2011

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Working Paper No. ZU-WP 2011-003

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March 30, 2011

Abstract

This paper develops a forward looking, multi-sector, dynamic computable general equilibrium model with oil for the United Arab Emirates. The model addresses three issues. The first is trade liberalization, where the UAE unilaterally lowers import tariffs. This has a favorable impact on welfare as domestic production is expanding, although labor-intensive sectors face a cost disadvantage and they are shrinking. The second issue, government revenue diversification, is simulated by increasing the indirect tax rate on goods to make the government less dependent on oil. This has an adverse effect on welfare as the economy is shrinking and production shifts from domestic production to exports, especially for labor-intensive sectors. Finally, a higher oil price has a favorable impact on welfare and overall, the economy is expanding, but more because of increased consumption and less because of increased production. This paper is the first attempt to address these issues in a dynamic forward looking general equilibrium context of the UAE and the Arab Gulf region.

Keywords: Dynamic CGE, trade liberalization, taxation, welfare.

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1 Introduction

The United Arab Emirates (UAE) is a small oil-producing Gulf country with a population of 4.2 million inhabitants. A striking feature of UAE economy is the dependency on immigrant labor. The population consists roughly of 900,000 nationals and 3.3 million mostly immigrant workers[2]. The UAE economy is oil dependent and in 2006 the GDP of the oil sector (at factor cost) reached 233 billion UAE Dirham (in the sequel this will be abbreviated as AED), which is approximately 61 billion US Dollars (this will be abbreviated to USD in the sequel) or 37% of total GDP. Recently, the level of GDP of the oil sector is rising as a percentage of total GDP as shown in Figure A.1 (all figures can be found in Appendix A). In the past, real economic growth in the UAE as measured by the growth rate of real GDP has been hovering between approximately 2% and 12%. Real economic growth has been steadily increasing recently and it reached a double-digit figure in 2006 (Figure A.2). Recently, the level of inflation is catching up (Figure A.3). There are few taxes in the UAE: an import tariff, an indirect tax on goods, and, an income tax (on profits of foreign banks and oil and gas companies). These tax revenues constitute a relatively small percentage of total government revenues (Figure A.4). The (estimated) tax rates for the import tariff (assuming all sectors are equally taxed) and the indirect tax rate are very low (Figure A.5). For the UAE the level of exports and imports are both rising over time (Figure A.6). Especially in later years, exports are larger than imports making clear that the UAE is earning money from the rest-of-the-world (ROW). The total sum of wages and the operation surplus as percentage of GDP at factor cost is shown in Figure A.7. Wages constitute approximately only 21% of GDP at factor cost and operating surplus 79% in 2006. In that same year, wages constituted 49% of GDP in the United States of America (BEA, 2008), and 56% of GDP in a European country such as The Netherlands (CBS, 2008). Consequently, considering labor and capital as the two factors of production, the relative size of the reward for capital is quite large, much larger than in some other countries.

The structure of the UAE economy is quite different from a Western economy because of its dependency on oil, the large proportion of immigrant workers, the low

[2] All figures in this section are provided by the UAE Ministry of Economy (MOE).

taxes and the large fraction of operating surplus in GDP. Because of these characteristics, it is interesting to study, in a general equilibrium setting, the consequences of various policy measures and disturbances that can take place, while taking into account the various links that exist among the various sectors of the economy and the relationship with the ROW through imports and exports. If the economy is divided into various sectors, it is also possible to see which sectors gain the most when the economy is expanding, or which sectors suffer the most when the economy is shrinking. In a multi-sector setting, it is even possible to see some sectors shrinking and others expanding at the same time. A multi-sector model makes it possible to trace out the effects on different sectors, particular in the case of counterbalancing forces. Employing a one sector model would not provide these insights. To this end, a forward looking dynamic multi-sector computable general equilibrium (CGE) model for the UAE economy is set up in this paper.

Subsequently, various simulations can be carried out with the model. The focus will be on those simulations that are currently of importance to the UAE. Three important issues are addressed that will determine the future path of the UAE economy. First, there is the issue of trade liberalization. In view of the WTO agreement, the UAE is currently negotiating several bilateral free trade agreements (FTAs) with a number of countries, such as the United States of America. One aspect of FTAs is the lowering of import tariffs. As the behavior of the trading partners of the UAE is not modelled in the paper, trade liberalization is simulated by a unilateral import tariff rate reduction. A second important issue is government revenue diversification where the aim is to diversify from oil to non-oil revenues. It is assumed that the government of the UAE is trying to achieve this goal by increasing the indirect tax rate on goods, thereby making it less dependent on oil. Finally, the effects of an increase in the world price of oil are traced out. In what way will the economy of the UAE benefit from higher oil revenues and what sectors will benefit the most? This paper is the first attempt to address these issues in a dynamic forward looking general equilibrium context of the UAE and the Arab Gulf region.

Section 2 includes a review of the literature discussing the choice of model used in this paper and relevant literature that has been published on the UAE. Section 3 presents the description of the proposed model. Section 4 discusses the calibration and the SAM on which the calibration is based, together with the base run solution of the model. In Section 5, three policy experiments are simulated: an import tariff reduction; the increase in the indirect tax rate of goods; and, an increase in the world's price of oil. Section 6 contains a sensitivity analysis. Finally, Section 7 concludes the paper and identifies the agenda for future research.

2 Literature Review

This paper models the economy of the UAE using a forward looking dynamic multi-sector computable general equilibrium (CGE) model. It is partly based on the one sector forward looking dynamic CGE model of Vellinga (2007), which is an improvement of the model by Devarajan and Go (1998) in that it removes a possible, but highly likely leakage. The Devarajan and Go model contains a rather complete picture of an economy in which consumers are assumed to be maximizing utility and make intertemporal efficient decisions as they exhibit forward looking behavior. Producers in the model are maximizing net income. The model of Devarajan and Go has been applied to Bangladesh, Jordan and Poland (see respectively Piazolo (1999), Feraboli (2003) and Raihan (2004)). Because the model of Devarajan and Go is a one-sector model, they introduce adjustment costs in the investment of physical capital in order for the dynamics not to degenerate. There are also other ways of achieving this. One of these alternatives is to have a multi-sector model. For such a multi-sector model it turns out that the dynamics also do not degenerate. The model used in this paper is, therefore, also partly based on the forward looking multi-sector dynamic CGE model of Diao, et al. (1998) which is applied to Turkey. The model of Devarajan and Go is richer in the sense that there are more flows of money than in the model of Diao, et al. These flows have also been incorporated in the present model. Other forward looking models are by Annabi and Rajhi (2001) for the economy of Tunisia, and Mabugu (2003) for the South African economy.

One can use a recursive dynamic model in which consumers, for instance, do not exhibit forward looking behavior. See, for instance, Andersen and Faris (2002) with a model for Bolivia, and Bugarin et al. (2003) with a model for Brazil. The assumed forward looking behavior, on the part of consumers for instance, is a more realistic description, and the present state of numerical software makes it possible to analyse these models.

Others have also analyzed the UAE economy in depth. See, for instance, Elhiraika and Hamed (2002) who look at economic growth in a growth accounting framework.

Sadik (2001) and Shihab (2001) provide detailed economic statistics about the UAE economy. Finally, Hassanain (2002) developed a computable general equilibrium model for UAE, but this model was a static model and only had one sector.

3 Model Description

The model that is being set up for the UAE is a dynamic CGE model and it is an extension of a three sector model for the UAE economy by Vellinga and Abdelgalil (2005). The model is a nine sector model

The economy is assumed to consist of four types of agents: a representative household as consumer; a representative firm; the government; and, the ROW. Each of them will be discussed separately in this section. All accounting rules are discussed together with the terminal conditions to guarantee that the economy is in a steady state in the final time period.

3.1 Divide Output over Domestic Market and Exports

In each of the sectors (denoted by i) are domestic firms supplying goods to the domestic market (D_{it}) and to foreign countries (exports denoted by E_{it}) at each instant of time t. For all sectors it is assumed that this division is governed by a constant elasticity of transformation (CET) production function (where the substitution parameter $\rho_{e_i} > 1$, the efficiency parameter $\alpha_{e_i} > 0$ and the distribution parameter $0 < \delta_{e_i} < 1$):

$$X_{it} = \alpha_{e_i} \cdot \left[\delta_{e_i} \cdot E_{it}^{\rho_{e_i}} + \left(1 - \delta_{e_i}\right) \cdot D_{it}^{\rho_{e_i}} \right]^{1/\rho_{e_i}} \tag{1}$$

The firms maximize revenues from the domestic and foreign market. The CET construction does justice to the fact that the total supply of goods and services within the UAE economy (X_{it}), whether domestically produced or imported, is divided between domestic use and the export. The term export refers here to both exports and re-exports because they constitute a composite good. The optimal ratio of export good and domestically supplied output good can be determined as a function of the prices of these goods (respectively PE_{it} and PD_{it}):

$$E_{it} / D_{it} = \left[\frac{PE_{it}}{PD_{it}} \cdot \frac{1-\delta_{e_i}}{\delta_{e_i}} \right]^{1/\rho_{e_i}-1} \tag{2}$$

There is also the zero profit condition (where PX_{it} is the price of the total supply of goods and services):

$$PE_{it} \cdot E_{it} + PD_{it} \cdot D_{it} = PX_{it} \cdot X_{it} \tag{3}$$

The price of the export good, for all sectors, is the world price of the export good of that sector (PWE_{it} in USD, so this is multiplied by the exchange rate er_t) minus the export tax levied on that good (the export tax rate is te_i):

$$PE_{it} = PWE_{it} \cdot er_t \cdot (1-te_i) \tag{4}$$

3.2 Production of Domestic Composite Good

For each sector there are firms that combine the good imported by that sector (M_{it}) with the domestically produced output good into a composite good that will be provided to the domestic market (C_{it}). The firms minimize the costs of combining the imported goods and the domestic product using a constant elasticity of substitution (CES) production function:

$$C_{it} = \alpha_{c_i} \cdot \left[\delta_{c_i} \cdot M_{it}^{-\rho_{c_i}} + \left(1-\delta_{c_i}\right) \cdot D_{it}^{-\rho_{c_i}} \right]^{-1/\rho_{c_i}} \tag{5}$$

The composite good construction through the CES function, together with the CET production function in the previous section, allow for re-export of imports, with or without adaptation, as the imports are used in the creation of the export goods. The re-export of imports is an important feature of the UAE economy. The Armington assumption is used whereby goods of the same type, but with different countries of origin, are treated as imperfect substitutes. Each country produces a unique set of goods, which, to a varying degree, are substitutes for, but not identical to goods produced in other countries. The CES function is used to capture the Armington assumption ($\rho_{c_i} > -1$, $\alpha_{c_i} > 0$ and $0 < \delta_{c_i} < 1$). The optimal ratio of import good and domestically supplied output good is determined as a function of the prices of these goods (PM_{it} is the price of the imported good by sector i):

$$M_{it} / D_{it} = \left[\frac{PD_{it}}{PM_{it}} \cdot \frac{1-\delta_{c_i}}{\delta_{c_i}} \right]^{1/\rho_{c_i} - 1} \quad (6)$$

The zero profit condition is now:

$$PM_{it} \cdot M_{it} + PD_{it} \cdot D_{it} = P_{it} \cdot C_{it} \quad (7)$$

The price of the import good is the world price of the import good (PWM_{it} in USD and this is multiplied by the exchange rate) plus the import tariff (the import tariff rate is tm_i). This is true for the goods of all sectors, except that the services sectors are assumed not to have import tariffs as only imported goods are taxed:

$$PM_{it} = PWM_{it} \cdot er_t \cdot (1 + tm_i) \quad (8)$$

3.3 Price for Domestic Spender Type

The price of good i for domestic spender type j (PC_{ijt}, where j can stand for consumers, the government, or capital) is dependent on the price of output good in sector i (P_{it}) and the appropriate indirect tax rate (tx_{ij}) according to:

$$PC_{ijt} = P_{it} \cdot (1 + tx_{ij}) \quad (9)$$

3.4 Description of the Government

It is assumed that government activities (like taxing and consuming) are fixed (exogenous) and that government saving is allowed to adjust to equate government spending and government receipts. Government consumption[3] (G_{it} priced at $PC_{i;G;t}$) and government transfers ($GTRS_t$) are taken as given. The government budget constraint states that taxes collected (TAX_t), together with the profits of the companies in the oil sector, are used to finance government transfers, government consumption and government savings (SAV_t^{Gov}):

$$TAX_t = GTRS_t \cdot PINDEX_t + \sum_{i=1}^{n} PC_{i;G;t} \cdot G_t + SAV_t^{Gov} \tag{10}$$

Where n denotes the number of sectors ($n = 9$ in our case) and the price index is given by:

$$PINDEX_t = \sum_{i=1}^{n} weight_i \cdot PC_{i;C;t} \tag{11}$$

The expression $PINDEX_t$ stands for the price index of a so-called composite consumption good at time period t comprised of the consumption goods of each of the sectors (CD_{it}). The weight is defined as follows:

$$weight_i = \frac{CD_{it}}{\sum_{i=1}^{n} PC_{i;C;t} \cdot CD_{it}}$$

Here $PC_{i;C;t}$ denotes the price of the consumption good for the domestic consumer type of consumers. Total taxes are comprised of import tariffs, export taxes, taxes on companies (with tax rate it_i and these taxes are negative, so in effect a subsidy),

[3] The government is paying an indirect tax on its own consumption to reflect the fact that it is consuming output goods that are being taxed for the other agents in the model. One could do without this taxation, as it is paid back to the government itself. In that case, the equation where the tax receipts are listed should be adjusted accordingly.

indirect taxes on consumption goods (at rate $tx_{i;C}$), government consumption goods (at rate $tx_{i;G}$) and investment goods (at rate $tx_{i;J}$), and income tax (TY_t):

$$\begin{aligned} TAX_t = \sum_{i=1}^{n} tm_i \cdot PWM_{it} \cdot er_t \cdot M_{it} + te_i \cdot PWE_{it} \cdot er_t \cdot E_{it} + it_i \cdot PX_{it} \cdot X_{it} + \\ \sum_{i=1}^{n} tx_{i;C} \cdot P_{it} \cdot CD_{it} + \sum_{i=1}^{n} tx_{i;G} \cdot P_{it} \cdot G_{it} + \sum_{i=1}^{n} tx_{i;J} \cdot P_{it} \cdot INVD_{it} + TY_t \end{aligned} \tag{12}$$

There is also the price of output goods in the sector i (P_{it}) and the level of investment goods in sector i ($INVD_{it}$). Savings by households (SAV_t^{HH}) are exempted from income tax. The income tax levied is, therefore, (income tax rate is ty and the income of households is Y_t):

$$TY_t = ty \cdot (Y_t - SAV_t^{HH}) \tag{13}$$

The tax rate for each of the taxes is considered exogenous and constant.

3.5 Description of the Rest-of-World

The level of foreign transfers ($FTRS_t$) is assumed given and, for the UAE, it has a negative value, reflecting the fact that migrant workers transmit money to their home country. Furthermore, world prices for imports and exports are dictated on the world market outside the influence of the country. The budget constraint for the UAE with respect to the ROW is in terms of the foreign currency (USD):

$$\sum_{i=1}^{n} PWM_{it} \cdot M_{it} = \sum_{i=1}^{n} PWE_{it} \cdot E_{it} + FTRS_t + r_t \cdot NFA_t + SAV_t^{ROW} \tag{14}$$

The UAE earns foreign currencies by exporting goods and services, by receiving foreign transfers, and by receiving interest on its net foreign assets position (world interest rate is r_t and the level of net foreign assets in USD is NFA_t). The foreign currency is then used to buy import goods from the ROW. If the receipts of foreign currency fall short of the expenses paid for imported goods, the ROW is increasing its savings (SAV_t^{ROW}), or equivalently, the UAE is borrowing from the ROW. Whatever the ROW is saving is added to the foreign debt of the UAE, or deducted from its net foreign asset position:

$$NFA_{t+1} = NFA_t - SAV_t^{ROW} + d_{adj} \cdot NFA_t \qquad (15)$$

All items in this equation are in terms of USD. In this equation there is a term similar to the depreciation term in the physical capital accumulation equation. This term with the parameter d_{adj} is added to the equation purely based on technical grounds. With this term it is possible to have a certain value for foreign savings and at the same time a constant level of net foreign assets. This property of the model is very convenient as it is required for the model to be in a steady state at the initial base period. In a steady state, the level of net foreign assets is constant over time and with a non-zero value for foreign saving this can be achieved by adding this extra term to the equation.

3.6 Investment Good Production

Production of the investment good (I_t) is governed by a Cobb-Douglas production function:

$$I_t = A_k \cdot \prod_{i=1}^{n} INVD_{it}^{\Theta_i} \qquad (16)$$

There is a company that is combining the investment goods ($INVD_{it}$) from the sectors into one investment good and maximizing production subject to a budget constraint where the total amount spent on investment (price time quantity, or $PI_t \cdot I_t$) is used to pay for the inputs into production, the investment goods of each of the sectors ($INVD_{it}$), each of them priced at $PC_{i;J;t}$. From this maximization problem the optimal ratios of investment goods (take, for instance, for i the value 2, 3 up to n and take for j the value 1) is derived:

$$\frac{PC_{i;J;t} \cdot INVD_{it}}{PC_{j;J;t} \cdot INVD_{jt}} = \frac{\Theta_i}{\Theta_j} \qquad (17)$$

There is also the original budget constraint which states that the profit made by the firm in the investment sector is zero:

$$PI_t \cdot I_t = \sum_{i=1}^{n} PC_{i;J;t} \cdot INVD_{it} \tag{18}$$

3.7 Banks - Investment Sector

Consumers save (SAV_t^{HH}) to be able to:

- Invest in the physical capital stock ($I_t^{Capital}$, which is equal to $PI_t \cdot I_t$)
- Invest in foreign assets (I_t^{NFA}, which is equal to $-SAV_t^{ROW} \cdot er_t$) and
- Finance the government deficit (I_t^{GovDef}, which is equal to $-SAV_t^{Gov}$)

Or:

$$\begin{aligned} SAV_t^{HH} &= I_t^{Capital} + I_t^{NFA} + I_t^{GovDef} \\ &= PI_t \cdot I_t + (-er_t \cdot SAV_t^{ROW}) + (-SAV_t^{Gov}) \end{aligned}$$

The familiar equation is found where investment equals savings made by the consumers, the ROW and the government:

$$PI_t \cdot I_t = SAV_t^{HH} + SAV_t^{ROW} \cdot er_t + SAV_t^{Gov} \tag{19}$$

To simplify the model there is no government debt and the consumers finance only the government deficit, or receive the government surplus. The size of the government deficit is under the control of the government and whatever the deficit is, the consumers will finance it. The decision of how much to invest in net foreign assets is determined through the savings by the ROW, where the latter is mainly dependent upon the levels of imports and exports (see Equation 14). To simplify the model calculations, the decision on how much to invest in the physical capital stock is taken out of the decision problem of the consumers and firms, even though the consumers own the capital stock. There are artificial artefacts, called banks, which make the investment decision on behalf on the consumers. Based on the reward for capital (rate of return on capital times the size of the stock of physical capital, or $wk_t \cdot K_t$) the banks determine how much is invested in the capital stock ($PI_t \cdot I_t$). The banks make this investment decision taking into account the evolution over time of the capital stock:

$$K_{t+1} = K_t + I_t - \delta \cdot K_t \tag{20}$$

The accumulation of capital stock over time is determined by the existing stock of capital, the level of investment and the depreciation which is assumed proportional with the stock of capital (δ is the depreciation rate). The maximization problem for the banks now reads:

$$\max_{I_t} \sum_{t=0}^{\infty} \left(\frac{1}{1+r_t} \right)^t \cdot (wk_t \cdot K_t - PI_t \cdot I_t)$$
$$s.t.\ K_{t+1} = K_t \cdot (1-\delta) + I_t$$

To solve this, the Hamiltonian is set up (Feichtinger and Hartl (1986)) and the first-order conditions are derived to end up with the following condition:

$$(1+r_t) \cdot PI_{t-1} = wk_t + (1-\delta) \cdot PI_t \tag{21}$$

In words, this equation states that investment is subject to the no-arbitrage condition in that the return to capital should be the same as the return to a perfectly substitute asset. If a person borrows at time period $t-1$ from the bank the amount to buy one unit of capital at the price PI_{t-1} she has to pay at time period t the borrowed amount and the interest, or $(1+r_t) \cdot PI_{t-1}$. This will be equal to the total receipts which consist of the return of capital and the receipts from selling the unit of capital. The latter is the price of a unit of capital minus the depreciation of the unit of capital, or $(1-\delta) \cdot PI_t$.

3.8 Consumers

The consumers, or households, own labor and financial wealth. Financial wealth comprises the capital stock and net foreign assets. Consumers are assumed to have financial assets and financial liabilities towards citizens and companies in foreign countries. Financial wealth can be defined as:

$$W_t = PI_{t-1} \cdot K_t + NFA_t \cdot er_t$$

Using this definition, one can derive an expression for the accumulation of wealth to discover the individual sources of wealth, and see where the wealth is used. Households make the decision to allocate part of their income on consumption goods from all the sectors and the remaining part is saved. Total income of the households is derived from labor income (wage rate times labor supply, or $wl_t \cdot L_t$), current income from the capital stock; in addition to foreign transfers, government transfers and interest income received from abroad on their net foreign assets:

$$Y_t = wl_t \cdot L_t + wk_t \cdot K_t + FTRS_t \cdot er_t + GTRS_t \cdot PINDEX_t + r_t \cdot NFA_t \cdot er_t \qquad (22)$$

Consumers allocate their income from labor and financial wealth over income tax, spending on consumption goods of all the sectors, and the remaining part is saved to increase future financial wealth:

$$Y_t = TY_t + \sum_{i=1}^{n} PC_{i;C;t} \cdot CD_{it} + SAV_t^{HH} \qquad (23)$$

Using Equations 15, 19, 20, and 21 it is possible to derive an equation describing the accumulation of wealth as:

$$W_{t+1} - W_t = r_t \cdot W_t + wl_t \cdot L_t + FTRS_t \cdot er_t + GTRS_t \cdot PINDEX_t + SAV_t^{Gov}$$
$$- d_{adj} \cdot NFA_t \cdot er_t - TY_t - \sum_{i=1}^{n} PC_{i;C;t} \cdot CD_{it}$$

Or:

$$W_{t+1} - W_t = r_t \cdot W_t + Income_t^{Net} - \sum_{i=1}^{n} PC_{i;C;t} \cdot CD_{it}$$

Where:

$$Income_t^{Net} = wl_t \cdot L_t + FTRS_t \cdot er_t + GTRS_t \cdot PINDEX_t + SAV_t^{Gov} - d_{adj} \cdot NFA_t \cdot er_t - TY_t \tag{24}$$

Net income $Income_t^{Net}$ consists of labor income, foreign transfers, government transfers, the savings of the government, minus the "depreciation" of net foreign assets and income tax payments. To rule out Ponzi games or chain letters whereby consumers can borrow an unlimited amount (leading to negative values of wealth) it is required that the present values of assets (wealth) must be asymptotically nonnegative. Or, as specified by Barro and Sala-i-Martin (1995):

$$\lim_{t \to \infty} W_t \cdot \prod_{\tau = t_0}^{t} \frac{1}{1 + r_\tau} \geq 0$$

Using this requirement, one can solve the differential equation in Wealth (W_t) and arrive at the level of wealth at time period $t = t_0$:

$$W_{t_0} = \sum_{t=t_0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \cdot \sum_{i=1}^{n} PC_{i;C;t} \cdot CD_{it}$$

This makes clear that wealth of the representative consumer is equal to the sum of all nominal per capita consumption levels for all sectors for all the time periods, starting with time period $t = t_0$.

It is assumed that the utility function for the consumer is a Cobb-Douglas like utility function (where σ, the reciprocal of the elasticity of intertemporal substitution, is not equal to one):

$$U(CD_{1t}, CD_{2t}, \ldots, CD_{nt}) = \frac{\left(\sum_{i=1}^{n} CD_{it}^{\alpha_i} \right)^{1-\sigma}}{1-\sigma}$$

To make the subsequent analysis not too burdensome, it is customary in the CGE literature to assume that consumers live forever and that they have perfect foresight. Furthermore, all consumers are assumed equal and this assumption allows us to work with just one representative consumer. The (representative) consumer derives utility from consumption. It is assumed that consumers give less weight to future levels of consumption and this is represented by the constant rate of time preference ρ. Utility is maximized subject to the wealth budget constraint:

$$\begin{aligned}
&\max_{CD_{it}} \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \cdot \frac{\left(\sum_{i=1}^{n} CD_{it}^{\alpha_i} \right)^{1-\sigma}}{1-\sigma} \\
&s.t.\, W_{t+1} - W_t = r_t \cdot W_t + wl_t \cdot L_t + FTRS_t \cdot er_t + \\
&\qquad GTRS_t \cdot PINDEX_t + SAV_t^{Gov} \\
&\qquad - d_{adj} \cdot NFA_t \cdot er_t - TY_t \\
&\qquad - \sum_{i=1}^{n} PC_{i;C;t} \cdot CD_{it}
\end{aligned}$$

To solve this intertemporal maximization problem, one sets up the Hamiltonian and derives the first-order conditions to arrive at a difference equation for consumption in the i^{th} sector:

$$\frac{CD_{i;t-1}}{CD_{it}} = \left(\frac{1+\rho}{1+r_t} \cdot \frac{PC_{i;C;t}}{PC_{i;C;t-1}} \right)^{-1/\sigma} \tag{25}$$

Additionally, the optimal price ratio is given by (take for i the value 2, 3, up to n; take for j the value 1):

$$\frac{PC_{i;C;t} \cdot CD_{it}}{PC_{j;C;t} \cdot CD_{jt}} = \frac{\alpha_i}{\alpha_j} \tag{26}$$

3.9 Goods Market Equilibrium

For the goods market in each sector to be in equilibrium, supply C_{it}, or total absorption, has to be equal to total demand. Total demand consists of consumption by households, investment good demand, intermediate demand ($INTD_{it}$), and finally, consumption by the government:

$$C_{it} = CD_{it} + INVD_{it} + INTD_{it} + G_{it} \tag{27}$$

3.10 Factors of Production

The total capital stock is equal to the stock of capital employed in each of the sectors (K_{it}):

$$K_t = \sum_{i=1}^{n} K_{it} \tag{28}$$

The same holds for total (per capita) labor[4]. It is equal to the sum of all the labor employed in the sectors (L_{it}):

$$L_t = \sum_{i=1}^{n} L_{it} \tag{29}$$

3.11 Value Added

The factors of production labor and capital are combined using a CES production technology[5] to produce value added ($\rho_{VA} > -1$, $\alpha_{VA} > 0$ and $0 < \delta_{VA} < 1$):

$$X_{it} = VA(L_{it}, K_{it}) = \alpha_{VA_i} \cdot \left[\delta_{VA_i} \cdot L_{it}^{-\rho_{VA_i}} + \left(1 - \delta_{VA_i}\right) \cdot K_{it}^{-\rho_{VA_i}}\right]^{-1/\rho_{VA_i}} \tag{30}$$

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[4] Notice that per capita labor is constant in the model. The model does not distinguish between the citizens of the UAE and the expatriates within the workforce. Therefore, the issue of UAE citizens competing with low wage experienced workers that come to work to the UAE cannot be dealt with in the current model.

[5] The efficiency parameter α_{VA_i} is constant, so there is no assumed Hicks-neutral technological progress.

The producers maximize temporal profits and this leads to the following optimal ratio of labor and capital employed in each of the sectors:

$$L_{it} / K_{it} = \left[\frac{wk_t}{wl_t} \cdot \frac{\delta_{VA_i}}{1-\delta_{VA_i}} \right]^{1/(\rho_{VA_i}+1)} \tag{31}$$

Given the first-order conditions, profits in each sector (in the value added production) turn out to be zero (where the price of value-added is denoted by PVA_{it}):

$$PVA_{it} \cdot X_{it} = wl_t \cdot L_{it} + wk_t \cdot K_{it} \tag{32}$$

Besides capital and labor, there is a third factor of production, the intermediate input supplied by all sectors (proportional to IO_{ij} times the level of output of sector i). The intermediate input is combined with the value added output into the output of goods from the i^{th}-sector. For this a Leontief technology is used. Suppose one looks at the output of the first sector ($i = 1$):

$$X_{1t} = f(VA(L_{1t}, K_{1t}), IO_{11} \cdot X_{1t}, IO_{21} \cdot X_{1t}, ..., IO_{n1} \cdot X_{1t}) = wl_t \cdot L_{it} + wk_t \cdot K_{it}$$

The producers have to pay a tax proportional to their output at a rate of it_i. As the production takes place using a Leontief technology, all inputs are used in fixed proportions and the net price of output will be:

$$(1 - it_i) PX_{it} = PVA_{it} + \sum_{j=1}^{n} P_{jt} \cdot IO_{ji}$$

Or, rearranging and for all the sectors:

$$PVA_{it} = (1 - it_i) PX_{it} - \sum_{j=1}^{n} P_{jt} \cdot IO_{ji} \tag{33}$$

Total intermediate demand for goods from the i^{th}-sector is given by:

$$INTD_{it} = \sum_{j=1}^{n} IO_{ij} \cdot X_{jt} \tag{34}$$

3.12 Terminal Conditions

The discrete time model will be solved using the numerical optimization software tool GAMS (see Brooke et al. (1998)). In theory, one would have to take an infinite number of time periods because only at $t = \infty$ will the model have reached the steady state where all (real) per capita variables are constant. This is, of course, not possible because it would require an infinite number of calculations. There is an adjustment needed to make sure that the numerical outcome of the model with a finite horizon is equivalent to the outcome with an infinite horizon. This is termed steady state invariance (see Mercenier and Michel (1994a) and (1994b)). For the current model this means that an additional term is added to the objective function, which is the utility function of consumers, representing the value of the objective function for all remaining time periods that are not considered. By assuming that from the last time period onward the economy is in a steady state, real per capita consumption in the utility function will be constant from that moment onward. Then, the additional term is simply the infinite sum of discounted utility levels. In line with the argument by Mercenier and Michel, the following conditions will have to be imposed to the model. Firstly, the per capita capital stock in the steady state is constant, or real per capita depreciation is equal to real per capita investment (refer to Equation 20 and T is the final time period):

$$\delta \cdot K_T = I_T \tag{35}$$

Finally, the per capita stock of external debt must be constant, which means that foreign borrowing is equal to the adjustment of foreign debt (refer to Equation 15):

$$d_{adj} \cdot NFA_T = SAV_T^{ROW} \tag{36}$$

3.13 Walras' Law

Because of Walras' law, a single equation of any of the equations describing one of the goods market equilibriums can be left out. As this is an arbitrary choice, in this paper, Equation 29 is chosen which describes labor market equilibrium and states that the total amount of labor is divided over the various sectors. This equilibrium condition can be left out as Walras' Law states that if all markets, except the labor market, are in equilibrium then the labor market is also in equilibrium. The remaining equations, 1 up to 36 (excluding 24 and 29) fully describe the model.

3.14 Price Numéraire

As the model is homogeneous of degree one in prices, one price is the Numéraire. In this paper the exchange rate er_t is chosen as the Numéraire as the UAE has a fixed exchange rate with respect to the USD. Its value is set to its historical value of 3.6725 AED per USD.

4 Data and Model calibration

The model is calibrated using publicly available data for the year 2006 from official sources. Vellinga (2006) assembled the first multi-sector (8 sectors) social accounting matrix (SAM) for the UAE for the year 2004. This approach is repeated with data for the UAE for the year 2006 (with nine sectors). Data from the MOE and UAE Central Bank (CB) are combined to arrive at a social accounting matrix (SAM) as a database for calibrating the model.

The MOE distinguishes the 15 separate sectors in the UAE economy. These 15 sectors are aggregated in nine sectors for the model calculations. The nine sectors and their underlying sub-sectors from the MOE are:

- A. Agriculture
- B. Crude oil/Natural gas combined with Quarrying
- C. Manufacturing combined with Electricity
- D. Construction
- E. Real estate
- F. Trade combined with Transport
- G. Restaurants and hotels

- H. Financial corporations sector
- I. Government services sector combined with Social and personal services

The sectors “Domestic services of households” and “Imputed bank services” have been dispersed over all other sectors because both sectors are small and, from an economic point of view, less interesting. The “Domestic services of households” sector has only labor and no capital. The “Imputed bank services” sector has a negative capital income and the latter issue would only complicate the calculations in the sequel.

Table B.1 in Appendix B contains the SAM for the UAE for the year 2006. The values in the SAM are all nominal values in millions AED, but in the sequel, per capita or real per capita values are shown and the latter values are in AED. Based on the data in the SAM, the various parameters and exogenous variables in the model can be calibrated. The economic data available is not sufficient to calibrate all the parameters in the model. Even additional economic data is not available to arrive at calibrated values for these parameters. The values for the CES and CET elasticities, for instance, have been assigned values that are in accordance with the literature on these types of elasticities (see Erbil (2004) and Melo and Tarr (1992)). The values chosen are closer to the lower bounds of the range reported in the literature because the economy of the UAE is not yet fully developed and diversified and, therefore, the substitutability is low in the UAE. The focus is mainly on trade (mostly re-export), tourism (hotels and restaurants) and real estate. Local production provides only limited types of goods, as most goods have to be imported. The same is true for the composition of the labor force. Substitutability would be high if local production could supply numerous types of goods and services.

4.1 Stability

In general, stability means that if after introducing a perturbation to the steady state of the model, the time path of the variables converges to a new steady state. If one looks only at small perturbations, local stability is considered. If, on the other hand, any perturbation would be applied, irrespective of size, one looks at global stability. The first-order conditions for optimality, together, determine the local optimum of the model. All functional forms are chosen in such ways that that the necessary conditions for an optimum are also sufficient conditions (see Chiang (1997)) for a global optimum to exist. One can think of certain concavity conditions with respect to the shape of the production functions, and the utility function.

4.2 Base run solution

The base run solution of the dynamic multi-sector CGE model is the steady state solution of the model corresponding to the particular calibrated set of values for the parameters, and the exogenous and endogenous variables of the model. The variables in the model are per capita values, and most of them are in real terms. In the steady state, the per capita (real) values are constant. Table 1 shows the base run results in real terms in an overview.

Table 1: Per capita (real) values of the base run simulation.

	Per capita (real) values (mostly AED)									
	A	B	C	D	E	F	G	H	I	UAE
Tax on income	-	-	-	-	-	-	-	-	-	533
Saving of ROW	-	-	-	-	-	-	-	-	-	-8,273
Net foreign assets (USD)	-	-	-	-	-	-	-	-	-	108,566
Interest income ROW (USD)	-	-	-	-	-	-	-	-	-	21,713
Foreign transfers	-	-	-	-	-	-	-	-	-	-22,571
Government transfers	-	-	-	-	-	-	-	-	-	-29,468
Consumption	5,887	0	730	9,419	13,195	16,708	2,596	6,517	9,735	64,788
Investment	0	7,510	10,728	5,836	5,965	0	0	0	0	30,039
Government consumption	183	0	9,405	415	882	2,078	235	460	614	14,270
Exports	0	202,828	38,266	0	0	31,531	4,318	4,618	511	282,072
Imports	2,963	14,394	20,563	11,186	11,433	24,464	2,525	8,636	0	96,165
Labor income	889	792	2,833	5,034	542	6,961	774	1,260	10,661	29,746
Capital income	1,985	51,317	16,518	5,630	10,176	16,751	1,677	7,064	832	111,950
Indirect tax on goods	30	37	103	78	99	93	14	35	51	540
Export tax	0	0	0	0	0	0	0	0	0	0
Import tariffs	39	189	271	147	150	322	0	0	0	1,118
Tax on firms	-90	0	-22	0	0	0	0	0	0	-113
Labor force size (x 1 person)	0.02	0.02	0.06	0.11	0.01	0.16	0.02	0.03	0.24	0.67
Population size (x 1 person)	-	-	-	-	-	-	-	-	-	1

Notes:
1. Some of the cells in the table are empty as these items are not sectoral data, or they are only presented in the model as a per capita real item.
2. All values in the table are in AED, unless otherwise indicated.

4. The total indirect taxes TX_t is defined as: $\sum_{i=1}^{n} tx_{i;C} \cdot CD_{it} + tx_{i;G} \cdot G_{it} + tx_{i;J} \cdot INVD_{it}$.

5. The capital letters are for the following sectors:

A - Agriculture
B - Crude oil/Natural gas combined with Quarrying
C - Manufacturing combined with Electricity
D - Construction
E - Real estate
F - Trade combined with Transport
G - Restaurants and hotels
H - Financial corporations sector
I - Government services sector combined with Social and personal services

The results of Table 1 can be interpreted as being in terms of values pertaining to an individual UAE inhabitant (either a UAE national (UAE citizen), or an expatriate). On average, a UAE inhabitant earns a wage income of AED 29,746 per year. Her wage consists of the wages earned in all nine sectors. From the oil sector (B) she earns AED 792. In addition to this there is capital income which amounts to AED 111,950 per year. The sector that contributes the largest capital income is the oil sector: AED 51,317. Every year, the UAE citizen pays AED 1,118 on import tariffs. The total amount of goods and services imported per UAE inhabitant is AED 96,165. The amount spent on consumption in one year is 64,788. Over and above this amount she has to pay the indirect tax on goods, which equals AED 540 per year. The UAE inhabitant owns in the same amount as all other UAE inhabitants a share in all the companies of the UAE. Because of this, she has to pay yearly AED 533 income tax. This is due to her share in owing a share in the foreign banks and oil companies that are active in the UAE. All other numbers, for the UAE as a whole or by sector, can be interpreted in a similar fashion.

5 Policy Experiments

This section presents some policy simulations that are relevant for the UAE's current situation and future prospects. The aim is now to look more closely at the impact of certain government economic policies on the future path of the UAE economy. The time paths of a number of variables are studied to trace out the effect of these policy simulations. The final outcome of each policy simulation is measured in terms of wealth and welfare. The following economic policies are simulated in this section:

- A decrease in the level of the import tariff
- An increase in the indirect tax rate on goods
- An increase in the world's price of oil

The first policy experiment focuses on the issue of trade liberalization. This policy is relevant for the UAE situation given its commitment to WTO agreements and the several free trade agreements (FTAs) that are currently being negotiated with a number of countries, including the United States of America. Part of a FTA is the partial or complete lifting of import tariffs and this paper looks at a unilateral lowering of the import tariff. The second policy experiment revolves around the issue of government revenue diversification away from oil to non-oil revenues. This policy is pertinent to the UAE situation given the recent endeavours of UAE to reduce its dependency on oil. This policy is simulated by increasing the indirect tax rate on goods. The third policy experiment is aimed at looking at the consequences of an increase in the world's price of oil. It is to be expected that the inhabitants in the UAE will be better off, but by how much? The results of each policy experiment are presented as percentage changes with respect to the corresponding base run value. The time horizon used in subsequent analysis is 10 years.

5.1 Reduction of import tariff

The policy of unilateral trade liberalization is simulated by a permanent and immediate reduction of the UAE import tariff from its base run value. It is assumed that the import tariff rate is the same for all sectors that import goods from the ROW. The services sectors do not import goods and the import tariff in these services sectors is therefore zero. The calibrated uniform import tariff rate (tm_i) is 1.32%. The economic impact of a change in the import tariff rate is analyzed in this section by reducing the current tariff rate by 30% from 1.32% to 0.92%. Table C.1 in Appendix C and Figure 1 through Figure 6 below give the results of this policy experiment.

The main results of the policy experiment can be summarized as follows:

1. Imports, consumption and investment increase
2. The domestic physical capital stock increases
3. Exports increase, except for labor-intensive sectors
4. Investments in net foreign assets are reduced

The rationale behind the first result is that the tariff reduction renders the imports less expensive and the demand for imports (M_t) increases. Imports and domestic goods are combined into a composite good and, as imported goods get cheaper, more of the composite good is demanded. This demand is for consumption and investment goods (first result). More investment leads to a larger domestic physical capital stock (second result) and this leads to a larger domestic supply and increased domestic production. With more capital relative to labor means that the reward for capital decreases and the wage increases. The three labor intensive sectors, "Trade/Transport", "Restaurants/Hotels" and "Manufacturing/Electricity", experience a rise in cost. Hence, production and exports of these sectors decrease, while for the other sectors production and exports rise (third result). Lower import tariffs reduce government receipts and as a result consumers have to finance a larger government deficit, or in the case of the UAE, receive less government savings. Consumers then invest less in net foreign assets (fourth result).

The levels of consumption, investment and the capital stock over time, relative to the base run, are depicted below in Figure 1 and Figure 2 respectively.

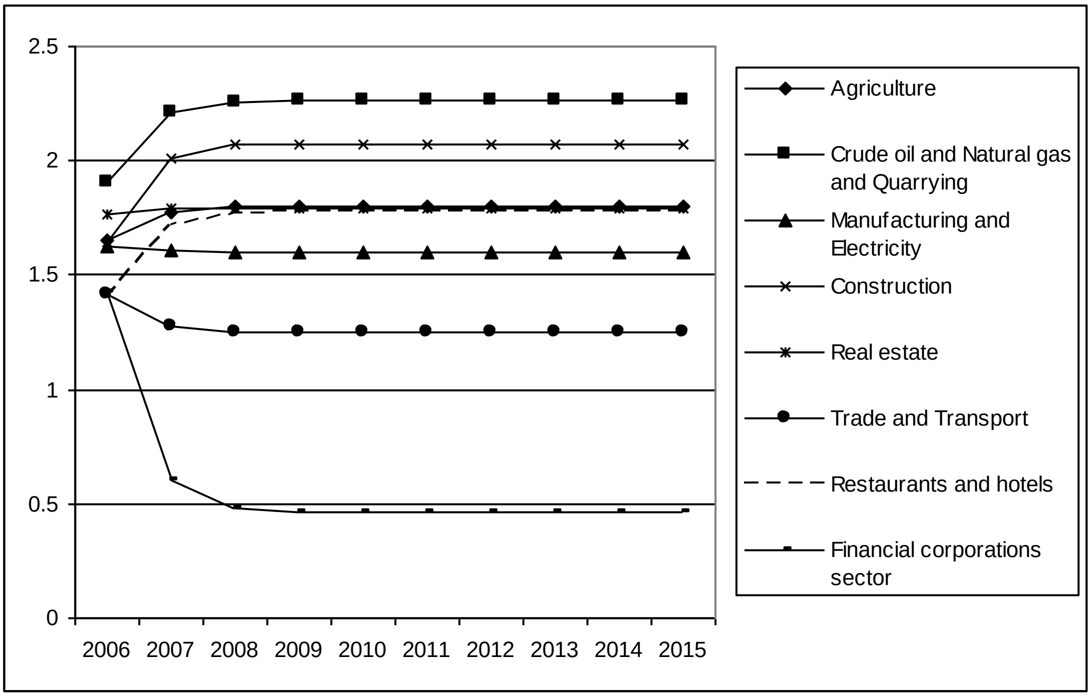

Figure 1: Level of consumption (percentage change with respect to base run).

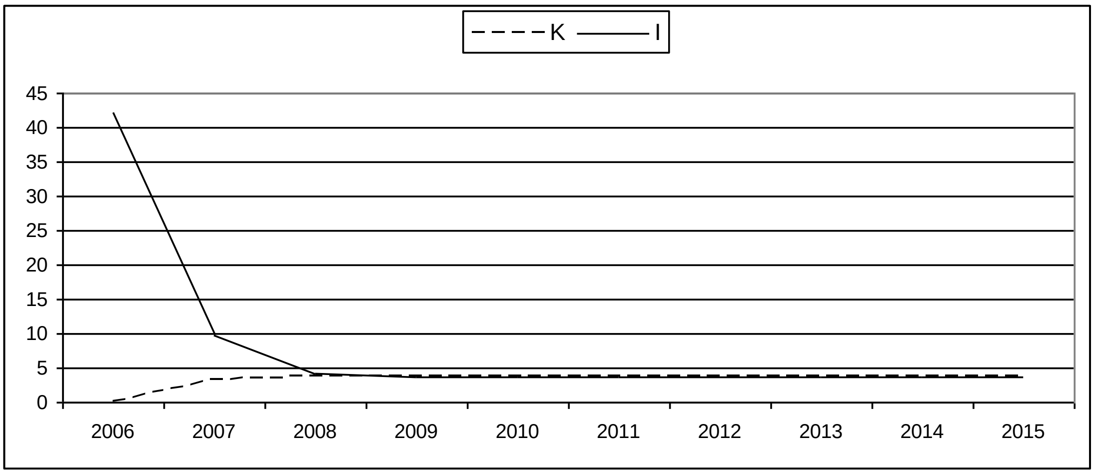

Figure 2: Level of capital stock (K) and investment (I) (percentage change with respect to base run).

From Figure 1 and Figure 2 it is clear that consumption and investment in each of the sectors are both higher compared to the base run, and the stock of capital increases due to the increasing level of investment. Imports for each of the sectors are also increasing as shown in Figure 3 and Figure 4.

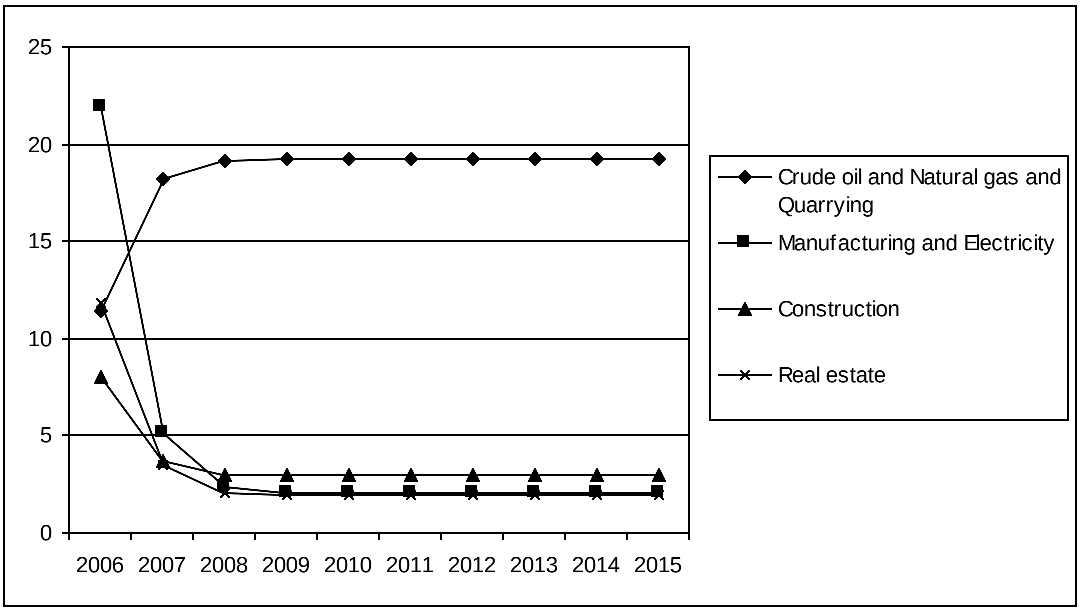

Figure 3: Level of imports for the four sectors where the increase in imports is relatively large (percentage change with respect to base run).

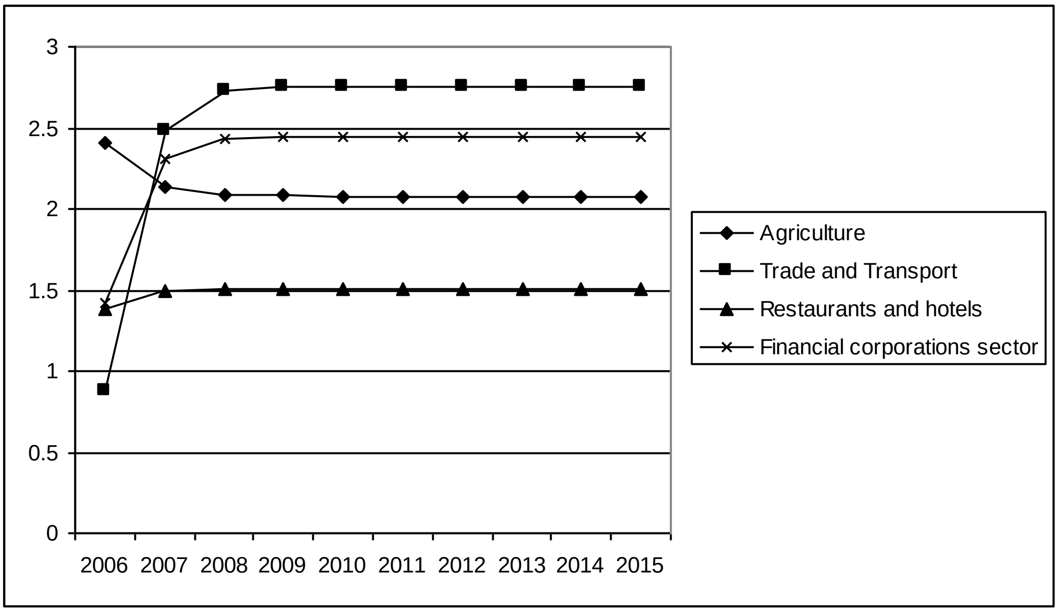

Figure 4: Level of imports for the four sectors where the increase in imports is relatively small (percentage change with respect to base run).

Exports are also increasing as shown in Figure 5.

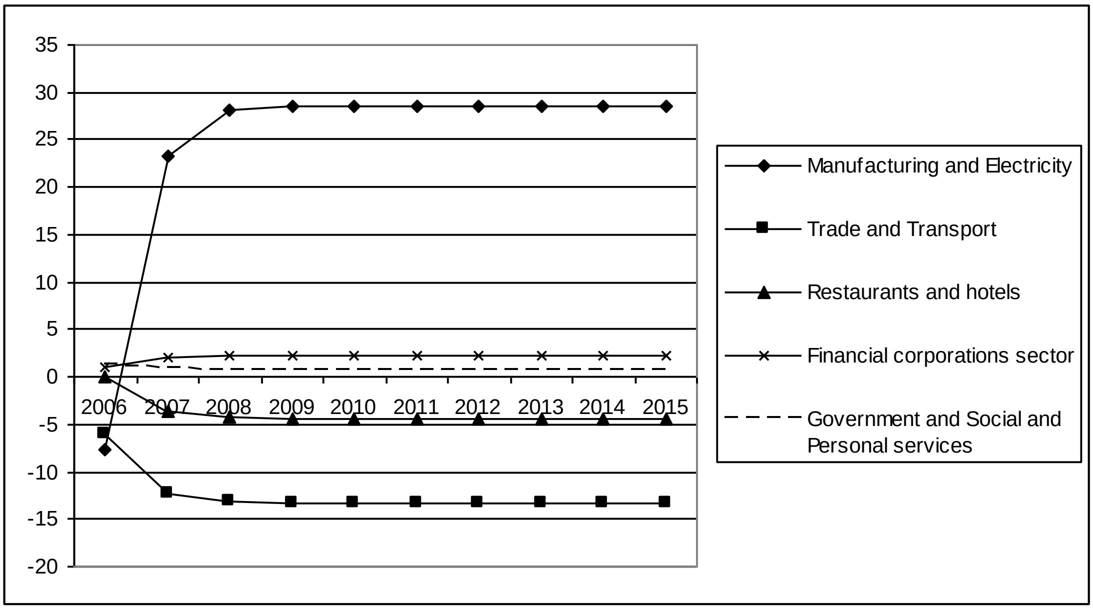

Figure 5: Level of exports (percentage change with respect to base run).

As Figure 6 below shows, the UAE net foreign assets position decreases.

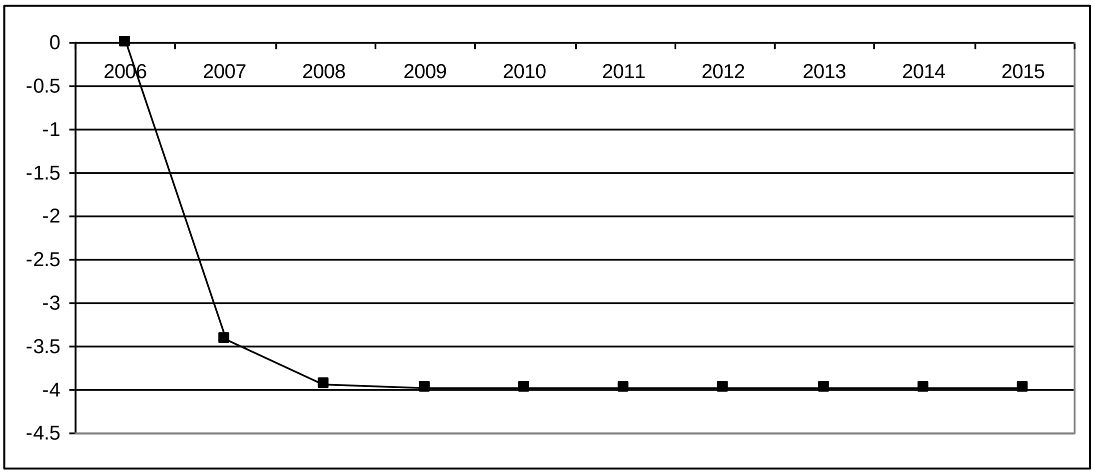

Figure 6: Level of net foreign assets (percentage change with respect to base run).

As mentioned in Section 3.8, the level of wealth in the base run is the sum of all nominal per capita consumption levels for all sectors for all years, starting with 2006. Nominal per capita consumption in the i^{th} sector is the level of real per capita consumption in that sector times the price in sector i that consumers have to pay. With the discount rate equal to 0.20, which is the rate of time preference[6], the simulated level of per capita wealth in the base run is AED 325,543. For this policy experiment the level of per capita wealth rises from its base run value to AED 331,280 (see Table 2). The consumers are better off as they consume more goods. The equivalent variation[7] (EV) per UAE inhabitant is estimated at AED −5,171 suggesting that consumers are willing to pay the government for this policy change to occur.

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[6] The world interest rate is chosen relatively high to reflect the fact that labor costs are relatively low in the UAE. As mentioned in Section 0, the share of wages in GDP is low and the share of operating surplus is high. It can therefore be expected that returns on capital are high in the UAE. UAE nationals are then only prepared to invest abroad if they receive a comparable high return. A high world rate of interest representing profitable investment returns abroad is then a good first approximation.

[7] The EV gives in money terms the amount by which consumers have to be compensated for the consequences of a policy change, where the prices used in the comparison are base run prices. EV is more appropriate than compensating variation, as compensating variation uses the simulated prices under each scenario for the comparison and they differ. In the sequel the focus is, therefore, on EV.

5.2 Increase the indirect tax rate on goods

One way to make the government less dependent on oil revenues is to increase the indirect tax rate on goods[8]. This policy experiment is simulated by increasing the indirect tax rate on all goods, both consumer and investment goods. The calibrated indirect tax rate for all domestic spender types for goods originating from any sector (tx_{ij}) is 0.50%. This uniform tax rate is increased (immediately and indefinitely) by 30% to 0.64%. Table C.2 in Appendix C shows the outcome of this policy experiment.

The main results of the policy experiment can be summarized as follows:

1. Consumption and investment decrease
2. A lower domestic physical capital stock
3. Lower levels of exports except for labor-intensive sectors
4. Higher investments in net foreign assets

From these results it becomes clear that an increase in the indirect tax rate has the opposite effects of a decrease in import tariff rates. Under the current model setup, with higher tax receipts, government savings increase and consumers have to finance a smaller government deficit as discussed in the beginning of Section 3.7. The increase of the indirect tax rate makes consumption and investment goods more expensive. Less of them is demanded (first result) leading to a decrease in supply. Domestic production shrinks and less investment in the domestic physical capital stock (second result) is needed. As a result of the lower capital stock, the return on capital increases and wages decrease as there is now less capital compared to labor. Contrary to other sectors, labor intensive sectors ("Manufacturing\Electricity", "Trade/Transport" and "Restaurants/Hotels") face a cost advantage. The demand for their output decreases and they can divert part of their supply to foreign markets and their level of exports increase (third result). As the government raises more taxes, government savings increase and consumers have to finance a smaller government deficit. Household savings are then directed towards investments in net foreign assets (fourth result). As the domestic capital stock decreases, the overall, the economy is

[8] The UAE government already levies an indirect tax on so-called harmful products, like alcohol and tobacco.

shrinking. In the current situation, the contribution of the sectors that experience an increase in exports is not sufficient to compensate for the lower level of exports in the other sectors. Production shifts from the domestic market to the foreign market through the export of labor-intensive sectors.

Most prices rise because of the higher indirect tax rate. Consumption levels decrease, but by more than the prices increase. Therefore, the simulated level of per capita wealth decreases from its base run value AED 325,543 to AED 324,171 (see Table 2). One can also look at net income, as defined in Equation 24, which is used to finance consumption to notice that some components lead to a decrease of net income, like labor income and the depreciation of net foreign assets. The government transfers increase as the price index increases and government savings rise. The income tax decreases leading also to an increase of net income. But, overall, net income decreases as the latter components are not strong enough to counterbalance the downward trend. Per UAE inhabitant, the equivalent variation is positive and equal to AED 1,549, implying that consumers are worse off as a consequence of this policy measure.

5.3 Increase in the World's Price of Oil

The third policy experiment is an experiment where the world oil price (PWE_i for the sector "Crude oil/Natural gas combined with Quarrying") increases by 5% in the year 2006 and stays at that high level from that year onward. Table C.3 in Appendix C presents the results of this policy experiment.

The main results of the policy experiment can be summarized as follows:

1. Consumption increases
2. More investments in net foreign assets
3. Investment and the domestic physical capital stock decrease
4. Exports increase except for capital-intensive sectors

As the price of oil increases, the profits of the oil sector increase. The level of exports of the oil sector is fixed by the quota of the OPEC. The increase in oil sector profits leads to rising government receipts and higher government savings, which are passed on to consumers as an increase in wealth for them. As the consumers' wealth rises, their net income increases and they consume more (first result). The money value of exports of the oil sector increases sharply and this means that the investments by the consumers in net foreign assets (second result) increase. As households consume more and invest more in net foreign assets, household savings are lowered and this subsequently leads to a reduction in investment in the domestic physical capital stock (third result), thus, leading to a lower size of the physical capital stock. The reward for capital increases as there is less capital compared to labor. The wage rate decreases. Capital-intensive sectors ("Manufacturing/Electricity" and the Oil sector) now face a cost disadvantage and their domestic production decreases. Other sectors have higher exports, but the export of the manufacturing sector decreases (fourth result). The economy expands at the expense of capital-intensive sectors, but this is more in terms of consumption and not in terms of production and investment. There is a shift from investing in the domestic physical capital stock to investing in net foreign assets.

The impact on per capita wealth of this policy is shown in Table 2 together with the equivalent variation. Per capita wealth for this policy experiment (AED 336,344) is higher than the simulated level of wealth in the base run (AED 325,543). The equivalent variation is AED −10,697 (per UAE inhabitant).

Table 2: Per capita wealth levels and equivalent variation (all in AED) for the base run and the policy simulations.

Simulation	Level of wealth	Change in Wealth	Equivalent variation
Base run	325,543	-	-
Decrease import tariff rate	331,280	5,737	-5,171
Increase indirect tax rate	324,171	-1,372	1,549
Increase in the oil price	336,344	10,802	-10,697

6 Sensitivity Analysis

As mentioned in Section 4 the SAM and additional economic data that is available is not sufficient to calibrate values for all the parameters of the model. The parameters for which empirically sound values have to be chosen are:

- r_t The world interest rate
- d_{adj} The parameter for "depreciation" of net foreign assets

- ρ_{e_i} The substitution parameter in CET production function for sector i
- ρ_{c_i} The substitution parameter in CES production function for sector i
- ρ_{VA_i} The substitution parameter in CES value added production function in sector i
- σ The reciprocal of the elasticity of intertemporal substitution

For the UAE, the level of net foreign assets and the interest received on these net foreign assets are unknown. The value for the parameter expressing the depreciation of net foreign assets determines the level of net foreign assets given the level of savings by the ROW (see the steady state version of Equation 15 where there is no time subscript). The interest received on these net foreign assets is the world interest rate times the level of net foreign assets. Either the interest received is estimated, or the world interest rate is estimated, to arrive at a value for the other unknown item.

In this section, a sensitivity analysis is carried out to see what effect choosing different values for each of these particular parameters has on the simulation results. The following table shows the level of equivalent variation for the initial values of the parameters (denoted by "Initial") and for each of the three simulations when each parameter is individually increased by 1% (except for the world interest rate which is decreased by 1%):

Table 3: Equivalent variation value for each of the simulations when individual parameters of the model are increased by 1% (the world interest rate is decreased by 1%).

	r_t	d_{adj}	ρ_{e_i}	ρ_{c_i}	ρ_{VA_i}	σ	Initial
Increase indirect tax	1,605	1,587	1,567	1,572	1,573	1,574	1,574
Decrease import tariff	-5,330	-5,273	-5,206	-5,220	-5,224	-5,228	-5,228
Increase in oil price	-10,778	-10,672	-10,690	-10,690	-10,690	-10,690	-10,690

The parameters are listed from right to left where the parameter on the far left has the most influence on the level of equivalent variation. As shown, the world interest rate and the depreciation parameter for the net foreign assets have the most effect.

It is also possible to look at the largest change (in %-point) of the ratio values for each of the simulations when, again, each parameter is individually increased by 1% (except for the world interest rate which is decreased by 1%). The results are as follows:

Table 4:Maximum percentage point change in ratio value for each of the simulations by increasing (decreasing for the world interest rate) individual parameters of the model by 1%.

	r_t	ρ_{e_i}	ρ_{c_i}	d_{adj}	ρ_{VA_i}	σ
Overall	0.443	0.147	0.051	0.050	0.017	0.003
Increase indirect tax rate	0.072	0.056	0.017	0.012	0.008	0.000
Decrease import tariff rate	0.443	0.147	0.051	0.050	0.017	0.003
Increase in oil price	0.101	0.054	0.017	0.016	0.006	0.001

In conclusion, reliable estimates especially for the level of net foreign assets and interest received on the net foreign assets will improve the reliability of the model results.

7 Concluding Remarks

This paper is the first attempt at addressing three important questions for the UAE economy using a dynamic forward looking multi-sector CGE model with oil. The benefit of using this type of model is the ability to trace out the effects on different sectors, particular in the case of counterbalancing effects. Employing a one sector model would not provide these insights.

The model results indicate that trade liberalization, through a unilateral import tariff rate reduction, has a favorable impact on the welfare of consumers. The import tariff rate reduction leads to more imports and to an expanding economy. Less is invested in foreign assets and more in the domestic physical capital stock. This drives up costs for the labor intensive sectors “Trade/Transport” and “Restaurants/Hotels”. The latter sectors are shrinking and their export levels fall. Government revenue diversification through the increase in the indirect tax rate has an adverse impact on welfare. As prices for consumption and investment increase less is demanded and domestic production shrinks. There are consequently less investments in the domestic physical capital stock and more in net foreign assets. This has a favorable effect on labor-intensive sectors, “Manufacturing\Electricity”, “Real estate” and “Restaurants/Hotels”, as they experience a cost reduction and consequently export more. Production is shifted from the domestic market to the foreign market. As expected, the oil price increase has a favorable impact on welfare. As the government earns more on oil revenues, this is passed on to households who then consume more. As the households are investing more in net foreign assets, a smaller amount is invested in the domestic physical capital stock. This means that capital-intensive sectors experience higher costs (the oil and “Manufacturing/Electricity” sectors) and this leads to lower domestic production. The economy expands, but more in terms of consumption and less in terms of production.

The policy recommendations are as expected, but by employing the model developed in this paper, sectoral differences become clear. Hence, the government can decrease the import tariff rate to improve welfare although labor-intensive sectors shrink. The government has to be hesitant about increasing the indirect tax rate as sectors shrink, although labor-intensive sectors expand. As expected, an increase in the oil price has beneficial effects on the economy of the UAE, although the domestic physical capital stock decreases.

The current model can be extended in various directions to study several issues that are pertinent to the UAE economy. One possible extension is to include imported intermediate and capital goods. A second possible extension is to disaggregate labor into different skill levels and/or make a distinction between expatriates and UAE nationals. In the case of the UAE, one would then have to take into account that expatriate workers are, in principle, available in almost unlimited amount at relatively low international wage rates. Also, the exploitation of the finite exhaustible resource oil could be modelled explicitly, and then the government behavior, which aims at making the UAE economy less dependent on oil, could be studied. In the current model capital is mobile between sectors and it remains to be seen if the results carry over to a model where capital is sector-specific. An extension of the current model might also be to introduce a separate stock of capital owned by the government. Instead of diverting part of the oil sector profits to households, the government could set aside part of the profits for investments in the education system of the UAE or for investments in the UAE's infrastructure. Furthermore, by explicitly modelling the behavior of the trading partners of the UAE, one can study the effects of FTAs with bilateral import tariff rate reductions. Finally, when more reliable data become available it is possible to calibrate more accurately the parameters mentioned in the sensitivity analysis of Section 6. The Input-Output table for the UAE can also be improved as it now depends on the Input-Output table for Kuwait. The overall results of the present model will then be more reliable and more in accordance with the actual economic situation in the UAE.

Appendix A: Economic Data on the UAE economy

This appendix contains graphs of various economic entities over time for the UAE economy:

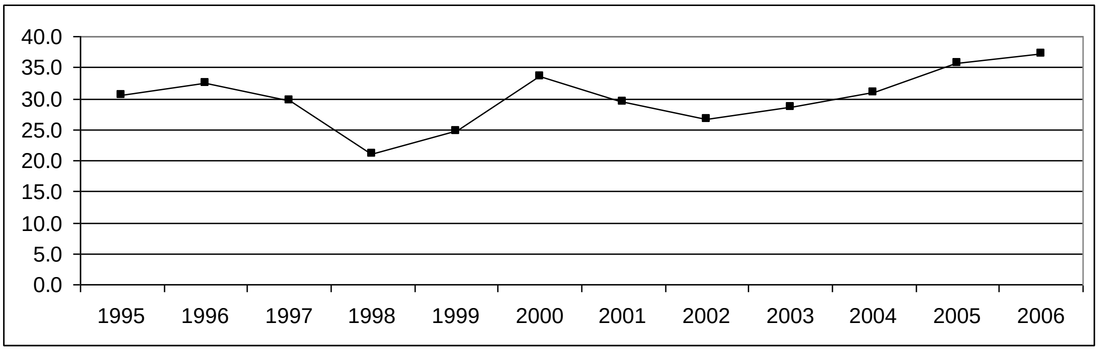

Figure A.1: GDP at factor cost of the oil sector as percentage of total GDP.

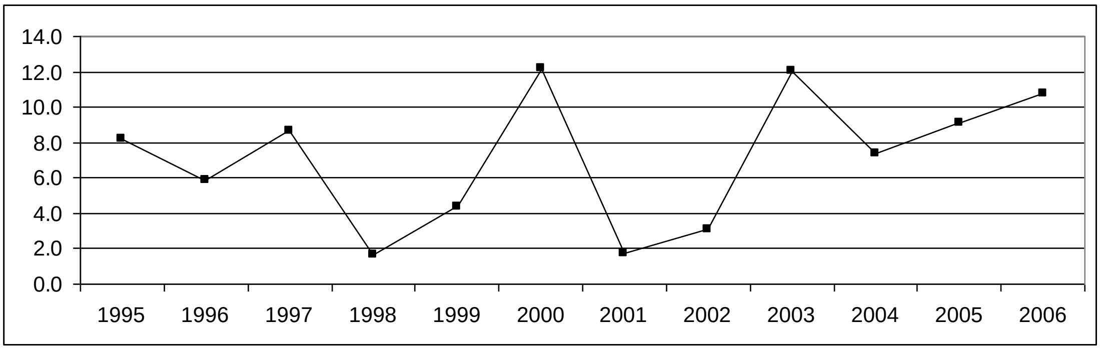

Figure A.2: Real economic growth.

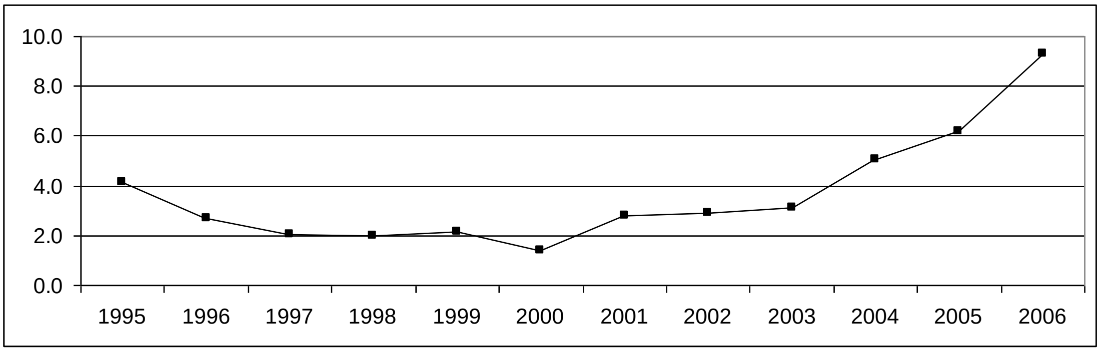

Figure A.3: The rate of inflation.

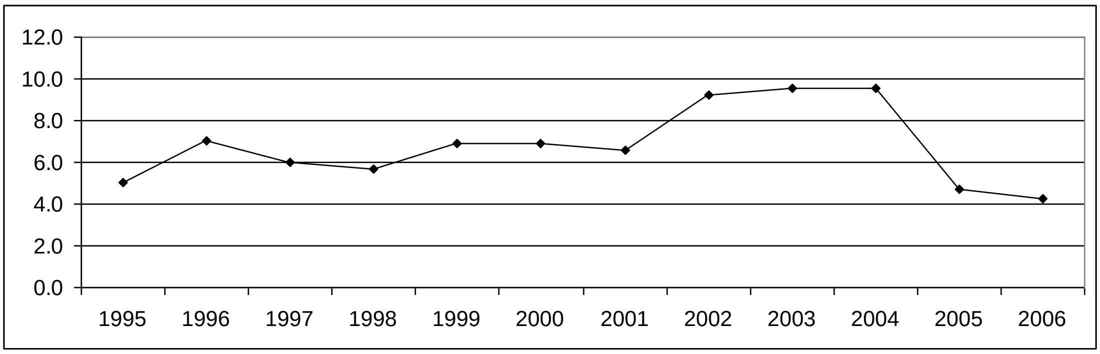

Figure A.4: Taxes as a percentage of total government revenues.

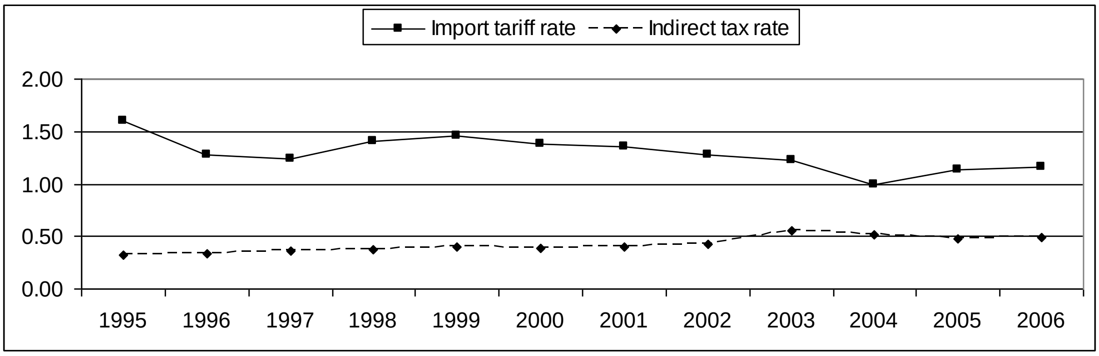

Figure A.5: Import tariff rate and indirect tax rate as percentage.

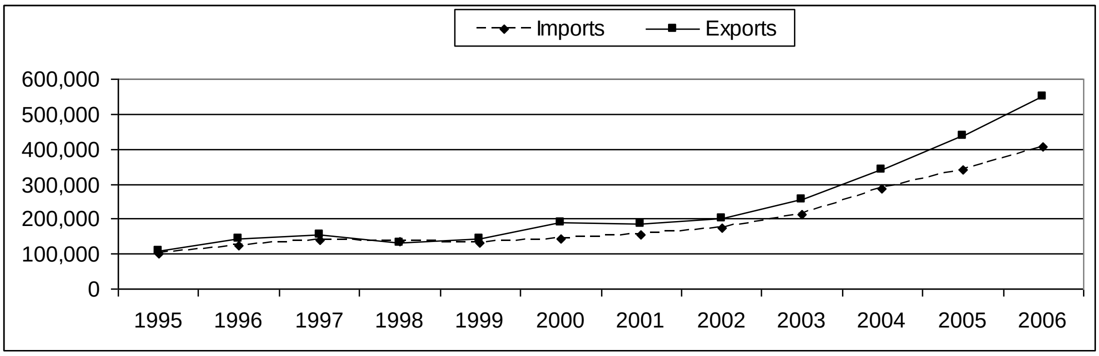

Figure A.6: Imports and exports (in millions AED).

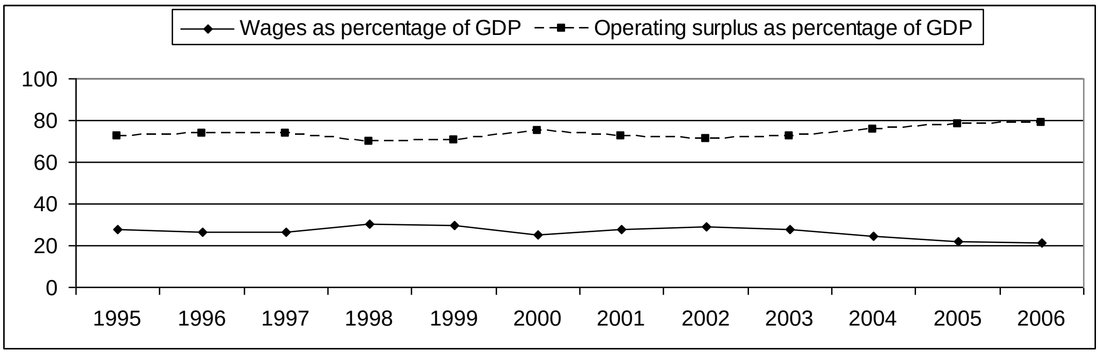

Figure A.7: Wages and operation surplus as percentage of GDP at factor cost.

Appendix B: SAM for the UAE

The actual SAM (in Table B.1) for the UAE in 2006 is presented in two parts. The values in the SAM are nominal values and all values are in millions AED. The capital letters A through I in the upper row represent the corresponding sector in the second column of the SAM.

Table B.1: SAM for the UAE in 2006.

		A	B	C	D	E	F	G	H	I	Sector Total
Production	A. Agriculture	0	0	0	2,845	0	0	0	0	0	2,845
	B. Crude oil and Natural gas and Quarrying	0	0	51,911	0	0	0	0	0	0	51,911
	C. Manufacturing and Electricity	0	0	0	0	0	0	0	0	0	0
	D. Construction	3,537	10,787	12,115	18,561	5,750	12,507	8,813	0	12,090	84,159
	E. Real estate	0	0	983	6,978	0	5,547	0	0	1,871	15,378
	F. Trade and Transport	0	94	8,182	9,133	0	8,972	0	0	1,782	28,163
	G. Restaurants and hotels	0	0	0	0	0	0	0	0	0	0
	H. Financial corporations sector	0	1,556	3,513	9,930	0	4,114	62	2,476	3,233	24,884
	I. Government and Social and Personal services	0	2,563	3,725	10,111	0	4,881	314	0	3,713	25,307
	Sector Total	3,537	15,000	80,429	57,558	5,750	36,020	9,189	2,476	22,689	232,648
Income creation	Labor income	3,760	3,350	11,981	21,291	2,291	29,439	3,271	5,327	45,086	125,795
	Capital income	8,395	217,018	69,854	23,811	43,034	70,841	7,090	29,872	3,518	473,435
Income distribution	Government subsidies	-464	0	-314	0	0	0	0	0	0	-778
	Government taxes	165	801	1,144	622	636	1,361	0	0	0	4,729
Institutions	Households	0	0	0	0	0	0	0	0	0	0
	Capital	0	0	0	0	0	0	0	0	0	0
	Government	0	0	0	0	0	0	0	0	0	0
	ROW current	12,532	60,872	86,963	47,305	48,350	103,458	10,680	36,523	0	406,682
	ROW capital	0	0	0	0	0	0	0	0	0	0
Total		27,925	297,041	250,057	150,587	100,061	241,119	30,230	74,198	71,293	1,242,511

Table B.1: SAM for the UAE in 2006 (continued).

		Sector Total	Labor income	Capital income	Income government subsidies	Income government taxes	Households	Capital	Government	ROW current	ROW capital	Grand Total
Production	A Agriculture	2,845					24,349	0	731	0		27,925
	B Crude oil and Natural gas and Quarrying	51,911					0	31,758	0	213,372		297,041
	C Manufacturing and Electricity	0					3,090	45,370	39,770	161,827		250,057
	D Construction	84,159					39,988	24,680	1,760	0		150,587
	E Real estate	15,378					55,736	25,225	3,723	0		100,061
	F Trade and Transport	28,163					70,818	0	8,792	133,346		241,119
	G Restaurants and hotels	0					10,980	0	991	18,259		30,230
	H Financial corporations sector	24,884					27,829	0	1,955	19,530		74,198
	I Government and Social and Personal services	25,307					41,198	0	2,626	2,162		71,293
	Sector Total	232,648					273,987	127,034	60,347	548,495		1,242,511
Income creation	Labor income	125,795										125,795
	Capital income	473,435										473,435
Income distribution	Government subsidies	-778										-778
	Government taxes	4,729					3,611	629	299	0		9,268
Institutions	Households		112,466	412,318					-124,622			397,908
	Capital			61,117			122,564		72,466			256,147
	Government				-778	9,268						8,490
	ROW current	406,682	13,329								128,484	548,495
	ROW capital							128,484				128,484
Total		1,242,511	125,795	473,435	-778	9,268	397,908	256,147	8,490	548,495	128,484	

Appendix C: Simulation Results

The simulation results of the model are presented in a series of tables with the simulated movement of the major set of variables over time relative to the base run. The results of each policy experiment are presented in real terms as a percentage change with respect to the corresponding base run value. Note that the initial policy impact is seen in the percentage change in 2006. The percentage changes for the subsequent years show the adjustment path over time from the base run steady state towards the new steady state.

Table C.1: Policy outcome for real per capita entities of the import tariff rate reduction (percentage change with respect to the base run).

	2006	2007	2009	2011	2015
E_t (Manufacturing Electricity)	-7.62	23.25	28.56	28.60	28.60
E_t (Trade Transport)	-5.99	-12.23	-13.25	-13.26	-13.26
E_t (Restaurants and hotels)	0.04	-3.71	-4.35	-4.35	-4.35
E_t (Financial corporations sector)	0.93	2.05	2.23	2.23	2.23
E_t (Government, social and personal services)	1.20	0.75	0.67	0.67	0.67
M_t (Agriculture)	2.41	2.13	2.08	2.08	2.08
M_t (Crude oil, natural gas and quarrying)	11.40	18.17	19.2	19.21	19.21
M_t (Manufacturing Electricity)	21.87	5.12	2.06	2.03	2.03
M_t (Construction)	8.03	3.75	2.94	2.94	2.94
M_t (Real estate)	11.87	3.47	1.93	1.92	1.92
M_t (Trade Transport)	0.88	2.48	2.76	2.76	2.76
M_t (Restaurants and hotels)	1.38	1.49	1.51	1.51	1.51
M_t (Financial corporations sector)	1.42	2.30	2.45	2.45	2.45
I_t	42.16	9.65	3.69	3.64	3.64
TAX_t	-13.96	-11.07	-10.72	-10.72	-10.72
SAV_t^{HH}	-1.61	-0.37	-0.15	-0.15	-0.15
wl_t	0.18	1.68	1.94	1.94	1.94
wk_t	0.22	-0.17	-0.23	-0.23	-0.23
K_t	0	3.11	3.64	3.64	3.64
CD_t (Agriculture)	1.65	1.78	1.80	1.80	1.80
CD_t (Manufacturing Electricity)	1.91	2.21	2.26	2.26	2.26
CD_t (Construction)	1.62	1.61	1.60	1.60	1.60
CD_t (Real estate)	1.65	2.01	2.07	2.07	2.07
CD_t (Trade Transport)	1.76	1.79	1.80	1.80	1.80
CD_t (Restaurants and hotels)	1.42	1.27	1.25	1.25	1.25
CD_t (Financial corporations sector)	1.4	1.72	1.77	1.77	1.77
CD_t (Government, social and personal services)	1.43	0.60	0.47	0.46	0.46
NFA_t	0	-3.41	-3.98	-3.99	-3.99

Note: The variables are as follows: E_{it} is exports, M_{it} is imports, I_t is investment, TAX_t is total taxes, SAV_t^{HH} is the savings of households, wl_t is the reward to labor, wk_t is the reward for capital, K_t is the capital stock, CD_{it} is consumption, and NFA_t is net foreign assets.

Table C.2: Policy outcome for real per capita entities of increasing the indirect tax rate (percentage change with respect to the base run).

	2006	2007	2009	2011	2015
E_t (Manufacturing Electricity)	2.76	-6.16	-8.17	-8.26	-8.26
E_t (Trade Transport)	1.28	3.31	3.77	3.79	3.79
E_t (Restaurants and hotels)	0.08	1.06	1.29	1.30	1.30
E_t (Financial corporations sector)	-0.44	-0.75	-0.83	-0.83	-0.83
E_t (Government, social and personal services)	-0.31	-0.23	-0.21	-0.21	-0.21
M_t (Agriculture)	-0.68	-0.60	-0.58	-0.58	-0.58
M_t (Crude oil, natural gas and quarrying)	-2.83	-5.00	-5.51	-5.53	-5.54
M_t (Manufacturing Electricity)	-6.17	-1.63	-0.63	-0.59	-0.58
M_t (Construction)	-2.24	-1.10	-0.85	-0.83	-0.83
M_t (Real estate)	-3.37	-1.08	-0.57	-0.55	-0.54
M_t (Trade Transport)	-0.22	-0.66	-0.76	-0.77	-0.77
M_t (Restaurants and hotels)	-0.46	-0.49	-0.49	-0.49	-0.49
M_t (Financial corporations sector)	-0.44	-0.69	-0.75	-0.76	-0.76
I_t	-11.96	-3.13	-1.19	-1.10	-1.09
TAX_t	4.65	4.38	4.29	4.29	4.29
SAV_t^{HH}	0.45	0.08	0.00	0.00	0.00
wl_t	-0.15	-0.51	-0.60	-0.60	-0.60
wk_t	0.02	0.12	0.15	0.15	0.15
K_t	0	-0.88	-1.08	-1.09	-1.09
CD_t (Agriculture)	-0.50	-0.53	-0.54	-0.54	-0.54
CD_t (Manufacturing Electricity)	-0.51	-0.58	-0.60	-0.60	-0.60
CD_t (Construction)	-0.49	-0.48	-0.48	-0.48	-0.48
CD_t (Real estate)	-0.53	-0.61	-0.63	-0.63	-0.63
CD_t (Trade Transport)	-0.48	-0.48	-0.48	-0.48	-0.48
CD_t (Restaurants and hotels)	-0.47	-0.43	-0.42	-0.42	-0.42
CD_t (Financial corporations sector)	-0.52	-0.59	-0.61	-0.61	-0.61
CD_t (Government, social and personal services)	-0.41	-0.21	-0.17	-0.16	-0.16
NFA_t	0	0.97	1.19	1.20	1.20

Note: The variables are as follows: E_{it} is exports, M_{it} is imports, I_t is investment, TAX_t is total taxes, SAV_t^{HH} is the savings of households, wl_t is the reward to labor, wk_t is the reward for capital, K_t is the capital stock, CD_{it} is consumption, and NFA_t is net foreign assets.

Table C.3: Policy outcome for real per capita entities for a rise in the world price of oil (percentage change with respect to the base run).

	2006	2007	2009	2011	2015
E_t (Manufacturing Electricity)	3.57	-8.11	-10.54	-10.65	-10.65
E_t (Trade Transport)	-2.26	0.29	0.83	0.85	0.85
E_t (Restaurants and hotels)	1.18	2.53	2.82	2.83	2.83
E_t (Financial corporations sector)	1.73	1.31	1.22	1.21	1.21
E_t (Government, social and personal services)	1.37	1.51	1.54	1.54	1.54
M_t (Agriculture)	2.77	2.88	2.90	2.90	2.90
M_t (Crude oil, natural gas and quarrying)	-3.78	-6.52	-7.11	-7.14	-7.14
M_t (Manufacturing Electricity)	-7.99	-1.90	-0.66	-0.61	-0.61
M_t (Construction)	-1.61	-0.07	0.24	0.26	0.26
M_t (Real estate)	-2.25	0.82	1.44	1.47	1.47
M_t (Trade Transport)	2.19	1.60	1.48	1.47	1.47
M_t (Restaurants and hotels)	3.06	3.03	3.02	3.02	3.02
M_t (Financial corporations sector)	1.64	1.31	1.24	1.24	1.24
I_t	-15.76	-3.92	-1.53	-1.42	-1.42
TAX_t	127.52	126.84	126.66	126.65	126.65
SAV_t^{HH}	-5.18	-5.64	-5.74	-5.75	-5.75
wl_t	0.65	0.14	0.03	0.02	0.02
wk_t	-0.16	-0.02	0.01	0.01	0.01
K_t	0	-1.16	-1.41	-1.42	-1.42
CD_t (Agriculture)	3.34	3.30	3.29	3.29	3.29
CD_t (Manufacturing Electricity)	3.41	3.31	3.28	3.28	3.28
CD_t (Construction)	3.28	3.29	3.29	3.29	3.29
CD_t (Real estate)	3.4	3.30	3.30	3.30	3.30
CD_t (Trade Transport)	3.28	3.28	3.28	3.28	3.28
CD_t (Restaurants and hotels)	3.21	3.27	3.28	3.28	3.28
CD_t (Financial corporations sector)	3.42	3.31	3.29	3.29	3.29
CD_t (Government, social and personal services)	2.92	3.21	3.27	3.28	3.28
NFA_t	0	1.28	1.55	1.56	1.56

Note: The variables are as follows: E_{it} is exports, M_{it} is imports, I_t is investment, TAX_t is total taxes, SAV_t^{HH} is the savings of households, wl_t is the reward to labor, wk_t is the reward for capital, K_t is the capital stock, CD_{it} is consumption, and NFA_t is net foreign assets.

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