

# Market imperfections in a general equilibrium framework

## An empirical analysis

Pantelis Capros, Pavlos Karadeloglou and Gregory Mentzas

*The present paper arises from efforts to include non-neoclassical features in empirical CGE models in order to represent market imperfections and rigidities. We examine the policy implications of adopting frameworks other than price induced market clearing in certain markets of a CGE model. In the course of the paper we design a general core CGE model and derive 12 alternative model variants by allowing for market imperfections in the markets for goods, labour and foreign exchange; these variants represent various research directions in the literature. We investigate the role of such rigidities in evaluating the macroeconomic impacts of European market integration on a small open economy, namely Greece.*

*Keywords:* Macroeconomic modelling; Computable general equilibrium models; European market integration

Computable general equilibrium (CGE) models exploit empirically the framework of Walrasian general equilibrium theory. In the last decade numerous applications have adopted the CGE approach for a broad range of issues which include resource economics, international trade, fiscal reform and production analysis.<sup>1</sup> CGE models have proved to be ideal tools for the study of income distribution, resource allocation, and the analysis of the restructuring effects of alternative policy measures (see Waelbroeck [27]).

A CGE model simulates the working of a market economy and solves for a set of prices that clears all markets. The markets may concern labour, commodities and foreign exchange while the corresponding prices are the wage rate, the domestic price and the exchange rate. Various applications of CGE models, however,

include non-neoclassical features in order to capture economic forces specific to the countries examined: see eg Adelman and Robinson [1], Taylor and Lysy [26], Lysy and Taylor [21] and Robinson [23]. The more important deviations from the theoretical framework aim to represent market rigidities and imperfections (ie the existence of unemployment, trade deficits etc) or include elements traditionally found in macroeconomic models such as the econometric determination of the price level. Such a deviation from the pure general theory can change the functioning and the simulation properties of a CGE model substantially. The known literature, however, lacks a formalized analysis of the implications of such formulations on the policy properties of the CGE model.

In this paper we attempt a contribution to this issue by empirically comparing a wide array of alternative hypotheses in the labour, commodities and foreign exchange markets of a CGE model and studying the impacts of these hypotheses on the policy responses of the model. Actually, we design and empirically apply a core CGE model that describes a one-sector,

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<sup>1</sup>For surveys see Devarajan and Robinson [14], Shoven and Whalley [25], Borges [4], Decaluwe and Martens [11].

three-market economy and is small scale (30 equations). This CGE model is general enough to incorporate a variety of macrospecifications. Twelve alternative variants of the core model are then derived. In the formulation of the variants we employ alternative hypotheses for market clearing, or not clearing, mechanisms and the corresponding price determinations. A number of simulation exercises explore the impacts of alternative assumptions on the policy making responses of the model.

As an illustrative example of our approach in real world policy making issues we use the problems faced by the Greek economy in view of the European internal market. These problems are mainly related to the adjustment of the existing market imperfections and rigidities of the Greek economy to a more flexible system which would minimize the costs and maximize the benefits induced by a unification of the European market.

The labour market is one example of a structurally rigid market in Greece. In order to fully take advantage of the increase in competition and economies of scale derived from the enlarged unified market it will be necessary to change the labour market mechanisms that currently prevail: see the Cecchini Report (CEC [10]). Noting that the deficit in the current account is an important feature of the Greek economy we formulate alternative exchange rate regimes and compare their role within the context of the unified market. Taking the priority of the enlargement of the European Monetary System for granted, the latter analysis may contribute to a determination of the necessary macroeconomic conditions for the entry of the Greek monetary unit.

The plan of the paper is as follows. In the next section we present the core CGE model including a discussion of the specification of the 12 variants and the literature relating to each. The third section explores the policy responses of the model variants obtained by simulation exercises and analyses the sensitivity of results to the model specification. Finally, in section four we give a brief overview of the work and the conclusions reached.

## Description of the model and variants

### Background

A CGE model is a numerical representation of the basic relationships of the Walrasian general equilibrium system. The grand ancestor of today's empirical research activities is the model by Johansen [18], while empirical effort began essentially as a result of Scarf's work [24] on the computation of equilibria. The theoretical framework for constructing a CGE model

Table 1. Different markets.

Market M1	Market M2	Market M3
$D = f(p)$	$D = f(p)$	$D = f(p)$
$S = g(p)$	$S = D$	$\bar{S} = D$
$D = S$	$p = h(S, D)$	$p = h(U, S, D)$
		$S = g(p)$
		$U = \bar{S}/S$

is well known: within a perfectly competitive economy, in which each economic agent behaves as a price taker, there exists a set of prices which satisfies in an optimum manner the objectives of agents, and all markets are in equilibrium; the set of homogeneity assumptions implies that only relative prices affect equilibrium conditions. Economic agents are divided into two categories, consumers and producers; consumers maximize their satisfaction over the bundles of commodities that can be purchased under budget constraints, and hence determine the demand for goods and the supply of labour force; producers maximize their profit using the process or processes available in the production set, and affect the demand for production factors and the supply of commodities. An essential condition is the satisfaction of Walras's law.

The market clearing procedure is usually called price adjustment. If a market is imperfectly competitive the determination of the equilibrium price should be rigid and this situation is usually represented by the introduction of an explicit econometric equation for this price. In this case equilibrium is obtained by equalling demand and supply, independently of the price level, and this procedure is called quantity adjustment of the market.

The empirical applications of CGE models do not always assume market clearing through price mechanisms; on the contrary they very often incorporate market rigidities and imperfections in an attempt to capture the macroeconomic forces that prevail in real-world cases: see Robinson [23]. In such cases some markets of the model may be cleared through price adjustment, while others include an econometric determination of the price level (like the one found in traditional macroeconomic models) which guarantees a quantity adjusted equilibrium. The sets of equations in Table 1 illustrate the alternative mechanisms for representing market types. If  $D$ ,  $S$  and  $p$  denote demand, supply and prices respectively it is clear that market type M1 corresponds to a price adjusted competitive market, since the market clearing price is determined from the demand–supply equality. Market types M2 and M3, however, are imperfectly competitive. In market M2 supply is perfectly elastic and adjusts

to demand, while the price is obtained from demand and cost considerations. In market *M3*, which is a generalization of market *M2*, supply is rationed by demand and this affects prices through the rate of utilization, *U*. In this latter case excess supply is assumed.

The formulation found in market *M1* is adopted for the market of goods in most CGE models (de Melo [12]). The situation described by market *M2* is assumed for the goods market in some CGE models, namely those of Johansen [18] and Hudson and Jorgenson [17], who formulate a cost dependent price determination. Market *M3* illustrates the formulation used for the labour market (or the foreign exchange market) when unemployment (or a trade deficit) prevails. Market *M3* is also the typical formulation of all markets represented in neo-Keynesian macro-econometric models (Capros, Karadeloglou and Mentzas [8]). In a multimarket CGE model all three types of market clearing formulations may coexist, in the sense that some markets are perfectly competitive while others are not.

*Overall specification*

The core CGE model, as well as the variants developed here, follow the research tradition of general equilibrium models applied to developing countries (Adelman and Robinson [1], Dervis, de Melo and Robinson [13] etc). An important subject in such models is the choice of the closure rule, whose theoretical and empirical consequences affect both the structure of the models and their properties (Taylor and Lysy [26], Rattso [22], Lysy [20], Dewatripont and Michel [15] and Adelman and Robinson [2]). The closure rule adopted in this paper is the one which is widely used in the large majority of existing CGE models and implies that investments equal total savings.

Our numerical representation of the theoretical framework is based on a three-market, one-sector small open economy (goods, labour, foreign exchange). Hence we examine three prices: the aggregate price of commodities, the wage rate and the exchange rate. Since only relative prices matter we have considered the capital cost as the numeraire. There is only one consumption good (also used as capital good) and three economic agents: the representative consumer; the representative producer; and the government sector. Households determine simultaneously the level of their consumption and the supply of labour force through an implicit utility function that covers both the consumption-saving and the labour-leisure choices. Firms satisfy demand by producing the composite good out of two inputs: capital and labour. The quantities of inputs used are the solution to a production cost minimization problem, while the

production possibility frontier is given by the familiar constant returns to scale constant elasticity of substitution (CES) production function. The behaviour of government, concerning consumption and investment, remains exogenous. Exports and imports are derived from implicit substitution functions: see Armington [3].

*Equations of the model*

In the following we present the entire list of equations, which form an overdetermined system. In order to build the model variants we shall select some of the equations according to assumptions related to the type of market equilibrium mechanisms.

The market prices are the price of domestic goods (*p<sub>v</sub>*); the wage rate (*w*); and the exchange rate (*e*). Given the three market prices, the derived ones can be evaluated. Import and export prices depend on the aggregate price of goods, the exogenous international price, *p<sub>f</sub>*, and the exchange rate; see Equations (1) and (2). As far as import prices are concerned it is assumed that the country is a price taker, while for the export price we assume that the country is neither a price taker nor a price maker.

$$p_m = \alpha_0(p_f e)^{\alpha_1} \tag{1}$$

$$p_x = \beta_0(p_f e)^{\beta_1} p_v^{\beta_2} \tag{2}$$

The consumer price index is an average of domestic and imported deflators, to which an import tariff, *t<sub>m</sub>*, and a value-added tax, *t<sub>v</sub>*, are applied:

$$p_c = \gamma_0 [p_m (1 + t_m)]^{\gamma_1} p_u^{\gamma_2} (1 + t_v)^{\gamma_1 + \gamma_2} \tag{3}$$

The deflated cost of capital is assumed to depend mainly on an exogenous interest rate, *i*, and is as follows:

$$c = p_v (1 + i - \Delta w/w) \tag{4}$$

Notice that, in all variants, this equation is not used since the cost of capital is taken as the numeraire.

The supply of goods, *V*, is evaluated by the two-factor CES production function:

$$V = V_0 e^{gV} [\delta K^{-\rho} + (1 - \delta)L_w^{-\rho}]^{-1/\rho} \tag{5}$$

with  $\rho = 1/\sigma - 1$ .

Labour demand of firms, *L<sub>w</sub>*, and optimum investment, *I<sub>p</sub>*, are derived from cost minimization: see Equations (6) and (7), respectively. These equations are derived from the production function. In the following we give a simplified representation of these two equations by using the symbol *F*, which denotes

the anticipation and adjustment mechanisms that were added.

$$\Delta L_w = F \left[ v_0 e^{-gt} (1 - \delta)^{1/\rho} \left( \frac{c}{w} \right)^{1/(1+\rho)} V \right] \quad (6)$$

$$I_p = F \left[ v_0 e^{-gt} \delta^{1/\rho} \left( \frac{c}{w} \right)^{-1/(1+\rho)} V \right] \quad (7)$$

Since in all variants we adopt the neoclassical closure rule the investment equation is not used. Investment is adjusted to total savings.

If the goods market is imperfectly competitive, Equation (5) evaluates potential production,  $V_c$ , and not effective production. Moreover, in that case, the price of goods is determined by the application of a mark up on production cost according to Equation (8):

$$p_v = \pi_0 \left( w \frac{L_w}{V} \right)^{\pi_1} \left( c \frac{K}{V} \right)^{\pi_2} \left( \frac{V}{V_c} \right)^{\tau} \quad (8)$$

where  $V_c$  is potential production determined by (5) and  $V$  is effective production adjusted to demand. The last term of the price equation represents the inflationary effect of disequilibrium in the goods market. If the goods market is price adjusted, Equation (8) is not used,  $V$  is determined by (5) and the price of goods is evaluated by the supply–demand equilibrium.

The consumer's decision problem is viewed as that of maximizing an intertemporal utility function subject to an intertemporal budget constraint. The utility level is the total present value of the annual utility derived from the consumption of goods,  $C_p$ , and leisure. The latter expresses the supply of labour force by households ( $L_s$ ). The budget constraint is equal to the sum of the present value of wealth (accumulation of annual savings), salary income and non-salary income. Through wealth we explicitly include the consumption–savings choice: if the consumer chooses to consume more than usual, savings will be reduced and he will consume less in the next period since the level of wealth will also be reduced. By assuming a myopic foresight we derive the following equations for consumption and labour supply:

$$\frac{C_p}{N} = \mu_0 \left( \frac{R_w}{p_c \cdot N} \right)^{\mu_1} \left( \frac{R_k + R_f}{p_c \cdot N} \right)^{\mu_2} \left( \frac{W}{p_c \cdot N} \right)^{\mu_3} \quad (9)$$

$$L_s = v_0 N^{v_1} \left( \frac{w \cdot C_p}{p_c} \right)^{v_2} \quad (10)$$

where  $R_w$  and  $R_k$  represent salary and non-salary income,  $R_f$  is net income from abroad and  $N$  denotes total population.

From an implicit assumption of an import aggregation and an export transformation function, we derive imports,  $M$ , and exports,  $X$ , as depending on demand and relative prices (foreign to domestic):

$$M = \varepsilon_0 V^{\varepsilon_1} \left[ \frac{p_m(1+t_m)}{p_v} \right]^{\varepsilon_2} \quad (11)$$

$$X = \delta_0 \left[ \frac{(p_f e)(1+t_e)}{p_v} \right]^{\delta_1} \left( \frac{p_f e}{p_x} \right)^{\delta_2} D_f^{\delta_3} \quad (12)$$

where  $t_m$  denotes the rate of import tariffs and  $t_e$  the rate of export subsidies, while  $D_f$  is an exogenous variable representing foreign demand.

The following set of identities represent flows of income and evaluate salary income,  $R_w$ , non-salary income,  $R_k$ , private savings,  $S_p$ , and public savings,  $S_g$ , which is equivalent to the public budget balance.

$$R_w = wL_w(1 - t_w) \quad (13)$$

$$R_k = (p_v V - wL_w)(1 - t_k) \quad (14)$$

$$S_p = R_w + R_k + R_f + p_x X t_e - p_c C_p \quad (15)$$

$$S_g = wL_w t_w + (p_v V - wL_w) t_k + p_c C_p t_v + p_m M t_m - (p_v C_g + p_v I_g + p_x X t_e) \quad (16)$$

Direct and indirect tax revenues constitute gross public income. Subsidies together with public investment (exogenous),  $I_g$ , and public consumption (exogenous),  $C_g$ , form public expenditure. A positive (negative) difference between gross income and expenditure corresponds to a surplus (deficit) in the public budget. Private savings are given as the difference between private income and consumption.

Equation (17) applies Walras's law. This equality represents the neoclassical closure rule we have adopted and is used for the evaluation of private investment:

$$p_v I_p = S_p + S_g - (p_x X - p_m M + R_f) - (p_c C_p t_v + p_m M t_m) \quad (17)$$

The following three equations evaluate the set of prices that clear markets:

$$V + M - (C_p + C_g + I_p + I_g + X) = 0 \quad (18)$$

$$L_s - L_w - L_t = 0 \quad (19)$$

$$p_x X - p_m M + R_f = 0 \quad (20)$$

where  $L_t$  represents the number of self employed persons which is evaluated proportionally to the level of production, as follows:

$$L_t = \theta_0 V^{\theta_1} \quad (21)$$

In the variants of the model which represent imperfections in the labour market, the wage rate is not determined by the equilibrium expressed by Equation (19). In this case, we employ a Phillips curve formulation: see also Bourguignon *et al* [5] and Dixon *et al* [16]. The equation is as follows:

$$\frac{\Delta w}{w_{-1}} = \lambda_0 + \lambda_1 \frac{\Delta p_c}{(p_c)_{-1}} + \lambda_2 U_R + \lambda_3 \frac{\Delta(V/L_w)}{(V/L_w)_{-1}} \quad (22)$$

where  $U_R$  is the rate of unemployment, which is evaluated by:

$$U_R = \frac{L_s - L_w - L_t}{L_s} \quad (23)$$

The model simulates a dynamic evolution of the economy through the accumulation of capital (Equation (24)), the accumulation of wealth (Equation (25)), the growth of population (Equation (26)) and the time dependent technical progress that appears in Equations (5) to (7). Capital, wealth and population are given by the following equations:

$$K = (I_p)_{-1} + (1 - r)K_{-1} \quad (24)$$

$$W = (S_p)_{-1} + (1 - s)W_{-1} \quad (25)$$

$$N = N_0 \exp(\lambda t) \quad (26)$$

In the variants that allow for rigidities in the current account we do not use Equation (20). The sign of the lefthand side of (20) determines whether there is a deficit or surplus on the current account. In this case we retain two alternative possibilities: either a fixed (exogenous) or a flexible exchange rate. In the latter case it is evaluated by a kind of purchasing power parity (PPP) formula, as follows:

$$\frac{\Delta e}{e_{-1}} = \zeta_0 + \zeta_1 \frac{\Delta(p_f/p_c)}{(p_f/p_c)_{-1}} + \zeta_2(p_x X - p_m M + R_f) \quad (27)$$

### The 12 variants

In the following we proceed to the definition of 12 variants of the core CGE model by adopting alternative formulations concerning equilibrium schemes in the three markets. In an attempt to cover all cases, we

present 12 model variants which scan all possible market types and combinations. Initially, the core variant of the CGE model formulates the goods, labour and foreign trade markets according to market  $M1$ . In the other variants we mix formulations representing market types  $M1$  with those of market types  $M2$  or  $M3$ . In the extreme, we build a variant in which all markets are quantity adjusted ie they are in accordance with market types  $M2$  or  $M3$ . In order to facilitate the analysis we name the models as follows. The name of each model is CGE-*abc-X*, where the letters *a*, *b* and *c* correspond to the nature of the markets for commodities, labour and foreign exchange respectively. These letters take the value of 0 or 1, depending whether the respective market is perfectly competitive or not. When the foreign exchange market is not perfectly competitive, we make use of the letter (*X*), which is either (*F*) or (*V*), showing that the exchange rate is either fixed or variable (in the latter case the PPP formulation of Equation (27) is used). For example, the variant that represents an economy where the goods market is cleared via a price adjustment (ie *a* is 0), the labour market is imperfectly competitive (ie *b* is 1) and the exchange rate is variable (ie *c* is 1 and *X* is *V*), is named CGE-011-V. These model variants cover a wide spectrum of alternative specifications found in the CGE literature and are very useful for sensitivity tests. Table 2 summarizes the model variants and their characteristics, as well as providing indicative references from the literature.

Table 3 lists all model variants and the equations used in each one. Notice that Equations (4) and (7) are eliminated in all variants; the former because the capital cost is the numeraire, and the latter because investment is determined from the closure rule (17). On the other hand, Equations (1), (2), (5), (6), (9), (10), (11), (12), (13), (14), (15), (16), (17), (21), (24), (25) and (26) are common to all 12 model variants.

In order to build the full equilibrium variant of the model (CGE-000) we drop Equations (8), (22) and (27) because the goods price, the wage rate and the exchange rate are determined from market equilibria, that is (18), (19) and (20). These three equations constitute the reduced form full equilibrium model, having  $p_r$ ,  $w$  and  $e$  as unknown variables. Consider now the case when the labour market is imperfectly competitive. We can build the corresponding variant of the model (ie CGE-010) by adding Equations (22) and (23) and dropping Equation (19), which expresses labour market equilibrium. If we allow for disequilibria in the current account we can build the corresponding variant of the model (ie CGE-001) by eliminating Equation (20) and adding Equation (27) or leaving the exchange rate exogenous. The latter choice defines two variants, one with flexible (CGE-001-V) and

Table 2. CGE model variants and related literature.

Name of the variant	Price adjusted equilibrium in the goods market	Price adjusted equilibrium in the labour market	Price adjusted equilibrium in the balance of trade	Related literature
CGE-000	Yes	Yes	Yes	de Melo [12]
CGE-001-F	Yes	Yes	No (fixed exchange rate)	Most World Bank models: see Decaluwe and Martens [11] for a survey
CGE-001-V	Yes	Yes	No (flexible exchange rate)	
CGE-010	Yes	No (Phillips curve)	Yes	Bourguignon <i>et al</i> [5] and a version of the ORANI model, see Dixon <i>et al</i> [10]
CGE-011-F	Yes	No (Phillips curve)	No (fixed exchange rate)	
CGE-011-V	Yes	No (Phillips curve)	No (flexible exchange rate)	
CGE-100	No	Yes	Yes	Taylor and Lysy [26]
CGE-101-F	No	Yes	No (fixed exchange rate)	The original Johansen [18] model and Hudson and Jorgenson [17] <sup>a</sup>
CGE-101-V	No	Yes	No (flexible exchange rate)	
CGE-110	No	No (Phillips curve)	Yes	Taylor and Lysy [26]
CGE-111-F	No	No (Phillips curve)	No (fixed exchange rate)	Similar to most empirical neo-Keynesian models <sup>b</sup>
CGE-111-V	No	No (Phillips curve)	No (flexible exchange rate)	

<sup>a</sup> Hudson and Jorgenson [17] employ the equality of the cost of production based price of goods with the equilibrium price of the goods market, given that the non-substitution theorem of Samuelson is satisfied.

<sup>b</sup> There is still a difference between the CGE-111 (either -F, or -V) variant and the empirical macroeconomic models that follow the neo-Keynesian paradigm. This is related to the closure rule: the empirical neo-Keynesian models employ an investment function, such as Equation (7), and solve Equation (17) for the value of the variation of stocks. The latter has no further consequences on the rest of the model. Hence neo-Keynesian macroeconomic models do not really produce behaviour compatible with the implications of Walras's law; for additional details see Capros, Karadeloglou and Mentzas [6], [8].

Table 3. Equations of the model variants.

CGE 000	CGE 001-F	CGE 001-V	CGE 010	CGE 011-F	CGE 011-V	CGE 100	CGE 101-F	CGE 101-V	CGE 110	CGE 111-F	CGE 111-V
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
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(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)
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---	---	---	---	---	---	(8)	(8)	(8)	(8)	(8)	(8)
(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)
(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)
(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)
(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)
(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)
(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)
(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)
(18)	(18)	(18)	(18)	(18)	(18)	---	---	---	---	---	---
(19)	(19)	(19)	---	---	---	(19)	(19)	(19)	---	---	---
(20)	---	---	(20)	---	---	(20)	---	---	(20)	---	---
(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)
---	---	---	(22)	(22)	(22)	---	---	---	(22)	(22)	(22)
---	---	---	(23)	(23)	(23)	---	---	---	(23)	(23)	(23)
(24)	(24)	(24)	(24)	(24)	(24)	(24)	(24)	(24)	(24)	(24)	(24)
(25)	(25)	(25)	(25)	(25)	(25)	(25)	(25)	(25)	(25)	(25)	(25)
(26)	(26)	(26)	(26)	(26)	(26)	(26)	(26)	(26)	(26)	(26)	(26)
---	---	(27)	---	---	(27)	---	---	(27)	---	---	(27)

another with fixed (CGE-001-F) exchange rate. Finally, if the goods market is imperfectly competitive (eg CGE-100), we retain Equation (8) for the determination of domestic goods prices. In this case Equation (5) evaluates the level of potential production,  $V_c$ , and Equation (18) evaluates the level of effective production,  $V$ .

The data used for the empirical estimation of the models consist of the Greek National Accounts for the 1965–85 period. The coefficients of the equations were econometrically estimated using standard techniques, in contrast to the majority of CGE models which use guesstimates: see also Jorgenson [19] for a similar approach. In estimating the equations of the model we put emphasis on the effective functioning and the behavioural quality of the whole model; we have neither used sophisticated formulations and econometrics nor tested alternative functional forms. Both the production and the private consumption blocks were estimated by TSLS applied to simultaneous systems of equations. For more information on the econometric work and the estimation results see Capros, Karadeloglou and Mentzas [8], [9]. The numerical resolution of all model variants is established as a dynamic sequence of one-period solutions to a system of simultaneous equations. We assume only backward looking anticipation. The system is numerically solved by means of a Newton-type algorithm.

## Scenarios and results

### Scenario construction

In order to examine the effects of adopting alternative hypotheses for market equilibrium in a CGE framework we examine the results obtained by all 12 model variants developed above for policy scenarios. We evaluate the percentage deviations of each policy scenario from the baseline case. All model variants ran dynamically over a time period of six years.

As already mentioned the policy issue examined here concerns the impact of current market imperfections and rigidities on the Greek economy in view of European market integration. We selectively examine two aspects of the completion of the internal market:

- (i) the elimination of foreign trade barriers; and
- (ii) supply side effects, such as economies of scale, technological innovation, restructuring, contraction of production cost, increased market competition etc.

The first kind of effect can be fully assimilated to reductions of both import tariffs and export subsidies.

In the simulation experiments we represent such effects through changes in two exogenous rates, namely the rate of import tariffs,  $t_m$ , and the rate of export subsidies,  $t_x$ . The second type of effect ie supply side effects contributes to an increase in the efficiency of production and use of production factors (and through duality to the reduction of production costs). These effects are represented by increasing the rate of technical progress,  $g$ , which acts positively on production and negatively on the demand for production factors. In the context of a perfectly competitive goods market an increase in the rate of technical progress implies an upward shift in the supply curve, which determines a lower equilibrium price if demand remains unchanged. In the case where the goods price is evaluated from production costs the price is also reduced through increased factor productivity.

In order to construct the policy scenario we assume a 1% increase in the rate of technical progress and a reduction by 1 percentage point of both the export subsidy and the import tariff rates. For space reasons the tabular presentation includes only the results of the scenario in which all these changes occur simultaneously and not the experiments with individual changes; the latter, however, are used for explanatory reasons in the conceptual analysis of the following subsection.

### Results

Before analysing the empirical results from the application of the combined exogenous shocks, an analysis of the model's reaction to each exogenous shock taken separately is presented. The empirical results in the following paragraph attempt to analyse the combined effects by the adoption of both exogenous shocks in the different variants of the model.

*Conceptual analysis* The reduced form of the full equilibrium version of the model (ie CGE-000) can be represented by 9 equations:

$$N^s = f \left[ \frac{w}{ap_v + (1-a)(p^*e)} \right] \quad (28)$$

$$N^d = f \left( \frac{w}{c} \right) \quad (29)$$

$$N^s = N^d \quad (30)$$

$$\frac{\partial N^s}{\partial \left[ \frac{w}{ap_v + (1-a)(p^*e)} \right]} > 0, \quad \frac{\partial N^d}{\partial \left( \frac{w}{c} \right)} < 0$$

$$Q^s = f\left(\frac{w}{c}, t, \frac{p_v}{p^*e}\right) \quad (31)$$

$$Q^d = f(p_v, w, e) \quad (32)$$

$$Q^s = Q^d \quad (33)$$

$$\frac{\partial Q^s}{\partial\left(\frac{w}{c}\right)} < 0, \frac{\partial Q^s}{\partial t} > 0, \frac{\partial Q^s}{\partial\left(\frac{p_v}{p^*e}\right)} < 0, \frac{\partial Q^d}{\partial p_v} > 0, \frac{\partial Q^d}{\partial w} > 0, \frac{\partial Q^d}{\partial e} > 0$$

$$X_{value} = f\left[\frac{(p^*e)(1+t_e)}{p_v}\right] \quad (34)$$

$$M_{value} = f\left[\frac{p_v}{(p^*e)(1+t_m)}, \frac{w}{c}\right] \quad (35)$$

$$X_{value} = M_{value} \quad (36)$$

$$\frac{\partial X_{value}}{\partial\left[\frac{(p^*e)(1+t_e)}{p_v}\right]} > 0, \frac{\partial M_{value}}{\partial\left[\frac{p_v}{p^*e(1+t_m)}\right]} > 0, \frac{\partial M_{value}}{\partial\left(\frac{w}{c}\right)} > 0$$

where  $p^*$  is exogenous and  $c$  is the numeraire. The group of Equations (28)–(36) represent equilibrium conditions in the labour, goods and foreign markets respectively. Equilibrium in these markets is obtained by adjusting the corresponding price of each market until total demand equals total supply. Such markets correspond to market type M1.

Assume for instance that the exchange rate is exogenous. According to Equations (31)–(33) the direct effect of an increase in the rate of technical progress is an upward shift in the domestic supply curve and a corresponding reduction in the equilibrium price of goods. In addition, efficiency in production is improved and hence labour demand is decreased. The latter pushes downward the wage rate which provides the equilibrium in the labour market: see Equations (28)–(30). The slopes of the labour demand and supply curves are such that the fall in the wage rate is higher than that in the price of commodities, resulting in the reduction of real salary income. However, real non-salary income is increasing, as a result of an expansion of output and a reduction in costs. Depending on the values of the income elasticities of private consumption and the shares of the two sources of income the change in consumption may be positive or negative. Since the main source of additional income comes from the profits of producers, private savings are expected to increase; the fact that consumption elasticities for this type of income are generally low is taken for granted. This allows for a rise in investment which provides a

higher growth potential in subsequent years. If the exchange rate is fixed exports rise because of gains in competitiveness. The sign of the change in imports is uncertain, since it is influenced positively by domestic demand and negatively by competitiveness.

By maintaining the assumption of an exogenous exchange rate, the direct effect of foreign trade liberalization ie of a reduction in the rates of both import tariffs and export subsidies, is an upward shift in the total supply curve and a downward shift in the total demand curve. These movements are due to imports and exports respectively. In fact imports are increasing and exports are reduced as a direct consequence of the reductions in tariffs and subsidies: see Equations (34)–(36). The result of these shifts is a reduction in the equilibrium price of goods. This implies gains in competitiveness which push exports upwards. Thus at equilibrium exports are found to be increased. The fall in the price of goods implies a rise in consumption since real income per capita is increased. It also implies an upward shift in the labour supply curve; the equilibrium wage rate is reduced, but its drop is expected to be lower than that of the price of goods. Hence real salary income is increased. Higher final demand sustains domestic supply but raises imports. The sign of the change in real non-salary income is uncertain. It depends positively on the growth of output but negatively on the difference between the changes in the wage rate and the price of goods. If the rise in the production costs prevails, real non-salary income is decreased and this implies reduced savings and hence investment.

From the above we can see that both exogenous shocks have deflationary and output expansion effects. However, the rate of technical progress shifts the labour demand curve indirectly towards less employment, while the foreign trade rates indirectly affect the labour supply curve towards more employment. In the former case the resulting wage rate decreases more than the price of goods, while the inverse situation is produced in the latter case. Thus the two exogenous shocks have opposite distributional effects on the economy and this has important consequences on savings and investment. In both cases, however, we obtain a deficit in the current account, although this should be attributed to the values of the elasticities of the foreign trade equations.

Concerning the role of the exchange rate, the policy dilemma about whether a re- or a devaluation of the national currency is appropriate for rectifying the current account has raised important controversies in the relevant literature. By referring to the Marshall–Lerner condition it is generally admitted that the answer depends on the values of the elasticities of exports and imports as well as on the initial state of

the current account. In the present case, the elasticities are such that the effects through relative prices dominate those through volumes. Taking into account the fact that the current account is initially in deficit, a revaluation is more appropriate for achieving an equilibrium.<sup>2</sup>

*Empirical results* Table 4 gives the results of the combined scenario for all 12 variants of the CGE model. The results are given in terms of percentage deviations from a baseline scenario. If we consider the combined applications of the above described shocks we find, in our particular numerical example (Table 4, variant CGE-001-F), that the effects of technical progress dominate those of foreign trade liberalization. Actually, we obtain a negative change in real salary income and a positive result for non-salary income, savings and investment. Notice that the deflationary and expansionary effects of the individual scenarios are maintained and reinforced.

With reference to the comments related to the exchange rate revaluation, as mentioned above, the equilibrium in all markets of the economy is obtained by revaluing the national currency by 10% (see variant CGE-000 in Table 4); in this case domestic prices decrease by 1.6% and the real wage rate improves by 1.18%. These prices lead to net welfare gains for the economy: both real salary and non-salary incomes rise, while investment and savings increase significantly. Thus, in the context of general equilibrium analysis, two of the direct impacts of the completion of the internal market imply significant positive effects on the Greek economy.

By comparing the results of CGE-000 with CGE-001-F it is clear that the multiplier role of the exchange rate is significant. The results of the case in which the exchange rate is determined by an econometric equation (based on the PPP principle ie CGE-001-V), stand between those of the totally flexible exchange rate ie CGE-000 and those of the fixed exchange rate case ie CGE-001-F. By revaluing the national currency up to the value permitted by constraints in the labour market, the economy takes advantage of an upward displacement of the goods supply curve, which is due

to competitiveness induced changes in foreign trade. The resulting gains in real wages sustain activity, savings and thus investment.

The impact of rigidities in the labour market can be analysed when considering versions CGE-010, CGE-011-F and CGE-011-V. In version CGE-010 the wage rate is determined from a Phillips curve and disequilibrium in the labour market is permitted. Depending on the initial state of the labour market, the presence of disequilibria can have two separate effects: if the labour market is in full equilibrium, the Phillips curve would have only downward pushing impacts on the wage rate (unemployment increase); if unemployment is present, the Phillips curve may have either positive or negative effects on employment.<sup>3</sup> In the specific scenario examined here this situation is equivalent to a relaxation of the labour supply constraint. In fact the additional growth can increase employment and reduce unemployment, thus increasing the multiplier effects. If we compare the results with those of the full equilibrium variant, we see that overemployment is possible and this permits a further enhancement of the net welfare gains of the economy (see the results of CGE-010).

This situation is modified when the exchange rate is exogenously fixed. Versions CGE-001-F and CGE-011-F represent two different labour market clearing mechanisms under the assumption of a fixed exchange rate. In this case the prices that clear the markets are reduced to two and the relative importance of each price is increased for the market clearing mechanism. The abolition of a market clearing mechanism for the wage rate will thus behave as an additional constraint in the functioning of the model. The Phillips curve formulation of wage rates acts as a rigidity in the equilibrium adjusting process. This rigidity implies a net welfare cost for the economy. Exchange rate exogeneity does not allow for positive deflationary results. Moreover wage rate changes created from the Phillips curve are not large enough to permit the reduction of unemployment. In the short term real wage rate rigidity, resulting from the Phillips curve, prevents real salary income from decreasing at the expense of non-salary income, domestic supply, savings and investment. In the long term this implies negative impacts on the economy. If the exchange rate is determined following a PPP process, as in CGE-011-V, results are less negative but still inferior to those obtained when the labour market is fully competitive. Both model variants with labour market rigidities ie CGE-011-F and V, lead to an increase in unemployment.

<sup>2</sup> By taking logarithmic derivatives of both sides of Equations (1), (2), (11), (12) and (20), that is by expressing the variables in terms of rates of growth, we can derive the exchange rate of equilibrium as a function of  $p_f$ ,  $p_n$ ,  $V$ ,  $D_f$  and the tax rates. It is easy to show that the sign of the coefficient of  $p_n$  is positive if the sum of price elasticities of exports and imports is greater than unity. Given that (i) our scenario implies a negative change of  $p_n$  and a positive change of  $V$ ; (ii) our model's properties imply that the percentage change in prices is greater than that of volumes; and (iii) the sum of price elasticities of exports and imports exceeds unity, we can conclude that if domestic prices decrease then a revaluation is required to rectify the current account.

<sup>3</sup> Recall that when price adjustment prevails in the labour market the demand and supply of labour move in the same direction leaving unemployment unaffected.

**Table 4. Scenario results: 1992, 1% increase in technical progress and 1 percentage point reduction in both the import tariff rate and the export subsidy rate.**

	First year	Last year	First year	Last year	First year	Last year	First year	Last year
<b>% deviation</b>	<b>CGE-000</b>		<b>CGE-001-F</b>		<b>CGE-001-V</b>		<b>CGE-010</b>	
Production price	-1.62	-1.00	-0.94	-1.33	-1.01	-1.36	-1.66	-0.76
Wage rate	-1.96	-4.47	-1.08	-1.24	-1.16	-1.35	-2.30	-7.85
Exchange rate	-10.02	-34.68	0.00	0.00	-0.98	-1.40	-10.80	-43.35
Consumer price	-3.14	-10.96	-0.82	-1.13	-1.04	-1.52	-3.33	-13.86
Capital/labour ratio	-0.42	0.06	-0.23	0.32	-0.25	0.36	-0.49	-0.88
GDP (volume)	0.62	3.33	0.43	0.46	0.45	0.62	0.69	5.60
Employment	0.05	0.84	-0.01	-0.02	-0.00	0.03	0.07	1.59
Private consumption	0.95	8.13	0.01	0.23	0.09	0.56	0.98	10.78
Exports	-4.54	-24.01	0.27	1.11	-0.19	-0.02	-4.94	-30.12
Imports	1.19	7.06	0.38	0.38	0.46	0.66	1.31	10.65
Real salary income	1.32	9.00	-0.30	-0.22	-0.15	0.16	1.21	10.32
Real non-salary income	2.76	18.68	0.66	0.69	0.86	1.32	3.15	28.99
Investment	6.25	27.41	2.96	1.10	3.27	2.56	7.14	44.79
<b>Absolute deviation</b>								
Public budget								
(million drachmas)	-266	3 868	-283	-464	-277	4	-265	6 827
Savings (million drachmas)	3 980	43 691	1 306	133	1 544	1 495	4 659	70 805
Current account								
(million drachmas)	0	0	-608	111	-561	-623	0	0
Unemployment rate (%)	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	-0.86
<b>% deviation</b>	<b>CGE-011-F</b>		<b>CGE-011-V</b>		<b>CGE-100</b>		<b>CGE-110</b>	
Production price	-0.92	-1.14	-0.99	-1.21	-1.00	-1.13	-1.30	-1.13
Wage rate	-0.45	-0.94	-0.61	-1.11	-1.30	-1.20	-1.53	-1.62
Exchange rate	0.00	0.00	-0.97	-1.35	-2.42	-0.73	-5.99	-4.85
Consumer price	-0.80	-1.01	-1.03	-1.41	-1.30	-1.20	-2.16	-2.20
Capital/labour ratio	-0.09	0.36	-0.13	0.38	-0.28	-0.15	-0.33	-0.20
GDP (volume)	0.30	-0.04	0.34	0.20	0.07	-0.03	0.30	-0.29
Employment	-0.05	-0.23	-0.04	-0.15	-0.01	-0.05	0.02	0.03
Private consumption	0.12	-0.02	0.19	0.33	0.11	0.16	0.51	0.65
Exports	0.26	0.80	-0.19	-0.22	-0.91	-0.17	-2.58	-3.05
Imports	0.27	-0.06	0.36	0.28	0.22	0.02	0.64	0.15
Real salary income	0.23	-0.44	0.31	-0.04	-0.01	-0.10	0.68	0.66
Real non-salary income	0.20	0.13	0.44	0.82	0.65	0.26	1.53	1.06
Investment	1.54	-1.14	2.03	0.66	1.23	-0.48	3.31	-0.23
<b>Absolute deviation</b>								
Public budget								
(million drachmas)	-302	-1 616	-293	-971	-652	-1 380	-472	-1 924
Savings (million drachmas)	356	-1 622	709	-15	833	-1 549	2 092	-555
Current account								
(million drachmas)	-442	881	-418	40	0	0	0	0
Unemployment rate (%)	0.06	0.29	0.06	0.24	0.00	0.00	-0.02	-0.03
<b>% deviation</b>	<b>CGE-101-F</b>		<b>CGE-101-V</b>		<b>CGE-111-F</b>		<b>CGE-111-V</b>	
Production price	-0.95	-1.17	-0.97	-1.06	-1.49	-1.00	-0.54	-0.81
Wage rate	-0.82	-1.02	-1.01	-1.29	0.11	-0.97	-0.51	-0.41
Exchange rate	0.00	0.00	-0.95	-1.29	0.00	0.00	-0.65	-0.03
Consumer price	-0.82	-1.02	-1.01	-1.29	-1.16	-0.92	-0.66	-0.77
Capital/labour ratio	-0.18	0.27	-0.22	-0.07	0.02	1.94	-0.11	0.53
GDP (volume)	0.43	-0.01	0.29	-0.27	2.03	-0.56	0.13	-0.20
Employment	-0.03	-0.12	-0.02	-0.07	-0.07	-0.22	-0.05	-0.35
Private consumption	0.06	0.05	0.08	0.13	0.74	-0.08	0.08	-0.05
Exports	0.27	0.87	-0.20	-0.40	0.51	1.46	-0.28	0.31
Imports	0.38	-0.03	0.31	-0.14	1.75	-0.52	0.18	-0.18
Real salary income	-0.07	-0.27	-0.05	-0.15	1.08	-0.61	0.04	-0.34
Real non-salary income	0.53	0.06	0.57	0.19	1.99	-0.50	0.38	-0.06
Investment	2.66	-1.20	2.09	-1.69	11.68	-5.22	1.27	-0.89
<b>Absolute deviation</b>								
Public budget								
(million drachmas)	-247	-1 465	-407	-1 985	1 412	-2 797	-272	-1 542
Savings (million drachmas)	1 038	-1 894	956	-2 114	4 263	-4 733	545	-2 817
Current account								
(million drachmas)	-597	930	-361	876	-2 538	3 668	-45	182
Unemployment rate (%)	0.00	0.00	0.00	0.00	0.07	0.22	0.05	0.35

We may conclude that in the context of a fixed exchange rate policy labour market rigidities reduce the efficiency of the economy, especially in the case where the economy needs to take maximum advantage of supply side improvements. Negative effects can be mitigated by adjusting the exchange rate and may become positive if the adjustment is such that full employment is achieved.

Let us relax the assumption of perfect competition in the goods market. The family of model variants CGE-100, CGE-101, CGE-110 and CGE-111 formulates a cost dependent determination of the price of goods. All these variants provide worse economic results if compared to those obtained by the variants in which the goods market is cleared through prices. Thus cost pricing of goods acts as a rigidity and reduces the economy's efficiency. For instance, compare CGE-100 with CGE-000. In the short term, although the macroeconomic effects of the scenarios are qualitatively similar in these two variants, the magnitude of results is significantly lower in CGE-100 and yet still insufficient to sustain growth in the long term.

Within the family of variants which apply cost pricing of goods we draw conclusions similar to those above about the role of the labour market and the exchange rate. The exchange rate policy is important for taking maximum advantage of supply side effects and maximum efficiency is obtained when it is possible to revalue the national currency up to the equilibrium of the current account. A Phillips curve formulation of the wage rate acts differently depending on the exchange rate regime, as stated previously. Notice that if the exchange rate is fixed, or even determined by a PPP formula, and the wage rate is evaluated by a Phillips curve, we obtain a net negative welfare impact. This result is independent of the way the price of goods is determined ie whether this is an equilibrium price or cost induced.

Within the family of variants that assume a cost induced pricing of goods, the price or quantity adjustment of the labour market is important for the kind of results obtained. In the case of a price adjustment of the labour market (see model variants CGE-100 and CGE-101) the assumption of a quantity adjusted goods market leads to a reduction in the simultaneity of the model and, finally, the rate of change of the equilibrium wage rate is equal to that of the consumer price. In the case of a quantity adjusted labour market, we observe that our variants (ie CGE-110 and CGE-111) replicate the properties of a Keynesian model. In fact in these variants income drives demand which determines supply. Because of wage rate rigidities real wages improve and employment demand is reduced. However, domestic production is increased because it is adjusted to demand, the latter

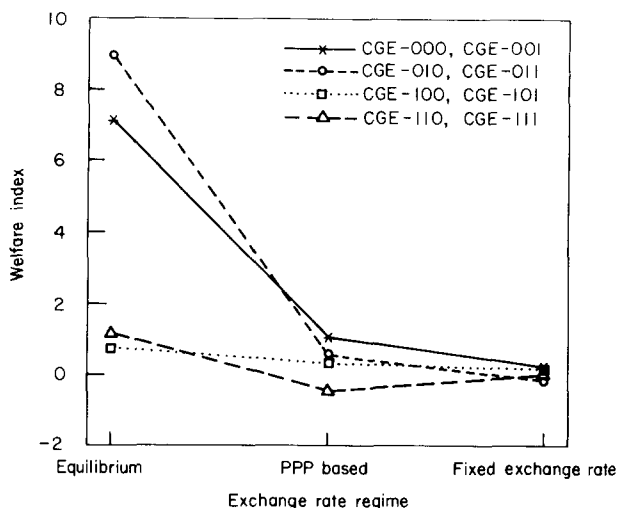


Figure 1. The role of the exchange rate regime.

being augmented because of the progress of incomes. Thus, apparently, factor productivities rise and this has further positive effects on the wage rate. This situation produces deficits mainly because the growth of non-salary income is significantly less important. In the long term these deficits produce negative economic effects, through investment and wealth. The latter situation would not be replicated in traditional macroeconomic neo-Keynesian models since they generally do not respect Walras's law.

We have attempted to summarize the effects of the policy scenario by measuring a welfare index for each variant of the model. This measure aggregates in an intertemporal manner the results concerning real salary income, real non-salary income and investment and it is corrected for any possible disequilibrium of the labour market or the current account. Figure 1 illustrates the role of the exchange rate regime by showing the values taken by the welfare measure in four groups of model variants, grouped following the situations in the two other markets. Within each group of model variants the case with an equilibrium derived exchange rate is clearly more efficient. The group of model variants assuming price adjusted equilibrium provide better results than those of the group of models that determine prices from production costs.

Figure 2 shows the role of the labour market clearing mechanisms separately for each exchange rate regime. If the exchange rate is evaluated in such a way that the current account is in balance, a Phillips curve formulation of the wage rate is more efficient than the fully competitive labour market, since overemployment is permitted. If the exchange rate is fixed, or PPP based, the Phillips curve formulation is inefficient and implies welfare costs.

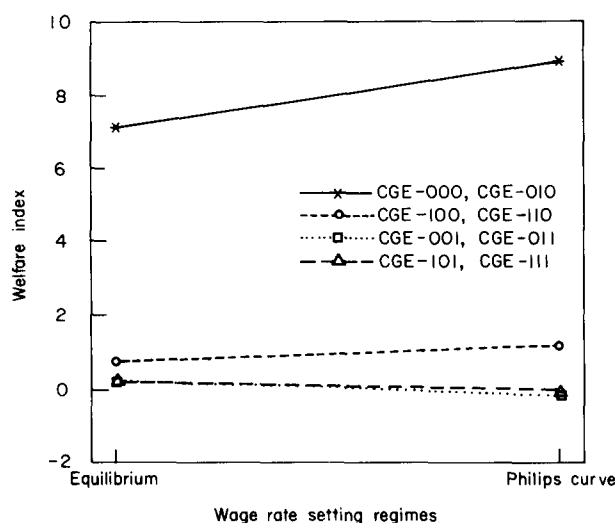


Figure 2. The role of wage rate setting regimes.

### Concluding remarks

The research presented here was motivated by recent efforts to include non-neoclassical features in CGE models in order to represent market imperfections and rigidities. Our aim was to examine the policy implications of adopting frameworks other than price induced market clearing in certain markets of a CGE model. In the course of the paper we designed a general core CGE model and derived 12 alternative model variants representing various research directions in the literature of empirical CGE modelling. In the formulation of the variants we employed alternative hypotheses for market clearing or not clearing mechanisms, and for the labour, commodities and foreign exchange markets.

The alternative formulations are as follows. For the foreign exchange market three cases were considered: clearing of the market through the exchange rate; a fixed exchange rate regime; and purchasing power parity evaluation of the exchange rate. For the labour market two alternative formulations were studied: the wage rate as the labour market clearing price; and a Phillips curve. Finally, the model evaluated the goods price either as the goods market clearing price or as determined by the cost of production. The 12 model variants scan the alternative combinations.

A formulation applying some sort of deviation from the price adjusted market equilibrium represents an imperfection or rigidity in the market. We investigate the role of such rigidities in evaluating the impacts of the European market integration on a small open economy, namely Greece. We limit the analysis to two issues of 1992, namely the output augmenting and factor saving effects of supply side restructuring, and foreign trade liberalization through the elimination

of barriers. Both issues imply positive supply side effects. The economic objective is to take advantage of these effects and expand output and income while simultaneously achieving deflation.

The results obtained from the model's variants are significantly different. The user should thus be aware of the particular formulation of a CGE model. The main conclusions are as follows:

- (i) In all cases, a price cleared market for goods performs better than one in which the price is determined by the production cost.
- (ii) If the exchange rate is fixed or PPP determined the rigidities of the labour market have important negative consequences; the inverse situation is produced in the current account equilibrium case, in which the Phillips curve provides a relaxation of the labour supply constraint and permits further gains in activity and income.
- (iii) In two of the variants there is no market that adjusts through prices; these variants partially replicate the properties of neo-Keynesian macroeconomic models; their results show that although the policy directions are the same, the overall macroeconomic evaluations differ significantly from those of the other variants; hence policy oriented results based solely on macroeconomic models may be misleading.

With reference to the specific policy scenario the following should be noted:

- (i) In so far as market imperfections are removed and the economy moves towards full price adjusted equilibrium, its efficiency improves and the gains from supply side effects are maximized.
- (ii) If important rigidities prevail in the labour market and if the exchange rate is fixed, or even PPP determined, the overall macroeconomic impacts are negative; this effect is relatively independent of the way the goods market adjusts.
- (iii) The exchange rate setting regime is a quite important instrument for maximizing gains from the effects of the European internal market; the regime in which the exchange rate guarantees a balanced current account produces better results than the two other regimes that imply rigidities in the exchange rate adjustment.

An important limitation of the research reported here deals with the lack of intersectoral detail. The examination of the above results with a multisectoral CGE model is an issue in our current research activities and a subject that provides various ideas for the empirical analysis of market imperfections. Actually, in a multisectoral framework one has the ability to formulate sectors in alternative regimes eg one sector

could be cleared through prices and another constrained by rigidities.

Other issues to be explored are related to the following three directions. The first is connected to the analysis of the empirical consequences from the choice of closure rule in the general equilibrium model. The second concerns the introduction of dynamics into the determination of consumer choices, which will contribute to the intertemporal analysis of the welfare implications of policy options. A third, and final, direction is tied to extensions of this research towards further elaboration of the financial sector.

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