for agriculture, forestry, and fishing sector is expected to increase (decrease) by (0.00452), 0.1316, (0.00182), (0.00289), 0.00999, (0.01628), and 0.01832 for a one percent increase in the price of petroleum refining; other manufacturing; electricity, gas, and water; wholesale and retail trade, restaurants, and hotels; transport, storage, and communication; finance, insurance, real estate, and business services; and community social and personal services sectors, respectively. On the other hand, an increase of one percent in the agriculture price sector is expected to decrease the quantity demanded for petroleum refining; other manufacturing; electricity, gas, and water; wholesale and retail trade, restaurants, and hotels; transport, storage, and communication; finance, insurance, real estate, and business services; and community social and personal services sectors by 0.0114, 0.0175, 0.0103, 0.0109, 0.0178, 0.0109, and 0.0171, respectively.

The price sensitivity analysis of agriculture, forestry, and fishing is explained to show the interdependence of this sector and the other economic sectors. The other sector interdependencies can be explained in a similar manner, which provides essential information to policy makers.

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## مرونة الطلب للقطاعات الاقتصادية في المملكة العربية السعودية

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(قُدّم للنشر في ١٥/٤/١٤١٣هـ، وقَبِل للنشر في ٢٣/٨/١٤١٣هـ)

ملخص البحث. تولي المملكة العربية السعودية تنمية القطاعات والأنشطة الاقتصادية المختلفة اهتماماً كبيراً بهدف تنوع القاعدة الاقتصادية والتقليل من الاعتماد على صادرات القطاع البترولي. وحيث إن تنمية القطاعات الاقتصادية يحتاج إلى دراسة وتحليل لأنشطتها بشكل متكامل وفي آن واحد وذلك لتداخل واعتماد علاقات هذه الأنشطة سواء من الناحية الإنتاجية أو الاستهلاكية مع بعضها البعض. ويعتبر توافر مثل هذه الدراسات من الأدوات التحليلية المهمة في تقويم الخطط الاقتصادية بشكل أكثر شمولية ودقة، علماً بأن توافر هذه المعلومات لا يساعد فقط في دراسة توازن الطلب والعرض الكلي للسلع ولكن أيضاً الإسهام في تخصيص الموارد بشكل أكثر فعالية وذلك لتطوير التنمية الاقتصادية في مختلف القطاعات الاقتصادية. لذلك فإن هذه الدراسة تهدف إلى تقدير شامل لنظام الطلب في ١١ قطاعاً اقتصادياً بالمملكة العربية السعودية ويتضمن التقدير كلاً من مرونة الطلب السعرية والدخلية لجميع القطاعات الاقتصادية. وقد أظهرت نتائج البحث باستخدام أسلوب Frisch أن قطاع الصناعة، الزراعة والغابات وصيد الأسماك، وخدمات المال والتأمين والعقارات وخدمات الأعمال على الترتيب، كان لها أكبر الأثر في القطاعات الاقتصادية الأخرى. بينما لم يكن لقطاع البترول الخام، الغاز الطبيعي، المعادن الأخرى، والتشييد والبناء أي تأثير مباشر في القطاعات الاقتصادية الأخرى. كما تشير النتائج إلى أن مرونة الدخل لكل من القطاعات الاقتصادية التالية: الصناعات الأخرى، النقل والتخزين والاتصالات، خدمات جماعية واجتماعية وشخصية أكثر مرونة من القطاعات الاقتصادية الأخرى. كما أن نتائج تحليل الحساسية للأسعار توضح مدى اعتماد العلاقات وتداخلها بين القطاعات الاقتصادية المختلفة.