THE IMPACT OF EXPATRIATE WORKERS ON THE ECONOMY OF SAUDIA ARABIA - "A COMPUTABLE GENERAL EQUILIBRIUM RESULTS"

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CHAPTER I

THE LABOR MARKET IN SAUDI ARABIA

Introduction

The dramatic increase in oil prices in 1973-74 coupled with the huge oil reserves and production potential of Saudi-Arabia generated huge revenues. Planners have attempted to transfer such revenues to diversified economic sectors capable of generating a more stable source of income. Ambitious development plans were implemented in order to reduce the country's overwhelming dependence on oil revenues as the main source of national income. Although Saudi Arabia has become free from the capital constraint, human capital resources have become a particularly acute issue that has hindered the development programs from being executed efficiently. The severe labor force shortage and accelerated economic growth have resulted in a demand for labor that is far beyond the capacity of the domestic labor market. Therefore, an enormous growth in the demand for expatriate workers has triggered a massive wave of expatriate inflow into the country. Millions of workers from neighboring labor-surplus nations, South Asia, and Western countries flock into the country to take advantage of the employment opportunities.

There are no consistent data on the number of expatriates in the country even among different government agencies. For example, according to the Third Development Plan (1980-85), expatriate workers were estimated to be 43 percent of the total labor force in 1980 with .2 percent growth rate over the plan period. Another government source reported that in 1981 expatriate workers accounted for about 70 percent of the Saudi Arabia's 2.5 million labor force (Hallwood, Spring 1987). However, both these sources do confirm that the ratio of expatriates in the labor force of Saudi Arabia is high both in absolute and in relative terms. In 1986, another source estimated the number of expatriate workers to be 2.5 million, which consists of about 63 percent of the total labor force in the country (Labor Force in the Kingdom of Saudi Arabia, 1986, p. 8).

Such a heavy utilization of imported labor has a measurable influence on various aspects of the economic life of the host country. Increasing the country's endowment of labor, given the necessary capital available, should lead to an increase in the available goods and services because more resources are available for production. On the other hand, since expatriate workers and their dependents are also consumers of these goods and services and hence, domestic consumption will increase as well.

Expatriate workers affect the labor market in several ways. The most important one is the decrease in domestic wages which results from the increased labor supply.

The increase in production capacity of the economy, which results from labor importation, leads to an increase in the export of goods and services. However, expatriate workers cause an increase in consumption and hence, imports of some goods and services will increase as well. The balance of payments is also affected by the remittances transferred by expatriates to their home countries.

Benefits and Costs

Benefits of Expatriate Labor

It goes without saying that Saudi Arabia has benefited greatly from the inflow of expatriate labor. These benefits are summarized as follows:

1. The most important benefit is the economic growth and improved services and living standards that have proceeded more rapidly than would have been possible with indigenous labor alone. Given the full employment situation in Saudi Arabia, the growth of the economy relies heavily upon expatriate labor. The Third Development Plan (1980-85) realized a growth of about 8.9 percent in non-oil GDP with an associated expansion in total labor requirements of about 6 percent per year (Sherbiny, 1984, p. 35). The resulting expansion in total employment (6 percent) exceeded the growth rate of domestic workers (3.1 percent) with the gap between the total demand and domestic supply of labor met by expatriates (Sherbiny, 1984, p. 36).

Empirically, it was estimated that in order for the economy to grow at 13.2 percent annually, 3.73 million expatriate workers are needed by 1990 (Assaf, 1982, p. 116). This study assumed a 15.9 and 3.5 percent annual growth rate in capital stock and domestic labor.

2. Importing labor prevents cost push inflation in the economy by making labor services available at a lower cost.

3. Expatriate labor provides the country with readily available human capital without paying any associated human capital cost required by education and training. In fact, labor surplus countries suffer "brain drain" of highly educated labor where a large number of them

migrate to the oil surplus countries. For example, 50 percent of the medical school graduates in Pakistan on graduation immediately emigrate to other countries, especially to the oil surplus countries (Paul Hallwood 1987, p. 43). While the labor surplus countries take the burden of educating and training the workers, Saudi Arabia, like other oil rich countries, enjoys the benefit of skills without incurring any cost.

4. The country's oil exports to labor surplus nations increase because the repercussion effects of expatriate remittances to their home countries. This increase occurs because expatriates represent an excellent source of foreign exchange inflow to these labor surplus countries. Most of the workers of North Yemen, Egypt, Jordan, and Sudan are working in the oil rich countries especially the Gulf countries. The remittances of these workers are very important source for financing their home countries' imports. Remittances in North Yemen, Jordan, Egypt, and Sudan represent 60, 38, 32, and 18 percent of their imports.

Cost of Expatriate Labor Force

These benefits to the country accruing from the expatriate inflow are a mixed blessing and are not acquired without costs. The following is a brief description of these costs.

1. Providing the infrastructure and social services to the expatriates results in a very high cost. In particular, the expatriates and their dependents increase the demand for physical and social services (Sinclair, et al., 1984, pp. 620-621). These services include schooling, social and medical services, public transportation, water, and power services.

These costs are, in fact, very high since such public goods are heavily subsidized by the government and the expatriates have the privilege of income tax exemption. Another reason that increases the cost of these public goods is the high number of dependents of the expatriate workers. It is estimated that nearly one fourth of expatriate males and almost one half of expatriate females are not of working age (Sirageldin, et al, 1984, p. 35). Another estimate shows that the ratio of dependency is 0.96 (AL-Thomaley, 1986, p. 13). As the dependency ratio increases among expatriates, not only the cost of providing social and infrastructure services for the working age expatriate increases but also the cost of providing these services to their dependents.

3. The expatriate inflow is a self-feeding process, in which the expatriate's existence translates into an increase in their demand and hence, aggravates the acute domestic labor shortages. This process was described by AL-Thomaley (1986, p. 51-52) who said,

> Immigrants increase the demand for consumer goods and social capital, creating an additional demand for manpower which have been met by more immigration. Therefore, the employment of a certain number of immigrants creates a need for an additional number. This has led Bohning to conclude that the satisfaction of manpower demand by immigration may be illusory.

The problem is getting worse as the number of expatriate dependents increase.

According to AL-Thomaley, this issue has been discussed and applied to west European experience by Bohning in 1974. Bohning theorized that labor migration passes through four development stages of the process he called "maturity" in migratory flow. Over these four stages the need for extra social infrastructure is cumulative, and at the final stage immigrants will start consuming more than what they actually produce and hence, immigration becomes self-feeding. Therefore, in the long run, a net gain from importing labor is questionable as the dependency on expatriate workers continues. If that is the case, then the very problem that the expatriates are brought in to solve (that is expanding and diversifying the economy) is not solved.

4. The expatriate workers' remittances to their home countries create a balance of payments problem through the drain of foreign exchange as shown by Table 1-1.

Statement of the Problem

In the long run, as AL-Thomaley points out (AL-Thomaley, 1986), the advantages gained from labor importation could result in self-feeding and thereby may not solve the very problem -- economic growth and diversification -- the expatriate workers are brought in to solve. The government's concern for this is best described in the Fourth Development Plan of 1985-90. The Plan stressed the need to reduce not only the share but also the absolute number of the expatriate workers. The plan calls for about 23 percent reduction in the number of expatriate workers, from 2.66 to 2.06 million (Fourth Development Plan, 1985-90). In order to ensure the realization of this goal, the plan states:

> Productivity gains must be made; Saudi worker's motivation must be high; the education and training systems must respond to labor market needs, and the theme of Saudiization' must be given a practical meaning at all levels of the labor market (Fourth Development Plan, p. 50).

In the short-run, however, the economy has definite benefits

TABLE 1-1

REMITTANCES OF EXPATRIATES IN SAUDI ARABIA TO THEIR HOME COUNTRIES

Year	Millions of U.S. Dollars
1973	391
1974	518
1975	554
1976	989
1977	1,506
1978	2,844
1979	3,365
1980	4,064
1981	4,100
1982	5,211
1983	5,236

Source: Nazli Chouri (1986), p. 701

accruing from the utilization of expatriates. It is also essential to utilize the expatriate labor force to its optimum level to ensure the continuous growth and diversification of Saudi economy.

As a result of this conflict between long-term and short-term interests of Saudi Arabia, the government is faced with the problem of striking a balance between these two interests as the impact of the expatriate is crucial to Saudi economy.

Objective of the Study

The objective of this dissertation is to study the impact of the expatriate workers on the economy of Saudi Arabia empirically. As mentioned earlier, the impact of expatriates is noticeable on production, consumption, the labor market, and balance of payments. It is difficult to isolate the interaction among all of the above factors in order to determine the net impact on each of them separately. Therefore, a thorough study is needed in order to capture comprehensively the impact on each factor and to reflect more precisely policy measures that can be adapted for development purposes.

This study will examine the impact of expatriate inflow on the Saudi economy in order to determine the effect of the expatriate labor force on several variables including production, consumtion, labor market, and balance of payments.

The model used in this study is based on the computable general equilibrium model developed by Dervis, De Melo and Robinson (1982). The core model has been modified wherever needed to suit the purposes of the present study.

Some Relevant Studies

The literature on manpower shortage models for the economy of Saudi Arabia is fairly limited. Moreover, only four models are cited in the available literature.

1. Assaf (1982) conducted an empirical study to explore the issue of the economic impact of expatriates on the Saudi Arabian economic growth. The study is simple in the sense that it relates output to two exogenously determined factors, labor and capital. A Cobb-Douglas type of production function was used for the first time to estimate the role of both capital and labor in the economic growth of Saudi Arabia. By dichotomizing labor into domestic and foreign, it was possible to calculate the contribution of expatriates to economic growth. The model was then used to investigate the impact of different mixtures of factors of production given a certain level of growth in output.

The study concluded that, with the existing rate of growth in capital and domestic labor, to keep the rate of growth of output constant at 13.2 percent annually, an additional 2.28 million expatriates are needed by 1990. Another important finding is that to sustain the level of output growth without further growth in the number of guest workers capital has to grow by 30 percent. Finally, the study found that expatriate workers have an adverse effect on income distribution, domestic labor supply, and inflation.

2. In the area of manpower planning in Saudi Arabia Aljiffry (1983) developed and applied an input-output model to analyze manpower planning. The main objective of this study was to project the country's future requirements for manpower and to choose the best available alternative to satisfy such requirements. The model also showed the

extent to which labor requirements are met through expansion of the educational system and through importation.

The main finding of the study is that Saudi Arabia continues to face labor shortages and will continue to require expatriate workers to achieve the country's development objectives for some more time to come.

3. AL-Khouli (1985) conducted another study focusing similarly on forecasting manpower requirements making use of two different models. The study makes use of the productivity and technical coefficients to forecast Saudi manpower requirements by nationality in various sectors of the economy. It also makes use of generalized production function and time series forecasting techniques to predict the total manpower skill requirement by nationality for the non-oil sectors.

The main purpose of the study was to provide decision makers with a tool that can be used to forecast requirements of different skills of human resources in different sectors during the period 1982-90. The study also forecasted the total number of Saudi manpower required to achieve the fourth development plans' targets.

It was found that the need for expatriates of different skills will continue for some more years to come. Enlargement of domestic labor participation through raising enrollment rates in vocational training and on-the-job training programs was concluded to be urgently needed.

4. Using a partial equilibrium analysis and focusing on the private non-agricultural sector, AL-Thomaley (1986) analyzed the impact of expatriate workers on domestic wages. AL-Thomaley also included in his study an estimation of the elasticity of substitution between domestic and expatriate workers at different skill levels. The main findings of this study is that expatriate workers did reduce domestic

wage growth and the employment level of local workers. He tested the impact of the expatriate workers on domestic wages of different skills and in different sectors as well. Using data for the period 1978-82, the estimated impact on wages of different skills ranges between -0.02 for production workers and -0.10 for managers and administrative workers. Using the same data set but classified by economic sectors, regression results show that the impact of the expatriates on domestic wages were significant in only three sectors. These three sectors are, manufacturing, trade, and community social and personal services. The regression coefficients in these sectors are -0.03, -0.03, and -0.08 respectively. The coefficients related to the rest of the sectors were not statistically different from zero.

Concerning the substitutability between domestic and expatriates, AL-Thomaley concluded that expatriates and locals are substitutable when they were taken as a homogeneous group as well as when they were disaggregated by occupational groups. His study shows that the elasticity of substitution between expatriates and domestic labor is -2.13, which means an increase in the employment of expatriates is likely to decrease the employment of locals. When the two groups (expatriates and native) were disaggregated into high skilled and low skilled labor, it was concluded that the elasticities are -5.17 and -2.33 respectively.

Significance of This Study

Although several authors have focused on the impact of expatriates on the economy of Saudi Arabia, there has been no general equilibrium framework used to analyze this very important issue.

Unlike the earlier studies which are limited in scope and application, this dissertation attempts to provide a comprehensive model to analyze the impact of expatriates in Saudi Arabia. The model applied in this study uses a multi-sectoral computable general equilibrium model similar to that developed by Dervis, De Melo and Robinson (1982). It employs price mechanisms, market interactions, and structural interdependence in a non-linear framework. The model, however, is static and barter, and hence, it does not take into consideration dynamic and monetary issues.

Because expatriate workers represent a significant share in the country's labor force, the reduction of their number will generate different effects (some adverse). Therefore, decision makers have to be aware of the consequences of a reduction in the expatriate labor force, particularly on production, consumption, balance of payments, and the labor market. Hence, a thorough framework is of importance to analyze the impact of an expatriate worker reduction policy on different economic sectors.

Labor Shortages

The reason for the enormous dependence on expatriate labor force is directly related to the local labor shortage. To understand why the labor shortage occurred, it is necessary to analyze the following important factors. These factors are small indigenous population, low rate of indigenous participation in total labor force, the traditional educational system, and the rapid growth of government expenditure.

Indigenous Population

The total indigenous population of Saudi Arabia is very small. The United Nations reported an approximate number of 5 million inhabitants in 1963. Prior to 1974 there was no nationwide census that estimated the total population in Saudi Arabia. The government conducted the first nationwide population census in 1974. The results of the census indicate a population of about 7 million inhabitants including expatriate workers.[1] In 1980, according to Sherbiny, the ratio of expatriates to total population was as high as 31 percent (Sherbiny, 1984, p. 35). It is clear that the Saudi indigenous population is not adequate to provide the labor force required to meet the demand resulting from large scale development projects in the country.

Low Indigenous Participation Rate

Male Participation. The small population size in Saudi Arabia is not the only reason for labor shortages in the country. A low participation rate of indigenous people in the labor force is an important factor in creating such shortages. Extreme youthfulness of the population, affluence, early retirement, and negative attitude toward doing some jobs result in the unusually low participation rate of the Saudi indigenous people are important factors.

1. Youthfulness of the population. The examination of the population age structure in Saudi Arabia indicates that people under 15 years old are about half of the population; about 6 to 7 percent of the

[1]Both the United Nations and the government population estimates have been taken from Johany et al. (1986), Table 1.1, p. 5.

indigenous population is older than 59 years old; and the remaining 45 percent are in the working age (15 to 59). However, the fact remains that about 50 percent of the population under 15 is expected to provide the economy with an abundant supply of labor in the future (Ismail Sirageldin, et al., 1984, p. 35).

2. Affluence. A substantial part of the Saudi society has become wealthy, due to the increase in oil revenues, relative to their previous standard of living. People, as a result, tend to be disinclined to work hard to make a living. Another factor that led to create this class of people, but to a lesser extent, is the government's extensive assistance and welfare services. In 1984, there were 903 thousand beneficiaries of government assistance programs compared to 443 thousand beneficiaries in 1975. The total amount of this assistance received in 1984 was about SR1.6 billion compared to SR358 million in 1975 (Achievements of the Development Plans, 1970-1984, p. 263). These generous non-earned income welfare payments has caused some people to withdraw from the labor force even though they are able to work and earn a living for themselves (Kavoussi, 1984, pp. 287-88). An elimination of this class of people by appropriate official policy will definitely expand the labor pool in the society.

3. Early retirement. According to Assaf (1982) early retirement is another factor which contributes to lowering the participation rate of indigenous labor. Though the normal retirement age is 65, many people prefer to retire as early as 60 (Assaf, 1982, p. 26). The early retirement came about as a result of the improved well-being of people.

4. Negative Attitude towards doing some jobs. Some jobs, like janitor and busboy, are considered socially undesirable.

Low Female Participation. The participation rate of Saudi females in the labor force is very low. Only 5.1 percent of working age Saudi females were estimated to be in the labor force during the third development plan (1980-85). This percentage is expected to increase to 5.5 percent by the end of the fourth development plan (1985-90) (Fourth Development Plan, p. 89). The employment of Saudi females is concentrated in the public sectors such as female education, and health services (nurses). About 80 percent of Saudi female labor force was employed in female education service in 1980 (Assaf, 1982, p. 27). Table 1-2 shows the occupational distribution of Saudi females in 1986. The majority of the working Saudi females were in the professional fields (68 percent) employed mainly in education and health services. The second most important occupation for women is health services (14 percent). The participation rate of Saudi females in occupations other than the above two categories is insignificant as shown by Table 1-2.

Table 1-3 summarizes the participation rate of Saudi females by occupation in the total Saudi labor force. It shows 27.11 percent of all Saudis who were engaged in professional work were females in 1986. About 16 percent of the labor category of miscellaneous occupation belonged to females.[2] About 8 percent of the health service workers were female Saudis. All other occupations show a negligible participation rate. Finally, the overall participation rate of Saudi females in the Saudi labor force pool is only an insignificant 7.11 percent.

The reasons for this low participation rate of Saudi females are

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[2]There is no detailed description about the type of jobs under this labor category.

TABLE 1-2

OCCUPATIONAL DISTRIBUTION OF SAUDI FEMALES (1986)

Occupation	Number	Percentage
Professionals	71,815	68.37
Administratives	261	00.25
Clericals	5,749	05.47
Sales	3,069	02.92
Services	14,370	13.68
Agricultural	3,419	03.25
Production and Construction	2,323	02.21
No Occupation Reported	4,039	03.85
Total	105,045	100.00

Source: Manipulated from Table 4, Appendix 2, Labor Force in the Kingdom of Saudi Arabia (1986).

TABLE 1-3

PARTICIPATION RATE OF SAUDI FEMALES IN TOTAL SAUDI LABOR FORCE BY OCCUPATION (1986)

Occupation	Percentage
Professionals	27.11
Administrative	0.47
Clerical	2.2
Sales	2.4
Service	7.8
Agriculture	2.2
Production and Construction	.57
No Occupation Reported	15.8
Overall	7.11

Source: Manipulated from Table 4, Appendix 2, Labor Force in the Kingdom of Saudi Arabia (1986).

the cultural and social values in the country. Saudi Arabia is the most conservative country in the region influenced by the Islamic teachings, which prohibits females from working with men unless they can be totally separated. Naturally, this separation creates limited options for women to participate in the labor force. However, developmental plans are trying to accommodate the female population in the labor force to a greater extent. Consequently, the government is paying attention to improving the education of women in Saudi Arabia. The Fourth Development Plan (1985-90) is projecting some additional 50 thousand Saudi women to enter the labor market by the end of the plan. The plan is faced with the challenge of finding jobs for these new female graduates in accordance with the Islamic teachings. However, the plan proposes that more jobs in fields like software engineering, process control, and laboratory activities, will become available for women without any contradiction with islamic teachings (Fourth Development Plan, 1985-90, pp. 51-52).

The demographic characteristics of Saudi Arabia are another reason for the low female participation rate. According to Assaf (1982), the large family size with relatively large numbers of children makes it hard for females to leave the house and enter the job market.

Increasing the participation rate of Saudi females wherever it is possible will definitely help in reducing the dependency on expatriates, but that process will not be free from social and cultural constraints. According to Martan (1980, p. 76):

> Women are an important element of any society. Enlargement of female participation in the economy wherever appropriate will help ease manpower shortages. It must be recognized, however, that traditional Islamic values relating to women and the family will in Saudi Arabia continue to take precedence over purely economic needs.

Educational System. The labor shortage is also caused by the inappropriate education and training programs resulting in an inefficient use of available domestic labor. The educational system before the oil boom was basically aimed at providing non-vocational education, concentrating on traditional subjects like humanities and physical sciences. Though educational policy has much changed after the developmental projects were initiated, Saudi Arabian students are not trained to be technicians or skilled workers to take the place of expatriate laborers. Moreover, the rural population does not receive the same standard of education as the urban population. In spite of the recent efforts by the government to establish vocational training centers in rural areas as well as in urban areas, there is not yet any significant improvement in replacing expatriate skilled laborers with domestic ones.

Government Expenditure Pattern

Because of the vast purchasing power of the government, labor shortages have been aggravated by public consumption and expenditure on developmental projects. Comparing 1975 and 1980, government expenditure on consumption and investment projects rose from SR15,911 and SR7,370 to SR88,206 and SR61,598 million respectively (SAMA Annual Report, 1981, p. 173). During the period 1975-80 these government expenditures averaged about 52 and 60 percent of the country's total consumption and investment expenditures (SAMA Annual Report, 1981, p. 173).

Not only public expenditure aggravated the labor shortage, but the government also provided private sectors with incentives which also increased their demand for labor. Direct incentives were provided through government lending agents, such as the Saudi Industrial Development Fund (SIDF), Public Investment Fund (PIF), Real Estate Development Fund (REDF), and the Saudi Agricultural Bank (SAAB). The credit disbursed by these lending agents to the private sector went up sharply from 1.7 (SIDF), 1.5 (PIF), 2.2 (REDF), 0.3 (SAAB) in 1976 to 5.2 (SIDF), 8.1 (PIF), 9 (REDF), and 3.5 (SAAB) billion Saudi Riyals in 1984 (Achievements of the Development Plans (1970-84), p. 171). Excluding the PIF, credit disbursed by all other agents captured about half of the private investment funds in 1984 (Achievements of the Development Plans (1970-84), p. 22). Investors are able to obtain loans from SIDF which cover up to 50 percent of their capital cost in the manufacturing sector and 100 percent coverage in the electric power industry, with a service charge of only 2.5 percent (Rostam, 1984, p. 287).

Labor Shortages and the Inflow of Expatriates

The inflow of expatriate labor into the country is clearly tied to the rise in the oil price that took place in the 1970s and early 1980s. Since the small population could not cope with the demand in the market for labor, resulting from the boom in oil revenue, a serious labor shortage has occurred allowing for a massive inflow of expatriate workers since the oil boom as mentioned earlier.

Historical Development of the Inflow of Expatriates

Table 1-4 shows a historical development in the expatriate inflow into the country during the period 1970-1982. An examination of the data in the table reveals a slow growth in the number of expatriates

TABLE 1-4

EXPATRIATE WORKERS INFLOW INTO SAUDI ARABIA (1970-82)

Year	Number	Percentage Change
1970	325,868	---
1971	356,544	9.4
1972	391,411	9.8
1973	435,142	11.17
1974	588,888	35.33
1975	726,714	23.40
1976	814,790	12.12
1977	1,022,773	35.53
1978	1,049,126	2.58
1979	1,216,917	15.99
1980	1,374,536	12.95
1981	1,464,960	6.58
1982	1,664,970	13.65

Source: Al-Khauli (1985), p. 76.

during the period 1970-1973. The drastic increase in the number of expatriates did not begin until 1974 rising by 35 percent relative to the previous year. By 1982, the number of expatriates had increased about 4 times (from 435,142 to 1,664,970) of its number in 1973.

With regard to the ratio of the expatriate workers to the total labor force, data for 1973 through 1982 are shown in Table 1-5. These ratios follow the same pattern found in Table 1-4. Compared to the ratio of 1 out of 10 and 1 out of 6 in the years of 1960 and 1965 respectively, the ratio of expatriate workers to the total labor force of the country has increased significantly to a ratio of 1 out of 1.8 (Sherbiny N., 1984, p. 35).

Composition of the Expatriates by Nationality

The yearly stock of expatriates classified by country of origin is not available. The only available data is the number of expatriates who entered and left the country in 1982. Taking these figures as an approximate indicator of the composition of expatriates by nationality, Table 1-6 suggests that the majority of the expatriate workers, about 57 percent, are from Arabian countries. Among the Arabs, Egyptians were 23 percent, Yemenese 21 percent, Palestinians and Jordanians 18 percent, and Sudanese about 3 percent (Arafat, 1985, p. 302, Table 33). This Arabian expatriate influx results from the proximity of the Arab states, together with the closely related cultural, language, and religious factors. Most of these countries are important as a source of teachers, administrators, clerks, and technical experts.

The second largest group, about 32 percent, is from non-Arab Asian countries. Among the Asians, Pakistanis were 27 percent, Indians

TABLE 1-5

THE RATIO OF THE EXPATRIATE WORKERS TO THE TOTAL LABOR FORCE OF SAUDI ARABIA (1970-82)

Year	Number of Domestic Workers	Number of Expatriate Workers	Total Labor Force	Ratio of Expatriates to Total Labor Force
1970	777,932	325,868	1,103,800	0.30
1971	888,363	356,544	1,244,907	0.29
1972	1,002,808	391,411	1,394,219	0.28
1973	1,128,501	435,142	1,563,643	0.28
1974	1,128,412	588,888	1,717,300	0.34
1975	1,019,766	726,714	1,746,500	0.42
1976	964,455	814,790	1,779,245	0.46
1977	970,820	1,022,773	1,993,593	0.51
1978	990,422	1,049,126	2,039,548	0.51
1979	989,580	1,216,917	2,206,497	0.55
1980	1,096,664	1,374,536	2,471,200	0.56
1981	1,221,337	1,464,960	2,686,297	0.55
1982	1,302,634	1,664,970	2,967,604	0.56

TABLE 1-6

EXPATRIATES ENTERING AND LEAVING SAUDI ARABIA BY NATIONALITY (1982)

Nationality	Entering		Leaving	
	Number	Percentage	Number	Percentage
Arab Countries	1,777,132	53.6	1,707,734	56.5
Asian Countries	1,075,919	32.4	829,817	27.5
Non-Arab African Countries	31,660	0.9	21,163	0.7
European Countries	264,060	8.0	287,117	9.4
American Countries	161,990	4.9	166,689	5.5
Australia	5,769	0.2	7,736	0.3
Other Countries	1,472	*	1,798	0.1
TOTAL	3,318,002	100	3,022,054	100

*less than .05 percent

Source: Statistical Indicators (1984), p. 227.

19 percent, Philippinos 18 percent, and Thais 8 percent (Arafat, 1985, p. 302). Part of the reason for Asians to rank as the second largest expatriate group is that wages are low in countries like Thailand and Phillipines, whereas unemployment and population problems are acute in Pakistan and India in addition to the religious factor for most of them.

Expatriates from Western countries (Western Europe and North America) accounted for about 13 percent of the total expatriates in the country. Most of these workers are in the oil industry and in some highly technical fields in the private and the government posts.

Sectoral Participation Rate of Expatriates

The sectoral participation rate of expatriate workers in 1982 is shown in Table 1-7. The table also shows the sectoral participation rate of domestic workers for the purpose of comparison. The overall expatriate workers' participation rate in total employment is about 56 percent. The table also shows a significant deviation from these overall participation rates in some sectors. Expatriate worker's participation rate tends to be very high in manufacturing (82 percent), construction (93 percent), transportation (80 percent), finance (81 percent), and the community social and personal services (75 percent), where the expatriates share in the labor force of these sectors is much higher than their overall share (56 percent).

The main reason for these high shares, in addition to the quantity and quality shortages of indigenous workers, is that domestic workers tend to avoid these sectors. Due to the oversupply of job opportunities for indigenous workers and the improvement in their living conditions,

TABLE 1-7

SECTORAL EMPLOYMENT DISTRIBUTION BY NATIONALITY (1982)

Sector	Domestic Workers		Expatriate Workers		Total
	Number	Percentage	Number	Percentage	Number
Agriculture	458,711	81.10	106,901	18.90	565,612
Crude Petroleum	26,759	87.30	3,892	12.70	30,651
Mining and Quarrying	4,981	50.30	4,922	49.70	9,903
Petroleum Refining	8,268	87.30	1,203	12.70	9,471
Manufacturing	21,980	18.40	97,177	81.60	119,157
Utility	18,909	45.80	22,377	54.20	41,286
Construction	29,567	06.90	398,934	93.10	428,501
Trade	230,201	56.00	180,873	44.00	411,074
Transportation	55,500	20.10	220,618	79.90	276,118
Finance	9,888	19.20	41,613	80.80	51,501
Community Social and Personal Services	161,858	24.90	488,173	75.10	650,031
Government Services	276,012	73.80	97,988	26.20	374,000
Grand Total	1,302,634	43.90	1,664,971	56.10	2,967,605

Source: Al-Khouli S. (1985), Appendix B, Tables in pages 371-376.

they tend to leave jobs that are laborious (which are required by these sectors) seeking easy jobs instead.

Another important factor is that the government has undertaken to provide jobs for all indigenous workers in the public sector. These public jobs tend to attract more indigenous workers because they are office based jobs as opposed to manual jobs. Therefore, indigenous workers tend to switch over to the public sector from the private sector, and in particular from construction and manufacturing sectors. As shown by data in Table 1-7, 74 percent of government workers are indigenous, while only 18 percent of the manufacturing and 6 percent of the construction workers are indigenous.

Although the crude oil and petroleum refining sectors are capital intensive and require highly skilled labor, the participation rate of domestic workers is very high. A possible explanation for this fact is the high quality of on-the-job training programs, which is special to ARAMCO, that are provided to the employees. Another reason is the relatively high wage payments and better working conditions which attract more domestic workers to the oil industry.

Reduction in the Number of Expatriates

Being an oil based economy, Saudi Arabia started facing a relatively soft international oil market in the early 1980s. Prices of oil as well as quantity exported have decreased substantially and the country lost about 52 percent of its oil revenues between 1980 and 1983 (Sherbiny, 1984, p. 34).

The fall in the country's oil revenues translated into a cut in development spending and consequently a fall in the demand for expatriate workers. It has been estimated that Saudi Arabia has experienced about 45 percent fall in the expatriate inflow since the mid-1980s (Secombe, 1986, p. 44). The expatriate inflow peaked in 1981, when about 850 thousand permits were issued, but in 1984 only 470 thousand expatriate permits were issued (Secombe, 1986, p. 45, Table 1).

The 23 percent reduction in expatriate workers (600 thousand expatriates) expected in the Fourth Development Plan will be mostly carried out by the private sector. The plan expects that the private sector will substitute 374 thousand expatriates with indigenous labor, while the remaining portion of expatriates (225 thousand) is expected to be replaced by the increase in the efficiency of domestic workers (Fourth Development Plan, 1985-90, p. 84).

To sum up, the labor shortage problem in Saudi Arabia is acute because of several factors. The major factors are the small indigenous population of the country, the low participation rate of indigenous people in the labor force, the incompatible education system, and the rapid growth of government expenditure.

As anticipated, the inflow of expatriate workers has increased parallel with the implementation of large scale developmental projects during the early 1970s and early 1980s.

As a result of these opposing forces, namely the small, labor supply pool and the remarkable increase in demand for labor, the total population expatriate workers has increased significantly to the extent that it exceeds the population of domestic workers in the country.

There is no doubt that the Saudi economy has benefited much from this cheap and readily available labor. However, utilization of expatriates is a mixed blessing and thus are acquired at a high cost to the country. Consequently, planners became more cautious about the flexible importation policy of expatriate workers. This concern is manifested in the country's Fourth Development Plan (1985-90) which calls for a policy aimed at Saudization of the labor force. However, it is likely that the plan will face the challenge of achieving a balance between the two apparently conflicting objectives. These conflicting objectives are the diversification of the economy and simultaneous labor-force Saudiization objectives.

Organization of the Study

The dissertation is divided into four chapters. Chapter I introduced the study and discussed some aspects of the labor market in Saudi Arabia. In particular, this chapter highlights the main reasons for the labor shortages in the country, demography of the expatriate community, and cost-benefit of imported manpower. In addition, it also presents a short review of literature that is relevant to labor shortages in Saudi Arabia.

Chapter II provides a review of literature about the computable general equilibrium models. The second part of this chapter presents a computable general equilibrium model for Saudi Arabia.

Chapter III describes the simulation of a number of alternative policy experiments. In particular, it analyzes the following four experiments: (1) reducing the participation rate of expatriates for all skills and across all sectors; (2) reducing the participation rate of expatriates across all sectors for each skill separately; (3) substituting the necessary capital for the reduction in the participation rate of expatriates in order to maintain the same level of sectoral outputs; and (4) determining the effect of devaluation on remittances. The chapter includes the results of these experiments and compares the results with the base run solution.

Chapter IV summarizes the main conclusions of the study and proposes areas in which future research will be fruitful.

The dissertation includes in the appendixes a list of the model's equations, basic data for the model, the GAUSS computer program used, mathematical derivations, statistical data, and estimated data and parameters.

CHAPTER II

A COMPUTABLE GENERAL EQUILIBRIUM MODEL FOR SAUDI ARABIA

Introduction

Computable General Equilibrium (CGE) models, which are also called general equilibrium models in the literature, are a recent economic tool developed in the early 1970's. Over the last ten to fifteen years, the economic literature on CGE models has grown very rapidly. These models have helped economists investigate a wide range of policy issues including trade policies, income distribution, structural adjustment to external shocks, tax policies, growth and structural change, and choices of development strategy. Economists have applied CGE models to both developed and developing countries and to single as well as multicountry economic issues.

This chapter consists of two main sections. The first section briefly surveys the literature relevant to the theoretical area that the present study falls.[1] The second section presents a detailed description of a CGE model that is used to analyze the impact of expatriate workers on the economy of Saudi Arabia.

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[1]This literature is surveyed in the following: Dervis, De Melo, and Robinson (1982), Shoven and Whalley (1984), Devarajan, Lewis, and Robinson (1986), Robinson (1988), and A. Kouwenaar (1988).

Survey of Literature

Historical Background

CGE models have their antecedents dating back to Leon Walras in the late nineteenth century. Walras, in his mathematical model, summarized the economic system in a set of excess demand equations in as many unknown prices. However, Walras was unsuccessful in his attempt to prove the existence of a unique equilibrium price vector that would solve his general equilibrium model simultaneously. He justified the existence of the solution by referring to the equality between the number of endogenous variables (prices) and the number of equations in his model. Walras also argued theoretically that a tatonnement process would guarantee the existence of the solution through successive price revisions that occur as a result of the discrepancy between quantity demanded and quantity supplied.

The conditions for the existence and uniqueness of the general equilibrium solution was not proved rigorously until 1951. Arrow (1951), Arrow and Debreu (1954), Gale (1955), and others who used the Brouwer's theorem to establish the consistency of the Walrasian model demonstrated this proof (Scarf and Hansen, 1973, p. 6.).

The application of general equilibrium models had to wait until computational techniques such as fixed point or numerical analysis approaches became available. Lief Johnsen's (1960) earlier work was the first empirical CGE model that was developed and tested using real data. He used his model to analyze policies related to resource allocation issues in Norway. His model assumed that factors of production (capital and labor) are fully employed and also perfectly mobile between sectors. Johnsen first linearized and then solved his model's equations by simple matrix inversion.

Another earlier work on the CGE model was that of Arnold Harberger (1962), who was the first to numerically analyze income tax policy applied to the United States' economy. He developed a two-sector, corporate and noncorporate, general equilibrium framework to find equilibrium tax schedules for each sector.

Finally came the important stimulus from Herbert Scarf (1967) who developed a computer algorithm for the numerical determination of the equilibrium of the Walrasian system of equations. These three contributions of Johnsen, Harberger, and Scarf (as Shoven and Whalley described them) provide background and stimulus for most of the general equilibrium models applying contemporary numerical methods (Shoven and Whalley, 1973, p. 1008).

The high cost of implementing numerical solutions has kept general equilibrium models from becoming popular. It was not until the early 1970's, when the numerical solutions became cheaper and more common to solve, that CGE models gained popularity in economic modeling.

In the early 1970's, the problem of income distribution was a prime concern for policy makers in developing countries. The Johnsen model and other CGE models present at that time did not address income distribution explicitly. The first model along this line was the Adelman-Robinson (1978) model of South Korea which was developed to explore the feasibility of using various policy instruments to change the distribution of income. A later model was constructed for Brazil which also focused on income distribution. These two models introduced a number of structural changes and incorporated basic structural variables in order to capture the stylized facts that characterize developing countries and are important to capture significant forces that affect income distribution. Later on, these two models were extended to allow for substitutability between local and imported goods -- an assumption which was not used in either the original Korea or Brazil models (Adelman and Robinson, 1987). Since then, a steady stream of CGE models has flourished with applications for more than 30 developing countries exploring a variety of economic issues.[2]

Typologies of CGE Models

The existing empirical CGE models can be classified in different ways: one approach classifies the models according to solution techniques while another divides them according to the policy focus. CGE models can also be classified as developed and developing countries CGE models, or as single and multicountry CGE models.[3]

Solution Technique Classification. This work takes into consideration five different solution techniques used in the classification of CGE models, the fixed-point algorithm, the log-linear approximation, the direct numerical, the non-linear programming, and the piecewise linear programming technique.

1. Fixed-point algorithm technique. The solution of a CGE model can be obtained by the method of finding a fixed-point in a mapping of

[2]Devarajan, Lewis, and Robinson (1986) provided an extensive bibliography of CGE models applied to developing countries.

[3]These classifications and the listing of models under each category is a combination of that given in Dervis, De Melo, and Robinson (1982), Shoven and Whalley (1984), and Sherman Robinson (1988).

prices-to-prices through excess demand equations. In 1967, Herbert Scarf pioneered this computer algorithm for the numerical determination of the equilibrium of a Walrasian system. Subsequent extensions to his fixed-point algorithm followed later. This algorithm technique and its subsequent extensions have solved a number of the empirical CGE models (Robinson, 1988, p. 4).

The major advantage of this technique is that a solution is guaranteed once the model satisfies the fixed point theorem. However, a major disadvantage of this technique is that it is very expensive to implement in models with high numbers of excess demand equations. Another major disadvantage is that it can not solve a model that does not satisfy the fixed point theorem.

2. Log-linear approximation technique. This technique involves first linearizing the log form of all the CGE model equations and then solving the models by simple matrix inversion techniques which achieve only an approximate solution. Johnsen (1960) first used this technique in his model for Norway as mentioned earlier. Then, Dixon and others (1982) extended it considerably by applying an extended version technique in solving their CGE model of Australia. However, this technique, as Norton and Hazel (1986, p. 211) described it, is limited by the property that the approximation error increases the further the solution departs from the initial equilibrium conditions (Norton and Hazell, 1986, p. 211).

3. Direct numerical technique. Adelman and Robinson (1978) developed a new generation of models based on solution algorithms that solve the non-linear model directly with no linearization. They first used this technique in their model for South Korea and a number of other

applications since then.[4]

This technique is based on price adjustment in each sector, in response to any excess demand in that sector, in an iterative fashion until all markets are cleared. The major advantage of this technique is that it is very efficient and easy to implement once the algorithm is adjusted to a particular model. However, this required adjustment in the algorithm is a disadvantage to those users who are not familiar with the algorithm properties. Furthermore, the technique becomes fussy and/or inefficient in models where its markets are highly interrelated.

4. Non-linear programming technique. The non-linear programming technique yields a solution whose shadow prices can be interpreted as market prices. Ginsburgh and Waelbroeck (1981) developed this method.

5. Piecewise linear programming technique. Norton and Scandizzo (1981) developed a better linearization technique using techniques of grid linearization. Unlike the log-linear approximation technique which shows the problem of positive dependency between the approximation error and how far the solution departs from the initial equilibrium solution, the linearization technique (grid linearization) has the property of independency between the approximation error and the numerical solution values. However, Norton and Scandizzo demonstrated the technique within the context of a very simple illustrative economy. Later, Norton, Scandizzo, and Zimmerman (1985) applied the grid linearization technique in a more extended economy, which incorporated investment, government, and foreign trade in their CGE model of Portugal. The main advantage of this technique is that it helps economists compute a CGE model via a

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[4]For example, Dervis (1975), Ahluwalia and Lysy (1979), Dungan (1980), and Lysy and Taylor (1980).

single linear programming solution, using a standard linear programming package with no restrictions on the number of variables in the model. Other techniques use iterative solution procedures and require writing special programs or using readily available computer packages where the number of variables to be solved is limited.

Policy Focus Classification. Computable general equilibrium models can also be classified by feature of policies or issues they handle. As mentioned earlier, economists have used CGE models to study income distribution effects as well as for simulating international trade policy. They have used some applications to evaluate tax policies and also to evaluate oil price effects.

CGE models have the feature of capturing most of the interactions of the different actors in the economy and hence, they are useful to analyze a wider range of policies efficiently. The following is a sample of studies grouped according to the major policy that is central to them.

1. Tax models. All general equilibrium tax models are built, in one way or another, on the work of Harburger (1962) using United States data. These models help economists mainly to evaluate tax policies in developed countries. In particular, they are used to compare the two equilibrium solution values before and after introducing changes in the tax system. Whalley (1975) also used this tax policy model to analyze the impact of 1973 tax changes in the United Kingdom. Several more recent tax policy models of this type were constructed by Greg et al (1979) on Canada, Keller's (1980) on Holland, Riggot (1980) on

Australia, and Jiam Serra-Puche (1984) on Mexico.[5]

2. Trade policy models. After the first oil crisis in 1973 and the second crisis in 1975, both developing country policy makers and international lending agents focused their attention on questions of structural adjustment in production and trade in order to adapt increased scarcity of foreign exchange. General equilibrium models have also focused on the issue of tariff abolition and some other correction policies for trade distortion. These studies include the ones by Boadway, et al (1978) for Canada, Evans (1972) for Australia, de Melo and Dervis (1977) for Turkey, Michel and Noel (1984) for Ivory Coast, etc.

3. Income distribution policy models. In the early 1970's, policy interests shifted to a concern about changing the distribution of income. Specifically, the concern shifted to the implication of a certain policy or development strategy on the distribution of income. What would be the best policy packages that would reduce the worsening of income distribution arising from rapid growth and structural changes. There was a growing concern that large groups of poor people were not deriving any benefit from growth. The CGE model handles such issues very efficiently since prices and income of different socioeconomic groups can be incorporated directly in the model. The first CGE model developed to explore questions of income distribution was the Adelman and Robinson (1978) model of South Korea and later, the Lysy and Taylor (1980) model of Brazil. The Adelman and Robinson model incorporates up to 15 household groups, adjusting capital stocks and

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[5]See Table 5 in Shoven and Whalley (1984) pp. 1007-1051, for more constructed tax models and summary of their features and main results.

labor supplies by skill type yearly in this model. Other models of this category have been constructed and applied to several other countries of interest. Examples of these models are de Melo and Robinson (1980) for Colombia, Bourguignon, et al (1983) for Venezuela, and Eckaus, Mohie-Eldin (1984) for Egypt, and Norton et al (1986) for Portugal.

4. Food Policy Models. Although most CGE models incorporate some agricultural policies, some of the models contain detailed specifications of the agricultural sector and food issues. In these models, the agricultural sector is disaggregated into several food processing and agricultural producing sectors in order to gain better insight about the impact of some policies on the agricultural sector. Some of them focus on the impact of food and fertilizer subsidies on some household classes and some agricultural products. Examples of these models are Duloy and Norton (1973) for Mexico and Norton (1985) for Bangladesh.

5. Energy Policy Models. The main policy focus of this group is on substitution possibilities for oil especially after the oil crisis of 1973. Hudson and Jorgenon (1974) conducted the first work in this area for the United States. Other models such as Berndt and Field (1981) and Borger and Goulder (1984) followed them.

<u>Developed and Developing Countries Classification</u>. There are a number of models that focus on issues that are more relevant to developed countries and also a number of models that are more relevant to developing countries. The literature survey presented above, as can be seen, is a mix of this class of models where some of them reflect the characteristics and policy issues in developed countries while others capture the special characteristics and policy issues in developing

countries. Issues related to the theory of public finance and international trade, etc. are under the main policy focus of developed countries. Issues related to income distribution, sectoral production adjustment, and international trade policies come under the main policy focus of developed countries, where trade policy issues are quite different from policy issues in developed countries. Shoven and Whalley (1984) provide a detailed survey of published work on CGE models which focus on issues of tax policy and international trade in developed countries. Devarajan, Lewis, and Robinson (1986) provide an extensive bibliography of published work on CGE models which focus on developing countries' issues. Table 2-1 summarizes some of these CGE applications.

Single and Multicountry Classification. Some CGE models are single-country types designed to investigate how developments abroad affect individual economies. Some others are multicountry models designed to analyze global issues such as the volume and direction of trade and their impact on particular regions. Multicountry CGE models also focus on the evaluation of tariff reductions and economic integration issues. Unlike in traditional Heckscher-Ohlin Samulson (HOS) trade model, both single and multicountry CGE models do not include the very restrictive assumption that production technologies are identical across trading partners. Therefore, differences in production technology in these models are another basis for trade to take place in addition to differences in relative factor endowments across trading countries. Another distinguishing feature of this CGE model is the use of the so-called Armington assumption which treats products as

TABLE 2-1

SUMMARY OF SOME DEVELOPING COUNTRIES' CGE MODELS

Country	Year	Author	Title
Algeria	1984	Alan Gelb and Patrick Conway	Oil Windfalls in a Controlled Economy: A 'Fix-Price' Equilibrium Analysis of Algeria
Brazil	1980	Frank J. Lysy and Lance Taylor	The General Equilibrium Income Distribution Model
	1985	Elisabeth Sadoulet	Investment Priorities and Income Distribution: The Case of Brazil in 1970
	1980	Lance Taylor, Edmar Bach, Eliana Cardoso and Frank J. Lysy	Models of Growth and Distribution for Brazil
	1985	Octavio A. F. Tourinho	Optimal Foreign Borrowing in a Multisector Dynamic Equilibrium Model: A Case Study for Brazil
Cameroon	1985	Nancy C. Benjamin and Shantayanan Devarajan	Oil Revenues and Economic Policy in Cameroon: Results from a Computable General Equilibrium Model
	1985	Nancy C. Benjamin and Shantayanan Devarajan	Oil Revenues and the Cameroonian Economy

TABLE 2-1 (Continued)

Country	Year	Author	Title
Chile	1985	Timothy Condon, Vittorio Corbo Jaime de Melo	Productivity Growth, External Shocks, and Capital Inflows in Chile During 1977-81: A General Equilibrium Analysis
	1985	Timothy Condon, Vittorio Corbo Jaime de Melo	Capital Inflows, the Current Account, and the Real Exchange Rate: Tradeoffs for Chile 1977-81
Costa Rica	1986	Rama Seth	Costa Rica: An Assessment of Alternative Borrowing Strategies
India	1985	Charles M. Becker, Edwin S. Mills, and Jeffrey G. Williamson	Modeling Indian Migration and City Growth 1960-2000
	1986	Pradeep Mitra and Suresh Tendulkar	Coping with Exogenous Internal and External Shocks: India, 1973-74 to 1983-84
Indonesia	1985	Alan Gelb	Are Oil Windfalls a Blessing or a Curse? Policy Exercises with an Indonesia-Like Model
	1985	Alan Gelb	The Impact of Oil Windfalls: Comparative Statics with an Indonesia-Like Model

TABLE 2-1 (Continued)

Country	Year	Author	Title
Ivory Coast	1984	Gilles Michel and Michel Noel	The Ivorian Economy and Alternative Trade Regimes
	1985	Benoit Morin and Michel Noel	Incentives Reform Strategies and Long-term Structural Adjustment in the Ivory Coast
	1984	Gilles Michel and Michel Noel	Short-Term Responses to Trade and Incentive Policies in the Ivory Coast: Comparative Static Simulations in a Computable General Equilibrium Model
Kenya	1986	Alan R. Roe and Shymalendu Pal	Kenya's Adjustment to the Oil Crises, 1972-82: A Further Analysis
South Korea	1978	Irma Adelman and Sherman Robinson	Income Distribution Policy in Developing Countries: A Case Study of Korea
Mexico	1983	Timothy J. Kehoe and Jaime Serra-Puche	A Computational General Equilibrium Model with Endogenous Unemployment: An Analysis of the 1980 Fiscal Reform in Mexico
	1984	Timothy Kehoe, Jaime Serra-Puche, and Leopoldo Solis	A General Equilibrium Model of Domestic Commerce in Mexico

TABLE 2-1 (Continued)

Country	Year	Author	Title
Mexico (continued)	1983	Jaime Serra-Puche	A General Equilibrium Model for the Mexican Economy
Nicaragua	1985	Bill Gibson	A Structuralist Macromodel for Post-Revolutionary Nicaragua
Norway	1960	Leif Johansen	A Multi-Sectoral Study of Economic Growth
Pakistan	1980	F. Desmond McCarthy and Lance Taylor	Macro-Food Policy Planning: A General Equilibrium Model for Pakistan
Senegal	1985	Hafez Ghanem	Senegal: A Study of Alternative Foreign Borrowing Strategies
Thailand	1984	Piyasvasti Amranand and Wafik Grais	Macroeconomic and Distributional Implications of Sectoral Policy Interventions: An Application to Tahiland
	1985	Shantayanan Devarajan and Hector Sierra	Growth Without Adjustment: Thailand, 1973-1982

TABLE 2-1 (Continued)

Country	Year	Author	Title
Thailand (continued)	1983	Arne Drud and Wafik Grais	Macroeconomic Adjustment in Thailand: Demand Management and Supply Conditions
	1982	Arne Drud, Wafik Grais and Dusan Vujovic	Thailand: An Analysis of Structural and Non-Structural Adjustments
	1981	Wafik Grais	Aggregate Demand and Macroeconomic Imbalances In Thailand: Experiments with the SIAM1 Model
	1986	Homi Kharas and Hisanobu Shishido	Thailand: An Assessment of Alternative Borrowing Strategies
Turkey	1978	Kemal Dervis and Sherman Robinson	The Foreign Exchagne Gap, Growth and Industrial Strategy in Turkey: 1973-1983
	1982	Kemal Dervis and Sherman Robinson	A General Equilibrium Analysis of the Causes of a Foreign Exchange Crisis: The Case of Turkey
	1984	Wafik Grais, Jaime De Melo and Shujiro Urata	A General Equilibrium Estimation of the Effects of Reductions in Tariffs and Quantitative Restrictions in Turkey in 1978
	1983	Jeffrey D. Lewis and Shujiro Urata	Turkey: Recent Economic Performance and Medium-Term Prospects, 1978-1990

TABLE 2-1 (Continued)

Country	Year	Author	Title
	1984	Jeffrey D. Lewis and Shujiro Urata	Anatomy of a Balance-of-Payments Crisis: Application of a Computable General Equilibrium Model to Turkey, 1978-1980
	1980	World Bank	Turkey: Policies and Prospects for Growth
	1986	Jeffrey D. Lewis	Coping With Adjustment: Turkey, 1973-1981

Source: Deravajan S., Lewis, J. and Robinson (1986).

heterogeneous rather than homogeneous as in HOS model.[6]

Barter and Monetary Models Classification. General equilibrium models can be either real models which exclude money and all financial assets or monetary models which incorporate all financial assets and their interaction with real variables in the system. However, the barter CGE model precludes any monetary issues, while under the monetary CGE model nominal prices are determined endogenously. Hence, causes of inflation and the effect of short-run stabilization policies can be analyzed. Economists have made attempts to extend the essentially microeconomic (barter) model to include monetary sector and macroeconomic behavior. There are, however, a few examples of these extended CGE models in the literature. Without specifying the money demand function explicitly, Dervis and Robinson (1978) introduce money creation in their model to finance the government deficit. Similarly, Lysy and Taylor (1980) include excess money supply implicity in their model. Applegate (1987) introduces a simple monetary equation which allows his model for Zambia to determine endogenously the general price level and nominal exchange rate, while Adelman and Robinson (1978) include a transaction money demand function for both households and firms. The money supply is exogenous and the economy achieves the money market equilibrium by adjusting the real cash balances rather than the interest rate.

Based on the focus of the investigation and time horizon of the issue, one may want to choose the most relevant model that fits the

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[6]For further features and more details see Shoven and Whaley (1984).

user's policy concern. For instance, the model may be monetary for the very short-run policy issues since there is a general agreement that money is much less neutral and therefore, more important in the short-run. For the medium and long-run policy issues, which is the case for most multisectoral planning models, one may want to use the relative price version instead (Dervis, de Melo, and Robinson, 1982, p. 152).

Model Type of the Present Study

The specific CGE model used in the present study is based on the open economy CGE developed by Dervis, de Melo, and Robinson (1982). To this core model a number of the features of the Saudi economy have been added to accommodate a variety of structural features and to provide a focus on the impact of the expatriate workers on the economy. In particular, the total labor supply and demand have been divided into domestic workers' supply and demand, and expatriate workers' supply and demand. Furthermore, the supply of expatriates is assumed to be perfectly elastic to reflect the fact that the country can import as much as it can at a given wage. Remittances are incorporated as part of the household income and the balance of payments equations to have a more precise specification of household domestic disposable income and also to measure their impact on the balance of payments. Oil and non-oil institutions have been incorporated following a social accounting matrix (SAM) framework.

The model is static and does not include dynamic processes such as technology, population, and capital stock changes.

In the next section, we describe the core CGE model that is applied to Saudi Arabia and used to simulate the impact of the expatriate workers on the economy.

The Model Construction

Basic Structure of a CGE Model

There are four main components that need to be specified in an applied CGE model. These main components are economic actors, behavioral rules, market adjustment mechanisms, and the institutional structure of the economy.

1. The economic actors or agents in the economy. Generally, these agents include consumers, producers, government, and the rest of the world. As mentioned earlier, this study includes two additional agents, oil and non-oil producers following the SAM framework.

2. Behavioral rules that govern the motivation of the various economic actors in the economy. The motivation of all economic actors is based on independently pursued optimization behavior in the economy. Assumedly, producers should maximize profits subject to technological constraints and consumers should maximize utility subject to their budget constraints.

3. Market adjustment mechanism. In CGE models, prices are the only signal agents need to know.

4. The institutional structure of the economy. The markets in CGE models are assumed to be perfectly competitive which amounts to assuming that all agents are price takers.

5. Equilibrium conditions. These are, in fact, system constraints that must be satisfied, and these conditions imply that quantity demand equals quantity supplied for all goods and factors in the system. These conditions also imply that producers receive no excess profits and all

agents are on their budget constraints. Furthermore, these system constraints are independent of any actor in the economy in making his or her economic decisions. Therefore, the equilibrium conditions can be defined as a set of signals in the economy such that the resulting decisions of all independent economic actors maximizing their profit and utilities given system constraints are reconciled.

Given the specified behavioral rules, institutional structure, economic actors, and the adjustment mechanism, the CGE model endogenously determines a set of prices which clear all markets in the system simultaneously. There are, in fact, three types of markets in the system, labor, output, and foreign exchange markets. Thus, the CGE model provides a set of equilibrium wages, product prices, and exchange rate (assuming flexible exchange rate) such that all markets are cleared simultaneously.

Therefore, prices are the adjusting mechanism that provides a general equilibrium between quantity supplied and quantity demanded in all markets. Domestic production and imports are the main components of total supply, while consumption, investment, intermediate, and government demands are the main components of total demand in addition to exports. Therefore, it is necessary to specify how each of the above mentioned components of both supply and demand relies on prices.

Mathematical Presentation of the Saudi CGE

This section gives a mathematical description of the static CGE model of Saudi Arabia. The subscripts i and j refer to sectors and the subscript s refers to the labor skill category. There are n sectors where n = 11 and s labor categories where s = 3. The price structure production and employment, income determination and demand for commodity, foreign trade and supply-demand balance are the major components of the model.

Prices. There are four price equations in the model that are used for different purposes. These prices are the domestic price of imports, PM_i, the world price of exports, PW_i, the composite goods price, P^i, and the value added or net price equations, PN_i. In addition to these four price equations, there are the sectoral domestic prices which are determined endogenously to clear the product markets.

The domestic price of imports (PM_i) is given by equation (1),

$$PM_i = \overline{PW}_i \ (1 + tm_i) \ \overline{ER} \tag{1}$$

where $\overline{PW}_i$ is the fixed world price of imports in "dollars" tm_i and $\overline{ER}$ are the fixed tariff and exchange rate (SR/$) respectively.[7]

Equation (2) defines the price of exports (PWE_i), in "dollars".

$$PWE_i = \frac{PD_i}{(1 + te_i)\overline{ER}} \tag{2}$$

where PD_i is the domestic price and te_i is the export subsidy rate.

The classical theory of international trade specifies that imports and domestic products are perfect substitutes, so the domestic consumer does not differentiate between them since both are homogeneous and equal in cost. However, one of the fundamental assumptions in the recent CGE models is what is called in literature the Armington assumption.

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[7]SR is the abbreviation for Saudi Riyal.

According to this assumption, domestically produced and foreign goods of the same sector category are heterogeneous rather than homogeneous. This assumption implies that imports and domestic goods are assumed to be imperfect substitutes. The implications of this imperfect substitutability are as follows:

1. For each tradable commodity category, the consumers are confronted with a composite commodity in which imports and domestic goods are combined according to a trade aggregation function such as a CES function.

2. This specification also implies that the domestic price of a traded good (PD_i) does not need to be equal to its world price (PM_i), which is a major departure from the classical theory of international trade.

Assuming that domestic consumers seek to minimize the cost of acquiring a given amount of the composite goods, given their budget constraints, the resulting first order conditions can be solved to yield the following price equation for the composite goods price (P_i),

$$P_i = \frac{1}{\epsilon_i} \left[\delta_i^{\sigma_i} PM_i^{1-\sigma_i} + (1 - \delta_i)^{\sigma_i} PD_i^{1-\sigma_i} \right]^{\frac{1}{1-\sigma_i}} \tag{3}$$

where σ_i is the trade elasticity of substitution between import and domestic goods and δ_i is the distribution parameter for CES a aggregation of imports and domestic output.

The net price (PN_i) or value added in sector i is obtained by subtracting from the domestic price the per unit indirect taxes and the per unit intermediate input purchases or by adding the subsidies, if any, to the domestic price.

$$PN_i = PD_i - td_i PD_i - \sum_j a_{ji} P_j \tag{4}$$

where td_i is the indirect tax rate and a_{ji} is the fixed input-output coefficient.

Production and Employment. Another important aspect of the model includes production and employment. The production side of the Saudi economy is disaggregated into eleven sectors, where each sector produces a homogenous output (X_i). The sectoral production technology is described by a two-level Cobb Douglas function of primary inputs (capital and labor) and a Leontief function of intermediate inputs,

$$X_i = \Omega_i \, L_i^{\alpha_i} \, \overline{K}_i^{\beta_i} \tag{5}$$

$$V_i = \sum_j V_{ij} = \sum_j a_{ij} \, X_j \tag{6}$$

where

X_i = sectoral output

Ω_i = productivity parameter in production

α_i, β_i = output elasticity with respect to labor and capital respectively

L_i = aggregate sectoral labor

$\overline{K}_i$ = sectoral capital stock

V_i = an aggregation of intermediate inputs

which implies substitutability for primary inputs and fixed coefficients for intermediate inputs. It is assumed that capital is fixed while labor is mobile across sectors. Given fixed capital stocks by sectors, the rental rate is assumed to differ across sectors. The labor market for each category is always assumed to be at full employment, which reflects the reality in an oil-labor short economy. The wages are assumed to adjust so that the demand for labor equals the supply for each category of labor. Given labor mobility across sectors, the nominal wages are assumed to be equal across all sectors for the same skill.

The labor market is segmented with three distinct labor skills. They are skilled, semiskilled, and unskilled labor.[8] The total sectoral labor input (L_i) is assumed to be an aggregation of the above three labor categories. This labor aggregation is also assumed to follow a Cobb Douglas aggregation form,

$$L_i = L_{i1}^{\alpha_{i1}} L_{i2}^{\alpha_{i2}} L_{i3}^{\alpha_{i3}} \quad (7)$$

which allows substitutability among labor skills, where L_{i1}, L_{i2}, L_{i3} are the skilled, semiskilled and unskilled labor respectively. The parameters α_1, α_2, α_3 are the proportions of skilled, semiskilled, and unskilled labor respectively in the total labor force of each sector.

The labor demand functions are derived implicitly from the behavior of the producers who are assumed to maximize their profits,

[8]Each skill level is an aggregation of the following:

Skilled = Professional & Technical and Administrative & Managerial workers,
Semiskilled = Clerical, Sales, and Production & Transportation workers,
Unskilled = Service and Farmers & Fishermen workers.

$$VMP_{L_s} \equiv PN_i \frac{\partial X_i}{\partial L_{is}} = W_s \quad (8)$$

Given the production technology and the institutional assumption of competitive labor and product markets, profits are maximized by equating the value of the marginal product of each labor category (VMP_{L_s}) to its nominal wage rate (W_s).

The decomposition of the total labor force into domestic and expatriates is incorporated in the model as follows: the total labor force of skill S ($\sum_i L_{is}$) is the sum of both total domestic ($\sum_i L^h_{is}$) and expatriate ($\sum_i L^e_{is}$) labor force in the corresponding skill,

$$\sum_i L_{is} = \sum_i L^h_{is} + \sum_i L^e_{is} \quad (a)$$

Total domestic labor demand, therefore, is defined as,

$$\sum_i L^h_{is} = \sum_i L_{is} - \sum_i L^e_{is} \quad (b)$$

where,

$$\ell_{is} = \frac{L^e_{is}}{L_{is}} \quad (c)$$

The parameter, ℓ_{is}, is interpreted as the participation rate of expatriate workers in the total labor force. Therefore, total expatriate labor demand of skill s can be expressed as,

$$L^e_{is} = \ell_{is} L_{is} \quad (d)$$

Solving equation (d) for L_{is} and substituting for L_{is} in equation (7) and (8) one obtains the following new form of labor aggregation and labor demand equations,

$$L_i = \left(\frac{1}{\ell_{i1}} L_{i1}^e\right)^{\alpha_{i1}} \left(\frac{1}{\ell_{i2}} L_{i2}^e\right)^{\alpha_{i2}} \left(\frac{1}{\ell_{i3}} L_{i3}^e\right)^{\alpha_{i3}} \qquad (7)'$$

$$PN_i \frac{\partial X_i}{\partial\left(\frac{1}{\ell_{is}} L_{is}^e\right)} = W_s \qquad (8)'$$

Domestic labor demand equation (b) can be rewritten as follows, after substituting for L_{is}^e from equation (d)

$$\sum_i L_{is}^h = \sum_i L_{is} - \sum_i \ell_{is} L_{is}$$

$$\sum_i L_{is}^h = (1 - \ell_{is}) \sum_i L_{is} \qquad (e)$$

Equation (e) defines the domestic labor demand of skill s as a function of the proportionality coefficient (ℓ_{is}). Therefore, the demand for domestic workers of skill s will be higher if the proportionality coefficient is lower and vice versa.

The expatriate labor supply of all skill levels is assumed to be perfectly elastic; there is no limitation on its supply since the country can import as much as it wants at a given wage rate. However, domestic total labor supply of all skill levels is assumed to be fixed and, when in equilibrium, must be equated to the total demand for domestic workers of all skill levels. Therefore, solving equation (d) for L_{is} and substituting for L_{is} in equation (e) obtain equation (9) which is nothing more than the supply-demand balance equation of domestic labor of skill s.

$$\sum_i \frac{1}{\ell_{is}} L^e_{is} - \sum_i \ell_{is} \frac{1}{\ell_{is}} L^e_{is} = \bar{L}^h_s$$

$$\sum_i \frac{1}{\ell_{is}} L^e_{is} - \sum_i L^e_{is} = \bar{L}^h_s \tag{9}$$

In order for labor market to be in equilibrium, the total demand (across sectors) for each category of domestic workers (s) must equal total available domestic labor of that category ($\bar{L}^h_s$). Given the assumption of full employment of all categories of domestic labor, the wage rate for each type of labor will adjust until the sum of sectoral demand for each skill equals the fixed supply of the corresponding skill.

As equation (9) shows, the participation rate of the expatriate workers in each sector and for each skill (ℓ_{is}), plays an important role in the equilibrium of the labor market. The coefficient ℓ_{is} is a government policy variable and hence, a decrease in ℓ_{is}, given other things fixed, leads to an increase in the demand for domestic workers, so nominal wages adjust to clear the labor market.

Demand for intermediate inputs is assumed to be given by fixed input-output coefficients, in which case equation (6) is a function only of output.

Equations (5), (7),and (8) show how the output supply vector (X_i, i = 1...n) depends on the vector of prices that is prevailing in the market. Given an initial domestic commodity price vector (PD_i, i = 1...n), production technology, production vector (X_i, i = 1...n), and sectoral capital stock, producers will maximize their profit by equating the VMP_{L_s} with the wage of skill s according to equation (8). The solution begins with an initial vector of domestic prices. The model uses equation (8) to compute the labor demand vector (L_{is}, ..., L_{ns}) at the given initial domestic price vector. The computed labor demand vector is then used as an input which determines production. If the new level of output vector is not consistent with the initially given vector, then a new labor demand vector is generated. This new labor demand vector is used to calculate a new level of output vector. The iteration continues in this fashion where labor vector that is demanded depends on production vector, and production vector depends on the labor vector that is demanded. This iteration continues until labor demand and output vectors converge, and they are consistent with each other at the given domestic commodity prices. Thus, the dependence of the supply vector of outputs on the commodity price vector, $X_i(PD_1, \ldots, PD_n)$, is established. From the above discussions, it is evident that $n \cdot s + n + s$ equations need to be solved for the $n \cdot s + n + s$ variables -- sectoral by skill expatriate labor demand (L^e_{is}), sectoral production (X_i), and nominal wage of each labor category (W_s).

As a result of the computed equilibrium values for sectoral outputs and the associated demand for factors, a stream of factor incomes is generated. Labor income is determined explicitly through the solution value of wages, while capital income is determined residually by subtracting the labor income from the computed total value added. The discussion, consequently, leads to an analysis of income determination and demand in the system.

Income Determination and Demand for Commodity. There are four kinds of recipients of income in the Saudi Arabian CGE model. These recipients are: households, government, oil sector, and non-oil sectors. The last two recipients are basically incorporated in order to determine how value added or factor income obtained from the solution is distributed among the first two recipients (households and government).

The model specifies only one representative household in the economy. The income of this representative household is defined as the gross domestic product (GDP) minus all incomes and taxes that do not accrue to households. Specifically, the total household disposable income (Y^h) is defined as,

$$Y^h = GDP - REM - Y_k^{oil} - Y_k^{noil} - \overline{NTPROPAI} - INDTAX + \overline{GTRAH} \qquad (10)$$

where

REM = remittances

Y_k^{oil} = oil capital income

Y_k^{noil} = non-oil capital income

$\overline{NTPROPAI}$ = net property and entrepreneural income

$INDTAX$ = indirect taxes less subsidies

$\overline{GTRAH}$ = government transfers to households.

Gross domestic product is defined as the sum of the value of all sectoral output minus the value of intermediate input plus payments to government employees and tariff revenues.

$$GDP = \sum_j PD_j X_j - \sum_j \sum_i a_{ij} (PD_j X_j) + \overline{WAG^g} + \sum_j PW_j tm_j M_j \qquad (11)$$

where $\overline{WAG}^g$ is the payment to government employees.

According to the Saudi SAM, oil capital income (Y_k^{oil}) is defined as follows,

Y_k^{oil} = value added of oil sectors - labor payments by oil sectors - indirect taxes on oil sectors - adjustment factor.

or

$$Y_k^{oil} = \sum_{j=2,4} v_j PD_j X_j - \sum_s \sum_{j=2,4} \frac{1}{\ell_{js}} L_{js}^e W_s - \sum_{j=2,4} td_j PD_j X_j$$

$$- g_1 PD_4 X_4 \qquad (10\text{-}a)$$[9]

where $v_j = 1 - \sum a_{ij}$, sectoral per unit value added. The parameter g_1 is a term introduced in this study to adjust for the data discrepancy between the oil sectors' capital income shown by the SAM and the standard definition that Y_k^{oil} is equal to the oil sectors' value added net of labor and indirect tax payments. The fact that part of the petroleum refining capital income finds its way to the private sector, who owns part of its capital stock, might justify the addition of the last term in equation (10-a).[10]

Similarly, non-oil capital income (Y_k^{noil}) is determined as,

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[9] j=2,4 means summing over crude oil sector (2) and petroleum refining sector (4). The numbers (2,4) are these sectors' order in the input-output Table.

[10] g_1 = Value added of oil sectors - labor payments by oil sector - indirect taxes on oil sectors divided by Y_k^{oil}.

Y_k^{noil} = value added of non-oil sectors - labor payments by non-oil sectors + subsidies to non-oil sectors - adjustment factor.

or

$$Y_k^{noil} = \sum_{j \neq 2,4} v_j PD_j X_j - \sum_s \sum_{j \neq 2,4} \frac{1}{\ell_{js}} L_{js}^e W_s - \sum_{j \neq 2,4} td_j PD_j X_j$$

$$- g_2 \sum_{j \neq 2,4} PD_j X_j \qquad (10\text{-b})^{11}$$

The addition of the adjustment parameter (g_2) might be due to the fact that some of the income remaining with non-oil sectors enterprises after they have distributed wage incomes to their workers is assumed to be retained by the enterprise for investment expenditure in fixed capital.

Finally, indirect taxes are defined by

INDTAX = import tariffs - subsidies

or

$$INDTAX = \sum_j tm_j M_j \overline{PW}_j \overline{ER} - \sum_j td_j X_j \qquad (10\text{-c})$$

For the model to capture the impact of expatriate remittances on household disposable income, the expatriates' transfers abroad (REM), which are the second term in equation (10), have been subtracted. The equation on remittances is,

$$REM = r \sum_s \sum_i L_{is}^e W_s \qquad (10\text{-d})$$

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[11] g_2 = Value added of non-oil sectors - labor payments by non-oil sector - indirect taxes on non-oil sectors divided by Y_k^{noil}.

The term $\sum_s \sum_i L^e_{is} W_s$ is the expatriate workers' total wage income, and r is the proportion of expatriates' incomes that are remitted abroad. Specifically, the parameter r is the base year ratio of expatriate remittances relative to their total income.

The net property and entrepreneural income (NTPRPAI) and the government transfers to households (GTRAH) are assumed exogenous.

The income flowing into the government budget (GR) is a collection of government income taxes, tariffs, and the interest earnings on government oil revenue surplus invested abroad.

GR = Oil exports taxes + non-oil income tax + household income tax + tariffs + interest earnings on government oil revenue surplus invested abroad.

$$GR = t_1\{\sum_{j=2,4} (\frac{PD_j}{1+te_j})(e_j X_j)\} + t_2\, Y_k^{noil} + t_3 Y^h + \sum_j tm_j\, \overline{PW}_j \overline{ER} + \overline{GTRAINRW} \qquad (11)$$

where

t_1, t_2, and t_3 = government tax rates on oil exports, non-oil, and household incomes respectively.

e_j = base year share of exports in total domestic production.

By virtue of the government's complete ownership of oil fields, oil revenues (the first term on the right hand side of equation 11) is the main source of government revenue. During the 1970s and the early 1980s, the share of the oil sector on the average amounted to 93 percent of the government's revenues (Tawi, S., 1984, p. 78).

Household income tax in many countries plays an important role in financing government expenditure. However, this is not the case in Saudi Arabia. The share of this component is almost negligible and it consists of a uniform rate of 2.5 percent levied on the total income minus fixed assets of Saudi Arabian nationals. Most of this tax (Zakah) is paid by the individuals themselves voluntarily as a religious duty to the poor which might explain why its value (t_3) based on data is much lower than 2.5 percent (.03 percent). Similarly, custom duties also have a very low share, compared to those of other countries.

Equation (12) is the investment-saving balance where investment is assumed to be saving determined. The saving is the sum of oil sector, non-oil sector, public, private, and foreign capital inflow.

$$INV = SAV^{oil} + SAV^{noil} + SAV^{g} + SAV^{p} + S^{f} - \overline{CHS} \qquad (12)$$

where $\overline{CHS}$ is the change in stock. The balance (closure rule) of oil sector and non-oil sector accounts is done on their savings, while the balance of government and household budgets is done on their consumption. The following two identities, which define the oil and non-oil savings, are derived from the country SAM,

SAV^{oil} = Oil Capital income - Government tax on oil exports - oil transfers to the rest of the world.

$$SAV^{oil} = Y_k^{oil} - t_1\{\sum_{j=2,4}(\frac{PD_j}{1+te_j})(e_jX_j)\} - \overline{OTRAROW} \qquad (12\text{-a})$$

SAV^{noil} = Non-oil capital income + Government transfers to non-oil sector - Government tax on non-oil capital income - Non-oil sector's transfers to the rest of the world.

$$SAV^{noil} = Y_k^{noil} + \overline{GTRANOIL} - t_2 Y_k^{noil} - \overline{NOTRAROW} \qquad (12\text{-b})$$

where $\overline{GTRANOIL}$ and $\overline{NOTRAROW}$ are the government transfers to the non-oil sector and non-oil sector's transfers to the rest of the world respectively. All other terms are defined earlier. Government and household savings (SAV^g, SAV^P) are specified as a fixed fraction of their corresponding income,

$$SAV^g = S_g GR \qquad (12\text{-c})$$

$$SAV^P = S_P Y^h \qquad (12\text{-d})$$

where S_g and S_P are the exogenous saving rates of the government and the households respectively.

After determining the income of the different economic agents net of savings, the residual is spent on consumer goods. Specifically, household and government total consumptions are defined in equations (13) and (14) respectively.

$$C^g = GR - \overline{WAG^g} - \overline{GTRANOIL} - \overline{GTRAH} - S_g GR$$

$$+ \sum_j td_j (PD_j X_j) - \overline{GTRAOUT} \qquad (13)$$

$$C^P = (1 - S_p - t_3)\ Y^h - \overline{HTRAROW} \tag{14}$$

Equation (13) determines the government demand for consumer goods. It adds the indirect tax revenue to the government's total revenue and subtracts from the government's total revenue the wage payments to government employees ($\overline{WAG^g}$), government transfers to non-oil sectors ($\overline{GTRANOIL}$), government transfers to individuals ($\overline{GTRAH}$), government savings, and government transfers abroad ($\overline{GTRAOUT}$). Similarly, equation (14) determines the household total consumption expenditure. It subtracts from the total income, the household income tax, household savings, and the household transfers to the rest of the world ($\overline{HTRAROW}$)

Sectoral investment demand is assumed to be a fixed share (γ_j) of aggregate investment (INV), where the factor of proportionality is the base year sectoral investment allocation shares,

$$INV_i = \gamma_i INV \tag{15}$$

Similarly, the sectoral allocation of both government and household consumption is defined in equations (16) and (17):

$$C_i^g = \theta_i C^g \tag{16}$$

$$C_i^P = q_i C^P \tag{17}$$

where θ_j and q_i are the base year fixed expenditure shares spent on good i.

These demand functions of households, government, etc., are all price sensitive to the set of commodity prices in the system. This price sensitivity is because income of these different consuming agents is determined either explicitly or implicitly by factor income which, in turn, is fully determined by commodity prices.

Foreign Trade. In the traditional theory of international trade, products in the same categories across trading partners are assumed to be either perfect substitutes or perfect complements. These two extreme assumptions lead to the conclusion that either price of imports and domestic products is identical (for perfect substitution) or there is a great deal of price rigidity (for perfect complementary) to any trade policy changes. In reality, differences in quality and aggregation methods are frequently observed between imports and domestic substitutes. Therefore, a more realistic assumption is obviously somewhere in between the above two extremes. Following Armington (1969), who applied imperfect substitutability in deriving partial equilibrium demand functions, Dervis et al. (1982) were the first to introduce this concept in a CGE model.

Imports and domestic goods are combined according to a CES trade aggregation function, with domestic consumers demanding the resulting composite commodity (Q_i). Mathematically, this aggregation takes the following form for each tradable commodity category.

$$Q_i = \overline{\beta}_i[\delta_i M_i^{-\rho} + (1 - \delta_i)D_i^{-\rho}]^{-\frac{1}{\rho}} \quad (18)$$

where $\overline{\beta}_i$ is constant, δ_i is the factor share parameter, and the trade elasticity of substitution between imports and domestic products (σ_i) is given by $\sigma_i = \frac{1}{1 + \rho_i}$.

Given equation (18), the standard assumption of utility maximization, and the specified prices for the imported (PM_i) and domestic goods (PD_i), the problem facing the domestic consumers is to maximize Q_i subject to their budget constraint.[12] By solving the first order condition which equates the marginal rate of substitution between imports and domestic products to the ratio PM_i/PD_i, the import demand function is obtained (see Appendix B for the derivation of the function).

$$\frac{M_i}{D_i} = \left(\frac{PD_i}{PM_i}\right)^{\sigma_i} \left(\frac{\delta_i}{1 - \delta_i}\right)^{\sigma_i} \tag{19}$$

The trade elasticity of substitution (σ_i) determines the ease with which the import-domestic products demand ratio (M_i/D_i) adjusts in response to changes in relative prices (PD_i/PM_i). The higher the magnitude of σ_i, the greater the sensitivity of imports to changes in relative prices (PD_i/PM_i) and hence, its share relative to domestic products. Therefore, trade policies, such as tariffs or exchange rate devaluation, can create a divergence between PD_i and PM_i and hence, become more effective in providing domestic protection or production structural changes given that σ_i is between zero and infinity exclusively.

Exports are assumed to be proportional to total domestic output

$$E_i = e_j\left(\frac{PD_j}{(1 + te_j)} X_j\right) \tag{20}$$

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[12]The consumer constraint is $PD_i \cdot D_i + PM_i \cdot {}_i = P_i \cdot Q_i$.

where the factor of proportionality is e_j, the base year share of sectoral exports in sectoral total production.

Equation (21) below gives the balance of payments constraint.

$$S^f = \sum_j \overline{PW}_i M_i \overline{ER} - \sum_j e_j \left(\frac{PD_j}{(1 + te_j)} X_j\right) + r \sum_j \sum_s L^e_{js} W_s$$

$$+ \overline{NTPROPAI} + \overline{NTRAPAI} + \overline{DPABRH} + \overline{GTRAOUT} \qquad (21)$$

where one incorporates remittances in the balance of payments' equation to reflect the impact of expatriate workers' transfers to their home countries on the balance of payments. The exogenous terms $\overline{NTRAPAI}$ and $\overline{DPABRH}$ are current transfers abroad and direct purchases abroad by the resident households respectively.

There are two alternative closure rules or mechanisms by which the equilibrium in the balance of payment of a CGE model can be achieved.

1. Assume fixed foreign capital inflow and let the nominal exchange rate adjust in order to achieve equilibrium in the foreign exchange market. Given an index of domestic prices as numeraire, changes in nominal exchange rate affect the domestic currency price of imports and exports relative to that of domestic sales and hence, result in changes in imports and exports.

2. Assume a fixed exchange rate and let foreign capital inflow adjust to achieve balance of payments equilibrium.

The present study chooses the second closure rule to suit the actual conditions of the Saudi economy.

Supply-Demand Balance. The various components of both supply and demand functions are all price sensitive functions as have been discussed earlier. Therefore, the general equilibrium condition is defined as a set of domestic prices such that sectoral supplies and demands are equal. But the model assumes that all components of sectoral demand are of the composite commodity (Q_i). Thus, part of the demand is satisfied by domestic production (D_i), while the rest of it is satisfied through imports (M_i). A factor of proportionality (d_i) can transform the composite commodity demand to the derived demand net of imported component (D_i).

Solving the first order condition derived from the consumers' optimization of Q_i, in equation (18), yields the desired ratio of domestic to composite goods (d_i),

$$d_i = \frac{D_i}{Q_i} = \left(\frac{P_i}{PD_i}\right)^{\sigma_i} (1 - \delta_i)^{\sigma_i} \beta_i^{\sigma_i - 1} \tag{22}$$

which is function of the relative cost of imports and domestic goods (see Appendix B for the derivation of this equation).

Therefore, the demand functions for composite commodities (equations (6), (15), (16), and (17)) can be transformed into demand for domestically produced commodities as follows:

$$D_i = d_i(V_i + C_i^g + C_i^P + INV_i) \tag{23}$$

where d_i is assumed the same for each component of demand.

Adding foreign demand of domestically produced goods (exports) to equation (23) obtains equation (24),

$$X_i^D = D_i + E_i \tag{24}$$

which is the total demand for domestic commodities.

Because all arguments of equation (24), including d_i, are functions of domestic prices, equation (24) can be rewritten as

$$X_i^D(PD_1, \ldots, PD_n) \qquad (25)$$

The general equilibrium condition requires that the following sectoral excess demand functions are zeros,

$$X_i^D - X_i = 0 \qquad (26)$$

Therefore, one has n of excess demand functions in n variables where the n variables are the domestic commodity prices.

The excess demand functions in equation (26) have the following important properties:

1. They are homogeneous of degree zero in all prices and can not be solved for the overall nominal price level since an infinite number of price vectors can be used to solve this system of equations.[13]

2. By Walras Law, there is a functional dependency in the system, i.e. there is only n-1 independent excess demand equations, and hence, one can only solve the model for relative prices. The price of oil is fixed and resulting in n-1 independent equations in n-1 variables where these n-1 variables are the commodity relative prices.[14]

Because the exchange rate is fixed in addition to the price of oil

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[13]For a proof of zero degree of homogenaty see Dervis et al (1982), p. 149.

[14]$PD^{oil} = \overline{ER}\ \overline{\Pi}^{oil}$, where $\overline{\Pi}^{oil}$ is the fixed world price of oil.

then not all markets are necessarily cleared. Therefore, the slack variable is added to the supply-demand balance equation for the oil sector.

Therefore, the choice of this numeraire closes the system, and the equations (1) through (26) represent the Saudi static computable general equilibrium model.

In the next chapter, this Saudi CGE model is used for comparative static simulations concerning the impact of the expatriates on the economy of Saudi Arabia.

This comparative static analysis starts with the assumption that the economy is initially in the position of internal and external equilibrium with the demands for all commodities equal to their supplies. Based on some chosen year's data (1981), using the GAUSS software package the model is calibrated in such a way that the following conditions are simultaneously satisfied:

1. Zero excess demand in all commodity markets.
2. Zero profit in all factor markets.
3. External sector balance.
4. Prices are equal to 1.

This benchmark equilibrium solution serves as a reference run to which some policy simulation activities can be compared, which is the subject of the next chapter.

CHAPTER III

ANALYSIS OF RESULTS

Introduction

This chapter discusses and analyzes the results of some comparative static experiments using the model developed in Chapter II. In particular, the scope of the analysis shall be limited to the effects of the following four experiments: (1) Experiment Number 1 - reducing the participation rate of expatriates for all skills and across all sectors; (2) Experiment Number 2 - reducing the participation rate of expatriates across all sectors for each skill separately; (3) Experiment Number 3 - substituting the necessary capital for the reduction in the participation rate of expatriates in order to maintain the same level of sectoral outputs; (4) Experiment Number 4 - determining the effect of devaluation on remittances.

Experiment Number 1

In this experiment the model was used to test the effect of a 15 percent reduction in the participation rate of expatriates across all sectors and for all skills. The choice of the 15 percent reduction is arbitrary merely to illustrate how the different variables in the model react to such a constraint.

Constraining the inflow of the expatriate supply in the economy, given other factors of production are fixed, should generate shortages in available goods and services because less resources are available for production. A tendency for an excess demand in the product market is generated as a result of this resource constraint which results in high domestic prices of these goods. However, looking from a more general perspective, restricting the imported labor supply with full employment may result also in a reduction in worker income and so reduces the demand for goods and services. Consequently, the decrease in the demand for goods and services will result in lower prices. Therefore, the net result will depend on the relative impact of both supply and demand and the interaction between them.

The following is a brief discussion of some of the highlights of Experiment Number 1. This discussion will focus first on changes in some macroeconomic variables in the Saudi economy which are summarized in Table 3-1. They are gross domestic product (GDP), household income, government income, household consumption, government consumption, total investment, foreign savings, and remittances.

The restriction of the expatriate inflow into the country reduces real GDP by 3.8 percent. It also forces a reduction in the economy's capacity for employment which results in a decline in real household income by 5.2 percent. It should be noted that annual wage income, a significant source of household income, has decreased (from SR60,927 to SR58,838 million) in spite of the higher equilibrium average wage, thus leading to the real household income decline. This decrease in annual wage income results from the fact that the overall percentage decrease in employment of different skills is greater than the overall percentage increase in the average wage of labor skills. The consequence of the reduction in household income is manifested in a reduction in real

TABLE 3-1

EXPERIMENT NUMBER 1: CHANGES IN SOME MACROECONOMIC VARIABLES RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EXPATRIATE LABOR

Variable	Percentage Change (Nominal)	Percentage Change (Real)
GDP	-2.4	-3.8
Income:		
household	-3.4	-5.2
government	-1.5	-2.9
Consumption:		
household	-3.4	-5.2
government	-2.96	-4.4
Total Investment	-15.1	-16.5
Foreign Savings	-6.5	-5.1
Remittances	-17.9	-19.3

household consumption which decreased by 5.2 percent.[1]

Real government income decreased by 2.9 percent for several reasons. The decrease in total imports reduced the government tariff revenue. A second reason is the reduction in the government tax revenues generated from the incomes of the oil sector and the non-oil sectors due to the reduction in their outputs. Finally, the reduction in the household wage income reduced the household income tax. Government consumption also decreased by 4.4 percent as a result of the decrease in revenue.

The restriction on the expatriate inflow has a negative impact on investment. As indicated, the economy registered a 16.5 percent decrease in real investment (see Table 3-1). Investment here is assumed to be saving determined. Saving from the oil sector has increased slightly, only by .05 percent. However, the decrease in foreign saving (6.5 percent), household saving (3.5 percent), government saving (1.5 percent), and non-oil sector saving (15.9 percent) have strongly outweighed the increase in the saving of the oil sector. The main reason for the increase in the oil saving is due to the insensitivity of oil production and, hence, its income to restrictions of labor supply. On the other hand, payments of this sector (wages, indirect taxes, etc.) have gone down faster than the reduction in its income which resulted in increased saving.

The exchange rate is assumed to be fixed. Foreign savings are assumed to adjust in order to neutralize the trade balance effect.

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[1]Household consumption fell by the same percentage as the decrease in household income. This is because the latter is specified to be a fixed fraction of the former.

Given this closure rule, the restriction on the expatriate inflow generates a 6.5 percent decrease in the foreign savings. The decomposition of improvement in trade balance may be shown as follows:

1) Expatriates' remittances have decreased by 18 percent (from SR4,175 to SR3,427 million) as a result of the direct effect of the decrease in their supply and, hence, their total transfers abroad.

2) Total imports have decreased by 10 percent (from SR111,854 to SR100,839 million) as a result of the decrease in aggregate demand which, in turn, reflects the overall decrease in consumption and total investment.

Export earnings have also decreased, but only by .05 percent (from SR360,858 to SR358,889 million) which is not strong enough to outweigh the two improving factors mentioned above. The reduction in exports comes about as a result of the sectoral output reduction of which exports are just a fixed fraction. The reduction in government and household savings is simply due to the reduction in their incomes of which savings are a fixed fraction.

The sectoral breakdown of some variables, such as prices, output, and trade changes in the economy, is now discussed. Starting with changes in the prices of domestic and composite goods the following aspects deserve to be noted with respect to the changes in their equilibrium values as shown in Table 3-2:

1) In some sectors (petroleum refining, trade, finance) the change in their equilibrium prices in reference to benchmark values are negative while others show a positive change. One possible explanation for this outcome may be due to the role of the market clearing process which is one of the key features in the general equilibrium model. In

TABLE 3-2

EXPERIMENT NUMBER 1: CHANGES IN PRICES RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EXPATRIATE LABOR

Sector	Percentage Change in Domestic Goods Price	Percentage Change in Composite Goods Price	$\frac{M}{Q}$
	(1)	(2)	(3)
Agriculture	6.8	1.1	.33
Crude Oil	0.0	0.0	0.0
Mining and Quarrying	12.5	10.6	.06
Petroleum Refining	-1.3	-1.3	0.0
Manufacturing	16.2	.003	.86
Utility	14.9	14.9	0.0
Construction	6.0	6.0	0.0
Trade	-0.8	-0.8	0.0
Transportation	11.4	8.4	.09
Finance	-2.1	-2.1	0.0
Community Social and Personal Services	9.8	9.8	0.0

particular, the price level will adjust iteratively in each sector in response to any excess demand resulting from constraining its labor endowment.

2) The change in the equilibrium price in the oil sector is zero. This fact can be explained by the model's structure which indicates that oil prices are externally dependent on the OPEC price agreements at least until the early 1980's.

3) The increase in domestic goods prices in relation to foreign goods prices is a very important factor in determining the pattern of the prices of composite goods. The composite price in the traded sectors (agriculture, mining and quarrying, manufacturing, and transportation) show relatively lower increases (1.1, 10.6, .003, 8.4) compared to their domestic price increases (6.8, 12.5, 16.2, 11.4) for the same sectors. This finding is due to the fact that traded components are held constant at their world prices; thus only their domestic price components respond to the generated domestic excess demands due to sectoral output supply restrictions.

4) The pattern of change in the composite prices of the import sectors are inversely related to the share of imports in total composite commodity demand. This conclusion is derived from comparing the values shown in the second and third columns in Table 3-2. The manufacturing sector, which imports 86 percent of its total domestic demand, exhibits the least increase in its composite price (.003 percent) in comparison with the other importing sectors. Although the domestic price increase of 16 percent in this sector is the highest among all sectors, its domestic production represents only 14 percent of the total supply of manufacturing goods. This extreme dependence on foreign sources makes

it less exposed to domestic inflation because the price of the remaining 86 percent is insensitive to domestic price changes. The examination of the other three import sectors (agriculture, transportation, and mining) confirms the above conclusion.[2]

Changes in sectoral output are shown in Column 3 in Table 3-3. All sectors, except for the finance, show a decrease in their production levels, with the decrease ranging from 23.8 percent in the mining and quarrying sector to .3 percent in the crude oil sector. This result can be explained as follows: Capital is assumed to be factor specific in each sector and labor is assumed to be fully employed. Therefore, restricting the supply of expatriate labor translates into a reduction in sectoral endowment of factors of production and, hence, a reduction in output.

It should be clear at the outset that the reduction in sectoral endowment of labor alone is not exclusively responsible for these structural output changes. Sectoral output changes are also determined by changes in sectoral per unit value added (net prices) and changes in nominal wages. Changes in net prices are, in turn, determined mainly by two factors. These two factors are: the intersectoral input-output relations, and the producer's prices (domestic prices). Domestic prices are, in turn, affected by changes in the different components of the aggregate demand, namely, government consumption, households

[2]Note that all import sectors have the same magnitude of trade elasticity of substitution (2.5). If different values for the trade elasticity of substitution (σ) is assumed, one should observe that the higher the value of σ, the easier for domestic consumers to substitute foreign for domestic goods and, hence, the less variation in composite prices will be as a result of any difference between aggregate demand and supply.

TABLE 3-3

EXPERIMENT NUMBER 1: CHANGES IN SECTORAL OUTPUT RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EXPATRIATE LABOR

Sector	$\frac{K}{L}$	Percentage Change in PN	Percentage Change in Output
	(1)	(2)	(3)
Agriculture	.048	9.4	-.102
Crude Oil	2.59	-.01	-.003
Mining and Quarrying	.006	24.7	-.238
Petroleum Refining	.298	-2.2	-.027
Manufacturing	.031	31.3	-.014
Utility	.005	28.3	-.168
Construction	.024	10.4	-.183
Trade	.114	-1.44	-.066
Transportation	.011	22.3	-.183
Finance	.188	-3.6	.044
Community Social and Personal Services	.024	18.1	-.125

consumption, investments, etc.

Now let us consider the determination of net prices (PN_i) and then proceed to that of nominal wages. Having done that, the analysis of sectoral output changes will follow.

Ignoring indirect taxes, net price of the i^{th} sector is defined as,

$$PN_i = PD_i - \sum_j a_{ji}P_j \quad ,$$

where a_{ji} is the constant input-output coefficient, PD_i and P_j are the sector's domestic price and composite price respectively. It is clear from the above equation that the decrease, for example, in PN_i is greater as the dependence of the i^{th} sector on output of others increase (high a_{ji}'s). At the same time the greater the increase (decrease) in sectoral composite prices (P_j's) in response to any policy change, the greater the decrease (increase) in PN_i. On the other hand, the changes in domestic prices (PD_i) depend to a large extent on changes in sectoral aggregate demand relative to changes in sectoral aggregate supply. The changes in the sectoral aggregate demand are determined by changes in nominal income and also by base year expenditure shares of the aggregate demand components across sectors.[3] In general, one could state that an income increase will stimulate demand for domestic production and, hence, result in an increase in the value added due to the upward pressure that is generated on the producer's price (PD_i). For example, for a given increase in total investment, the increase in investment demand in each sector will be greater the greater the base year expenditure share of that sector in total investment. The net gain or

[3]Changes in sectoral aggregate supply, in turn, is determined by changes in sectoral nominal wages and net prices.

loss in net price, therefore, depends crucially on the direction and the relative strength of the change in both domestic price and intermediate cost. If the outcome is a net gain (loss), then production is becoming more (less) profitable and as a result output will expand (contract).

In light of the above discussion of the net price determination, we will proceed to analyze the behavior of the net prices presented in Table 3-3. The crude oil sector has the lowest change in its net price (decreases by .01 percent) as compared with the other sectors' net prices. This result may be explained by the following reasons:

1) The crude oil sector is almost completely independent of other sectors and hence less exposed to the variation in the composite prices (as shown in Table 3-2) of its total intermediate purchases from other sectors ($\sum_j a_{ji}P_j$).[4]

2) The oil producer's price is held constant in the model and, hence, net price will not be affected by the domestic oil price. Therefore, net change in the per unit value added in the crude oil sector turns out to be an extremely small reduction. The manufacturing sector exhibits the highest change in its net price (increase by 31.3 percent) relative to all other sectors. Again this finding is due to the fact that the change in its domestic price is the highest among all sectors (increase by 16.2 percent). This fact leads to a strong positive effect on the sector's net value added. On the other hand, the increase in the cost of the manufacturing sector's intermediate input is very limited. This is because of the fact that most of the

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[4]The crude oil sector's extreme independence can be seen from its extremely low intermediate purchases relative to the total purchases of other factors.

manufacturing sector's intermediate input (68 percent) has been brought from the sector itself in which its composite price increases only by a very small percentage of .003 percent (see Table 3-2).[5] In general, one could state that some sectors (e.g., crude oil, petroleum refining, trade, and finance) exhibit a net loss in their net prices. This is because the negative effect of the reduction in their domestic prices have been reinforced by an increase in the cost of their intermediate inputs.[6] However, the other seven sectors (i.e., agriculture, mining, manufacturing, utility, construction, transportation, and community and social services) exhibit an increase in their net prices (9.4, 24.7, 31.3, 28.3, 10.4, 22.3 and 18.1 percent respectively). This gain results from the increase in domestic prices in all of these sectors which outweighs the loss resulting from the increase in the cost of their intermediate purchases from the other sectors with certain variations among them.

Next, the determination of nominal wages is considered. If the level of output would have to increase (decrease) as a result of the net gain (loss) in the value added, nominal wages would have to increase (decrease) for the following reasons: labor is assumed to be fully employed and capital is assumed to be fixed and specific to all sectors. Therefore, we would expect that the pressure on output expansion from the net increase in value added would boost the nominal

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[5]See the input-output table for the high reliance of the manufacturing sector in obtaining most intermediate purchases from itself.

[6]This observation also can be confirmed by the fact that the net loss in their net prices is greater than the reduction in their domestic prices.

wages to restore equilibrium in the labor market. The cost of production, as a result, will increase and generate a force which suppresses the tendency for output to increase. Given the assumption of a constant labor supply and flexible wages, there will be a reallocation of labor across sectors until wages of each skill are equalized among all sectors. The nominal wages of skilled and semiskilled labor have increased by 9 percent and 56 percent respectively, while the wage of unskilled have decreased by 0.1 percent. These wage changes are simply a result of the market-clearing process, given the specifications of full employment and flexible wages that equilibrate supply and demand for labor in the economy. In particular, the wages of skilled and semiskilled labor have increased for the following reason. The exogenous reduction in labor supply of these types creates an upward pressure on their wages. However, the aggregate commodity demand and, hence, demand for labor in general have gone down, which counteracts the upward pressure on wages. The decrease in demand for labor, however, is not enough to neutralize the supply reduction pressure. Therefore, wages of skilled and semiskilled labor rise. This relative strength of skilled and semiskilled labor supply and demand is reversed in the market for unskilled labor. The labor supply effect seems weaker because the participation rate of the expatriates in unskilled labor is the lowest (14 percent) of the three occupational groups. Therefore, a 15 percent reduction in the supply of unskilled labor does not reduce total unskilled labor supply by as much compared to the reduction in total supplies of skilled and semiskilled which captured around 46 and 81 percent of their totals, respectively. This results in an excess supply for unskilled labor and their wage decreases as a result. Using the same argument, one may conclude that the wages of semiskilled workers are inflated by the greatest amount (56 percent) because they represent the highest share in the sector's use of expatriate workers.

Before analyzing the changes in the sectoral output levels, one should consider the following important fact: the nature of this general equilibrium model makes it hard to trace the exact contribution of each of the above mentioned factors in changing the sectoral output level. This difficulty is due to the large set of interrelated variables which enter into play in a general equilibrium framework. In the process of the economy's adjustment toward its new equilibrium point, some of these variables reinforce and some of them dampen the initial effect of the reduction in the number of expatriates. The net outcome is a combination of different forces that enter into play in the model's path toward equilibrium.

In analyzing the changes in the structure of sectoral output presented in Table 3-3 above, production contracts by 10 percent in the agricultural sector. This contraction occurs because nominal wages have increased across sectors by an average of 35.5 percent, while the agricultural sector net price increased by only 9.4 percent.[7] Therefore, real labor cost must increase to reflect these changes. The labor demand equation (Equation 8') in Chapter II indicates that an increase in real labor cost generates a reduction in employment and, hence, a reduction in agricultural output. The manufacturing output suffers the least reduction, next to the crude oil sector, because the

[7]Average wage is defined as: W = 9(.12) + 56(.61) -1(.27) = 35.5, where the values .12, .61, .27 and 9, 56, -1 are the shares of each labor skill in total labor force and the percentage change in wages of each labor skill respectively.

increase in its net price is the highest and, hence, the increase in its real labor cost is the smallest. Although net prices in crude oil, petroleum refining, trade, and finance sectors decrease (which reinforce the effect of nominal wage increase on real labor cost) it is observed that only a mild reduction in their output results in comparison to the other sectors' response to changes in their real labor cost. This outcome is apparently because these sectors are highly capital intensive (see Column 1, Table 3-3). Thus, these sectors' outputs are relatively less sensitive to the resulting decrease in their employment levels as their labor costs increase. On the contrary, the mining sector suffers much more than what is expected, given the significance of the increase in its net price of 25 percent and, hence, the much lower increase in its real labor cost. This is due to the fact that this sector is highly labor-intensive and the fact that the construction sector, which demands a large share of its output, contracts significantly by a rate of 18 percent. Examination of the patterns of output change in the utility and the community social and personal services sectors leads to the following conclusion: the net price increase in the former (28 percent) is higher than that in the latter (18 percent). However, the contraction in the output of the utility sector (16 percent) is greater while the other sector contracts only by 12 percent. This paradoxical result may be explained by the fact that the utility sector is extremely labor-intensive relative to the community and social services sector.[8]

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[8]Generally, it is the sectoral price elasticity of supply that determines the sectoral output response to change in net price. Meanwhile, sectoral price elasticity of supply, in turn, is determined by the elasticity of substitution in production between capital and

The capital labor ratio in the utility sector is .005, while in the community social and personal services sector it is .024 as shown in Column 1, Table 3-3.

The impact of the expatriate labor supply restriction on foreign trade causes a reduction in the value of exports for all sectors. On the other hand, imports decrease in both agricultural and manufacturing sectors, and increase in mining and transportation sectors (see Table 3-4). Sectoral exports are assumed to be a fixed fraction of sectoral output. Therefore, the reduction in sectoral outputs, as shown in Table 3-3, implies a corresponding reduction in exports for all sectors except for finance sector, whose output increases. On the import side, imports of mining and transportation sectors have increased for the following two reasons: 1. These two sectors' output has decreased significantly by 24 and 18 percent respectively, for reasons explained previously. The strong reduction in their output creates severe shortages in domestic market which lead to importing more foreign goods. 2. Domestic prices of mining and transportation sectors are risen by 13 and 11 percent respectively (see Table 3-2). Given that foreign prices are fixed, these sectors become less competitive and hence consumers start to substitute foreign goods for domestic production leading to an

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labor (σ_i^X) and the factor shares for capital (θ_{ik}) and labor (θ_{iL}) as given by, $\varepsilon_i^S = \sigma_i^X \theta_{iL}/\theta_{ik}$ (see Dervis, Melo, Robinson). Since we have assumed the Cobb Douglass production function, it is only the factor intensity that is important in determining the sectoral price elasticity of supply (since $\sigma_i^X = 1$). Therefore, the greater the labor intensity in a sector, the greater the price elasticity of supply and hence the greater the responsiveness of a sector to net price change.

TABLE 3-4

EXPERIMENT NUMBER 1: CHANGES IN SECTORAL IMPORTS AND EXPORTS RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EXPATRIATE LABOR

Sector	Imports		Exports	
	Base Year	Simulation Results	Base Year	Simulation Results
Agriculture	3,976	3,870	90.2	87
Crude Oil	0.0	0.0	335,543	334,578
Mining and Quarrying	224	236	5.8	5
Petroleum Refining	0.0	0.0	19,680.7	18,917
Manufacturing	104,345	93,083	1,016.2	1,165
Utility	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0
Trade	0.0	0.0	249	231
Transportation	3,314	3,650	3,787.96	3,449
Finance	0.0	0.0	4,877	457
Community Social and Personal Services	0.0	0.0	0.0	0.0

increase in total imports. Therefore, the imports of mining and transportation sectors have increased, because their production contracts severely and because their competitiveness with the foreign goods has been lowered. The agriculture and manufacturing sectors' domestic production only slightly decreased, especially for the manufacturing sector which contracted by only 1.4 percent. Therefore, no severe shortage is created in the availability of manufacturing and agricultural goods in comparison with the other above mentioned two sectors. Domestic prices have increased by 6.8 percent for agriculture and 16 percent for manufacturing leading consumers to substitute foreign for domestic goods and hence imports tend to increase. However, with the reduction in aggregate demand and the substitution of 33 percent and 86 percent of the demand for agriculture and manufacturing goods by foreign goods (see Table 3-2), imports have decreased significantly to the extent that it outweighed the substitution effect of the increase in their domestic prices.

Under the assumption of full employment and flexible wages, the reallocation of workers across sectors is as shown in Table 3-5. As shown in Table 3-5, the levels of employment have decreased from their benchmark levels for all sectors except for the manufacturing in which employment has increased by .013 percent. Ranking sectors according to changes in their employment, it is observed that employment contracts more significantly in construction with a magnitude of 30 percent, while employment expands slightly by .013 percent in the manufacturing sector. It is interesting to note that the ranking of sectors according to their employment contraction is not parallel to their ranking based on production contraction. This finding can be explained by the labor

TABLE 3-5

EXPERIMENT NUMBER 1: CHANGES IN EMPLOYMENT RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EXPATRIATE LABOR

	Percentage change in Employment	Percentage Change in Output	Percentage Change in Net Prices
	(1)	(2)	(3)
Construction	-30	-18.3	10.4
Trade	-29	-6.6	-1.4
Finance	-29	-4.4	-3.6
Mining and Quarrying	-27	-23.8	24.7
Petroleum Refining	-26	-2.7	-2.2
Agriculture	-24	-10.2	9.4
Transportation	-23	-18.3	22.3
Crude Oil	-23	-.03	-.01
Community and Social Services	-20	-12.5	18.1
Utility	-18	-16.8	28.3
Manufacturing	.013	-1.4	31.3

demand equation (Equation 8') of Chapter II. In fact, given the specification of wage equality across sectors, the discrepancy in both the percentage change in output and the percentage change in net prices for all sectors is expected to be the main reason for the resulting difference between the ranking methods. The more severe the decrease (increase) in a sector's output and/or net price is, the more significant is the contraction (expansion) in its employment level. As shown by Table 3-5, the manufacturing sector (for example) registers the highest increase in its net price and also the lowest contraction in its output (next to the oil sector) relative to all other sectors. Therefore, it exhibits not only the lowest contraction in employment, as a result of restricting the number of expatriates in the economy, but a .013 percent expansion instead. As for the transportation and construction sectors, both register exactly the same percentage change in their production each contracting by 18.3 percent. But the former leads the latter in the percentage change in net price (22.3 vs 10.4). This net price change difference is what makes the reduction in the employment in transportation (23 percent) less than that of the construction (30 percent). Although the output reduction in finance (4.4 percent) is less than that of the trade (6.6 percent), the resultant reduction in employment for both sectors is the same. This is due to the fact that the changes in their net prices neutralizes the output effect and hence they end up with the exact employment reduction of 29 percent. Following the same line of argument, one could analyze the pattern of employment behavior in the remaining sectors of the economy.

The restriction on the supply of expatriates results in a 23 percent reduction in the overall employment and a 30 percent increase in the overall nominal average wage with variation among wages across occupational groups as shown in Table 3-6. The nominal (real) wages for skilled and semiskilled workers increase by 8.99 (7.56) and 56.43 (55.03) percent respectively. Meanwhile, the nominal (real) wage for unskilled workers decreases slightly by .98 (2.38) percent. The share of labor owner's income in total value added of 12 percent remains the same as in that of base year solutions. This fixed share of labor income in total value added is a necessary result of the production function specification where a Cobb-Douglas production function is used.

Conclusions. 1. The purpose of labor importation is to achieve rapid growth for the different sectors in the Saudi economy. Therefore, any attempt to discourage the inflow of expatriates is expected to generate less growth and standard of living. The 15 percent reduction in the participation rate of expatriates results in a 3.8 percent reduction in real GDP. Real household consumption decreases by 5.2 percent. Total real savings and hence real investment decrease by 16.35 percent. The reduction in savings is considered a long run problem since it implies that capacity of the economy to invest and hence, for growth, is restricted.

2. The study shows that the output of some sectors are strongly related to each other while other sectors seem to be more isolated and independent of the others. Given the development plan priorities, planners should carefully assess the consequence of restricting the expatriate inflow in general and in some sectors in particular. They, therefore, must take into consideration the intersectoral spillover

TABLE 3-6

EXPERIMENT NUMBER 1: PERCENTAGE CHANGE IN WAGES RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EXPATRIATE LABOR

	Skilled Workers	Semiskilled Workers	Unskilled Workers	Overall Average Wage
Nominal Wage	8.99	56.43	-.98	29.68
Real Wage	7.56	55.03	-2.38	28.28

effect. For example, the study shows that contraction in the construction sector (by 18 percent) contributes to the decline in the mining sector even though its per-unit value added increases significantly (25 percent). Therefore, if the mining sector's growth should maintain a certain minimum rate, then planners should carefully assess any attempts to reduce the number of expatriates not only in the mining sector but also in the construction sector as well.

3. Developing the agricultural sector is among the top priorities in the country in order to reduce its dependency on imported food. Given this strong emphasis, it might be advisable to subsidize agricultural producers in order to keep their production intact after constraining the inflow of expatriates. The model results shows that the 10 percent reduction in agricultural output is because of the increase in its real labor cost. Therefore, providing agricultural producers with a subsidy that is enough to offset the nominal wage increase will keep their output intact.

4. The results also indicate that restricting the expatriate workers inflow will severely slow down the rate of economic growth of those sectors that are labor intensive such as mining and utility sectors. The government may encourage upgrading into more capital-intensive technologies in labor intensive sectors. This can be achieved by mechanization, automation, computerization, and improving management to cut down on workers.

5. Reducing the number of expatriates exerts an upward pressure of average nominal wage. Since wages of the different skill groups are given as per capita incomes, we equivalently conclude that nominal per capita incomes for skilled, semiskilled, and unskilled labor have also

changed by 8.99, 56.43, and -.98 percent respectively.[9] This means that the overall per capita income for labor has increased by 30 percent.[10] Furthermore, the differential changes in real wages, as presented in Table 3-6, imply a serious redistribution of income among the different labor groups. For instance, semiskilled labor group benefited the most from this policy since their real wages increase by 55.03 percent. The unskilled group suffered from loosing part of their income since their real wages decrease by 2.38 percent.

6. The real per capita income for capital owers decreased since the real capital income decreased from SR432,230 to 426,388 million, while the number of people in this group remained fixed by assumption.

Experiment Number 2

In this experiment, again, the participation rate of expatriates is reduced by 15 percent across all sectors. The only difference from the first experiment is that, in this experiment all occupational groups are not restricted at the same time, but instead each one of them is

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[9]Per capita income of skill s $= \frac{\sum_i W_s L_{si}}{\sum_i L_{si}} = \frac{W_s \sum_i L_{si}}{\sum_i L_{si}}$

$= W_s \frac{\sum L_{si}}{\sum L_{si}} = W_s$

[10]Total labor per capita income $= \frac{\sum_s \sum_i W_s t_s L_{si}}{\sum_s \sum_i L_{si}} = W_s t_s \frac{\sum_s \sum_i L_{si}}{\sum_s \sum_i L_{si}}$

$= W_s t_s$ where the weight t_s is the share of labor skill s in total labor force, i.e. $t_s = \frac{\sum_i L_{si}}{\sum_s \sum_i L_{si}}$

restricted separately. In particular, in all eleven sectors, we will reduce the participation rate by 15 percent for:

a. skilled expatriates alone; then

b. semiskilled expatriates alone; and finally

c. unskilled expatriates.

Table 3-7 summarizes the changes in some selected macroeconomic variables. For comparison purposes the fourth column in Table 3-7 is added to represent experiment (1). In general, the figures in Table 3-7 suggest that all variable changes in Column 1 through 3 exhibit the same trend that was observed in experiment (1). Changes in income, consumption, investment, and foreign savings are negative in both cases. The only difference in the variable changes among the first three columns is that the changes in each column exclusively reflect differences in the magnitude of the participation rate of expatriates in the total labor force of each skill. Semiskilled expatriates capture 81 percent of the total supply of semiskilled labor force, which indicates that the impact of reducing this labor group is by far greater than reducing the skilled or the unskilled groups which represent only 46 and 14 percent of the total supply of skilled and unskilled labor respectively.

One needs to emphasize the substitutability between the different labor skills in the model. The use of a Cobb Douglas labor aggregation function implies a unity elasticity of substitution between all three kinds of skills. It also implies an upward as well as (equivalently) a downward substitutability which is somewhat unrealistic. However, such a restriction could be relaxed in the future as necessary data become available. It might be preferable to have less than one or even zero

TABLE 3-7

EXPERIMENT NUMBER 2: PERCENTAGE CHANGE IN SOME MACROECONOMIC VARIABLES RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EACH EXPATRIATE SKILL SEPARATELY

Variable	Skilled Expatriates	Semiskilled Expatriates	Unskilled Expatriates	All Skills of Expatriates
	(1)	(2)	(3)	(4)
GDP	-.024	-2.2	-.003	-2.4
Income:				
household	-.03	-3.1	-.003	-3.4
government	-.014	-1.3	-.002	-1.5
Consumption:				
household	-.03	-3.1	-.003	-3.4
government	-.03	-2.7	-.003	-2.96
Investment	-1.6	-13.5	-.02	-15.1
Foreign Saving	.07	5.8	.008	6.5
Remittances	-3.20	-14.27	-.054	-17.9

substitutability between skilled and unskilled labor. Having that, reducing the skilled expatriates by a certain percentage will result in a much more contractionary effect upon the economy and, hence, much more reduction in the figures presented in Column 1 of Table 3-7. This outcome is simply due to the technical difficulty (which is not in this model) to substitute lesser skilled labor for higher skilled labor. Therefore, as a result of this constraint, the economy will have to suffer a greater contraction when it loses part of its skilled labor. In the extreme case of no substitutability at all, given the assumption of full employment and fixed capital stock in the short run, the only choice for producers is that to cut their production by the full amount of the lost skilled labor productivity.

Changes in the sectoral prices, production, imports, exports, and employment are presented in Tables 3-8, 3-9, 3-10 and 3-11 respectively. It is clear that the pattern of change in these variables follows closely the corresponding patterns in Experiment Number 1. The scale is smaller in this experiment, but nevertheless, the patterns are essentially similar. This outcome is due to the fact that the labor supply of each skill is reduced separately rather than simultaneously. Looking at columns where semiskilled labor is restricted one may conclude that most of the changes in Experiment Number 1 are coming from the restriction imposed on the semiskilled labor group. As the above tables show, reducing this group's participation rate alone captures most of the variation in the figures as presented by Experiment Number 1.

The changes in wages are presented in Table 3-12 below. Table 3-12.a shows that the wage of skilled labor increases by 12.5 percent,

TABLE 3-8

EXPERIMENT NUMBER 2: PERCENTAGE CHANGE IN DOMESTIC PRICE AND COMPOSITE PRICE RESULTING FROM THE 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EACH GROUP OF EXPATRIATE LABOR

Sector	Skilled Expatriates		Semiskilled Expatriates		Unskilled Expatriates	
	Domestic Price	Composite Price	Domestic Price	Composite Price	Domestic Price	Composite Price
Agriculture	.65	.11	6.05	0.99	.06	0.01
Crude Oil	0.0	0.0	0.0	0.0	0.0	0.0
Mining and Quarrying	1.10	0.96	11.08	9.45	0.12	0.11
Petroleum Refining	-.09	-.09	-1.14	-1.14	-0.02	-0.02
Manufacturing	1.54	.0004	14.48	0.003	0.17	0.0001
Utility	1.31	1.31	13.17	13.17	0.14	0.14
Construction	0.55	.55	5.40	5.40	0.06	0.06
Trade	-.07	-.07	-0.66	-0.66	-0.02	-0.02
Transportation	1.03	.78	10.15	7.48	0.11	0.08
Finance	-.20	-.20	-1.84	-1.84	-0.03	-0.03
Community Social and Personal Services	0.90	0.90	8.66	8.66	0.09	0.09

TABLE 3-9

EXPERIMENT NUMBER 2: PERCENTAGE CHANGE IN SECTORAL OUTPUT RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EACH GROUP OF EXPATRIATE LABOR

Variable	Skilled Expatriates	Semiskilled Expatriates	Unskilled Expatriates
	(1)	(2)	(3)
Agriculture	-.01	-.091	-.001
Crude Oil	-.0003	-.003	-.00003
Mining and Quarrying	-.025	-.215	-.003
Petroleum Refining	-.003	-.024	-.0003
Manufacturing	+.0006	-.001	-.0004
Utility	-.017	-.151	-.002
Construction	-.019	-.165	-.002
Trade	-.007	-.059	-.0008
Transportation	-.019	-.165	-.002
Finance	-.004	-.039	-.0005
Community Social and Personal Services	-.014	-.112	-.001

TABLE 3-10

EXPERIMENT NUMBER 2: PERCENTAGE CHANGE IN SECTORAL IMPORTS AND EXPORTS RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF EACH GROUP OF EXPATRIATE LABOR

Sector	Skilled Expatriates		Semiskilled Expatriates		Unskilled Expatriates	
	Imports	Exports	Imports	Exports	Imports	Exports
Agriculture	-0.18	-0.37	-2.39	-3.66	0.0	-0.05
Crude Oil	0.0	-0.03	0.0	-0.26	0.0	-0.003
Mining and Quarrying	0.45	-1.50	4.91	-12.80	0.0	-0.17
Petroleum Refining	0.0	-0.35	0.0	-3.49	0.0	-0.05
Manufacturing	-1.10	1.65	-9.70	13.42	-0.13	0.17
Utility	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0
Trade	0.0	-0.73	0.0	-6.55	0.0	-0.09
Transportation	0.94	-0.88	9.02	-8.01	0.09	-0.10
Finance	0.0	-0.62	0.0	-5.68	0.0	-0.08
Community Social and Personal Services	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 3-11

EXPERIMENT NUMBER 2: PERCENTAGE CHANGE IN SECTORAL TOTAL EMPLOYMENT RESULTING FROM A 15 PECENT REDUCTION IN THE PARTICIPATION RATE OF EACH GROUP OF EXPATRIATE LABOR

Variable	Skilled Expatriates	Semiskilled Expatriates	Unskilled Expatriates
	(1)	(2)	(3)
Agriculture	-1.15	-22.24	-.64
Crude Oil	-1.07	-21.18	-.63
Mining and Quarrying	-1.50	-24.39	-.69
Petroleum Refining	-1.45	-24.41	-.67
Manufacturing	2.04	0.24	-.29
Utility	-0.30	-16.19	-.54
Construction	-2.06	-27.85	-.75
Trade	-1.81	-26.58	-.72
Transportation	-0.96	-20.98	-.62
Finance	-1.79	-26.53	-.72
Community Social and Personal Services	-0.63	-18.59	-.58

TABLE 3-12

EXPERIMENT NUMBER 2a: PERCENTAGE CHANGE IN WAGES RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF SKILLED EXPATRIATES

	Nominal Wage	Real Wage
Skilled Workers	12.50	12.35
Semiskilled Workers	-0.32	-0.47
Unskilled Workers	-0.32	-0.47

EXPERIMENT NUMBER 2b: PERCENTAGE CHANGE IN WAGES RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF SEMISKILLED EXPATRIATES

	Nominal Wage	Real Wage
Skilled Workers	-2.99	-4.29
Semiskilled Workers	57.14	55.84
Unskilled Workers	-2.99	-4.29

EXPERIMENT NUMBER 2c: PERCENTAGE CHANGE IN WAGES RESULTING FROM A 15 PERCENT REDUCTION IN THE PARTICIPATION RATE OF UNSKILLED EXPATRIATES

	Nominal Wage	Real Wage
Skilled Workers	-0.04	-0.05
Semiskilled Workers	-0.04	-0.05
Unskilled Workers	2.49	2.48

while for the semiskilled and unskilled, wages decreased by the same percentage of 0.32 when the supply of skilled expatriates is restricted. The results of restricting the supply of each of the other two groups separately are given in Tables 3-12.b and 3-12.c. It is clear that the same pattern of change in wages is shown with differences limited only to the magnitude of changes. This outcome is due to the same reasoning that is used in analyzing the results of the Tables 3-7 through 3-11.

It is interesting to note that, in all of the three Tables, 12.a, 12.b and 12.c, the wages of the restricted skill increase, while wages of the unrestricted skills decrease. This is because the reduction in the number of skilled expatriates (for example) results in reducing both its total supply as well as total demand. The supply reduction of this type of skill comes about as a result of the 15 percent exogenous reduction, while reduction in demand comes about as a result of the reduction in income (see Table 3-7). As a result of the fall in income, demand for goods and services fall which causes a general decrease in labor demand. The net effect on skilled wages, therefore, depends on the relative shifts in the skilled labor supply-demand relations, which turn out to be an increase in the wages of the skilled labor by 12.5 percent. On the other hand, the semiskilled and unskilled labor exhibit a decrease in their demands, while their supplies stay intact since only the skilled labor is reduced. Thus, wages of both semiskilled and unskilled labor decrease by .32 percent.

Conclusions. The policy implication of such a result may be as follows: suppose the government desires to increase the participation rate of unskilled Saudi workers. Using the figures in Table 3.12c, the government may achieve this goal by just restricting the supply of unskilled expatriates which will lead to increase the wage level of this group, thus, attracting more domestic workers to this type of skill. In general, the government can increase the participation rate of Saudis in any labor skill by just restricting the participation rate of expatriates in that skill group. Though, the core issue of the current study is domestic labor shortages, the low participation rate of Saudis in total labor force (as discussed in Chapter II) does exist and needs to be dealt with. It is believed that a policy of improving the participation rate of Saudis by increasing wages, among other incentives, will definitely help in overcoming the country's heavy reliance on expatriate work force.

Experiment Number 3

In this experiment, the model is substituting the necessary capital for the 15 percent reduction in the participation rate of the expatriates in order to maintain the same level of sectoral outputs. The outcome of this experiment, using the same macro variables used in the previous two experiments, is shown in Table 3-13. Most of the variable changes obtained by this experiments are somewhat different from the results of the first two experiments, both in terms of change in magnitude and the direction of change. As illustrated in Table 3-13, the nominal values of household income, government income, and foreign savings all have increased by .33, .03, and .39 percent respectively. On the other hand, the nominal values of GDP and investment have decreased by .024 and .46 percent respectively, while the domestic inflation rate has gone down by .041. The restriction on the sectoral

TABLE 3-13

EXPERIMENT NUMBER 3: PERCENTAGE CHANGE IN SOME MACROECONOMIC VARIABLES RESULTING FROM CAPITAL LABOR SUBSTITUTION

Variable	Percentage Change (Nominal)	Percentage Change (Real)
GDP	-.024	-.024
Income:		
household	.33	.33
government	.03	.03
Consumption:		
household	.33	.33
government	.06	.06
Total Investment	-.46	-.46
Foreign Savings	.39	.39
Remittances	-15.3	-15.3

outputs to stay intact, due to substituting capital for the loss in the sectors endowment of labor, is the main reason leading to large changes in the above mentioned variables when compared with that of the first two experiments.

Unlike Experiment Number 1, the overall percentage increase in the per capita wage in the economy is greater, i.e., 34 as compared to 30 in Experiment Number 1, or about 4 percentage points difference. But, the percentage decline in the level of the overall employment here is greater, i.e., 25 compared to 23 in Experiment Number 1. However, that is not enough to outweigh the average per capita wage increase and, hence, wage income falls by only .34 percent as compared to 3.43 percent in Experiment Number 1. This outcome may be explained by the fact that the increase in the marginal physical product of labor (see Equation 2) exceeds its increase in Experiment Number 1. This larger increase in the marginal physical product of labor, in turn, is due to the simultaneous increase in the availability of sectoral capital stocks. This increase in the capital per unit of labor allows for an increase in the productivity of labor inputs and, hence, in wage payments that firms are willing to pay.

The increase in household income may be explained by analyzing the changes in the different arguments shown in Table 3-14. The GDP's indicator, as discussed previously, has fallen by .024 percent. Capital income of oil and non-oil sectors rose, but only by .01 and .19 percent respectively. The reason for this mild increase in the capital incomes of these two sectors is the insignificant change in their labor cost as shown by Table 3-14. Therefore, all the adverse effects on the household income are very negligible. On the other hand, the

TABLE 3-14

EXPERIMENT NUMBER 3: CHANGE IN HOUSEHOLD INCOME RESULTING FROM CAPITAL LABOR SUBSTITUTION (MILLION OF SAUDI RIYAL)

Variable	Base Year Value	Simulation Result	Percentage Change
1. GDP	520583	520458	-.024
2. - Remittances	4175.2	3536.7	-15.3
3. - (Capital Income of Oil Sectors =	351511	351550.1	0.01
Value added	359021	359074.2	
- Labor cost	4800	4806.7	
- Indirect tax	4.4	4.45	
- Adjustment factor)	2705	2713	
4. - (Capital Income of Non-oil Sectors =	46321	46408.52	0.19
Value added	129061	128880.9	
- Labor cost	56125	55915.01	
+ Indirect tax	5079	5084.33	
- Adjustment factor)	31694	31641.69	
5. - Net Profit Paid	7986.4	7986.4	
6. + Indirect Subsidies	2480.7	2482	
7. + Government Transference to Households	4929.1	2482	
= Household Income	117999	118388	.33

expatriates' transfers abroad (remittances) has gone down by 15.3 percent (see Table 3-14). This strong positive effect on the total household income outweighs all the previously mentioned negative effects and, hence, the household income ends up increasing instead by .33 percent.

Government nominal income has increased too, but only by .03 percent. This income increase is mainly due to the increase in household income, and consequently household income tax. Other major sources of government income, such as income tax from oil and non-oil sectors, have shown a very negligible increase (.001 percent). This oil income tax increase is generated from the very slight increase of .3 percent in the refining producer's price as shown in Table 3-17. The government tax on non-oil sectors has also increased but only by .19 percent. The reason for this insignificant increase is the mild increase in the capital income of the non-oil sectors as discussed previously (see Table 3-15).

Total savings have increased, but only by .46 percent. The decomposition of total savings is presented in Table 3-15. The reduction in the foreign savings, by SR591 millions, is the main reason for the slight fall in the total savings of the economy (see Table 3-15). Other savings have registered either a mild increase as for the non-oil, government, and household savings, or a slight decrease as in the case of oil savings. The fall in remittance of expatriate labor by SR638.5 millions is the main source of the decline in the foreign savings as illustrated by Table 3-16.

The sectoral breakdown of the changes in prices, capital stock, imports, exports, and employment are given in Tables 3-17 through

TABLE 3-15

EXPERIMENT NUMBER 3: CHANGE IN TOTAL SAVINGS RESULTING FROM CAPITAL LABOR SUBSTITUTION (MILLION OF SAUDI RIYALS)

Variable	Base Year Value	Simulation Result	Net Change
Oil Savings:	31127	31115.59	-11.41
Capital income in oil	351511	351550.1	
- Oil income tax	310494	310544.5	
- OTRAROW	9890	9890	
+ Non-Oil Savings:	19084	19126.18	42.18
Capital income in non-oil	46321	46408.52	
- GTRANOIL	1656	1656	
- Non-oil income tax	23957	24002.94	
- NOTROW	4936	4936	
+ Government Savings	211792	211854.4	62.4
+ Household Savings	2672	2681.49	9.49
+ Foreign Savings	-151865	-152456.4	-591
- Change in Stock	6427	6427	0.0
Total Savings	106383	105894	-489

TABLE 3-16

EXPERIMENT NUMBER 3: CHANGE IN FOREIGN SAVINGS RESULTING FROM CAPITAL LABOR SUBSTITUTION (MILLION OF SAUDI RIYALS)

Balance of Payments Components	Millions of Saudi Riyals
Imports	101
- Exports	+ 53.6
+ NTPROPAI	0.0
+ NTRAPAI	0.0
+ Remittances	-638.5
+ DPABRH	0.0
+ GTRAOUT	0.0
Foreign Savings	- 591.1

3-20. The relationships between domestic and composite prices, as given in Table 3-17, do not differ from the findings of the previous experiments. This outcome is due to the fact that composite prices vary by less than domestic prices since world prices of imports, as a component in composite prices, remain unchanged. However, both sectoral composite prices and domestic prices have deviated from their benchmark levels but by very small percentages. Unlike the situation in Experiment Number 1, reducing the participation rate of expatriates by 15 percent while increasing the amount of sectoral capital stock simultaneously prevents the occurrence of a heavy pressure on prices since the productive capacity of the sectors are kept intact.

The required total capital stock for the economy, which is needed to maintain the same level of production capacity after restricting its labor availability, is about SR456,675 millions. This condition requires that the total capital stock has to increase by about 6 percent over the available capital stock in the base year, 1981, in order to compensate for the 15 percent loss in the participation rate of the expatriate labor force.

However, it would be more indicative to the analysis to find out the required change in the total capital stock only in the non-oil sector for the following reasons:

1. The amount of the capital stock in the oil sector represents about 82 percent of the total capital stock in the economy. Yet, its capital stock is required to increase only by about .44 percent as labor supply of expatriates in this sector is cut by 15 percent. This percentage increase of .44 is extremely low relative to the required increase in the capital stock of the non-oil sectors. This low

TABLE 3-17

EXPERIMENT NUMBER 3: PERCENTAGE CHANGES IN DOMESTIC PRICES AND COMPOSITE PRICES RESULTING FROM CAPITAL LABOR SUBSTITUTION

Sector	Domestic Price	Composite Price
Agriculture	.003	.0005
Crude Oil	0.0	0.0
Mining and Quarrying	-.0034	-.0029
Petroleum Refining	.003	.0028
Manufacturing	-.006	-.0001
Utility	.002	.0023
Construction	-.0038	-.0038
Trade	.0003	.0003
Transportation	.0003	.0002
Finance	.001	.001
Community Social and Personal Services	.0003	.0027

percentage biases down the non-oil capital requirement (see Table 3-18).[11]

2. Actually, 93 percent of the expatriate labor are employed by the non-oil sectors, hence, it is more indicative to know how much additional capital stock is needed by these sectors to compensate for the non-oil sectors' loss of expatriates.

Table 3-18 shows that the capital stock in the non-oil sectors alone is required to increase by 29 percent in order to compensate for the 15 percent cut in their expatriate work force. Within the non-oil sectors, the required capital stock increase ranges from more than quadruplicate as in the case of the utility sector to 4.46 percent as in the finance sector.

However, in reality, technical constraints might arise and create some limitation on the possibility of substitution between capital and labor in some of these sectors. Due to this expected mix limitation, some of the high percentages in Table 3-18 may need to be restricted not to exceed certain technical limits which might be less than what the results suggest. In other words, one may not be able to choose any capital labor mix that is dictated by any point on a sector's isoquant and still maintain its output intact. However, determining such limited range of substitutability is out of the scope of this study hoping for further exploration in future studies.

Sectoral imports show very small positive changes (see Table 3-19). The reason for their slight increase is the following: Sectoral output is held constant by assumption, therefore, any increase in demand

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[11] Oil sectors include both crude oil and petroleum refining.

TABLE 3-18

EXPERIMENT NUMBER 3: CHANGES IN SECTORAL CAPITAL STOCK RESULTING FROM CAPITAL LABOR SUBSTITUTION (MILLION OF SAUDI RIYALS)

Sector	Capital Stock (Base Year)	Capital Stock (Simulation Result)	Percentage Change in Capital Stock
Agriculture	3988.5	4729	19.57
Crude Oil	337631	338711	.32
Mining and Quarrying	339	1256	270.5
Petroleum Refining	16586	17047	2.78
Manufacturing	4228	5564	31.60
Utility	218	942	332.11
Construction	24401	34381	49.90
Trade	20379	21907	7.50
Transportation	5409	11288	108.69
Finance	16405	17137	4.46
Community Social and Personal Services	2636	3713	40.86
TOTAL	432220.5	456675	

TABLE 3-19

EXPERIMENT NUMBER 3: CHANGES IN SECTORAL IMPORTS AND EXPORTS RESULTING FROM CAPITAL LABOR SUBSTITUTION (MILLION OF SAUDI RIYALS)

Sector	Imports		Exports	
	Base Year	Simulation Results	Base Year	Simulation Results
Agriculture	3976	3992	90.2	90.44
Crude Oil	0.0	0.0	335543	335543
Mining and Quarrying	224	222	5.8	5.78
Petroleum Refining	0.0	0.0	19680.7	19736.06
Manufacturing	104345	104427	1016.2	1010.02
Utility	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0
Trade	0.0	0.0	249	249.07
Transportation	3314	3319	3787.96	3789.08
Finance	0.0	0.0	487.7	488.17
Community Social and Personal Services	0.0	0.0	0.0	0.0

must be satisfied from abroad. In fact aggregate demand has actually increased slightly because of the small increase in government and household incomes (see Table 3-13). Therefore, this demand increase induced an increase in the volume of sectoral imports since the import prices are fixed by assumption. Meanwhile, sectoral exports have changed exclusively due to the increase in domestic prices. Therefore, as the domestic price of a sector increases (decreases) the value of its exports also increases (decreases). This argument can be verified by comparing sectoral domestic prices and exports of Tables 3-17 and 3-18.

As illustrated by Table 3-20, the level of employment has decreased in all sectors almost equally by 25 percent. In conclusion, real GDP has dropped only by .024 percent. The changes in all other macro real variables of Table 3-13 exhibit no difference from changes in its nominal values (compare Column 2 with Column 1). This outcome is due to the lower inflation rate of .05 compared to its benchmark rate in the base year. This low rate of domestic inflation, obtained in this experiment, comes as a result of maintaining the production capacity of the economy intact, as well as the negligible change in aggregate demand as demonstrated above.

The average wage in the economy has increased by about 34 percent as shown by the occupational wage changes which are given in Table 3-21. Real per capita incomes have increased with semiskilled workers gaining the highest rate, which reached 61.44 percent.

The Capital owners' nominal income has fallen slightly from SR432,230.3 to SR432,117.6, i.e., 0.24 percent. This outcome suggests that the decline in per capita income of capital owners in this experiment is much less than its decline in Experiment Number 1 where

TABLE 3-20

EXPERIMENT NUMBER 3: PERCENTAGE CHANGE IN SECTORAL TOTAL EMPLOYMENT RESULTING FROM CAPITAL LABOR SUBSTITUTION

Sector	Rate of Change
Agriculture	-.248
Crude Oil	-.251
Mining and Quarrying	-.256
Petroleum Refining	-.248
Manufacturing	-.260
Utility	-.248
Construction	-.257
Trade	-.251
Transportation	-.251
Finance	-.250
Community Social and Personal Services	-.247

TABLE 3-21

EXPERIMENT NUMBER 3: PERCENTAGE CHANGES IN WAGES OF EACH LABOR SKILL RESULTING FROM CAPITAL LABOR SUBSTITUTION

	Skilled Workers	Semiskilled Workers	Unskilled Workers	Overall Average Wage
Nominal Wage	12.49	61.44	2.19	33.54
Real Wage	12.54	61.51	2.24	33.60

the capital owner's income has fallen by 1.4 percent.

Real consumption for both household and government has increased, but by small percents (see Table 3-13). Real investment in this simulation has fallen but only by .46 percent.

Conclusions. Based on the above discussion of Experiment Number 3, we arrive at the following conclusions:

1. Real GDP exhibits an extremely small decline of .024 percent after substituting the required amount of capital stock for the 15 percent reduction in the participation rate of expatriates. This small reduction seems to be very close to what the production theory predicts since the economy is just moving to a different point on its most attainable isoquant curve.

2. Using consumption level as a welfare indicator, the results show that the society welfare has increased since both household and government consumption have increased.

3. Saving has gone down and so the economy is not better off in the long-run (see Table 3-15).

4. Restricting the expatriate workers inflow did increase total household disposable income where a major source to this increase is the reduction in the expatriates transfers abroad. (see Table 3-14).

5. Restricting the expatriate workers inflow does have a significant improving effect on the balance of payments position.

6. The capital stock in the non-oil sectors alone is required to increase by 29 percent in order to compensate for the 15 percent cut in their expatriate work force.

7. The question is raised at this point is how to finance the required investment that is needed to facilitate the suggested

substitution between capital and labor. The availability of the required investment funds might be a real constraint in addition to the technical one, which might prevent the suggested substitution at its full scale.

8. The per-capita income of workers increases significantly (by 34 percent), while it decreases slightly (by .24 percent) for capitalists. The reason for the rise in the per capita income of workers is the increase in their efficiency due to the increase in the amount of capital per each unit of labor.

Experiment Number 4

In this experiment a 5 percent exchange rate devaluation has been applied to the country's domestic currency. The model has been solved again to find out the impact of this devaluation policy on the same macro variables used in the previous experiments.

Table 3-22 summarizes the macroeconomic results of this simulation. The devaluation of domestic currency raises nominal GDP by .81 percent and the general price level by .37 percent. However, real GDP increase is limited to only .44 percent.

Real government income also shows a 3.65 percent increase. Devaluation increases total domestic production of both oil and non-oil sectors, but decreases labor cost since wages fall and result in increasing the capital income of both the oil and non-oil sectors. Therefore, government income taxes from these two sources increase as well (see the first two terms in Equation 11 of Chapter II). However, as a result of devaluation, government revenues from household income tax and import duties decrease because household income and imports fall

TABLE 3-22

EXPERIMENT NUMBER 4: CHANGES IN SOME MACROECONOMIC VARIABLES RESULTING FROM DEVALUATION

Variable	Percentage Change (Nominal)	Percentage Change (Real)
GDP	.81	.44
Income:		
household	-9.9	-8.78
government	4.02	3.65
Consumption:		
household	-9.9	-8.78
government	10.49	10.12
Total Investment	-5.72	-6.09
Foreign Savings	11.04	10.67
Remittances	-14.62	14.99

by 8.78 and 5.90 percent respectively. Since the effect of the reduction in household income tax and import duties outweighs the effect of the increase in the first two government income sources (oil and non-oil income taxes), net government income in nominal terms increased by 4.02 percent (see Table 3-22).

Total savings and, hence, total investment decreased by 5.72 percent as shown in Table 3-22. Changes in the different components of total savings are summarized in Table 3-23. It seems the main reason for the reduction in savings is the large reduction in foreign savings which outweighs the increase in the other savings sources.

The overall effect in the external balance, as given by Table 3-24, is a decline in the foreign savings by an amount of SR16,768.95 million. It seems the major two reasons for this decline in foreign savings are the increase in the value of exports and the decrease in the value of imports as shown in Table 3-24. The impact of remittances on foreign savings also reinforces the effects of exports and imports on foreign savings which decreased by an amount of 610.5 million of Saudi Riyals. In the following section, the discussion will turn to the resource reallocation and the resulting sectoral output effects.

Generally, a devaluation of domestic currency leads to an increase in export and domestic sources of demand for each sector's output. In particular, a devaluation leads to an increase in both export demand and domestic demand for domestic output. Foreign demand for exports increases since they become more competitive due to the fall in their export prices expressed in foreign currency, hence, making foreigners buy more of the domestic products. Similarly, domestic demand on domestic production increases as well because the ratio of domestic

TABLE 3-23

EXPERIMENT NUMBER 4: CHANGE IN TOTAL SAVINGS
RESULTING FROM DEVALUATION
(MILLION OF SAUDI RIYALS)

Variable	Base Year Value	Simulation Result	Change in Savings
Oil Savings:	31127	33771	2644
Capital income in oil	351511	368001	
- Oil income tax	310494	324339	
- OTRAROW	9890	9890	
+ Non-Oil Savings:	19084	18880	-204
Capital income in non-oil	46321	45896	
- GTRANOIL	1656	1656	
- Non-oil income tax	23957	23736	
- NOTROW	4936	4936	
+ Government Savings	211792	220302	8510
+ Household Savings	2672	2409	-263
+ Capital Outflow*	-151865	-168634	-16769
- Change in Stock	6427	6427	0.0
Total Savings	106383	100301	-6082

*As capital outflow resulting from trade surplus.

TABLE 3-24

EXPERIMENT NUMBER 4: CHANGE IN FOREIGN SAVINGS
RESULTING FROM DEVALUATION
(MILLION OF SAUDI RIYALS)

Variable	Change
Imports	-1295.05
- Exports	14863.4
+ NTPROPAI	0.0
+ NTRAPAI	0.0
+ Remittances	-610.5
+ DPABRH	0.0
+ GTRAOUT	0.0
Total Change in Foreign Savings	-16768.95

price for home goods to domestic currency price of foreign goods changes, with home goods becoming cheaper. Therefore, domestic demand shifts from foreign to domestically produced goods as a result of this relative price change.

The effect of devaluation on sectoral domestic production depends on the direction of change in the following factors: the change in net prices, which in turn is affected by changes in both domestic prices as well as the intermediate cost of production, the change in nominal wages, and the sectoral expenditure shares of the final demand agents.

Following the procedure used in the previous experiments, the sectoral price changes as presented in Table 3-25 will be discussed first.

The reduction in all domestic prices, except crude oil prices which is fixed by assumption, reflects the market clearing process that is already discussed in the previous experiments. Sectoral domestic price of imports rises by the full percentage increase in the exchange rate (Column 3 of Table 3-25) since the foreign currency price of imports is fixed by assumption. Composite goods prices, as defined in Equation 3 of Chapter II, decrease as a result of devaluation (see Column 2 in Table 3-25). This decrease in the composite goods prices is due to the fact that the fall in the domestic goods prices outweigh the rise in the domestic prices of imports (compare Column 1 and 3, Table 3-25).[12] Changes in the composite price of the non-import sectors (all sectors except agriculture, mining, manufacturing, and transportation sectors) reflect exactly the change in domestic prices which is made clear by

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[12]Except for the crude oil sectors whose composite price increases by 5 percent since its domestic price is fixed by assumption.

TABLE 3-25

EXPERIMENT NUMBER 4: CHANGES IN PRICES RESULTING FROM DEVALUATION

Sector	Percentage Change in Domestic Goods Price	Percentage Change in Composite Goods Price	Percentage Change in Domestic Price of Imports
	(1)	(2)	(3)
Agriculture	-9.31	2.11	5.0
Crude Oil	5.0	5.0	5.0
Mining and Quarrying	-6.07	-4.78	5.0
Petroleum Refining	-8.69	-8.69	5.0
Manufacturing	-31.69	4.98	5.0
Utility	-6.80	-6.80	5.0
Construction	-6.14	-6.14	5.0
Trade	-8.97	-8.97	5.0
Transportation	-6.57	-4.09	5.0
Finance	-6.90	-6.90	5.0
Community Social and Personal Services	-7.31	-7.31	5.0

comparing Columns (1) and (2) of Table 3-25. These identical changes are due to the fact that these sectors' supplies are exclusively provided locally and hence, their composite prices as defined by its Equation (3) are unaffected by devaluation.

On the other hand, one notices the following within the import dependent sectors of agriculture, mining, manufacturing, and transportation. Although, the domestic price of the manufacturing sector falls by 31.69 percent while the domestic currency price of its imports increases by only 5 percent, we notice an overall increase in the manufacturing composite price of 4.98 percent. This outcome may be explained by the fact that 86 percent of the manufacturing sector's supply is provided through imports from abroad. Therefore, the change in the price of the manufacturing foreign goods is heavily weighted by .86 weight as compared to the .14 weight assigned to the change in the price of manufacturing home goods.

The fall in the domestic goods prices of the mining sector of -6.07 and in the transportation sector of -6.57 are heavily weighted by .94 and .91 respectively. On the other hand, the rise in the domestic price of the imports of these two sectors, by the devaluation rate, are weighted by only a small weights of .06 and .09 respectively. Thus, the overall effect on the composite price is a net decrease by 4.78 and 4.09 percent respectively.

The ultimate effects of this 5 percent devaluation on resource allocation and, hence, on sectoral output levels depends on how it affects net prices and nominal wages (see Equation 8', Chapter II). The change in net prices, as mentioned in Experiment Number 1, depends on the change in both domestic goods prices and intermediate cost in each sector. Meanwhile the intermediate cost, in turn, depends on the change in the composite goods prices weighted by the sector's input-output coefficients' structure.

Table 3-26 summarizes the change in net prices and how it depends on the change in domestic goods prices and the sectoral intermediate cost.[13] Change in the domestic goods prices have been already discussed, and so the focus turns to the discussion of the changes in the sectoral intermediate cost which is listed in Column 2 of Table 3-26.

Of course, the change in the per unit intermediate cost due to devaluation varies across sectors. The figures listed in Column 2 reflect the fact that sectors which use intermediate inputs from those sectors whose composite prices rise (fall) strongly, exhibit a strong increase (decrease) in their intermediate cost. In addition, for a given change in composite prices, the higher the weight assigned to each of them in calculating the sectoral intermediate cost, the higher the variations in the sectors' intermediate costs.

The reduction in the per unit intermediate costs of the trade and finance sectors are, in fact, because the weighted change in the value of its intermediate purchases (weighted by the structure of its input-output coefficients, a_{ji}'s) declines. All other sectors show an increase in their intermediate input costs when devaluation took place. Indirect taxes decrease mainly because of the decrease in domestic prices (see Table 3-26, Column 3).

Having done with the analysis of changes in domestic goods prices

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[13]For completeness, Column 3 has been added to Table 3-26 to list the change in the indirect taxes.

TABLE 3-26

EXPERIMENT NUMBER 4: CHANGE IN SECTORAL NET PRICE, AND IN ITS DETERMINANTS (DOMESTIC PRICE, INTERMEDIATE COST, INDIRECT TAX) RESULTING FROM DEVALUATION

	Change in Domestic Price (1)	Change in Intermediate Cost (2)	Change in Indirect Tax (3)	Change in Net Price (4)
Agriculture	-.0931	.0068	-.0065	-.1062
Crude Oil	.05	.0001	0.0	.0499
Mining and Quarrying	-.0607	.0019	0.0	-.0626
Petroleum Refining	-.0869	.0029	-.00002	-.0897
Manufacturing	-.3169	.0075	0.0	-.3243
Utility	-.0680	.0097	-.0352	-.1129
Construction	-.0614	.00001	0.0	-.0614
Trade	-.0897	-.0038	-.0096	-.0955
Transportation	-.0657	.0046	-.0013	-.0716
Finance	-.0690	-.0031	-.0001	-.0658
Community Social and Personal Services	-.0731	.0064	0.0	-.0794

and the intermediate cost, the discussion turns to the analysis of the pattern of change in sectoral net prices which is determined by changes in the domestic goods prices and the intermediate cost.

Table 3-26 shows that net prices also have declined in all sectors except in the crude oil sector which increased by 4.99 percent. It is also noticeable that in the sectors that show a drop in its intermediate cost as the trade and finance have recorded a lower rate of decline in their net price. Other sectors that show an increase in their intermediate cost recorded a higher decline in net prices. The significant drop in the net price of the manufacturing sector of 32.43 percent is mainly due to the significant drop in this sector's domestic price which recorded a contraction of 31.69 percent. The increase in crude oil net price is almost equal to the increase in exchange rate since this sector's net price increased by 4.99 percent. That means the oil domestic price increases by a rate equal to the increase in the exchange rate or by 5 percent. Meanwhile its intermediate cost has decreased by only .01 percent.

Nominal wages of skilled, semiskilled, and unskilled labor have fallen by 14.62 percentage points for each group. Table 3-27 shows changes in the sectoral real labor cost. The first impact of devaluation, as mentioned above, is changing relative prices between imported and domestic goods. The aggregate demand, therefore, diverts to domestically produced commodities. But the demand for domestic production eventually decreases as a result of the decline in the two major components of the total final demand, investments and household incomes. Thus, an excess supply of domestic production is created, which in turn, tends to decrease the demand for labor. Given the

TABLE 3-27

EXPERIMENT NUMBER 4: CHANGES IN SECTORAL REAL COST OF LABOR (w/PN*) AND THE LEVEL OF OUTPUT RESULTING FROM DEVALUATION

	Average Real Wage			Percentage Change in Output
	Base Year	Simulation Results	Percentage Change	
	(1)	(2)	(3)	(4)
Agriculture	.034262	.034048	-.625	.332
Crude Oil	.026053	.021178	-18.71	.207
Mining and Quarrying	.057435	.056964	-.820	3.34
Petroleum Refining	.035415	.034472	-2.66	.231
Manufacturing	.051697	.125661	243.0	-51.99
Utility	.033692	.033732	.119	-.499
Construction	.051701	.050327	-2.66	2.91
Trade	.028882	.027605	-4.42	1.03
Transportation	.052237	.052147	-.172	.396
Finance	.038752	.036707	-5.28	.474
Community Social and Personal Services	.050116	.050576	.918	-.993

*w is the weighted average wage of the different skills, where weights are the share of each labor skill in total labor force.

model's specification of the labor market of full employment and variable nominal wage, the nominal wage rate adjusts downward to the point where the labor market clears at the full employment level. In terms of Equation (8') in the model, the process starts with a decline in the domestic goods prices as a result of the excess supply in production. Net prices, therefore, decline and, hence, value of marginal physical product decreases causing the nominal wage to drop in order to maintain the equality between value of marginal physical product of labor and the nominal wage.

The effect of devaluation, on resource reallocation and, hence, on sectoral output, depends ultimately on how devaluation translates into changes in sectoral real labor cost, which in reality, is the ratio of wages to net prices (see Equation 8'). As shown in Table 3-27, sectoral real labor cost recorded a percentage increase in all sectors except in manufacturing, utility, and the community and social services sectors. Therefore, domestic output exhibits an expansion in all sectors except in the above mentioned three sectors. Although the per unit cost of labor (wage) falls, the decline in the wage for these three sectors is not large enough to compensate for the dramatic decline in the per unit value added (net price). The final outcome is the increase in real labor costs which led to reduce domestic production levels (see Columns 3 and 4 of Table 3-27).

Devaluation, in general, is expected to have an expansionary effect on sectoral output because it increases the price of foreign goods relative to domestic goods, hence, generating an excess demand for domestic production. In contrast to this theoretical expectation, an exchange rate devaluation seems to be contractionary for some of the sectors as suggested by Column 4 of Table 3-27. This seemingly unexpected result has been brought to attention by Paul Krugman and Lance Taylor (1978) who have argued that devaluation may create an initial excess supply, instead, because of the contracts in the aggregate demand for home goods. Specifically, Krugman and Taylor 1978 (1978, p. 445) argue that:

> Theoretical treatments of currency devaluation generally conclude that it stimulates economic activity. The initial increase in the price of foreign goods relative to home goods is presumed to produce an excess demand for home goods. . . . The possibility that price movements caused by devaluation will create enough losers in real terms to cause an initial excess supply of home goods is almost always left out.
>
> This oversight persists, even though there is substantial empirical evidence suggesting that devaluation often reduces aggregate demand (vide Cooper (1971a)). Even a few theorists like Hirschman (1949, Diaz-Alejandro (1963), Cooper (1971b) and others have suggested that falling output and employment after devaluation are quite frequently to be expected.

Therefore, one can understand from this background why output levels in some sectors decrease, although its competitiveness is improved by devaluation; led to diverting the demand to domestic substitutes. It is the dramatic decline in demand for manufacturing, utility, and community and social services goods that causes the severe reduction in their output levels. As shown in Table 3-22, real household consumption and total investments have fallen by 10.19 and 6.07 percent respectively as a result of the decline in household income and total savings. In addition, intermediate demands also have declined by 7.28 percent. The extent of this decline in the private consumption, investment, and intermediate demands on each sector's output depends on the structure of the expenditure shares of these three final demand agents. The significant reduction in the demand for the manufacturing sector's output results from the large expenditure shares of 38 percent for household and 14 percent for investment besides the shares of intermediate demands on the manufacturing goods. Therefore, the large decline in these agents' demands coupled with the significance of their expenditure shares on the manufacturing goods creates huge excess supply in this sector and resulting in a 33 percent drop in its domestic price. Therefore, the manufacturing per unit value added falls by 32 percent. Although nominal per unit labor cost declines by 14.62 percent, the net price decline is still greater and hence, per unit real labor cost exhibits an increase instead. This outcome seems to be the main reason for the decline of the manufacturing output which exceeds 50 percent of its output level before devaluation. However, it should be noted that government nominal income does increase by 4.02 percent. But this increase is still not strong enough to boost the total demand for the manufacturing goods because the share of government consumption expenditure of .512 percent on the manufacturing commodity is insignificant. Furthermore, the total final government consumption represents only 45 percent of total household consumption alone. Hence, it will not be able to compensate even for the reduction in the household consumption. Therefore, redistributing income in favor of the government budget does not necessarily help to enhance the demand for manufacturing goods. The same reasoning can be followed in explaining the decline in the output of the utility and the community and social services sectors.

The demand for labor services follows exactly the same pattern of output. Sectoral labor mobility is presented in Table 3-28. Since labor supply is restricted, employment in some sectors shows positive

TABLE 3-28

EXPERIMENT NUMBER 4: CHANGES IN SECTORAL TOTAL EMPLOYMENT RESULTING FROM DEVALUATION (MAN WORK PER YEAR)

Sector	Base Year Value	Simulation Result	Percentage Change
Agriculture	83085	83889	.968
Crude Oil	130255	160566	23.27
Mining and Quarrying	52503	54707	4.20
Petroleum Refining	55528	57178	2.98
Manufacturing	135127	26689	-80.25
Utility	39137	38876	-.667
Construction	1003980	1061376	5.72
Trade	178121	188276	5.70
Transportation	481594	484330	.568
Finance	87062	92598	6.36
Community Social and Personal Services	110958	108861	-1.89

changes while in the manufacturing, utility, and community and social services sectors, it shows negative changes. As a result of the increase in output of some sectors and the decrease in output of the others and since labor supply is assumed fixed at its full employment level, labor resources do shift from the contracting sectors to the expanding ones as shown in Table 3-28.

Sectoral imports have declined because they become less competitive relative to domestic substitutes. These changes in sectoral imports are presented, along with changes in sectoral exports, in Table 3-29. The exports of all sectors have fallen, except crude oil which has risen slightly by 5.22 percent. These changes in exports are mainly due to the changes in sectoral output levels, of which exports are a fixed fraction, and to the change in domestic goods prices. The impact of the significant drop in domestic prices, in fact, outweighs the impact of the slight increase in sectoral output, resulting in net decline in the value of exports. The value of oil exports have increased because of the increase in both its domestic price (by the devaluation rate) and production level. This reason explains why oil exports have exhibited a 5.22 percent increase, which slightly exceeds the devaluation rate by .22 percent.

<u>Conclusions</u>. 1. Real GDP exhibits a small negative percentage change since it has declined by .44 percent. However, one should take this result cautiously since labor is assumed to be fully employed and in the short run capital stock is fixed by assumption. The production possibility curve (PPC) position has not changed since the economy is still operating at the full utilization of its factor of production endowments. Therefore, what changes, in fact, is the output composition

TABLE 3-29

EXPERIMENT NUMBER 4: PERCENTAGE CHANGE IN IMPORTS AND EXPORTS RESULTING FROM DEVALUATION

Sector	Imports	Exports
Agriculture	-14.66	-9.00
Crude Oil	0.0	5.22
Mining and Quarrying	-19.64	-2.92
Petroleum Refining	0.0	-8.48
Manufacturing	-4.94	-67.21
Utility	0.0	0.0
Construction	0.0	0.0
Trade	0.0	-8.03
Transportation	-23.39	-6.20
Finance	0.0	0.0
Community Social and Personal Services	0.0	0.0

in the economy as a whole. Geometrically, the economy moves into a different point on its PPC due to the change in the relative prices introduced by the devaluation policy.

2. Workers' real per capita income has decreased by 14.62 percent, because of the reduction in real wages. Capitalist real per capita income has increased because their income has increased from SR432,230.3 to SR436,747.2, while their number is constant by assumption.

3. Real household consumption declines significantly by about 11 percent (see Table 3-22).

4. Real total investment has dropped by 6.07 percent.

5. The government budget deficit has increased since the government's nominal income has increased by 4.02 percent, while government consumption increased by about 11 percent (see Table 3-22).

6. Conclusions 3 and 5 imply that income has been redistributed from private to public users. Since these two agents have different propensities to consume (expenditure shares in this case) for the different commodities in the economy as well as different propensities to save, i.e., .023 for private vs .63 for public, the observed redistribution of income between the two agents led to restructuring the domestic demand for the different commodities.

7. Devaluation turns out to be an effective policy for improving the trade balance position, which had experienced about 11 percent increase in foreign exchange.

CHAPTER IV

CONCLUSIONS AND POLICY IMPLICATIONS

The CGE model used in this study to investigate the impact of expatriate labor force on the economy of Saudi Arabia offers the advantages of a general equilibrium analysis and of a disaggregated economy. The results of the study demonstrate the interaction among the different economic sectors of the economy. They also demonstrate the importance of the interaction of the different economic actors with each other in the process of attaining new general equilibrium solutions.

In this chapter some of the major conclusions and their policy implications will be discussed first. In addition, the chapter will also include a discussion of relevant future research that could be done if the required data are available.

Concerning the impact of the expatriate workers on domestic wages we arrive at the following conclusions:

a. The existence of the expatriate labor has a significant effect on domestic wages. This conclusion can be drawn from the results of experiments number 1 and 2. According to experiment 1, a one percent reduction in the participation rate of all skills of expatriate labor will lead to about 0.60 and 3.76 percent increase in domestic wages of skilled and semiskilled labor respectively. Wages of unskilled labor, however, will decrease by 0.007 percent as a result of one percent decrease in the participation rate of expatriate labor for all skills.

On the average, we may conclude that a one percent decrease in the participation rate of expatriate labor will cause a 2 percent increase in the overall domestic wage in the country.

According to experiment 2, a one percent decrease in the participation rate of skilled expatriate labor alone will result in 0.87 percent increase in domestic wages of skilled labor and 0.002 percent decrease in wages of other skills.

If only the participation rate of semiskilled expatriate labor is reduced, then for each one percent decrease in this category, the domestic wage of this category will have to increase by 4 percent. Other wages will have to decrease by 0.2 percent each.

The policy implication of the wage increases of skilled and semiskilled labor has an important impact on the domestic labor participation rate. Some affluent people will join the labor force, and the existing domestic labor will tend to work for more hours because they are attracted by the higher wages. Restricting labor importation, however, creates a cost-push inflation because of the increased average domestic wage. According to the results of experiment 1, the cost-push inflation is manifested in a 1.4 percent increase in the average composite commodity price in the economy.

b. Changes in labor demand associated with changes in its supply must be taken into account in considering the impact of expatriate labor on Saudi Arabia economy. Such an approach will help us to gain a more precise and determined conclusion about the net effect of the reduction of labor supply on domestic wages. Although the supply of the unskilled labor has decreased, which tends to increase the wage, the study (in experiment number 1) shows that unskilled labor wage has decreased due to the decrease in the unskilled labor demand. Demand for the other two categories of labor has also decreased as a result of the fall in commodity demand. However, the decreases in skilled and semiskilled labor demand is not strong enough to outweigh the supply effect, so wages of both these categories of labor have been increased.

Experiment number 2 shows that domestic wage is determined by the change in demand for labor which is the result of change in demand for commodity. Although the labor supply restriction is applied to each labor skill separately, wages of the unrestricted labor skills decrease as well. Again, this reduction in wages of the unrestricted skills is due to the fall in commodity demand and hence, in labor demands.

This conclusion leads us to a very important policy implication. Rural areas in Saudi Arabia are a rich source for the unskilled labor and, thus, the unskilled labor must be encouraged to migrate to urban areas in the country through a reasonable increase in their wages. Therefore, policy makers have to make sure that the reduction in the participation rate of unskilled expatriate labor is high enough to outweigh any demand effect that might lead to reduce wages of unskilled labor and hence, discourage rural urban migration.

c. The wage changes described above should be viewed as a short run outcome and they may not hold good in the long run. In order to determine the long run impact, the model may need to include the evolution of population and investment over time, because changes in population and investment lead to changes in domestic labor supply and investment demand. These changes in domestic labor supply and investment demand complicate the market adjustment mechanism and may lead to a different conclusion about the wage adjustment in the long run. However, the model in its present form remains within the static framework and hence, the model can not deal with dynamic issues.

Although the model can not explicitly determine changes in sectoral capital rent, these changes can be determined implicitly as follows.

a. All sectors, except the manufacturing, have decreased employment of labor as indicated by Table 3-5. Since each sector has an unchanged quantity of capital, by assumption, the rents of capital in all sectors (excluding the manufacturing) have decreased, reflecting the fact that capital in each of these sectors now has less labor to work with. In the manufacturing sector, however, capital has more labor to work with and hence, the sector's capital rent increased instead.

b. Since the model does not allow for capital mobility across sectors, the loss in per capita rent will vary across sectors depending on the employment reduction in each sector. Capital owners in the construction sector will suffer the most since the reduction of its employment level is higher than those of other sectors. On the other hand, capital owners in the utility sector will suffer the least since the sector's employment level reduction is lower than those of other sectors. However, capital owners in the manufacturing sector are gaining more per capita income due to the slight increase in the manufacturing employment.

Therefore, given the high dependency of the private sector on expatriates, reducing the number of expatriates does not favor the domestic entrepreneur and businessmen because this policy increases their labor costs and decreases profits and ultimately domestic investment.

The availability of some commodities at a low cost to domestic consumers can not be attributed to the employment of expatriates in their production. The manufacturing goods are a case in point. As Table 3-2 indicates, the composite market price of manufacturing goods increased by only .003 percent after the departure of 15 percent of expatriate workers. The main reason behind this price insensitivity is that 86 percent of the manufacturing products are imported and hence, are unaffected by the increased domestic labor cost. Another example, but to a lesser extent, is the agricultural composite market prices which also show a small increase (see Tables 3-2 and 3-8) in response to the 15 percent expatriate labor reduction.

Furthermore, the decrease in the expatriate labor force creates an excess supply for some capital intensive goods, whose composite prices are thereby decreased. This excess supply is evident from the resulting decrease in the composite price of petroleum refining, trade, and finance sectors. The levels of output in these capital intensive sectors are not very much tied to changes in domestic labor force which also includes the expatriates (for example, see Table 3-3). On the other hand, consumption shares of these commodities in consumers' budgets are relatively high (see Appendix B, Table B-3). Therefore, reducing the number of expatriates results in domestic excess supply and hence, there is a decrease in the price of capital intensive goods.

The utilization of expatriate labor force in the production of some labor intensive commodities, however, lowers the prices to the consumer whose real income thereby increases.[1] Therefore, a major reduction in

[1]Unlike the manufacturing and agricultural commodities, prices of these labor intensive goods are very much exposed to the increase in domestic wages since all or most of their supplies are produced domestically.

the number of expatriates in the production of labor intensive commodities might call for greater government intervention to subsidize these goods and services in order to maintain a lower cost to domestic consumers. The major labor intensive commodities include utility, community social and personal services, transportation, and construction.

Developing the manufacturing and agricultural sectors is one of the top priorities in the Fourth Development Plan and in future plans. The reason behind these planned structural changes in the economy is to create a diversified economic base and to reduce dependency on imported food. The results of experiment number 1, for example, show that the output of the agricultural sector decreased by 10 percent due to the 15 percent reduction in the participation rate of expatriates in the economy as a whole. The results suggest that this agricultural output contraction is mainly attributed to the increased real labor cost in the agricultural sector. This increased real cost discourages agricultural domestic production and at the same time diverts domestic demand to foreign substitutes whose prices are unaffected and, therefore, are more competitive.

Exempting the agricultural sector from restricting the use of expatriates will not protect its output from falling.[2] In fact, the percentage of contraction of the agricultural output (9.2 percent) is the same as the percentage of reduction when the sector is not exempted.

Subsidizing the producers in the agricultural sector, in addition

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[2]The exemption is applied by keeping the participation rate of expatriates of all skills in agriculture (ℓ_{is}, i = agriculture) unrestricted.

to the exemption from labor restriction, is expected to encourage them to produce more, thus preventing the sector's output from unfavorable contraction. We may propose levying higher tariff rates on agricultural imports, the receipts of which can be redistributed to agricultural producers as subsidies. At the same time, the increased tariffs divert domestic demand to domestic agricultural products, whose competitiveness are improved.

However, an economic inefficiency will result from distorting the market solution by the government intervention. This inefficiency may be reflected in a reduction in the real values of GDP, investment, and income. Restricting the choice of domestic consumers in selecting between domestic and foreign products is another source of inefficiency that is created by the increased tariff rate.

Similarly, the manufacturing sector can be promoted by levying tariffs on manufacturing products and by redistributing the receipts to producers in manufacturing. The impact of labor restriction on growth in manufacturing sectors in very small (see Tables 3-3 and 3-9). The inefficiency resulting from imposing tariffs can be ignored if planners are satisfied with this reduction in manufacturing output. However, if the government desires to protect domestic infant industries, at least in the short-run, then the government may implement the tariff increased policy to promote diversification in the economy.

Reducing the participation rate of expatriates by 15 percent required the following amounts of capital stock in order to maintain the productive capacity of the economy at the same level. The capital stock in the economy as a whole has to increase by 6 percent. In the non-oil sectors alone, the capital stock has to grow by 29 percent. In other words, for each reduction in the participation rate of expatriates in non-oil sectors by one percent, capital stock has to increase by about 2 percent to keep its production level unchanged. Within the non-oil sectors, capital stock has to more than quadruple in utility, triple in mining, and double in transportation.

Reducing the participation rate of expatriate labor force also has a vital impact on total output, consumption, investment, and the balance of payments.

The 15 percent reduction in the participation rate of expatriates causes a 2.4 percent reduction in the real GDP. Also, this expatriate reduction has decreased real private and public consumption by 4.8 and 4.3 percent respectively (see experiment 1 for details). Real per capita consumption of households, however, has increased due to the reduction in expatriate population. Using real per capita consumption level as a welfare measure we can conclude that the welfare of the society increases when the expatriate labor force is reduced.

Real investment drops by 16.3 percent after the 15 percent reduction in expatriate participation rate. This implies that the economy will suffer in the long run. Reduction in investment implies that the economy's capacity to invest and hence, for growth is restricted.

Restricting expatriate labor inflow improves the balance of payments position. This effect is seen in a noticeable reduction in imports and in the foreign exchange transfers abroad by expatriate workers.

Devaluation turns out to be an effective policy in improving the balance of payments position by an increase of 11 percent in foreign exchange. This improvement is due to a decrease in imports and remittances abroad and an increase in exports.

Devaluation is expected to exert an expansionary effect on production due to the increase in competitiveness of domestic products. This study, however, shows that when demand effect is incorporated, some sectors such as manufacturing, utility, and community social and personal services experience a contraction in their output levels instead. Devaluation, therefore, does not favor infant industries, whose output have fallen due to the decrease in total demand.

The remaining part of this chapter is a discussion of data problems and limitations of the present study and of basic data that are necessary for future extensions.

Estimating parameters econometrically is difficult because the necessary data are not available. As required data becomes available, these parameters can be estimated econometrically.

Consistent data about wages and labor distribution by sector, occupation, and nationality are not available. The availability of such data will improve the parameter estimate and the performance of the model.

Disaggregation of some trade flows will provide better insight and more powerful conclusions. For example, data on remittances of expatriates are scarce. According to the Saudi SAM, expatriate labor transfers only 12 percent of its income which is probably an underestimate. It is believed that some remittance data are combined with other outflows that are specified exogenously in the present study (Assaf, 1982, p. 93). Including all remittances may not alter the final conclusions obtained, but it will increase the impact of expatriate labor reduction on income, consumption, production, investment, and the balance of payments.

The model in its present form is static and could be changed into dynamic in order to incorporate the movements of the economy over time. As some of the model's variables grow over time at different growth rates, structural changes in the economy could be incorporated. These variables include domestic labor supply and investment. Domestic labor supply growth, therefore, could be connected to the educational system in the country. Certain educational policies can be adapted in order to test the domestic-expatriate labor substitution. With a dynamic version of the model, it is possible to endogenate the capital stock and introduce the financial constraint in capital labor substitution conducted in Experiment Number 3.

The present model assumes a representative household, where individuals are grouped together assuming they all have equal income, tastes, and savings rate. Households are likely to have different rates of incomes, tastes, and savings. Therefore, disaggregating into more than one representative household will improve the simulation results of the model. The number of expatriates in the country, as reported in the study, is large in number. Given that they differ from the Saudi Arabia nationals in terms of consumption and saving patterns, one may want to incorporate such differences in modeling an economy with such large number of expatriate labor force. Again, if data on the rate of consumption, income, and savings by different nationals (domestic vs. expatriates) are available, then it is possible to eliminate the aggregation problems in future research.

One might use a CES production function instead of the Cobb Douglas form that is used in the present study. As sufficient data needed to estimate the CES parameter econometrically become available, one may allow for differences in the elasticity of substitution among primary inputs across production sectors.

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APPENDIX A

EQUATIONS OF THE COMPUTABLE GENERAL EQUILIBRIUM
MODEL FOR SAUDI ARABIA

I. Prices

Number of Equations[a]

Import price equations

(1) $PM_i = \overline{PW}_i(1 + tm_i)\overline{ER}$ — n

Export price equations

(2) $PWE_i = \dfrac{PD_i}{(1 + te_i)\overline{ER}}$ — n

Composite price equations

(3) $P_i = \dfrac{1}{\varepsilon_i}[\delta_i^{\sigma_i} PM_i^{1-\sigma_i} + (1 - \delta_i)^{\sigma_i} PD_i^{1-\sigma_i}]^{\frac{1}{1-\sigma_i}}$ — n

Net price equations

(4) $PN_i = PD_i - td_iPD_i - \sum_j \bar{a}_{ji}P_j$ — n

II Production and Employment

Production functions

(5) $X_i = \Omega_i L_i^{\alpha_i} \overline{K}_i^{\beta_i}$ — n

Labor agregation functions

(6) $L_i = (\frac{1}{\ell_{i1}} L_{i1}^e)^{\alpha_{i1}} (\frac{1}{\ell_{i2}} L_{i2}^e)^{\alpha_{i2}} (\frac{1}{\ell_{i3}} L_{i3}^e)^{\alpha_{i3}}$ — n

[a]The total number of equations is 16n + s·n + s + 14 = 226. These equations have been reduced to 89 equations by substitution in order to conform to the GAUSS software specifications.

Number of Equations

Labor demand functions

$$(7)^{b} \quad PN_i \frac{\alpha_{is} X_i}{(\frac{1}{\ell_{is}} L^e_{is})} = W_s \qquad n \cdot s$$

Labor market equilibrium

$$(8) \quad \sum_i (\frac{1}{\ell_{is}} - 1) L^e_{is} = \overline{L}^h_s \qquad 3$$

III. Foreign Trade

Import demand functions

$$(9) \quad \frac{M_i}{D_i} = (\frac{PD_i}{PM_i})^{\sigma_i} (\frac{\delta_i}{1 - \delta_i})^{\sigma_i} \qquad n$$

Export demands functions

$$(10) \quad E_j = \bar{e}_j (\frac{PD_j}{(1 + te_j)} X_j) \qquad n$$

Balance of payments equilibrium

$$(11) \quad S^f = \sum_j \overline{PW}_i M_i \overline{ER} - \sum_j e_j (\frac{PD_j}{(1 + te_j)} X_j)$$

$$+ r \sum_j \sum_s L^e_{js} W_s + \overline{NTPROPAI} + \overline{NTRAPAI}$$

$$+ \overline{DPABRH} + \overline{GTRAOUT} \qquad 1$$

---

[b]See Appendix D for the mathematical derivation.

IV. Income and Investment

Number of Equations

Household income equation

$$(12)\quad Y^h = GDP - REM - Y_k^{oil} - Y_k^{noil} - \overline{NTPROPAI} - INDTAX + \overline{GTRAH}$$ 1

Gross domestic product equation

$$(13)\quad GDP = \sum_j PD_j X_j - \sum_j \sum_i a_{ij}(PD_j X_j) + \overline{WAG}^g + \sum_j \overline{PW}_j tm_j M_j$$ 1

$$(14)\quad REM = r \sum_s \sum_i L_{is}^e W_s$$ 1

$$(15)\quad INDTAX = \sum_s \sum_j tm_j M_i \overline{PW}_j \overline{ER} - \sum_j td_j X_j$$ 1

Oil capital income equation

$$(16)\quad Y_k^{oil} = \sum_{j=2,4} v_j PD_j X_i - \sum_s \sum_{j=2,4} \frac{1}{\ell_{js}} L_{js}^e W_s - \sum_{j=2,4} td_j PD_j X_j - g_1 PD_4 X_4$$ 1

Number of Equations

Non-oil capital income equation

(17) $$Y_k^{noil} = \sum_{j\neq 2,4} v_j PD_j X_j - \sum_s \sum_{j\neq 2,4} \frac{1}{\ell_{js}} L_{js}^e W_s - \sum_{j\neq 2,4} td_j PD_j X_j - g_2 \sum_{j\neq 2,4} PD_j X_j$$ 1

Government income equation

(18) $$GR = t_1\{ \sum_{j=2,4} (\frac{PD_j}{1 + te_j})(e_j X_j)\} + t_2 Y_k^{noil} + t_3\, Y^h + \sum_j tm_j\, \overline{PW}_j \overline{ER} + \overline{GTRAINRW}$$ 1

Oil savings equation

(19) $$SAV^{oil} = Y_k^{oil} - t_1\{ \sum_{j=2,4} (\frac{PD_j}{1 + te_j})(e_j X_j)\} - \overline{OTRAROW}$$ 1

Non-oil saving equation

(20) $$SAV^{noil} = Y_k^{noil} + \overline{GTRANOIL} - t_2 Y_k^{noil} - \overline{NOTRAROW}$$ 1

Government savings equation

(21) $$SAV^g = S_g GR$$ 1

Household savings equation

(22) $$SAV^P = S_P Y^h$$ 1

Investment-saving balance

(23) $$INV = SAV^{oil} + SAV^{noil} + SAV^g + SAV^P + S^f - \overline{CHS}$$ 1

Sectoral investment equations | Number of Equations

(24) $INV_i = \gamma_i INV$ | n

V. Product Markets

Household consumption equation

(25) $C^P = (1 - S_p - t_3)Y^h - \overline{HTRAROW}$ | 1

Government consumption equation

(26) $C^g = GR - \overline{WAG^g} - \overline{GTRANOIL} - \overline{GTRAH}$

$- S_g GR + \sum_j td_j(PD_j X_j) - \overline{GTRAOUT}$ | 1

Household sectoral consumption equations

(27) $C_i^P = q_i C^P$ | n

Government sectoral consumption equations

(28) $C_i^g = \theta_i C^g$ | n

Intermediate demand equations

(29) $V_i = \sum_j a_{ij} X_j$ | n

Domestic demand equations

(30) $D_i = d_i(V_i + C_i^g + C_i^P + INV_i)$ | n

Domestic use ratio function — Number of Equations

(31) $d_i \equiv \frac{D_i}{Q_i} = \left(\frac{P_i}{PD_i}\right)^{\sigma_i} (1 - \delta_i)^{\sigma_i} \beta_i^{\sigma_i - 1}$ — n

Total domestic demand

(32) $X_i^D = d_i\left(\sum_j a_{ij}X_j + \frac{\theta_i}{P_i} C^g + \frac{q_i}{P_i} C^P + \frac{\gamma_i}{P_i} INV\right) + e_i X_i$ — n

Supply-demand balance equations[c]

(33) $X_i = X_i^D + SLACK_{oil}$ — n

List of Variables and Parameters

Endogenous Variables

Number	Variable	Definition
n	PM_i	Import prices
n	PWE_i	Export prices
n	P_i	Composite good prices
n	PN_i	Net prices
n	PD_i	Domestic prices
n	X_i	Sectoral outputs

[c]Because the exchange rate is fixed in addition to the price of oil then the oil sector is not cleared. Therefore, the slack variable (SLACK) is added to the supply-demand balance equation for the oil sector.

Number	Variable	Definition
n	L_i	Aggregate sectoral labor
s·n	L_{is}^e	Sectoral expatriate labor by category
3	W_s	Wages by category
n	M_i	Sectoral imports
n	E_i	Sectoral exports
1	S^f	Foreign capital inflow
1	Y^h	Household income
1	GDP	Gross domestic product
1	REM	Expatriate remittances
1	INDTAX	Indirect taxes
1	Y_k^{oil}	Oil capital income
1	Y_k^{noil}	Non-oil capital income
1	GR	Government revenue
1	SAV^{oil}	Oil savings
1	SAV^{noil}	Non-oil savings
1	SAV^g	Government savings
1	SAV^P	Household savings
1	INV	Total investment
n	INV_i	sectoral investment
1	C^P	Household consumption
1	C^g	Government consumption
n	C_i^P	Household sectoral consumption

Number	Variable	Definition
n	C_i^g	Government sectoral consumption
n	V_i	Intermediate demand
n	D_i	Domestic demand
n	d_i	Domestic use ratio
n	X_i^D	Total domestic demand

$16n + s \cdot n + S + 14$

Exogenous Variables

$\overline{PW}_i$	World price of imports
$\overline{ER}$	Exchange rate
$\overline{K}_i$	Sectoral capital stock
$\overline{L}_s^h$	Total domestic labor of category S
$\overline{NTPROPAI}$	Net property and entrepreneural income
$\overline{NTRAPAI}$	Net current transfers abroad
$\overline{DPABRH}$	Direct purchases abroad by the resident household
$\overline{GTRAOUT}$	Government transfers abroad
$\overline{GTRAINRW}$	Interest earnings of government investments abroad
$\overline{GTRANOIL}$	Government transfers to non-oil sector
$\overline{NOTRAROW}$	Non-oil sector's transfers to the rest of the world
$\overline{OTRAROW}$	Oil transfers to the rest of the world
$\overline{CHS}$	Change in stock
$\overline{HTRAROW}$	Household transfers to the rest of the world
$\overline{WAG}^g$	Government employees wage payments
$\overline{GTRAH}$	Government transfers to households

Parameters

tm_i	Import tariff rate
te_i	Export subsidy rate
σ_i	Trade elasticity of subsititution
δ_i, ε_i	Parameters for CES trade aggregation function
a_{ij}	Input-output coefficient
td_i	Indirect tax rate
Ω_i	Productivity parameter in production
α_i, β_i	Output elasticity with respect to labor and capital respectively
α_{i1}, α_{i2}, α_{i3}	Proportions of skilled, semiskilled, and unskilled workers respectively in total labor force of each sector
ℓ_{is}	Participation rate of expatriate workers in total labor force
e_j	Base year share of sectoral output that is exported
r	Proportion of expatriates' income remitted abroad
v_j	Base year per unit value added $(1 - \sum_j a_{ij})$
g_1, g_2	Adjustment parameters
t_1	Tax rate on oil exports
t_2	Tax rate on non-oil capital income
t_3	Tax rate on household income
S_g	Government saving rate
S_p	Household saving rate
γ_i	Sectoral investment allocation shares
q_i	Household expenditure shares
θ_i	Government expenditure shares

APPENDIX B

BASIC DATA FOR THE MODEL

This appendix presents the complete set of consistent data that is used to solve the Saudi CGE model for the base year of 1981.

TABLE B-1

ESTIMATED PRODUCTION AND LABOR AGGREGATION PARAMETERS*
(1981)

Sector	α_{i1}	α_{i2}	α_{i3}	β_i	Ω_i
Agriculture	0.090605	0.209514	0.049885	0.649995	1.011265
Crude Oil	0.002552	0.005908	0.001409	0.990130	1.038208
Mining and Quarrying	0.207725	0.478685	0.114102	0.199988	0.449672
Petroleum Refining	0.020641	0.047704	0.011329	0.920326	1.467925
Manufacturing	0.117116	0.270804	0.064484	0.547596	1.215469
Utility	0.212837	0.492146	0.117137	0.177881	0.240954
Construction	0.133406	0.308485	0.073455	0.484655	1.034904
Trade	0.047704	0.110308	0.026266	0.815723	1.111249
Transportation	0.180459	0.417287	0.099361	0.302893	0.599538
Finance	0.031213	0.072164	0.017179	0.879444	1.580044
Community Social and Personal Services	0.134898	0.311923	0.074272	0.478907	0.987663

Source: See Appendix F for estimation procedure.

*β_i's are not estimates. They are calculated from Table E-4.

TABLE B-2

INPUT-OUTPUT TABLE FOR SAUDI ARABIA (1981)
COEFFICIENTS MATRIX

Sector	Agriculture	Crude Oil	Mining and Quarrying	Petroleum Refining	Manufacturing	Utility	Construction	Trade	Transportation	Finance	Community Social and Personal Services
Agriculture	0.0241345	0.0000000	0.0000000	0.0000000	0.0000389	0.0000000	0.0000238	0.0000000	0.0022722	0.0000000	0.0000000
Crude Oil	0.0815998	0.0010057	0.0044281	0.0341352	0.0059168	0.1128670	0.0153574	0.0092209	0.0792235	0.0287474	0.0542096
Mining and Quarrying	0.0000000	0.0000685	0.0685999	0.0023279	0.0017925	0.0014588	0.0356707	0.0001598	0.0001607	0.0005910	0.0003055
Petroleum Refining	0.0036884	0.0000454	0.0002123	0.0015430	0.0002655	0.0051119	0.0006940	0.0004155	0.0035773	0.0012970	0.0024456
Manufacturing	0.1390774	0.0041576	0.3123451	0.1410850	0.3420220	0.3890531	0.2635408	0.0704223	0.2507615	0.1280664	0.2755222
Utilty	0.0000000	0.0000189	0.0022817	0.0006399	0.0007577	0.0019325	0.0007715	0.0012430	0.0010973	0.0031229	0.0025862
Construction	0.0000000	0.0000049	0.0000265	0.0001620	0.0005699	0.0008104	0.0024892	0.0001576	0.0077033	0.0025083	0.0003467
Trade	0.0305338	0.0007732	0.0746040	0.0262673	0.0639149	0.0737922	0.0577446	0.0142662	0.0477622	0.0244876	0.0516731
Transportation	0.0288741	0.0012767	0.0825634	0.0433177	0.0680270	0.1239137	0.0647445	0.0617928	0.0862316	0.0584246	0.0594878
Finance	0.0070817	0.0005135	0.0045634	0.0174270	0.0161957	0.0412069	0.0543030	0.0540101	0.0459261	0.0832381	0.0369655
Community Social and Personal Services	0.0000000	0.0000890	0.0003714	0.0030172	0.0004986	0.0011845	0.0047659	0.0008489	0.0008562	0.0006753	0.0007028

Source: Derived from Table E-2.

TABLE B-3

FINAL DEMAND BUDGET SHARES
(1981)

Sector	(θ_i)	(q_i)	(γ_i)	(ϕ_i)	(e_i)
Agriculture	0.00016	0.10132	0.0	0.02617	0.01109
Crude Oil	0.0	0.0	0.0	0.0	0.97618
Mining & Quarrying	0.0	0.0	0.0	0.0	0.00154
Petroleum Refining	0.00474	0.03824	0.0	0.0	0.79706
Manufacturing	0.00806	0.38307	0.14182	0.70849	0.06581
Utility	0.00301	0.00988	0.0	0.0	0.0
Construction	0.27473	0.0	0.80662	0.0	0.0
Trade	0.00692	0.10434	0.02578	0.13267	0.00892
Transportation	0.02148	0.12159	0.02578	0.13267	0.10496
Finance	0.04611	0.11092	0.0	0.0	0.01743
Community Social and Personal Services	0.01302	0.08109	0.0	0.0	0.0

Source: Derived from Table E-3.

TABLE B-4

TARIFF, EXPORT SUBSIDY, AND INDIRECT TAX RATES
(1981)

Sector	tm_i	te_i	td_i
Agriculture	0.01990	0.0	-0.06942
Crude Oil	0.0	0.0	0.0
Mining and Quarrying	0.02004	0.0	0.0
Petroleum Refining	0.0	0.0	0.00018
Manufacturing	0.02406	0.0	0.0
Utility	0.0	0.0	-0.51848
Construction	0.0	0.0	0.0
Trade	0.0	0.0	-0.10746
Transportation	0.0	0.0	-0.02037
Finance	0.0	0.0	0.00184
Community Social and Personal Services	0.0	0.0	0.0

Sources: tm_i is calculated from Table E-3
td_i is calculated from Table E-4 and B-10

TABLE B-5

ESTIMATED PARAMETERS FOR IMPORT AND COMPOSITE PRICE FUNCTIONS (1981)

Sector	σ_i	δ_i	ε_i
Agriculture	2.5	0.653607	0.548201
Crude Oil	0.5	0.0	1.0
Mining and Quarrying	2.5	0.322563	0.574179
Petroleum Refining	0.5	0.0	1.0
Manufacturing	2.5	0.964265	0.919210
Utility	0.5	0.0	1.0
Construction	0.5	0.0	1.0
Trade	0.5	0.0	1.0
Transportation	2.5	0.386821	0.531498
Finance	0.5	0.0	1.0
Community Social and Personal Services	0.5	0.0	1.0

Source: See Appendix F for estimation procedure.

TABLE B-6

SECTORAL PARTICIPATION RATE OF EXPATRIATE WORKERS BY OCCUPATION
(1981)

Occupation Sector	Skilled Labor	Semiskilled Labor	Unskilled Labor
Agriculture	0.4614	0.8051	0.1448
Crude Oil	0.4614	0.8051	0.1448
Mining and Quarrying	0.4614	0.8051	0.1448
Petroleum Refining	0.4614	0.8051	0.1448
Manufacturing	0.4614	0.8051	0.1448
Utility	0.4614	0.8051	0.1448
Construction	0.4614	0.8051	0.1448
Trade	0.4614	0.8051	0.1448
Transportation	0.4614	0.8051	0.1448
Finance	0.4614	0.8051	0.1448
Community Social and Personal Services	0.4614	0.8051	0.1448

Source: Obtained by dividing the total sum of each column in Table E-11 by the corresponding total sum in Table E-10.

TABLE B-7

OTHER PARAMETERS
(1981)

Sector	v_i	ql_i	θl_i
Agriculture	0.68501	0.10661	0.00042
Crude Oil	0.99205	0.0	0.0
Mining and Quarrying	0.45000	0.0	0.0
Petroleum Refining	0.73008	0.04024	0.01253
Manufacturing	0.50000	0.40304	0.02131
Utility	0.24867	0.01039	0.00796
Construction	0.49989	0.0	0.72636
Trade	0.78746	0.10978	0.01830
Transportation	0.47443	0.12792	0.05680
Finance	0.66884	0.11670	0.12191
Community Social and Personal Services	0.51576	0.08532	0.03442

Source: Derived from Tables E-3 and B-2.

TABLE B-8

SECTORAL CAPITAL STOCK (1981)
(MILLION OF SR)

Sector	$\overline{K}_i$
Agriculture	3988.5
Crude Oil	337631.2
Mining and Quarrying	339.2
Petroleum Refining	16586.3
Manufacturing	4228.1
Utility	218.9
Construction	24401.2
Trade	20379.7
Transportation	5409.0
Finance	16404.6
Community Social and Personal Services	2636.0

Source: National Accounts of Saudi Arabia (1982), pp. 42-43.

TABLE B-9

SECTORAL PRICES* (1981)

Sector	PD_i	P_i	$\overline{PW}_i$
Agriculture	1.0	1.0	1.0
Crude Oil	1.0	1.0	1.0
Mining and Quarrying	1.0	1.0	1.0
Petroleum Refining	1.0	1.0	1.0
Manufacturing	1.0	1.0	1.0
Utility	1.0	1.0	1.0
Construction	1.0	1.0	1.0
Trade	1.0	1.0	1.0
Transportation	1.0	1.0	1.0
Finance	1.0	1.0	1.0
Community Social and Personal Services	1.0	1.0	1.0

*All prices are assumed equal to one in the base year including exchange rate (ER) and world price of oil (WPOIL).

TABLE B-10

DOMESTIC AND FOREIGN SUPPLY BY SECTOR
(1981)

Sector	Domestic Output (X_i)	Imports (M_i)
Agriculture	8,133.6	3,977.4
Crude Oil	343,730.9	0.0
Mining and Quarrying	3,769.1	224.5
Petroleum Refining	24,691.5	0.0
Manufacturing	15,442.4	104,348.1
Utility	1,604.1	0.0
Construction	100,716.4	0.0
Trade	27,917.0	0.0
Transportation	36,088.4	3,314.4
Finance	27,987.2	0.0
Community Social and Personal Services	10,672.1	0.0

Source: National Accounts of Saudi Arabia (1982), p. 54.

TABLE B-11

ESTIMATED EXPATRIATE WORKERS BY OCCUPATION AND SECTOR
(1981)

Occupation Sector	Skilled Labor	Semiskilled Labor	Unskilled Labor
Agriculture	4572	40806	3258
Crude Oil	7157	63946	5115
Mining and Quarrying	2890	25770	2060
Petroleum Refining	3059	27288	2173
Manufacturing	7436	66366	5300
Utility	2154	19223	1534
Construction	55230	492970	39367
Trade	9800	87472	6985
Transportation	26497	236504	18886
Finance	4791	42758	3414
Community Social and Personal Services	6016	54494	4352

Source: See Appendix F for estimation procedure.

TABLE B-12

BASE YEAR MACROECONOMIC VARIABLES (1981)

Variable	Million of SR
GDP	520,588.8
Income	
household (Y^h)	118,015.2
government (GR)	337,702.6
Consumption	
household (C^P)	114,905.1
government (C^g)	52,008.9
Investment (INV)	106,375.9
Foreign Saving (S^f)	151,863.8

Source: National Accounts of Saudi Arabia (1982)

TABLE B-13

ESTIMATED ANNUAL WAGES AND DOMESTIC LABOR FORCE (1981)

Skill Level	Wages (Thousand of SR)	Number of Domestic Workers
Skilled Workers	56.1117	151,391.1
Semiskilled Workers	25.3654	280,232.8
Unskilled Workers	13.6029	545,989.1

Source: See Appendix F for estimation procedure.

TABLE B-14

OTHER EXOGENOUS VARIABLES (1981)

Variable	Millions of SR
$\overline{\text{GTRANOIL}}$	1,656.6
$\overline{\text{GTRAH}}$	4,929.1
$\overline{\text{GTRAINRW}}$	232.2
$\overline{\text{GTRAOUT}}$	32,337.5
$\overline{\text{OTRAROW}}$	9,890
$\overline{\text{HTRAROW}}$	9.0
$\overline{\text{NOTRAROW}}$	4,936
$\overline{\text{NTRAPAI}}$	46,939.8
$\overline{\text{NTPROPAI}}$	7,986.4
$\overline{\text{DPABRH}}$	5,693.1
$\overline{\text{CHS}}$	6,427.5
$\overline{\text{WAG}}^{g}$	29,905.7

Source: National Accounts of Saudi Arabia (1982).

TABLE B-15

OTHER PARAMETERS

Parameter	Rate
t_1	0.8740864
t_2	0.5172100
t_3	0.0036300
S_g	0.6271500
S_p	0.0226500
g_1	0.1095560
g_2	0.1363810

Source: National Accounts of Saudia Arabia (1982).

Note: $t_1 = \frac{\text{Government revenue from oil sector}}{\text{Value of oil exports}}$

$$t_2 = \frac{\text{Government revenue from nonoil sectors}}{\text{Capital income of non-oil sectors}}$$

$$t_3 = \frac{\text{Government revenue from household}}{\text{Household income}}$$

$$S_g = \frac{\text{Government saving}}{\text{Government revenue}}$$

$$S_p = \frac{\text{Household saving}}{\text{Household income}}$$

APPENDIX C

GAUSS COMPUTER PROGRAM

```
/*=============================================================
  BELOW IS THE GAUSS COMPUTER PROGRAM THAT HAVE BEEN USED TO
  SOLVE THE SAUDI CGE MODEL .
                                                            */
/*----------------------------------------------------------*/
/* STEP 1: specify kx1 vector of starting values -- there MUST
  be the same number of starting values as there are equations.
=============================================================*/

/* list starting values here -- name should be kept X0 */

let x0[89,1] = 8133 343730 3769  24691 15441  1603 100721 27916
               36087 27986 10671 4571 7155  2890  3058 7434 2153
               55235 9800 26496 4791.0  6105 40800  63945  25771
               27284 66354 19220 493016  87468.00  236493  42755
               54487 3257  5114  2060  2173 5299 1534 39371 6985
               18886  3413  4351 1 1 1 1 1 1 1 1 1 1 1  0.056111
               0.025365 0.013603 520583  3977 0.0 225 0.0 104345
               0.0  0.0  0.0  3314 0.0 0.0 1 1 1 1 1 1 1 1 1 1 1
               -151865.2 114889 52011 337707 117999 106383 0 1 ;


  @ All of the folloing load files are found in Appendix B @

LOAD q[11,1]  = c:q ;
LOAD d[11,1]  = c:d ;
LOAD te[11,1] = c:te;
LOAD e[11,1]  = c:e ;
LOAD tm[11,1] = c:tm;
LOAD A[11,11] = c:A ;
LOAD TD[11,1] = c:TD;
LOAD q1[11,1] = c:q1;
LOAD PW[11,1] = c:PW;
LOAD 11[11,1] = c:11;
LOAD 12[11,1] = c:12;
LOAD 13[11,1] = c:13;
LOAD v[11,1]  = c:v ;
LOAD K[11,1]  = c:K ;
LOAD phi[11,1] = c:phi;
LOAD GAM[11,1] = c:GAMMA;
LOAD a1[11,1]  = c:ALPHA1;
LOAD a2[11,1]  = c:ALPHA2;
LOAD a3[11,1]  = c:ALPHA3;
LOAD DELTA[11,1] = c:DELTA;
LOAD SIGMA[11,1] = c:SIGMA;
LOAD ALPHA[11,1] = c:ALPHA;
LOAD THETA[11,1] = c:THETA;
LOAD OMEGA[11,1] = c:OMEGA;
LOAD THETA1[11,1] = c:THETA1;
LOAD EPSILON[11,1] = c:EPSILON;
```

```
let ER = 1.0;
let RWAGg = 29905.7;
let GTRAH = 4929.1;
let HTRAROW = 9.0;
let GTRAINRW = 232.2;
let WAGg = 29905.7;
Let GTRANOIL = 1656.6;
Let GTRAOUT = 32337.5;
let OTRAROW = 9890.0;
let NOTRAROW = 4936;
let DPABRH = 5693.1;
let CHS = 6427.5;
let wpoil = 1 ;
let NTPROPAI = 7986.4;
let NTRAPAI = 46939.8;
let Lh1 = 151391.1;
let Lh2 = 280232.8;
let Lh3 = 545989.1;

let t1 = 0.8740864;
let t2 = 0.51721;
let t3 = 0.00363;
let g1 = 0.109568;
let g2 = 0.13642;
let Sg = 0.6271479;
let Sh = 0.02265;
let  r = 0.1101731;

@THE FOLLOWING VECTORS ARE USED TO SUM OVER THE OIL SECTORS
(INCLOIL) , NON-OIL SECTORS (EXCLOIL) , AND TO INCLUDE THE
PETROLEUM REFINING SECTOR ONLY . THE D VECTOR USED TO INCLUDE
DOMESTIC PRICE OF CRUDE OIL ONLY . @

let INCLOIL[11,1] = 0.0 1.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0;
let EXCLOIL[11,1] = 1.0 0.0 1.0 0.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0;
let INCLREF[11,1] = 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0;
let D[11,1]       = 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0;

/*-----------------------------------------------------------*/
 vf = zeros(rows(x0),1); /* size of this vector is determined
                                  from x0 */
 proc f(x);
/*-----------------------------------------------------------*/
/* STEP 2: specify the equations to be solved, as a function of
   the arguments . The objective is to solve for values such
   that f(x) = 0.
=============================================================*/
LOCAL  O ,  Le1,  Le2,  Le3 ,  PD , W1 , W2 , W3 , GDP , Yh ,
       Cp , GR , Cg , INVS , M , P , Sf , SLACK , Py ;


          O=X[1:11,1];             M=X[60:70,1];
          Le1=X[12:22,1];          P=X[71:81,1];
          Le2=X[23:33,1];          Sf=X[82,1];
          Le3=X[34:44,1];          Cp=X[83,1];
          PD=X[45:55,1];           Cg=X[84,1];
          W1=X[56,1];              GR=X[85,1];
          W2=X[57,1];              Yh=X[86,1];
          W3=X[58,1];              INVS=X[87,1];
          GDP=X[59,1];             SLACK=X[88,1];
                                   Py=X[89,1];
```

```
VF[1:11,1] = O - OMEGA.*(((1./l1).*Le1).^(a1)).*(((1./l2).*Le2)
             .^(a2)).*(((1./l3).*Le3).^(a3)).*((K).^(1-a1-a2-a3));

VF[12:22,1] = (PD-TD.*PD-A'P).*(a1.*O)-((1/l1).*Le1).*ONES(11,1)
              .*(W1);

VF[23:33,1] = (PD-TD.*PD-A'P).*(a2.*O)-((1/l2).*Le2).*ONES(11,1)
              .*(W2);

VF[34:44,1] = (PD-TD.*PD-A'P).*(a3.*O)-((1/l3).*Le3).*ONES(11,1)
              .*(W3);

VF[45:55,1] = O -  (1./PD).*(GAM.*INVS+PHI.*CHS+q.*Cp+THETA.*Cg
              +A*(P.*O)+D.*slack)-e.*O+(1./PD).*((PW.*(1+tm).*ER)
              .*M);
VF[56,1] = ((1/l1)-1)'*(Le1)-Lh1;

VF[57,1] = ((1/l2)-1)'*(Le2)-Lh2;

VF[58,1] = ((1/l3)-1)'*(Le3)-Lh3;

VF[59,1] = GDP - ONES(1,11)*(pd.*O) + (ONES(1,11)*A)*(pd.*O)  -
           RWAGg - pw'(tm.*M);

VF[86,1] = Yh -GDP+r.*(ONES(1,11)*(Le1.*W1+Le2.*W2+Le3.*W3))+v'*
           (INCLOIL.*(PD.*O))-INCLOIL'*(((1/l1).*Le1).*W1+((1/l2)
           .*Le2).*W2+((1/l3).*Le3).*W3)- incloil'* (td.*(PD.*O))
           -g1*(INCLREF'*(PD.*O))+v'*(EXCLOIL.*(PD.*O))-EXCLOIL'*
           (((1./l1).*Le1).* W1+((1./l2).*Le2).*W2+((1/l3).*Le3)*
           W3)-excloil'*(td.*(pd.*o)) - g2 *(EXCLOIL'*(PD.*O)) +
           NTPROPAI+((PW'*(tm.*M))*ER)+(td'*(PD.*O)) -GTRAH;

VF[83,1] = Cp-(1-Sh-t3).*Yh+HTRAROW;

VF[85,1] = GR -t1*(INCLOIL'*((PD.*(1./(1+te))).*(e.*O)))-t2*(v'*
           (EXCLOIL.*(PD.*O)) - EXCLOIL'* (((1./l1).*Le1).* W1 +
           ((1./l2).*Le2).*W2+((1./l3).*Le3).*W3)-EXCLOIL'*(td.*
           (pd.*o))-g2*(EXCLOIL'*(PD.*O)))-t3*Yh -(PW'*(tm.*M))
           *ER - GTRAINRW;

VF[84,1] = Cg -GR+WAGg+GTRANOIL+GTRAH+Sg*GR-TD'*(PD.*O)+GTRAOUT;

VF[87,1] = INVS-v'*(INCLOIL.*(PD.*O))+INCLOIL'*(((1./l1).*Le1).*
           W1+((1./l2).*Le2).*W2+((1./l3).*Le3).*W3)+INCLOIL'*(td
           .*(pd.*o))+g1*(INCLREF'*(PD.*O))+ t1*(INCLOIL'*((PD.*
           (1./(1+te))).*(e.*O)))+OTRAROW-v'*(EXCLOIL.*(PD.*O))+
           EXCLOIL'* (((1./l1).* Le1).* W1+ ((1./l2).*Le2).* W2+
           ((1./l3).*Le3).* W3) + EXCLOIL'* (td.* (PD.*O)) + g2*
           (EXCLOIL'*(PD.*O))-GTRANOIL+t2*(v'*(EXCLOIL.*(PD.*O))
           - EXCLOIL'* (((1./l1).*Le1).*W1 +((1./l2).*Le2).* W2+
           ((1./l3).*Le3).* W3) - EXCLOIL'* (td.* (PD.*O)) - g2*
           (EXCLOIL'*(PD.*O)))+NOTRAROW-Sg*GR-Sh*Yh-Sf+CHS;
```

```
 VF[60:70,1] = M -((delta.^sigma).*(P./(PW.*(1+tm)*ER)).^sigma).*
                 (gam.*(invs/(gam'*P))+ phi.*(chs/(phi'*P))+q.*(cp/
                 (q1'*P))+theta.*(cg/(theta1'*P))+A*O);

VF[71:81,1] = P - epsilon.*((DELTA.^SIGMA) .* ((PW.*(1+tm)) *ER)
                .^(1-SIGMA) + ((1-DELTA).^SIGMA).*(PD.^(1-SIGMA)))
                .^(1./(1-SIGMA));

VF[82,1] = Sf+ONES(1,11)*((PD.*(1./(1+te))).*(e.*O))-((PW).*ER)'
           *M-(NTPROPAI)-(NTRAPAI)-(r*(ONES(1,11)*(Le1*W1+Le2*W2
           +1e3*W3)))-DPABRH-GTRAOUT ;

VF[88,1] = D'*P - ER*WPOIL ;

VF[89,1] = Py - (O./(ONES(1,11)*O))'*P ;
/*-------------------------------------------------------------*/
retp( vf );
endp;
/*-------------------------------------------------------------*/
/* STEP 3: specify the options you want.
=============================================================*/
output file = nl.out reset; /* specify output file,if desired */
convtol = 1e-6;             /* convergence tolerance.         */
prntit = 1;                 /* if 1, will print on every --
                            ITERATIOn--however, pressing ANY key
                            while the program is running will
                            toggle the printing on and off.   */
prntout = 1;                /* if 1, will print final output;
                            NOTE: the solution vector is always
                            assigned to x1,and will be in memory
                             when the program is completed.   */
fname = &f;                 /* change this if the name of the
                            proc containing the functions is not
                            = f*/
gradname = &grad1;          /* change this to specify another
                            proc to compute the Jacobian matrix,
                            if desired.*/
jc0 = 0;                    /* change this to specify a KxK
                            matrix to be used as the initial
                            value of the Jacobian, if desired.*/
/*=============================================================*/
/* The following code actually calls the proc that solves the
equations.*/

x1 = nlsys(fname,x0,jc0,convtol,prntit,prntout);

OUTPUT FILE=c:R RESET ;
PRINT  X1';
END;

/*=============================================================*/
```

APPENDIX D

MATHEMATICAL DERIVATIONS

The import demand (M_i), composite good price (P_i), and the factor of proportionality (d_i) functions are derived as follows (suppressing the i notation):

Maximize $Q = \beta[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}}$ (D-1)

Subject to $P \cdot Q = PM \cdot M + PD \cdot D$ (D-2)

The lagrangian theorem for optimization is as follows:

$$df - \lambda dg = 0 \quad \text{(D-3)}$$

where

$$f \equiv Q - \beta[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}} = 0 \quad \text{(D-4)}$$

$$g \equiv P\beta[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}} - PM \cdot M - PD \cdot D = 0 \quad \text{(D-5)}$$

and

$$d = (\frac{\partial}{\partial M}, \frac{\partial}{\partial D}) \quad \text{(D-6)}$$

$$\frac{\partial f}{\partial M} = -\frac{\beta}{\rho}[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}(-\rho\delta)M^{-\rho-1} \quad \text{(D-7)}$$

$$= \beta\delta[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}M^{-\rho-1} \quad \text{(D-8)}$$

$$\frac{\partial f}{\partial D} = - \frac{\beta}{\rho}[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}(1-\delta)(-\rho)D^{-\rho-1} \quad \text{(D-9)}$$

$$= \beta(1-\delta)[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}D^{-\rho-1} \quad \text{(D-10)}$$

$$\frac{\partial g}{\partial M} = P\beta(-\frac{1}{\rho})[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}\delta(-\rho M^{-\rho-1}) - PM \quad \text{(D-11)}$$

$$= P\beta\delta[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}M^{-\rho-1} - PM \quad \text{(D-12)}$$

$$\frac{\partial g}{\partial M} = - \frac{P\beta}{\rho}[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}(1 - \delta)(-\rho)D^{-\rho-1} - PD \quad \text{(D-13)}$$

$$= P\beta(1 - \delta)[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}D^{-\rho-1} - PD \quad \text{(D-14)}$$

From Equation (D-3), we obtain the following,

$$\frac{\partial f}{\partial M} - \lambda\frac{\partial g}{\partial M} = 0 \quad \text{(D-15)}$$

$$\frac{\partial f}{\partial D} - \lambda\frac{\partial g}{\partial D} = 0 \quad \text{(D-16)}$$

Substituting Equations (D-8) and (D-12) in (D-15), obtains,

$$\beta\delta[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}M^{-\rho-1} =$$

$$\lambda[P\beta\delta[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}M^{-\rho-1} - PM] \quad \text{(D-17)}$$

$$(1 - \lambda P)[\beta\delta[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}M^{-\rho-1}] = - \lambda P\cdot PM \quad \text{(D-18)}$$

$$[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}-1}M^{-\rho-1} = \frac{\lambda PM}{(\lambda P-1)\beta\delta} \quad \text{(D-19)}$$

Similarly, substituting equations (D-10) and (D-14) in (D-16) obtains,

$$\beta(1 - \delta)[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho} -1} D^{-\rho-1}$$

$$= \lambda[P\beta(1 - \delta)[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho} -1} D^{-\rho-1} - PD] \tag{D-20}$$

$$(1 - \lambda P)[\beta(1 - \delta)[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho} -1} D^{-\rho-1}] = -\lambda PD \tag{D-21}$$

$$[\delta M^{-\rho}+ (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho} - 1} D^{-\rho-1} = \frac{\lambda PD}{(\lambda P - 1)\beta(1 - \delta)} \tag{D-22}$$

Rewriting the constraint (D-2), obtains,

$$P\beta[\delta M^{-\rho} + (1 - \delta)D^{-\rho}]^{-\frac{1}{\rho}} - PM\cdot M - PD\cdot D = 0 \tag{D-23}$$

Therefore, we have 3 equations (D-19, D-22, and D-23) in 3 unknowns (M, D, and λ).

<u>Import Demand Functions (M)</u>

Dividing (D-19) by (D-22) obtains,

$$\left(\frac{M}{D}\right)^{-\rho-1} = \frac{\lambda PM}{(\lambda P - 1)\beta\delta} \; \frac{(\lambda P - 1)\;\beta(1 - \delta)}{\lambda PD} \tag{D-24}$$

$$\left(\frac{M}{D}\right)^{-\rho-1} = \frac{PM}{PD} \cdot \frac{1 - \delta}{\delta} \tag{D-25}$$

$$\left(\frac{M}{D}\right)^{\rho+1} = \frac{PD}{PM} \cdot \frac{\delta}{1 - \delta} \tag{D-26}$$

Therefore, the import demand function is

$$\frac{M}{D} = \left(\frac{PD}{PM}\right)^{\frac{1}{\rho+1}} \left(\frac{\delta}{1 - \delta}\right)^{\frac{1}{\rho+1}} \tag{D-27}$$

$$\boxed{\frac{M}{D} = \left(\frac{PD}{PM}\right)^{\sigma}\left(\frac{\delta}{1 - \delta}\right)^{\sigma}} \text{ , where } \sigma = \frac{1}{\rho+1} \tag{D-28}$$

Composite Good Prices (P)

Equation (D-23) can be rewitten as,

$$P\beta\left[D^{-\rho}\left((1 - \delta) + \delta \frac{M^{-\rho}}{D^{-\rho}}\right)\right]^{-\frac{1}{\rho}} - PM\cdot M - PD\cdot D = 0 \tag{D-29}$$

or

$$P\beta D\left[(1 - \delta) + \delta\left(\frac{M}{D}\right)^{-\rho}\right]^{-\frac{1}{\rho}} - PM\cdot M - PD\cdot D = 0 \tag{D-30}$$

Divide through by D obtains,

$$P\beta\left[(1 - \delta) + \delta\left(\frac{M}{D}\right)^{-\rho}\right]^{-\frac{1}{\rho}} - PM\,\frac{M}{D} - PD = 0 \tag{D-31}$$

Substitute for $\frac{M}{D}$ (from D-27) and solve for P obtains,

$$P = \frac{PM\left(\frac{PD}{PM}\right)^{\frac{1}{\rho+1}} \left(\frac{\delta}{1 - \delta}\right)^{\frac{1}{\rho+1}} + PD}{\beta\left[(1 - \delta) + \delta\left(\left(\frac{PD}{PM}\right)^{\frac{-\rho}{\rho+1}} \left(\frac{\delta}{1 - \delta}\right)^{\frac{-\rho}{\rho+1}}\right)\right]^{-\frac{1}{\rho}}} \tag{D-32}$$

But $\sigma = \frac{1}{\rho+1}$, so $1 - \sigma = \frac{\rho}{\rho+1}$ and therefore, the denomenator of (D-32) can be rewritten as

$$\beta[(1 - \delta) + \delta \frac{PD^{\sigma-1}}{PM^{\sigma-1}} \cdot \frac{\delta^{\sigma-1}}{(1 - \delta)^{\sigma-1}}]^{-\frac{1}{\rho}}$$

or

$$\beta[\frac{PM^{\sigma-1}(1 - \delta)^{\sigma} + \delta PD^{\sigma-1}\delta^{\sigma-1}}{PM^{\sigma-1}(1 - \delta)^{\sigma-1}}]^{-\frac{1}{\rho}} \tag{D-33}$$

The numerator of (D-32) can be rewritten as,

$$PM(\frac{PD}{PM})^{\sigma}(\frac{\delta}{1 - \delta})^{\sigma} + PD = PM^{1-\sigma}PD^{\sigma}\frac{\delta^{\sigma}}{(1 - \delta)^{\sigma}} + PD$$

or

$$\frac{PM^{1-\sigma}PD^{\sigma}\delta^{\sigma} + PD(1 - \delta)^{\sigma}}{(1 - \delta)^{\sigma}} \tag{D-34}$$

Therefore,

$$P = \frac{\delta^{\sigma}PM \cdot PD^{\sigma} + (1 - \delta)^{\sigma}PM^{\sigma}PD}{\beta[(1 - \delta)^{\sigma} PM^{\sigma-1} + \delta^{\sigma}PD^{\sigma-1}]^{-\frac{1}{\rho}}} \tag{D-35}$$

$$P = \frac{PM \cdot PD^{\sigma}\delta^{\sigma} + PD \cdot PM^{\sigma}(1 - \delta)^{\sigma}}{\beta[\frac{PM^{\sigma}(1 - \delta)^{\sigma}}{PM} + \frac{\delta^{\sigma}PD^{\sigma}}{PD}]^{-\frac{1}{\rho}}} \tag{D-36}$$

$$= \frac{PM \cdot PD^{\sigma} \delta^{\sigma} + PD \cdot PM^{\sigma}(1 - \delta)^{\sigma}}{\beta[\frac{PD \cdot PM^{\sigma}(1 - \delta)^{\sigma} + PM\delta^{\sigma}PD^{\sigma}}{PM \cdot PD}]^{-\frac{1}{\rho}}} \tag{D-37}$$

$$= \frac{1}{\beta/(PM\cdot PD)^{-\frac{1}{\rho}}}\left[PM\cdot PD^{\sigma}\ \delta^{\sigma} + PD\cdot PM^{\sigma}(1 - \delta)^{\sigma}\right]^{1 + \frac{1}{\rho}} \qquad \text{(D-38)}$$

$$= \frac{1}{\beta}(PM\cdot PD)^{-\frac{1}{\rho}}\left[PM\cdot PD^{\sigma}\delta^{\sigma} + PD\cdot PM^{\sigma}(1 - \delta)^{\sigma}\right]^{1 + \frac{1}{\rho}} \qquad \text{(D-39)}$$

$$= \frac{1}{\beta}\ PM^{-\frac{1}{\rho}}\ PD^{-\frac{1}{\rho}}\left[PD^{\sigma}PM^{\sigma}(PM^{1-\sigma}\delta^{\sigma} + PD^{1-\sigma}(1 - \delta)^{\sigma}\right]^{\frac{1}{1-\sigma}} \qquad \text{(D-40)}$$

$$= \frac{1}{\beta}\ PM^{-\frac{1}{\rho}}PD^{-\frac{1}{\rho}}PD^{\frac{\sigma}{1-\sigma}}\ PM^{\frac{\sigma}{1-\sigma}}\left[PM^{1-\sigma}\delta^{\sigma} + PD^{1-\sigma}(1 - \delta)^{\sigma}\right]^{\frac{1}{1-\sigma}}$$

$$= \frac{1}{\beta}\ PM^{-\frac{1}{\rho}}\ PD^{-\frac{1}{\rho}}\ PD^{\frac{1}{\rho}}\ PM^{\frac{1}{\rho}}\left[PM^{1-\sigma}\delta^{\sigma} + PD^{1-\sigma}(1 - \delta)^{\sigma}\right]^{\frac{1}{1-\sigma}} \qquad \text{(D-41)}$$

$$\boxed{P = \frac{1}{\beta}\left[\delta^{\sigma}PM^{1-\sigma} + (1 - \delta)^{\sigma}PD^{1-\sigma}\right]^{\frac{1}{1-\sigma}}} \qquad \text{(D-42)}$$

Domestic Use Ratios (d)

Substituting Equation (D-28) in Equation (D-2) obtains,

$$P\cdot Q - PD\cdot D + PM\ \left(\frac{PD}{PM}\right)^{\sigma}\left(\frac{\delta}{1 - \sigma}\right)^{\sigma}\ D \qquad \text{(D-43)}$$

Divide both sides by Q,

$$P = PD\,\frac{D}{Q} + PM\left(\frac{PD}{PM}\right)^{\sigma}\left(\frac{\delta}{1 - \delta}\right)^{\sigma}\frac{D}{Q} \tag{D-44}$$

$$= \frac{D}{Q}\left[PD + PM\left(\frac{PD}{PM}\right)^{\sigma}\left(\frac{\delta}{1 - \delta}\right)^{\sigma}\right] \tag{D-45}$$

$$= \frac{D}{Q}\left[PD + \frac{PM\cdot PD^{\sigma}\delta^{\sigma}}{PM^{\sigma}(1 - \delta)^{\sigma}}\right] \tag{D-46}$$

$$= \frac{D}{Q}\left[\frac{PD\cdot PM^{\sigma}(1 - \delta)^{\sigma} + PM\cdot PD^{\sigma}\delta^{\sigma}}{PM^{\sigma}(1 - \delta)^{\sigma}}\right] \tag{D-47}$$

$$P\cdot PM^{\sigma}(1 - \delta)^{\sigma} = \frac{D}{Q}\left[PD\cdot PM^{\sigma}(1 - \delta)^{\sigma} + PM\cdot PD^{\sigma}\ \delta^{\sigma}\right] \tag{D-48}$$

$$\frac{D}{Q} = \frac{P\cdot PM^{\sigma}(1 - \delta)^{\sigma}}{PD\cdot PM^{\sigma}(1 - \delta)^{\sigma} + PM\cdot PD^{\sigma}\delta^{\sigma}} \tag{D-49}$$

$$\frac{D}{Q} = \frac{P^{\sigma}}{PD^{\sigma}}\ \frac{P^{1-\sigma}PM^{\sigma}(1 - \delta)^{\sigma}}{(PD^{1-\sigma}PM^{\sigma}(1 - \delta)^{\sigma} + PM\delta^{\sigma}} \tag{D-50}$$

But from Equation (D-42)

$$P = \frac{1}{\beta}\left[\delta^{\sigma}PM^{1-\sigma} + (1 - \delta)^{\sigma}PD^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

Therefore, the term P^{σ} in Equation (D-50) can be rewritten as

$$(P\beta)^{1-\sigma} = \delta^{\sigma}PM^{1-\sigma} + (1 - \delta)^{\sigma}PD^{1-\sigma} \tag{D-51}$$

$$(P\beta)^{1-\sigma}PM^{\sigma} = \delta^{\sigma}PM + (1 - \delta)^{\sigma}PM^{\sigma}PD^{1-\sigma} \tag{D-52}$$

Substituting (D-52)in (D-50) obtains,

$$\frac{D}{Q} = \frac{P^{\sigma}}{PD^{\sigma}} \frac{P^{1-\sigma}(1 - \delta)^{\sigma}PM^{\sigma}}{P^{1-\sigma}\beta^{1-\sigma}PM^{\sigma}} \tag{D-53}$$

$$\boxed{d \equiv \frac{D}{Q} = (\frac{P}{PD})^{\sigma}(1 - \delta)^{\sigma}\beta^{\sigma-1}} \tag{D-54}$$

The labor demand function is derived as follows. From Chapter II, the labor demand function (equation 8') is,

$$PN_i \frac{\partial X_i}{\partial(\frac{1}{\ell_{is}} L^e_{is})} = W_s \tag{D-55}$$

The production function is

$$X_i = \Omega_i(\frac{1}{\ell_{i1}} L^e_{i1})^{\alpha_{i1}} (\frac{1}{\ell_{i2}} L^e_{i2})^{\alpha_{i2}} (\frac{1}{\ell_{i3}} L^e_{i3})^{\alpha_{i3}} (\overline{K}_i)^{\beta_i} \tag{D-56}$$

$$\frac{\partial X_i}{\partial L^e_{i1}} = \alpha_{i1}\Omega_i(\frac{1}{\ell_{i1}} L^e_{i1})^{\alpha_{i1}-1} (\frac{1}{\ell_{i2}} L^e_{i2})^{\alpha_{i2}} (\frac{1}{\ell_{i3}} L^e_{i3})^{\alpha_{i3}} (\overline{K}_i)^{\beta_i} \tag{D-57}$$

$$\frac{\partial X_i}{\partial L_{i1}^e} = \alpha_{i1}\Omega_i \frac{\left(\frac{1}{\ell_{i1}} L_{i1}^e\right)^{\alpha_{i1}}}{\frac{1}{\ell_{i1}} L_{i1}^e} \left(\frac{1}{\ell_{i2}} L_{i2}^e\right)^{\alpha_{i2}} \left(\frac{1}{\ell_{i3}} L_{i3}^e\right)^{\alpha_{i3}} (\overline{K}_i)^{\beta_i} \qquad \text{(D-58)}$$

$$\frac{\partial X_i}{\partial L_{i1}^e} = \alpha_{i1} \frac{X_i}{\frac{1}{\ell_{i1}} L_{i1}^e} \qquad \text{(D-59)}$$

Similarly, $\frac{\partial X_i}{\partial L_{i2}^e}$ and $\frac{\partial X_i}{\partial L_{i3}^e}$ are equal to,

$$\frac{\partial X_i}{\partial L_{i2}^e} = \alpha_{i2} \frac{X_i}{\frac{1}{\ell_{i2}} L_{i2}^e} \qquad \text{(D-60)}$$

$$\frac{\partial X_i}{\partial L_{i3}^e} = \alpha_{i3} \frac{X_i}{\frac{1}{\ell_{i3}} L_{i3}^e} \qquad \text{(D-61)}$$

Therefore, substituting equations (D-59), (D-60), and (D-61) in equation (D-55) where S = 1, 2, 3, obtains

$$\boxed{PN_i = \frac{\alpha_{is} X_i}{\frac{1}{\ell_{is}} L_{is}^e} = W_s} \qquad \text{(D-62)}$$

APPENDIX E

STATISTICAL DATA

TABLE E-1

SCHEMATIC DIAGRAM FOR THE INPUT-OUTPUT TABLE FOR SAUDI ARABIA (1981)

Output / Input	x_1 x_2 . . . i . . . x_{11}	Total Intermediate demand	C^g C^p INV CHS E M	Total Final Demand	Total Output
x_1 x_2 . . . j . . . x_{11}	**Interindustry Transactions**	+	**Structure of Final Demand**	=	Total Receipts
Total Intermediate Cost	+				
Labor Capital Indirect Tax	**Value Added**		**Other Final Demand**		
Total Value Added	=				
Total Cost of Production	Total Outlay				Gross Output

TABLE E-2

INPUT-OUTPUT TABLE FOR SAUDI ARABIA (1981)
INTERINDUSTRY TRANSACTIONS
(MILLION OF SR)

Sector	Agriculture	Crude Oil	Mining and Quarrying	Petroleum Refining	Manufacturing	Utility	Construction	Trade	Transportation	Finance	Community Social and Personal Services	Total
Agriculture	196.3	0.0	0.0	0.0	0.6	0.0	2.4	0.0	82.0	0.0	0.0	281.3
Crude Oil	663.70	345.70	16.69	842.85	91.37	181.05	1,546.74	257.42	2,859.05	804.56	578.53	8,187.68
Mining and Quarrying	0.0	23.54	258.56	57.48	27.68	2.34	3,592.62	4.46	5.8	16.54	3.26	3,992.3
Petroleum Refining	30.0	15.6	0.8	38.1	4.1	8.2	69.9	11.6	129.1	36.3	26.1	369.8
Manufacturing	1,131.2	1,429.1	1,177.26	3,483.6	5,281.64	624.08	2,6542.88	1,965.98	9,049.58	3,584.22	2,940.4	57,209.94
Utilty	0.0	6.5	8.6	15.8	11.7	3.1	77.7	34.7	39.6	87.4	27.6	312.7
Construction	0.0	1.7	0.1	4.0	8.8	1.3	250.7	4.4	278.0	70.2	3.7	622.9
Trade	248.35	265.76	281.19	648.58	987.0	118.37	5,815.83	398.27	1,723.66	685.34	551.46	11,724.08
Transportation	234.85	438.83	311.19	1,069.58	1,050.5	198.77	6,520.83	1,725.07	3,111.96	1,635.14	634.86	16,931.58
Finance	57.6	176.5	17.2	430.3	250.1	66.1	5,469.2	1,507.8	1,657.4	2,329.6	394.5	12,356.3
Community Social and Personal Services	0.0	30.6	1.4	74.5	7.7	1.9	480.0	23.7	30.9	18.9	7.5	677.1
Total	2,562	2,734.1	2,073.0	6,664.8	7,721.2	1,205.2	50,368.8	5,933.4	18,965.6	9,268.2	5,167.9	112,664.2

Note: The original form of the Table (Aljiffory, 1983) is a ten by ten matrix for the year of 1976. Dean Schreiner has updated the table of 1976 to the year of 1981 and extended it into an eleven by eleven matrix. The present Table is a modefication of Schreiner's Input-Output Table (1981). rows have been adjusted for trade and distribution margins. Trade and distribution margins were extracted from all rows, which include these margins and were added to the trade and transportation rows of the same table.

TABLE E-3

INPUT-OUTPUT TABLE FOR SAUDI ARABIA (1981)
STRUCTURE OF FINAL DEMAND
(MILLION OF SR)

Sector	Government Consumption	Private Consumption	Fixed Capital Formation	Change in Stock	Exports	Imports	Tariffs	Net Final Demand
Agriculture	8.3	11,642.5	0.0	168.2	90.2	3,977.4	79.5	7,852.3
Crude Oil	0.0	0.0	0.0	0.0	335,543.2	0.0	0.0	335,543.22
Mining and Quarrying	0.0	0.0	0.0	0.0	5.8	224.5	4.5	-223.2
Petroleum Refining	246.5	4,394.5	0.0	0.0	19,680.7	0.0	0.0	24,321.7
Manufacturing	419.12	44,016.26	15,085.78	4,553.8	1,016.2	104,348.1	2,510.6	41,767.54
Utilty	156.5	1,134.9	0.0	0.0	0.0	0.0	0.0	1,291.4
Construction	14,288.4	0.0	85,805.1	0.0	0.0	0.0	0.0	100,093.5
Trade	360	11,988.92	2,742.51	852.8	249.0	0.0	0.0	16,192.92
Transportation	1,117.29	13,970.7	2,742.51	852.7	3,787.9	3,314.4	0.0	19,156.82
Finance	2398	12,745.2	0.0	0.0	487.7	0.0	0.0	15,630.9
Community Social and Personal Services	677	9,318.1	0.0	0.0	0.0	0.0	0.0	9,995
Total	19,671.11	109,211.08	106,375.9	6,427.5	360,860.8	111,864.4	2,594.6	600,752.7

Source: National Accounts of Saudi Arabia (1982), pp. 54-55.

Note: An adjustment for trade and distribution margins have been applied in this Table as well.

TABLE E-4

INPUT-OUTPUT TABLE FOR SAUDI ARABIA (1981)
VALUE ADDED
(MILLION OF SR)

Sector	Agriculture	Crude Oil	Mining and Quarrying	Petroleum Refining	Manufacturing	Utility	Construction	Trade	Transportation	Finance	Community Social and Personal Services	Total
Labor	2,147.7	3,365.6	1,356.9	1,435.9	3,493.1	1,011.7	25,946.4	4,603.9	12,448.8	2,262.9	2,868.2	60,941.1
Captial	3,988.5	337,631.2	339.2	16,586.3	4,228.1	218.9	24,401.2	20,379.7	5,409	16,404.6	2,636	432,222.7
Indirect Tax	-564.6	0.0	0.0	4.5	0.0	-831.7	0.0	-3000	-735	51.5	0.0	-5,075.3
Total	5,571.6	340,996.8	1,696.1	18,026.7	7,721.2	398.9	50,347.6	21,983.6	17,122.8	18,719	5,504.2	488,088.5

Source: National Accounts of Saudi Arabia (1982), p. 43.

TABLE E-5

INPUT-OUTPUT TABLE FOR SAUDI ARABIA (1981)
OTHER FINAL DEMAND
(MILLION OF SR)

Description	Government Consumption	Private Consumption	Fixed Capital Formation	Change in Stock	Exports	Imports	Tariffs
Direct Purchases Abroad by Government Services on Current Account	32,337.5					32,337.5	
Government Employees Payments	29,905.7						
Direct Purchases Abroad by Resident Households less Direct Purchaser by Non-Resident Household in the Domestic Market		5,693.1			7,564.2	13,257.3	
Total	62,243.2	5,693.1			7,564.2	45,594.8	

Source: National Accounts of Saudi Arabia (1982).

TABLE E-6

SCHEMATIC DIAGRAM FOR THE AGGREGATE SOCIAL ACOUNTING MATRIX IN SAUDI ARABIA USING SYMBOLS FROM THE MODEL

		Factors of Production		Institutional Sectors								
		Labor	Capital	Oil Sector	Non Oil Sector	Government	Households	Consolidated Capital Account	Activities	Commodities	The Rest of the World	Total
		1	2	3	4	5	6	7	8	9	10	11
Labor	1					$\overline{WAG^g}$			$\sum_i \sum_s L_{is} W_s$			total labor income
Capital	2								$\sum \overline{K_i}$		$\overline{PROREC}$	total capital income
Oil Sector	3		Y_k^{oil}									total income of oil sector
Non Oil Sector	4		Y_k^{noil}			$\overline{GTRANOIL}$						total income of non oil sector
Government	5			$t_1 E^{oil}$	$t_2 Y_k^{noil}$		$t_3 Y^h$			$\sum tm_j \overline{PW_j}\,\overline{ER_j} M_j$	$\overline{GTRAINRW}$	GR
Households	6	household labor income	household capital income			$\overline{GTRAH}$						Y^h
Consolidated Capital Account	7			SAV^{oil}	SAV^{noil}	SAV^g	SAV^p					total savings
Activities	8					$\sum td_j PD_j X_j$				$\sum_i PD_i X_i$		gross outputs
Commodities	9					C^g	C^p	INV+CHS	$\sum_j \sum_i a_{ij} X_j$		E	total commodity demands
The Rest of the World	10	REM	$\overline{PROPAI}$	$\overline{OTRAROW}$	$\overline{NOTRAROW}$	$\overline{GTRAOUT}$	$\overline{HTRAROW}$	S^f		M		disposal of current receipts
Total	11	compen-sation of employee	total cost of capital	oil sector total exenditures	non-oil sector total expenditures	government total expenditures	household total expenditures	savings	total cost of production	total supply of commodities	current receipts	

TABLE E-7

AGGREGATE SOCIAL ACOUNTING MATRIX IN SAUDI ARABIA (1980/81)
(MILLION OF SR)

			Factors of Production		Institutional Sectors								
			Labor	Capital	Oil Sector	Non Oil Sector	Government	Households	Consolidated Capital Account	Activities	Commodities	The Rest of the World	Total
			1	2	3	4	5	6	7	8	9	10	11
	Labor	1					29905.7			60941.1			90846.8
	Capital	2								432222.7		24368.0	456590.7
	Oil Sector	3		351512.4									351512.4
	Non Oil Sector	4		46309.3			1656.6						47965.9
	Government	5			310496.4	23951.4		428.0			2594.6	232.2	337702.6
	Households	6	86671.5	26414.6			4929.1						118015.2
Consolidated Capital Account		7			31126.0	19078.5	211789.5	2673.1					264667.1
Activities		8					5075.3				600752.7		605828.0
Commodities		9					52008.9	114905.1	112803.3	112664.2		368425.0	760806.5
The Rest of the World		10	4175.3	32354.4	9890.0	4936.0	32337.5	9.0	151863.8		157459.2		393025.2
Total		11	90846.8	456590.7	351512.4	47965.9	337702.6	118015.2	264667.1	605828.0	760806.5	393025.2	

SOURCE: National Accounts of Saudia Arabia (1982), p. 29.

TABLE E-8

GROSS DOMESTIC PRODUCT AND EXPENDITURE (1981)
(MILLION OF SR)

Compensation of employees	90846.8	Total Government Expenditure	81,914.6
Private	60,941.1	Goods & Services (C^g)	52,008.9
Public ($\overline{WAG^g}$)	29,905.7	Wages of Government Employees (WAG^g)	29,905.7
Operating Surplus	432,222.7	Private Consumption (C^P)	114,905.1
Indirect Taxes Less Subsidies ($\overline{INDTAX}$)	-2,480.7	Gross Fixed Capital Formation (INV)	106,375.9
		Increase in Stock ($\overline{CHS}$)	6,427.4
		Exports of Goods and Services (E)	36,8425
		Less Imports of Goods and Services	157,459.2
GDP	520,588.8	Expenditure of GDP	520,588.8

Source: National Accounts of Saudi Arabia (1982), p. 31.

TABLE E-9

EXTERNAL TRANSACTIONS (1981)
(MILLION SR)

Current Transactions			
Exports of Goods and Services (E)	368,425	Imports of Goods and Services (M)	157,459.2
Property and Enterpreneural Income from the Rest of the World (PROREC)	24,368	Compensation of Employees Employees to the Rest of the World (REM)	4,175.3
Other Current Transfers from the Rest of the World (GTRAINRW)	232.2	Property and Entrepreneural Income to the Rest of the World (PROPAI)	32,354.4
		Other Current Transfers to the Rest of the World (TRAPAI)	47,172.5
		Surplus of the Nation Nation on Current Transaction (S^T)	151,863.8
Current Receipts	393,025.2	Disposal of Current Receipt	393,025.2

Capital Transactions			
Surplus of the Nation on Current Transactions	151,863.2	Net Acquisition of Foreign Financial Assets	151,863.8
Receipts	151,863.8	Disbursements	151,863.8

Source: National Accounts of Saudi Arabia (1982), p.34.

TABLE E-10

TOTAL LABOR FORCE BY SECTOR (1981)

Sector	Number
Agriculture	582,505
Crude Oil	29,026
Mining and Quarrying	8,500
Petroleum Refining	8,969
Manufacturing	111,642
Utility	36,089
Construction	376,207
Trade	357,145
Transportation	243,490
Finance	42,353
Community Social and Personal Services	560,371
TOTAL	2,356,297

Source: Al-Khouli (1985), p. 371.

TABLE E-11

TOTAL SECTORAL BY OCCUPATION LABOR FORCE IN SAUDI ARABIA (1981)*

Sector	Skilled	Semiskilled	Unskilled	Total
Agriculture	33,785	192,809	355.911	582.504
Crude Oil	4,614	22,670	1,742	29,026
Mining and Quarrying	1,038	7,190	272	8,500
Petroleum Refining	1,426	7,005	538	8,969
Manufacturing	7,034	101,817	2,791	111,642
Utility	5,233	28,691	2,165	36,089
Construction	33,858	323,163	19,186	376,207
Trade	22,143	273,930	61,072	357,145
Transportation	37,497	179,452	26,540	243,490
Finance	11,224	27,402	3,727	42,353
Community Social and Personal Services	123,281	272,900	164,189	560,371
Total	281,133	1,437,851	638,362	2,357,346

Source: Al-Khouli (1985), p. 371.

*The distribution across skills is obtained by using the percentage coefficients found in the same reference, p. 234.

TABLE E-12

EXPATRIATE SECTORAL BY OCCUPATION LABOR FORCE IN SAUDI ARABIA (1981)*

Sector	Skilled	Semiskilled	Unskilled	Total
Agriculture	10,513	93,836	7,493	111,841
Crude Oil	368	3,288	263	3,919
Mining and Quarrying	383	3,415	273	4,071
Petroleum Refining	114	1,017	81	1,212
Manufacturing	7,976	71,188	5,685	84,848
Utility	1,797	16,048	1,281	19,127
Construction	33,135	295,752	23,618	352,506
Trade	14,100	125,851	10,050	150,001
Transportation	18,379	164,044	13,100	195,523
Finance	3,273	29,209	2,332	34,814
Community Social and Personal Services	39,665	354,024	28,271	421,960
Total	129,703	1,157,672	92,447	1,379,822

Source: Al-Khouli (1985), p. 376.
Ministry of Labor and Social Affairs Annual Report (1982), p. 49.

*The distribution of expatriates across skills is obtained by using the distribution coefficients in the Ministry Annual Report.

APPENDIX F

ESTIMATED DATA AND PARAMETERS

Data for Production and Labor Functions

There is no consistent data available on the number of workers and their wages by sectors and occupational categories. The problem is even worse if one wants to disaggregate these data by nationality. This data inconsistency makes it hard to calibrate the Saudi CGE model for the base year of 1981.

Consistent data and parameters, therefore, have been estimated and been used to solve the present model. The following steps briefly describe the procedure used to obtain the estimated variables and parameters that are shown in Appendix B.

Step 1. The following is a system of equations that were solved in this step.

$$PN_i \frac{\alpha_{is} X_i}{(\frac{1}{\ell_{is}})(Z_i L_{is}^e)} = C(W_s) \qquad \text{(F-1)}$$

$$\sum_i (\frac{1}{\ell_{is}} - 1) Z_i L_{is}^e = L_s^h \qquad \text{(F-2)}$$

$$\sum_s \sum_i \frac{1}{\ell_{is}} Z_i L_{is}^e = \overline{L} \qquad \text{(F-3)}$$

$$\sum_s \alpha_{is} = \alpha_i \qquad \text{(F-4)}$$

where $\overline{L}$ is the total labor force which includes both domestic and expatriate workers in the base year (1981). The variables Z_i and C are artificial variables. The role of these artificial variables will become clear in the next step. All other variables have already defined in Appendix A.

With the exception of including the artificial variables (Z_i and

C), equations (F-1) and (F-2) remain the same as that of equations (7) and (8) in Appendix A. Equation (F-3) is the total labor constraint in the economy. Equation (F-4) is included in the system to guarantee that the sum of the solution values of α_{is}'s ($\sum_s \alpha_{is}$) equal the base year sectoral share of labor (α_i) in sectoral valued added.

Given the base year values of PN_i, X_i, L^e_{is}, ℓ_{is}, and W_s, equations (F-1) through (F-4) were solved simultaneously for the variables α_{is}, L^h_s, Z_i, and C.[1] The solution values of these variables are shown in Table F-1.

Step 2. The solution values of Z_i and C obtained from Step 1 are then used to get the estimated values of L^e_{is} and W_s (L^{ea}_{is} and W^a_s). In particular, these estimated values are now defined as,

$$L^{ea}_{is} = Z_i L^e_{is} \quad \text{(F-5)}$$

$$W^a_s = CW_s \quad \text{(F-6)}$$

The variable Z_i in equation (F-5) redistributes the number of expatriate workers of skill s across sectors but leaves their relative distribution across skills unchanged. Similarly, the variable C adjusts wages while their levels relative to each other is the same.

These values of L^{ea}_{is} and W^a_s in addition to L^{ha}_s are shown in Tables (F-2) and (F-3).[2] It should be noted that if the system of equations

[1]The values of X_i,L_{is}, L^e_{is}, and W_s are obtained from Appendix E.

[2]L^{ha}_s is the estimated number of domestic workers of skill S that is obtained from Step 1.

TABLE F-1

ESTIMATED VALUES OF α_{is} and Z_i (1981)

Sector	a_{i1}	α_{i2}	α_{i3}	Z_i
Agriculture	0.090605	0.209514	0.049885	0.434864
Crude Oil	0.002552	0.005908	0.001409	19.448383
Mining and Quarrying	0.207225	0.478685	0.114102	7.546077
Petroleum Refining	0.020641	0.047704	0.011329	26.832003
Manufacturing	0.117116	0.270804	0.064484	0.932269
Utility	0.212837	0.492146	0.117137	1.197821
Construction	0.133406	0.308485	0.073455	1.666829
Trade	0.047704	0.110308	0.026266	0.695042
Transportation	0.180459	0.417287	0.099361	1.441709
Finance	0.031213	0.072164	0.017179	1.463855
Community Social and Personal Services	0.134898	0.311923	0.074272	0.153927

TABLE F-2

ESTIMATED NUMBER OF SECTORAL BY OCCUPATION EXPATRIATE WORKERS (1981)

Sector	L^{ea}_{i1} (Skilled)	L^{ea}_{i2} (Semiskilled)	L^{ea}_{i3} (Unskilled)
Agriculture	4,572	40,806	3,258
Crude Oil	7,157	63,946	5,115
Mining and Quarrying	2,890	25,770	2,060
Petroleum Refining	3,059	27,288	2,173
Manufacturing	7,436	66,366	5,300
Utility	2,154	19,223	1,534
Construction	55,230	492,970	39,367
Trade	9,800	87,472	6,985
Transportation	26,497	236,504	18,886
Finance	4,791	42,758	3,414
Community Social and Personal Services	6,106	54,494	4,352

TABLE F-3

ESTIMATED ANNUAL DOMESTIC WAGES AND TOTAL SUPPLY OF DOMESTIC WORKERS FOR EACH SKILL (1981)

Skill Level	W^{a}_{s} (Thousand of SR)	L^{ha}_{s}
Skilled	56.1117	151,391
Semiskilled	25.3654	280,232
Unskilled	13.6029	545,989

(F-1) through (F-4) are solved again with L^{e}_{is} and W_s replaced by L^{ea}_{is} and W^{a}_{s} instead, then the solution value of C must equal to one and that of Z_i's must be a vector of ones.

Step 3. Given the estimated values of α_{is} (from Step 1), L^{ea}_{is} (from Step 2), and the base year values of X_i, $\overline{K}_i$, and the ℓ_{is}, the production function,

$$X_i = \Omega_i\left(\frac{1}{\ell_{i1}} L^{ea}_{i1}\right)^{\alpha_{i1}} \left(\frac{1}{\ell_{i2}} L^{ea}_{i2}\right)^{\alpha_{i2}} \left(\frac{1}{\ell_{i3}} L^{ea}_{i3}\right)^{\alpha_{i3}} \left(\overline{K}_i\right)^{\beta_i} \qquad \text{(F-7)}$$

is solved for the parameter Ω_i. These estimated values of Ω_i's are presented in Table F-4.

<u>Estimating the Parameters δ_i and ε_i</u>

This section explains the procedure used to calculate the paramters δ_i and ε_i using equations (3) and (9) of Appendix A. These equations are rewritten below,

$$\frac{M_i}{D_i} = \left(\frac{PD_i}{PM_i}\right)^{\sigma_i} \left(\frac{\delta_i}{1 - \delta_i}\right)^{\sigma_i} \qquad \text{(F-8)}$$

$$P_i = \frac{1}{\varepsilon_i}\left[\delta_i^{\sigma_i} PM_i^{1-\sigma_i} - (1 - \delta_i)^{\sigma_i} PD_i^{1-\sigma_i}\right]^{\frac{1}{1-\sigma_i}} \qquad \text{(F-9)}$$

The estimation procedure starts with a guess of the trade elasticity of substitution (σ_i) as shown in Table (F-5). The value of σ_i's are assumed 2.5 for the traded sectors and 0.5 for the non-traded sectors.[3]

[3]For the same purpose these guessed values are also assumed by Alsabah (1986) in a study about Kuwait.

Given the base year values of M_i, D_i, PD_i, and PM_i and given the guessed value of σ_i, equation (F-8) is solved for δ_i.[4] Similarly, given the base year values of all prices (PD_i, PM_i, P_i), the guessed values of σ_i, and the estimated value of δ_i (obtained by solving equation F-8), equation (F-9) is solved for ε_i. The estimated values of δ_i and ε_i, in addition to the guessed σ_i, are presented in Table F-5.

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[4]Domestic prices (PD_i) and composite prices (P_i) are assumed to equal unity in the base year.

TABLE F-4

ESTIMATED VALUES OF Ω_i (1981)

Sector	Value
Agriculture	1.011265
Crude Oil	1.038208
Mining and Quarrying	0.449672
Petroleum Refining	1.467925
Manufacturing	1.215469
Utility	0.240954
Construction	1.034904
Trade	1.111249
Transportation	0.599538
Finance	1.580044
Community Social and Personal Services	0.987663

TABLE F-5

ESTIMATED VALUES OF δ_i AND ε_i (1981)

Sector	σ_i	δ_i	ε_i
Agriculture	2.5	0.653607	0.548201
Crude Oil	0.5	0.000000	1.000000
Mining and Quarrying	2.5	0.322563	0.574179
Petroleum Refining	0.5	0.000000	1.000000
Manufacturing	2.5	0.964265	0.919210
Utility	0.5	0.000000	1.000000
Construction	0.5	0.000000	1.000000
Trade	0.5	0.000000	1.000000
Transportation	2.5	0.386821	0.531498
Finance	0.5	0.000000	1.000000
Community Social and Personal Services	0.5	0.000000	1.000000

VITA

Saleh Ahmed Tawi

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE IMPACT OF EXPATRIATE WORKERS ON THE ECONOMY OF SAUDI ARABIA - "A COMPUTABLE GENERAL EQUILIBRIUM RESULTS"

Major Field: Economics

Biographical:

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