EGYPT'S EXPERIENCE FROM CGE MODELING: A CRITICAL REVIEW

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Working Paper 9411

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BY

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ABSTRACT

This paper reviews Egypt's experience of SAM-based CGE modeling, dating back to the mid-1970s. Its purpose is to extract lessons for the future application of such models to Egypt and other LDCs. The paper provides a detailed review of seven models, covering their data bases, key aspects of their structures (with regard to production, consumption, foreign trade, micro and macro closures), as well as policy simulations. It is concluded with critical observations and suggestions for future research.

ملخـــص

تستعرض هذه الورقة تجربة مصر في صياغة نماذج Computable General Equilibrium (CGE) المستندة الى مصفوفة الحسابات الاجتماعية SAM التي يرجع تاريخها الى منتصف السبعينات. وتستهدف هذه الورقة استخلاص الدروس المستفادة من اجل تطبيق هذه النماذج في المستقبل على مصر وغيرها من الدول النامية. وتستعرض الورقة بالتفصيل سبعة نماذج تغطي قواعد البيانات الخاصة بها، الهياكل الاساسية لهذه النماذج (فيما يتعلق بالانتاج، الاستهلاك، التجارة الخارجية، والمتغيرات الاقتصادية الجزئية والكلية)، هذا الى جانب وضع نماذج محاكاة للسياسات الاقتصادية. وتنتهي الورقة بتقديم ملاحظات واقتراحات هامة للبحوث المستقبلية.

1. INTRODUCTION

This paper reviews the major CGE studies that have emerged from Egypt's relatively rich experience with Computable General Equilibrium (CGE) modeling.[1] Its purpose is to derive lessons for future research. Section 2 provides a brief background on CGE modeling in Egypt. In Section 3, specific aspects of the model structures are contrasted and evaluated. Simulations of policies and exogenous shocks are discussed in Section 4. A concluding evaluation with guidelines for future research follow in Section 5.

2. BACKGROUND AND OVERVIEW

CGE models may be defined as a economy-wide models the solutions to which depict a simultaneous general equilibrium in all markets of the economy. Most but rarely all of the data required may be derived from a Social Accounting Matrix (SAM). The first CGE model was developed by Johansen [1960]. The first applications to LDCs came in the early 1970s. Since then, these models have become standard tools for policy analysis in LDCs.

The studies of Egypt that will be reviewed in this report are listed in chronological order in Table 1. In the table, the models are classified by their time frame (static or dynamic), underlying theoretical paradigm (neoclassical or structuralist), and policy focus. A static model is typically solved for only one time period whereas, the dynamic models under review are solved for several periods with recursive links between the solutions

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*The author gratefully acknowledges a number of constructive comments from Motaz Khorshid on an earlier version of this paper.

[1]For further guidance regarding CGE modeling, see Bergman [1990], Dervis et al [1982], Robinson [1989], and Taylor [1990].

Table 1. Summary of model features

MODEL FEATURE	TAYLOR [1979]	ECKAUS, McCARTHY, & MOHIE-ELDIN [1979]	CHOUCRI & LAHIRI [1983a]	KHORSHID [1984]	DETHIER [1985]	AHMED, BHATTACHARYA, GRAIS & PLESKOVIC [1985]	KHEIR-EL-DIN & EL-LAITHY [1990]
A. OVERVIEW							
Static-Dynamic	Static	Static	Static	Static	Dynamic	Dynamic	Static
Theoretical basis	Structuralist	Neoclassical	Structuralist	Structuralist	Neoclassical	Neoclassical	Neoclassical
Disaggregation							
prod'on sectors	3	12	10	5	8	9	12
primary factors	2 (labor, capital)	3 (labor, capital, land)	2 (labor, capital)	1	8 (capital, 7 for labor	3 (labor, capital, land)	3 (labor, capital, land)
households	2 (urban, rural)	6 (3 urban, 3 rural)	1	1	9 (urban & rural)	2 (urban, rural)	2 (urban, rural)
Policy focus	Food subsidies	Taxes, subsidies & income distribution	Domestic oil pricing	Aggregate demand, tax & subsidy policies	Food policy & income distribution	Public sector reform	Aggregate demand, tax & subsidy policies
SAM (year; size)	18 x 19; 1975	40 x 40; 1976	22 x 20; 1977	33 x 33; 1980/81	1979; 47 x 47 ?	1979; 362 x 362	1983/84; 121 x 121
B. PRODUCTION FUNCTIONS, INPUTS & PRODUCER TAXES/SUBSIDIES							
Factors	Fixed coeff. for labor; variable cost markup to capital	Cobb-Douglas for capital, labor & land	Fixed coeff. for labor; variable cost markup to capital	Fixed coeff. for aggregate factor	Two-level CES with capital & composite labor at level 1 & 7 labor types at level 2	Labor, capital & land in CES	Fixed coeff's for labor & capital
Intermediate inputs	Fixed coeff's for domestic goods & non-competitive imports	Fixed coeff's for domestic goods & non-competitive imports	Fixed coeff's for domestic goods & non-comp. imports; flexible energy coeff's for energy-intensive sectors	Fixed coeff's for composite goods	Fixed coeff's for composite goods	Composite domestic goods & composite imports in CES; Leontief aggregation for both types of composite goods	Fixed coeff's for composite goods
Producer taxes/ subsidies	Producer-specific subsidies on intermediate inputs	Producer-specific taxes & subsidies on intermediate inputs	Producer subsidies on sectoral output values	Subsidies/taxes uniform for all users	Subsidies/taxes uniform for all users	Subsidies/taxes uniform for all users	Subsidies/taxes uniform for all users

cont. Table 1

MODEL FEATURE	TAYLOR [1979]	ECKAUS, McCARTHY, & MOHIE-ELDIN [1979]	CHOUCRI & LAHIRI [1983a]	KHORSHID [1984]	DETHIER [1985]	AHMED, BHATTACHARYA, GRAIS & PLESKOVIC [1985]	KHEIR-EL-DIN & EL-LAITHY [1990]
C. FOREIGN TRADE							
Internat'al Prices	exog	exog	exog	exog (imports) endog (exports)	exog (imports) endog (exports)	exog (imports) endog (exports)	exog (imports) endog (exports)
Import Quantities	endog/exog	endog/exog	endog/exog	endog	endog	endog	endog
Import Substitut'y	zero/infinite	zero/infinite	zero/infinite	imperfect	imperfect	imperfect	zero
Export Quantities	exog	exog	exog	endog (constant elasticity demand functions)	endog (constant elasticity demand functions)	endog (constant elasticity demand functions)	endog (constant elasticity demand functions)
Export Substitut'y	perfect	perfect	perfect	perfect	perfect?	perfect	perfect
D. REAL SYSTEM CONSTRAINTS: EQUILIBRATING VARIABLES							
Goods Markets	supply (1a): all	price-quantity (1b): all	price (1c): constr'on imports (1d): agricult'e supply (1a): all other	exports (1e): oil supply (1a): all other	imports (1d): agricult'e price-quantity (1b): all other	price-quantity (1b): all private exports (1e): oil-public supply (2a): electr'y & services, both public domestic demand (2b/c): other public	price-quantity (1b): all
Labor Markets	supply (1a)	price (1c)	supply (1a)	supply (1c): agg. factor	supply (1a), see (1) price (1c): see (1)	supply (1a): rural price (1c): urban	price (1c)
Capital Markets	supply (mark-up)	price (1c)	supply (mark-up)	supply (1c): agg. factor	price (1c)	price (1c)	price (1c)
E. NOMINAL SYSTEM CONSTRAINTS: EQUILIBRATING VARIABLES							
Government balance	government savings	government savings	government savings	government savings	government spending	government savings	government spending
Balance of Payments	foreign savings	foreign savings	foreign savings	foreign savings	foreign savings	borrowing/import rationing/exchange rate	exchange rate
Savings-Investment	output	aggregate price level	output	output	government savings	public: output & prices private: investment	foreign savings

Notes: 1. Dethier's model has seven labor types with two alternative closures: supply adjustment with a fixed nominal wage (e.g. for skilled industrial workers), and a flexible wage (e.g. for construction workers); 2. The references (1a), (1b), ..., (2c) in Part D of the table refer to Panels 1 and 2.

for one period and the solutions for preceding periods. I.e. in addition to exogenous parameter updating, some of the updated parameter values depend on the simulated values for earlier periods. In its stylized form, a neoclassical model assumes profit-maximizing firms, utility-maximizing consumers, continuous production and utility functions, and price-clearing competitive markets for all goods and factors.[2] A model may be termed structuralist if it significantly deviates from these assumptions. Structuralist features commonly included are fixed input coefficients, not only for intermediate inputs but also for primary factors, markup pricing, the clearing of markets via mechanisms other than price adjustment, and constraints on nominal macro aggregates [Robinson 1989:913-915]. Most applied models of LDCs deviate from the pure neoclassical case. Thus, the classification in Table 1 should be understood in relative terms. Next, we will briefly outline the institutional context and the areas on which each of these models was focused. While the information provided in Table 1 will be analyzed, it will, throughout this paper not be restated.

The first CGE of Egypt, an aggregate model focused on food subsidies, was developed by Lance Taylor in 1976 as part of a World Bank assignment. It was published in 1979. While Taylor is not the author of any of the other studies, models he developed for Pakistan and India provide the basic framework for the models presented by Eckaus, McCarthy, and Mohie-Eldin [1979], and Choucri and Lahiri [1983a; 1983b].[3] The first large-scale activity, started in 1977, was carried out within the framework of a Cairo University - M.I.T. research project. It produced the first disaggregated Egyptian SAM, for 1976 [Eckaus et al. 1981], and subsequently provided most of the data for the CGE model of

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[2]The term "good" is used broadly to cover both goods and services.

[3]See McCarthy and Taylor [1980], and Taylor [1983].

Eckaus et al. [1979], named GEM (General Equilibrium Model). In this review, we refer to one of its versions, GEM-3.[4] GEM is relatively disaggregated, especially for income distribution and government activities, including taxes and subsidies. The importance of this project is indicated by the large number of studies that are based on its model and/or its 1976 SAM.[5] The research of Choucri and Lahiri [1983a; 1983b], was also carried out within a Cairo University - M.I.T. project. Their model was geared toward analyzing energy-economy interactions but also applied to exploring the impact of changes in worker remittances.

Between 1981 and 1983, a substantial effort was made in the data area. A disaggregated SAM for 1979 was built by the project "Economywide Modeling and SAM Updating", with the participation of Cairo University, various Egyptian government ministries, and the World Bank. As a follow-up, Egypt's Central Agency for Public Mobilization and Statistics (CAPMAS), embarked on the project "Social Accounting Matrices and Economic Modelling in Egypt," one result of which was a SAM for 1980/81. The model developed by Khorshid, called MISR1, was a key component of this CAPMAS project.[6] This was the first CGE activity carried out almost exclusively by Egyptians, suggesting that the technology transfer involved had achieved a reasonable degree of success. While their model was solved for several years, it is nevertheless considered static since there are no recursive links between model solutions for different years.

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[4]The difference between GEM-3 and the other versions lies in the closure rules for the factor markets [Eckaus et al 1979:1].

[5]See Boutrus-Ghali and Taylor [1980], Dethier and Esfahani [1981], Eckaus and Mohie-Eldin [1980; 1984], a background paper to an ILO study by Osman M. Osman (see Hansen and Radwan 1982:292], and Nugent [1988]. The latter two studies were unfortunately not available for this review.

[6]Three papers relevant to MISR1 are found in CAPMAS [1984]: Khorshid [1984] (model structure); Kheir-El-Din, Khorshid and El-Safty [1984] (model validation); and Khorshid and Kheir-El-Din [1984] (policy experiments).

Dethier [1985] and Ahmed, Bhattacharya, Grais, and Pleskovic [1985] developed the first dynamic CGE models for Egypt. In the data area, both studies have the above-mentioned 1979 SAM as their starting point. Their model structures belong to the brand of CGE models presented in Dervis, de Melo, and Robinson [1982]. Dethier's model is part of a Ph.D. dissertation at the University of California at Berkeley. The comparative advantage of his model lies in its disaggregated treatment of households and labor categories, permitting analysis of distributional issues. The between-period module includes a recursive link for the capital stock. Ahmed et al. built their model, MISR2, as an assignment for the World Bank. At the time when it was developed, this study embodied state of the art modeling. Its distinguishing characteristics include a high degree of disaggregation in the foreign exchange area and along the private-public dimension for production and savings-investment. The last model surveyed in this paper, MISR3, was developed by Kheir-el-Din and El-Laithy [1990], both of whom are on the Faculty of Economics and Political Science at Cairo University. The model is based on a 1983/84 SAM developed by a joint team from Cairo University and CAPMAS [CAPMAS 1988]. In general, it is quite disaggregated. Like the model by Khorshid [1984], it was solved for several years. In the absence of any recursive links, it is, nevertheless, considered a static model. It should also be noted that more recently CAPMAS published a SAM for 1986/87 [CAPMAS 1991] and that an ongoing CAPMAS project is involved in constructing a SAM for 1989/90.

Three high-quality models, not included in this review, should also be mentioned.[7] The first is the Domestic Resource

[7]In addition, Arne Drud and Wafik Grais have developed a disaggregated CGE model focused on the public-private sector dichotomy. The model has, however, not been published in any manner. A more recent model, Khorshid [1992], was available too late to be included in this review.

Mobilization (DRM) model, developed by Dervis and others at the World Bank [World Bank 1980; 1983]. It is an economy-wide dynamic growth model for consistent projections designed to analyze alternative mechanisms for resource mobilization. Prices are exogenous. Given that this structure strongly deviates from that of a standard CGE model, it was not included. The other two models are by Pleskovic [1982; 1989] and Umari [1990]. The primary purpose of Pleskovic's work was to extend the Harberger fiscal incidence model to include inter-industry transactions and preexisting taxes. Umari [1990] presents a structuralist CGE model aimed at testing the impact of changes in inter-sectoral terms of trade on industrial capital accumulation. These last two models were left out due to their highly stylized nature and the fact that the formulations they use also appear in one or more of the models in Table 1.

3. A TOPICAL REVIEW OF SELECTED MODEL ASPECTS

In this section, we will present and comment on the structures of reviewed models -- production, household incomes and consumption, the treatment of foreign trade, and system constraints.

3.1. Production

From Section A of Table 1 it is apparent that the levels of disaggregation for primary factors and sectors/goods (including intermediate inputs) vary greatly across the reviewed studies.

Section B of Table 1 summarizes the treatments of production relations, linking factors, intermediate inputs, and outputs. In general, fixed coefficients are used for intermediate inputs and, in structuralist models, also for labor in combination with a

markup on variable cost paid to capital.[8] For a neoclassical model, primary factors enter continuous production functions with factor demand functions derived from the assumption of profit maximization. Invariably, the latter category of models assume that firms are price-takers.

As variations on this general picture, Choucri and Lahiri introduce price-responsive energy coefficients derived from a CES unit cost function for "aggregate" energy [Choucri and Lahiri 1983b:25-27]. The models by Dethier and Ahmed et al. both rely on two-level specifications, with the inputs at the lower level "producing" a composite (or aggregate) input entering the function at the higher level.[9] Such specifications provide a means of allowing for different substitution possibilities between different subsets of the inputs. In addition, Dethier's model is characterized by a complex pattern of labor disaggregation by sector and skill [1985:204].

3.2. Household Incomes and Consumption

Section A in Table 1 shows that, in all models except those by Choucri and Lahiri [1983a], and Khorshid [1984], households are disaggregated. The most detailed treatments are found in Eckaus et al. [1979] and Dethier [1985]. Both rely on disaggregations that, at least in part, are based on percentile income groups

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[8]In the case where capital receives a markup on variable costs, it is, strictly speaking, not specified whether the capital input coefficient is fixed or variable -- this is irrelevant given that capital is paid a markup, not a unit price, and the accompanying assumption of sufficient surplus capacity to meet any demand for capital.

[9]Similarly, Boutrus-Ghali and Taylor extended the GEM model of Eckaus et al. by introducing a two-level CES formulation, with disaggregated labor at the lower level and aggregate labor, capital, and land at the higher level [1980:7-8].

rather than the socio-economic characteristics of the households.[10]

The sources and uses of household incomes obey the following standard pattern: incomes are derived from factor employment and transfers, and allocated in fixed shares to direct taxes, savings and consumption. The allocation of consumption over different goods is determined by the linear expenditure system (LES). The only exception is the model of Ahmed et al. which uses a logistic function generalization of the LES [1985:159].

3.3. Foreign Trade

In Section C of Table 1, the treatments of Egypt's foreign trade are summarized. With regard to imports and exports, the models may be divided into two groups: the first-generation models by Taylor, Eckaus et al., and Choucri and Lahiri; and the second-generation models by Khorshid, Dethier, Ahmed et al., and Kheir-el-Din and El-Laithy. The earlier studies divide imports into two groups, competitive and non-competitive (perfect substitutes and perfect complements to domestic goods, respectively). Competitive imports are exogenous whereas non-competitive imports are endogenous, depending on household incomes (for consumption goods) and production levels (for intermediate goods).[11] For exports, the earlier models assume that both prices and quantities are exogenous.

The more recent models rely on weaker assumptions. They assume that imports and domestic output used at home are imperfect

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[10]For a discussion, see Dethier [1985:139-170].

[11]For agriculture, Choucri and Lahiri deviate from this general picture by assuming that imports are endogenous and perfect substitutes for domestic goods [1983a:13-15]. In the earlier models -- by Taylor, Eckaus et al, and Choucri and Lahiri -- non-competitive investment imports are exogenous.

substitutes by means of a CES (Armington) function in which composite goods are "produced" by domestic and imported goods entering it as "inputs". The mixture between goods from these two sources is a function of the import/domestic price ratio. For exports, the more recent applications assume that export demand is a function of the endogenous export supply price via a constant elasticity function.[12]

However, all models treat import prices as exogenous. The justification for this asymmetric treatment of import and exports prices is Egypt's smaller share in the world market for most of its imports. Another assumption common to all models is perfect substitutability between the domestically produced goods that are exported and those used domestically. This assumption was made in spite of the option of incorporating imperfect substitutability via a Constant Elasticity of Transformation (CET) function or a logistic function.[13]

3.4. Real System Constraints

System constraints, or "closure rules", are those constraints that have to be satisfied by the economic system, but which are not considered in the decisions of any micro agent. They may be classified as real and nominal [Robinson 1989:907-908]. The real constraints, applying to markets for goods and factors, are summarized in Section D of Table 1. The numbers in brackets refer to the corresponding demand-supply diagrams in Figure 1.

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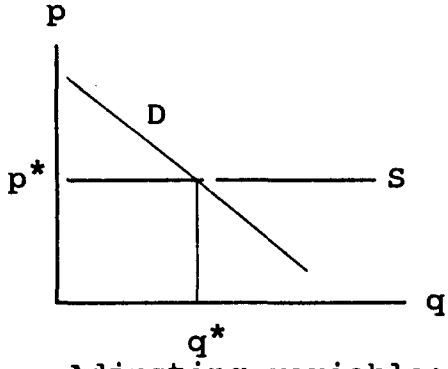
[12]For this case, a distinction is made between the "world price", an aggregate international price level and the price at which exports are sold -- Egypt's export supply price. The export supply price (which may deviate from the world price) is computed as the domestic price level adjusted for any export taxes/subsidies and transformed into foreign currency via the exchange rate [Dervis et al. 1982:225-226].

[13]The approach relying on a logistic function is covered in Dervis et al [1982:228-230]; the CET approach is explained in a CGE context in Condon et al [1985:80-81].

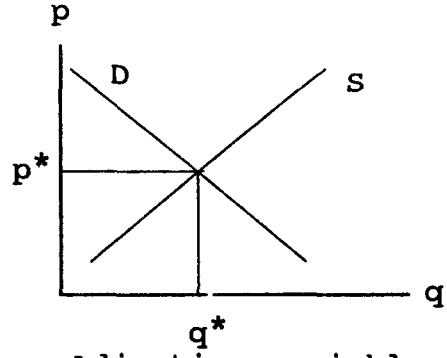
Figure 1. Alternative Closures for Goods and Factor Markets

Panel a



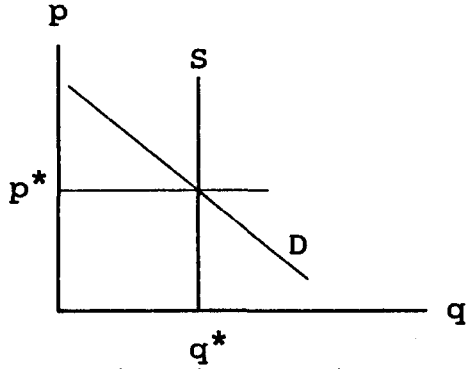
Adjusting variable:
Supply

Panel b



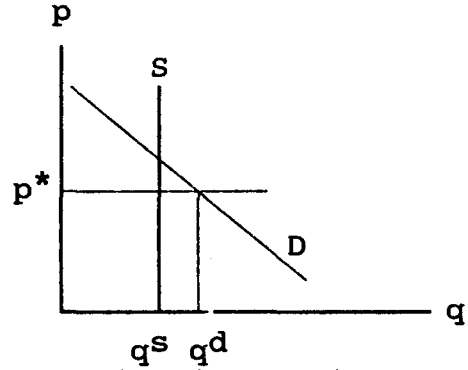
Adjusting variables:
Price-Quantity

Panel c



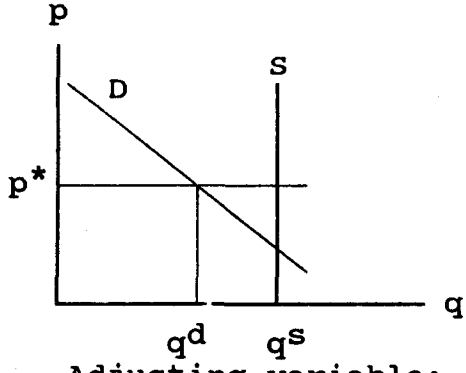
Adjusting variable:
Price

Panel d



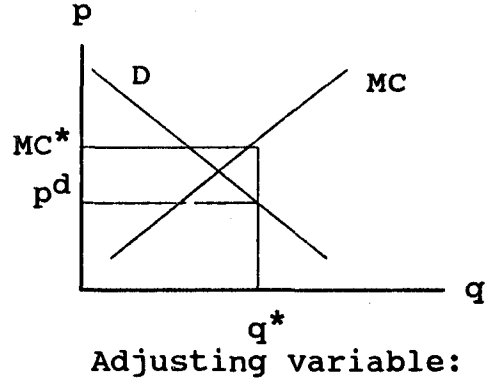
Adjusting variable:
Imports (= $q^d - q^s$)

Panel e



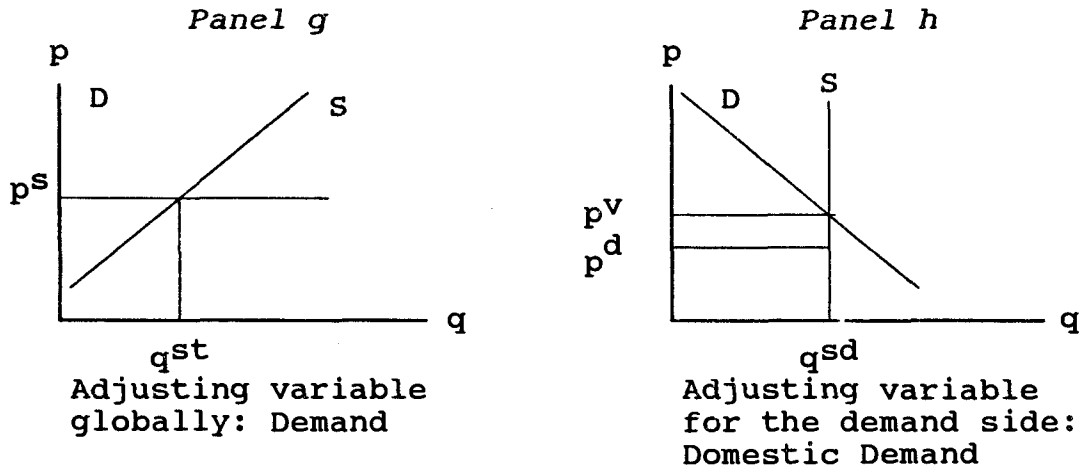
Adjusting variable:
Exports (= $q^s - q^d$)

Panel f



Adjusting variable:
Supply

cont. Figure 1.



Panels (a)-(e) presents the five most common equilibrating mechanisms. (All curves are arbitrarily drawn as straight lines.) Panel (a) shows an infinitely elastic supply at a fixed price, while Panels (b) and (c) assume an equilibrating price, accompanied by supply and demand adjustments for (b) but with a fixed supply for (c). Panels (d) and (e) assume, respectively, that imports and exports clear the market; in either case, their quantities have to be endogenous and they have to be perfect substitutes to domestic outputs sold at home. In both panels, domestic price and supply are fixed. With regard to the factors, most studies assume that capital, once installed, is sector-specific whereas labor tends to enjoy a larger degree of mobility.[14]

For goods markets, the treatment in the MISR2 model of Ahmed et al. is quite complex. By means of a composite-good approach, they permit price differentials between public and private sector goods. For private sector goods, it is assumed that flexible

[14]For capital, Kheir-el-Din and El-Laithy deviate by assuming that the existing stock is sectorally mobile [1990:18, 36].

prices clear the markets, as in Panel (b). All public sector prices are, on the contrary, fixed (by government policy). The adjusting variables in the markets for public sector goods are export demand [for oil, Panel (e)], domestic supply [for electricity and services, Panel (f)], or domestic demand [for remaining markets, Panels (g) and (h)]. For the case of supply adjustment, it is assumed that the public sector supplies any quantity demanded at the fixed price, p^d. Given the assumed marginal cost (MC) schedule, this price falls short of the MC at q^* (MC^*), thus, forcing the producer to deviate from profit maximizing behavior [Ahmed et al. 1985:15-17]. For the case of domestic demand adjustment, the domestic public sector determines its total quantity supplied, q^{st}, as a function of the fixed supply price, p^s [Panel (g)]. Exports, if any, are determined endogenously as a function of the supply price in foreign currency, in its turn determined by supply price in domestic currency, subsidies/taxes, and the exchange rate [cf. Panel (a)]. The quantity supplied to the domestic market, q^{sd}, is the residual [domestic supply *less* exports; see Panel (h)]. The demand price is fixed at p^d. Equilibrium is achieved via rationing with the goods received by the domestic demanders with the highest reservation prices (p^v or higher) [Ahmed et al. 1985:15].[15]

This is a wide range of alternative closures, indicative of the richness of the CGE methodology. The choice between these alternatives should, inter alia, depend on the structure of the economy, its base-year state, the degree of model disaggregation,[16] and the time frame. However, when the reviewed

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[15]The rent, received by the demanders, is represented by the area $(p^v-p^d)q^{sd}$. This approach to consumer rationing is due to Neary and Roberts [1980]. The model of Ahmed et al. constitutes the first CGE application [Dewatripont et al. 1990:220, 238].

[16]Dethier's treatment of labor exemplifies how a high degree of

models are contrasted, the differences between their closures are quite striking not easily explained with reference to these considerations. For example, while Taylor [1979] assumes general excess capacity (no constraints for factor supplies or sectoral output levels), Eckaus et al. [1979] assume fixed factor supplies, effectively fixing the aggregate output level. Similarly, Khorshid [1984] and Choucri-Lahiri [1983a] make different assumptions for oil, agriculture, and construction.[17] This suggests that satisfactory information has not been available to the model builders.

3.5. Nominal System Constraints

In a typical CGE model, the nominal system constraints are the government balance, the balance of payments, and the savings-investment balance. The selected equilibrating mechanisms should aim at reflecting the actual workings of the modeled economy. The different treatments of these constraints in the reviewed models are summarized in Section E of Table 1. The modeling of the two first balances is relatively uniform. In the standard case, government savings is the residual that clears the government balance while foreign savings clears the balance of payments. For the government balance, the only exceptions are Dethier [1985:220, 227] and Kheir-el-Din and El-Laithy [1990:20], both of whom assume that government spending is adjusted. For the balance of payments, Ahmed et al. [1985] and Kheir-el-Din and El-Laithy [1990] deviate from the general picture. The latter assume that

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model disaggregation permits a finetuning of closure rules. Moreover, on the basis of empirical data, he imposes sectoral wage differentials for each labor type [Dethier 1985:191-192, 203-204, 224].

[17]Those involved in the MISR1 project were aware that their closure assumptions were too simplistic, especially for the construction sector [Kheir-El-Din et al. 1984:143]. Choucri and Lahiri's assumption of unutilized oil capacity is contrary to the assumptions of Khorshid [1984:127] and Ahmed et al. [1985:10].

an endogenous exchange rate clears the balance of payments [Kheir-el-Din and El-Laithy 1990:37], while Ahmed et al., reflecting the policy regime of 1983, have a highly detailed treatment in this area, including three foreign exchange pools -- the Central Bank pool, and the Commercial Bank pool, and the free market -- each of which is associated with an exchange rate and a specific clearing mechanism [1985:11, 32-35].

Balance between savings and investment is the condition for overall macroeconomic equilibrium. With one exception, all models assume that investment is fixed (in real or nominal terms). The three models earlier defined as structuralist -- Taylor [1979], Choucri and Lahiri [1983a], and Khorshid [1984] -- have a uniform treatment: in the absence of supply constraints, output and income are adjusted until savings meets the level of investment. In addition, income redistribution is a potential parallel means of achieving overall savings-investment equality given that savings behavior differs across income recipients. Each of the remaining models presents its specific mechanism for achieving savings-investment balance -- changes in the overall price level [Eckaus et al. 1979:29], foreign savings [Kheir-el-Din and El-Laithy 1990:22], and government savings [Dethier 1985:219]. Compared to the other models, Ahmed et al. have a more disaggregated treatment with separate savings-investment balances for the public and private sectors. Total savings generated by the private sector of the economy is made available for both private and public sector investment, according to exogenous shares. Private sector investment is determined by the level of private savings made available through this mechanism -- this is the only example of savings-driven investment in the reviewed models. Public sector investment spending is, on the other hand, exogenous. Variations in prices and output adjust the size of the savings pool available for public sector investment [Ahmed et al. 1985:32-35].

Thus, there are also considerable variations across the models for the nominal system constraints, apparently in part reflecting uncertainty about the functioning or state of the economy. As for the real constraints, a more disaggregated treatment can make these choices less difficult, as exemplified by Ahmed et al. [1985]. In addition, in the presence of uncertainty it may be fruitful to test the sensitivity of any simulation results to alternative rules for system constraints, both real and nominal.[18]

4. SIMULATION OF POLICY CHANGES AND EXOGENOUS SHOCKS

The ultimate motive behind the development of CGE models, in Egypt and elsewhere, has been a desire to better understand the economic effects of alternative policies. Experiments with CGE models are counterfactual: the question "what if?" is addressed through comparisons between a base case and simulations involving changes in policies and/or various exogenous phenomena. Table 2 presents the types of policy changes and exogenous shocks that have been simulated with each model.[19] Some of the issues were analyzed separately, some in combined experiments. All models except Khorshid [1984], Dethier [1985], and Ahmed et al. [1985] were used for simple comparative static experiments. In spite of that it is static, Khorshid's model was used in a "dynamic mode" -- it was solved for a series of years with changes in exogenous parameters between the different solutions.

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[18]Dethier and Esfahani [1981] follow this route in a set of experiments with the GEM of Eckaus and coauthors.

[19]The results of the simulations are not discussed in this section since this cannot be done adequately without a relatively detailed consideration of the structure of each model. No policy experiments are reported in Kheir-el-Din and El-Laithy [1990].

A CGE model may help in assessing the approximate magnitudes of the impacts on a large number of indicators. An important characteristic enhancing their relevance is that the indicators are from both the macro and the micro levels. The most important indicators have typically included GDP, sectoral production levels, wages, household incomes and consumption, as well as Egypt's macro (im)balances -- the savings-investment balance, the government deficit, and the current account deficit. Depending on the model structure, additional aspects have also been considered, such as income distribution in the models by Eckaus et al. [1979] and Dethier [1985].

The information in Table 2 suggests that the issues addressed closely coincide with the key concerns faced by Egypt's policy-makers since the mid-1970s. This choice of simulation topics is also compatible with the comparative advantage of CGE models -- they are particularly good at analyzing price, tax, and subsidy policies as well as exogenous shocks.[20] The only areas of relative neglect may be the foreign exchange system and trade policy. Apart from Ahmed et al. very little attention was paid to these issues in spite of both their policy relevance and the relative strength of CGE models in this area.

The fact that the experiments have targeted important policy areas does not automatically mean that they have been used by (or useful to) policymakers. On the contrary it seems that, while they indeed have provided some direct input to decision-making, their value has, so far, primarily been academic.[21] This may in part be due to a lack of institutionalized channels for inter-

[20]The emphasis on these issues in an LDC context is evident from the survey of Decaluwé and Martens [1988:551].

[21]The simulations with the model of Eckaus et al., reported in Hansen and Radwan [1982], may have reached the largest audience among the reviewed studies -- their book constitutes the report of a large ILO mission to Egypt concerned with issues of employment and equity.

Table 2. Simulations of Policy Changes and Exogenous Shocks

	MODEL REFERENCE					
SIMULATION AREA	TAYLOR [1979]	ECKAUS, McCARTHY, & MOHIE-ELDIN [1979]	CHOUCRI & LAHIRI [1983a]	KHORSHID [1984]	DETHIER [1985]	AHMED, BHATTACHARYA, GRAIS & PLESKOVIC [1985]
Aggregate Demand	economywide investment	econ-wide invest. (DE)	econ-wide inv (CLa, CLb) gov't spending (CLa)	economywide investment	agricultural investment economywide investment	public investment
Taxes		direct taxes (DE, HR) land tax (HR)		indirect taxes		
Subsidies	food	food (EM, DE) agricultural inputs (DE) producer & consumer (HR)			food	
Domestic pricing		agriculture (DE)	petroleum (CLa)		agriculture	public sector
Wages & employment	nominal wage change	nominal wage change (HR)		nominal wage change	nominal wage change	public sector wage & employment liberalization; public sector borrowing from private sector
Exchange rate					liberalization	liberalization; devaluation
Others		remittances (HR)	remittances (CLb)	remittances		foreign borrowing
		terms of trade (HR)		export demand		
		reduced armed forces combined with changes in labor force & taxes (HR)		oil prod'on (capacity)		

Explanation: For models other than Eckaus et al. [1979], Choucri and Lahiri [1983a], and Khorshid [1984], the simulations are without exception reported in the model reference. The source for Khorshid is Khorshid and Kheir-el-Din [1984]. The following abbreviations were used for Eckaus et al., and Choucri and Lahiri: CLa = Choucri and Lahiri [1983a]; Clb = Choucri and Lahiri [1983b]; DE = Dethier and Esfahani [1981]; EM = Eckaus and Mohie-Eldin [1984]; HR = Hansen and Radwan [1982].

action between economic analysts and policymakers. However, it may also reflect that the analyses at best only provide very rough guidance to policy making due to various shortcomings, an issue to which we will return in the concluding section.

5. CONCLUSIONS

This review shows that CGE models of Egypt have included a wide variety of formulations, providing a foundation upon which future model builders can draw. They have been used to address some of the most crucial policy issues of the last decades. While a SAM was an unknown concept until the mid-1970s (at least in its socio-economic form), SAM building has now become an institutionalized process.

While much has been achieved, the value of these studies has so far primarily been academic. Progress in a number of areas could significantly enhance the future contributions of CGE modeling. First, there is an urgent need for more current and more extensive data. As an indicator, the two most recent SAMs, for 1983/84 and 1986/87, appeared in October 1988 and May 1990, respectively -- i.e. with a lag of three to four years. Moreover, the disaggregation of these SAMs is insufficient in many areas, including labor, households, and production (in particular, the absence of disaggregation along private-public sector lines in the 1986/87 SAM is disturbing), making it very difficult to analyze key issues like unemployment, poverty, income distribution, and privatization. These difficulties are augmented by limited access to existing complementary data as well as by time-consuming approval procedures for specialized surveys. From a different angle, there is a need for increased emphasis on econometric parameter estimation in the areas of production, consumption, and foreign trade. For the reviewed models very few

references are made to econometric studies -- it seems that the selected parameter values are typically "guesstimates".[22]

Second, the more advanced of the reviewed models represent the state of the art as of the mid 1980s. Since then, advances have been made, including the incorporation of imperfect competition, economies of scale, and financial aspects.[23] The ability of CGE models to reflect Egypt's economic structure may be enhanced if these advances are drawn upon. However, to a significant extent, the ability to do so critically depends on an improved data base and work in the econometric area.

Third, most of the reviewed models suffer from shortcomings in accuracy and style, ranging from missing or unclear variable and parameter definitions to inconsistent equations, unspecified equation domains, and the absence of a complete mathematical statement.[24] Many of these shortcomings could be minimized if the model documentation, as a rule, included a complete mathematical statement, definitions of all model elements, the parameter values for the base run, the changes introduced in the simulations, the results of the policy experiments, as well as a printout of key computer input files.[25] Moreover, increased

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[22]Among the exceptions are Choucri and Lahiri for substitutability between energy inputs [1983a:27], Dethier for consumer demand [1985:122], and Kheir-El-Din and El-Laithy for general input substitutability [1990:12, 35]. However, robust econometric parameter estimates may not be found easily. As noted by Shoven and Whalley, econometric analyses tend to yield conflicting and frequently changing values for key elasticities [1984:1031].

[23]Harris [1984] is a pioneering study including both imperfect competition and economies of scale. For a real-financial model, see Bourguignon et al. [1992].

[24]See Löfgren [1992:36-38] for more details.

[25]Some of these points are from Kendrick [1984]. It is easier to produce an accurate mathematical statement if the format in which the model is stated for computer solution closely corresponds to the mathematical statement. This is the case for the GAMS software which, in addition, makes it possible to include all data transformations in the input file. See Brooke et al. [1988]

emphasis on peer review and the formal refereeing of the publication process should raise the quality of future studies.

Fourth, the intermittent nature of previous activities and the small number of researchers involved suggest that an effort should be made to broaden the base of researchers working on a continuous basis in this area, perhaps most importantly by training graduate students and by developing institutions engaged in CGE modeling and supporting data activities. With regard to institutional development, it is important to learn from the successes of others; in the CGE area, the Australian experience may be the most impressive.[26]

Given the shortcomings referred to in this concluding section, it is not surprising if the input to policymaking of these studies has been limited. Some of these shortcomings are, however, due to a lack of support from government institutions, including limited funding and data problems. With increased data access, the incorporation of methodological advances, improved quality control, and a larger base of active researchers, CGE modeling should be able to make an effective contribution to the understanding of some of the critical issues currently facing Egypt.

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for further details about GAMS.

[26]For Australia's experience, see Powell and Lawson [1990], and Vincent [1990].

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