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Empirical Analysis of Macroeconomic Stabilisation Measures:

A Computable General Equilibrium Modelling Approach

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Introduction

Within the empirical macroeconomic analysis field, traditional econometric forecasting techniques and models seem now unable to address adequately current policy issues, which are mostly involving structural changes. For example, in the European Community, most countries proceed actively in privatisation of state-owned enterprises and further liberalisation of markets, while they are preparing themselves for the economic and monetary union. Also, in semi--industrialised or peripheral to central Europe countries, governments are implementing stabilisation packages accompanied with structural reforms aiming, in particular, at liberalising financial and commodity markets. These examples, together with the new situation in Eastern Europe, suggest that structural changes of economies are to be at present in the focus of empirical macroeconomic analysis.

In spite of this requirement, technical approaches currently followed in Europe, are mostly restricted to the paradigm of econometric forecasting, which in particular characterizes the large-scale macroeconomic models traditionally used. These models may exhibit accuracy in their econometric behavioural equations or be rich in disaggregated accounting analysis, but they still suffer from two kinds of limitation: they are mainly demand-driven, so they lack sufficient representation of supply side mechanisms; and regarding their overall structure they are open, in the sense that they do not incorporate strong mechanisms able to react and correct persisting disequilibria (e.g. in the balance of payments, unemployment, etc.). By their nature, these models cannot study the implications of structural features and changes of the economy.

The other main stream in empirical macroeconomic modelling, is based on the computable general equilibrium (CGE) approach, which has significantly progressed in the last decade, mainly motivated by the World Bank. Despite this progress, the CGE approach has hardly be present in industrialised countries and especially in Europe and CGE models have been limited to developing countries and academic. CGE modelling seems quite promising for the study of structural features and the normative analysis of government policy, issues currently emerging, as stated above.

To use the CGE approach in industrialised countries, one has to surmount a number of shortcomings in the current state-of-the-art. These include: (i) the static formulation of models; (ii) the dependency on the closure rule; (iii) the absence of a financial and monetary sector; (iv) the inability of these models to support forecasting, because of the arbitrary fixing of one of the prices as the numeraire.

The idea explored in this paper, is to borrow elements from both streams of macroeconomic modelling and to define a more general framework. This will incorporate price-induced market equilibrium mechanisms from the CGE approach, as well as supply-side behaviours (in other terms microeconomic mechanisms), while it retains the basic IS-LM scheme and complex econometric behavioural equations and dynamic mechanisms of traditional (neo-Keynesian) models.

The mix of methodological elements from both modelling streams and the incorporation into a single macroeconomic modelling framework, which is proposed in this paper, provides three kinds of new features:

(i) it permits the representation of different market clearing regimes and other institutional characteristics;

(ii) it integrates a financial/monetary sector within the CGE framework;

(iii) in spite of the complexity of the model's equilbrating mechanisms, it incorporates complex econometric equations and the related dynamic adjustment processes.

The IS-LM mechanism, and especially the incorporation of a financial sector fully integrated with the real sector, permits also to cope with the problem of the closure rule and the numeraire, so to raise the main limitations of traditional CGE models. Results of the proposed framework are obtained from the simultaneous interaction of two mechanisms: the market clearing processes and the macroeconomic IS-LM closure consisting in achieving the savings-investments balance through the financial/monetary sector and its interaction with the real sector.

The framework is general because it permits the representation of alternative regimes in different markets. Each alternative regime corresponds to a special structural feature or institutional condition and refers to the commodity markets, the labour market, the exchange rate determination mechanism and several issues of the financial/monetary sector. The proposed CGE framework covers the whole range of modelling approaches, in the sense that, by selecting appropriate market regimes, one may derive either a traditional CGE model or a traditional neo-Keynesian econometric model, while preserving the same behavioural equations. It may also represent, simultaneously in the model, different types of market clearing regimes in the various sectors and thus obtain more accurate representations of actual or changing situations.

The modelling framework is used in the following manner: first the user should select the appropriate market regimes that represent more closely the conditions that prevail actually in the country; thus, he builds not only a reference (or baseline) scenario, as with a traditional model, but also a reference version of the model; the alternatives to compare with the reference projection comprise not only different values of exogenous variables and parameters, as done with traditional models, but also the user may select alternative regimes in some markets; for instance, the user may define a set of new taxation rates, as usually, but, also, a new regime for the interest rate determination, for instance; thus, the modelling framework permits the assessment of macroeconomic policy packages that comprise institutional or structural measures.

The empirical construction of the model departs from the HERMES macroeconomic model, as applied to Greece [see Capros, Karadeloglou, Mentzas (1988), D' Alcantara and Italianer (1982) and Valette and Zagame (1990)], which is a typical traditional econometric model. From HERMES we preserve econometric behavioural equations and accounting identities. The model is, however, radically changed by introducing computable general equilibrium mechanisms in all markets: commodity markets, labour markets, financial assets. The new structure exhibits the features mentioned above.

In the present paper, we use only one variant of the model, namely the one corresponding to full price-computable equilibrium in all markets (except the energy market). We use this model variant to analyse a set of simple government policies that are part of a stabilization package aiming at reducing the persisting public deficit. The model provides a normative type of analysis for this issue.

The interested reader may refer to earlier policy results, published in Capros, Karadeloglou and Mentzas (1989a to 1989d), regarding the combined use of many model variants in the study of structural changes.

Model Description

Theoretical issues

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 (1979), while empirical effort began essentially as a result of Scarf's work (1969) on the computation of equilibria.

The CGE theoretical framework requires that all markets are clearing through prices. This procedure is usually called price-adjustment of the markets. 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 equation for this price. In this case, equilibrium is obtained by equalling demand and supply and the procedure is called quantity-adjustment of the market. The latter situation combined with the assumption of excess supply in all markets prevail in traditional (neo-Keynesian) econometric models.

Descriptions of CGE models can be found in: Shoven and Whalley (1972) and (1984), Hudson and Jorgenson (1974 and 1977), Adelman and Robinson (1978), Deardorff and Stern (1982), Dervis, de Melo and Robinson (1982), Lysy (1983), Cordon et al. (1985), Blitzer and Eckaus (1986), Devarajan and Sierra (1986), Levy (1987), Pereira and Shoven (1988), Decaluwe and Martens (1987 and 1988) and De Melo (1988). Concerning the closure rule problems, mentioned in the introduction, one may refer to Rattso (1982), Taylor and Lysy (1979) and Dewatripont and Michel (1987).

There is a huge economic literature on modelling and applications that follow the neo-Keynesian approach (see Deleau, Malgrange, Muet (1984) for a standardization of the neo-Keynesian model properties).

The empirical applications of CGE models do not always assume market clearing through price mechanisms in all markets; on the contrary authors often incorporate non-neoclassical hypotheses concerning market rigidities and imperfections in an attempt to capture the macroeconomic forces that prevail in real-world cases; see Robinson (1986), Bourguignon et al. (1983 and 1989). In such cases some markets of the model may be cleared through price-adjustment, while some others include an endogenous determination of the price level (like the one traditionally found in macro-econometric models) which guarantees a quantity-adjusted equilibrium. Extensions of the traditional CGE model by linking a financial/monetary sub-model may be found in Bourguignon et al. (1989) and de Melo Marhta, Leduc and Razmara (1989). Extensions dedicated for foreign trade deficits may be found in Kharas and Shashido (1987) and Lewis and Urata (1984).

The following sets of equations illustrate the alternative mechanisms for representing markets-types:

Market M1	Market M2	Market M3
[Equation: D = f(p)] [Equation: S = g(p)] [Equation: D = S] [Equation: p = h(S,D)]	[Equation: D bar = f(p)] [Equation: S bar = f(p)] [Equation: D = S = min { S bar, D bar }] [Equation: U = S/[S bar]] [Equation: p = h(U,S)]	[Equation: D = f(p)] [Equation: S bar = g(p)] [Equation: S = D]

D, S and p denote demand, supply and prices, respectively, bars indicate potential production and demand and the absence of bars corresponds to effective supply and demand. 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 ones. In market M2, there is rationing of supply or demand, while the price is obtained from demand and cost considerations. Market M3 is assuming excess supply. Here, supply is rationed by demand and this affects prices through the rate of utilization U.

The formulation found in market M1 is adopted for the market of goods and labour in most CGE models; see De Melo (1988). The situation described by market M2 is assumed for the goods market in some CGE models, namely those of Johansen (1979) and Hudson and Jorgenson (1974), who formulate a cost-depending price determination. Market M3 illustrates the formulation used for the labour market (or the foreign exchange market) when unemployment (and usually a trade deficit) prevails. Market M3 is also the typical formulation of all markets represented in neo-Keynesian macro-econometric models; see Capros, Karadeloglou and Mentzas (1989a). In a multi-market CGE model, all three types of market-clearing formulations may co-exist, in the sense that some markets are perfectly competitive, while others are not.

The mechanisms that achieve consistency of transactions at the macroeconomic level, called often macro-framework, is particularly important for appraising the model's properties, and this is independent of the way markets clear. The macro-framework mechanism may be represented by four simultaneous identities: the national income identity, the balance of payment, the public budget balance and the savings-investment identity. In traditional CGE models, the savings-investment identity is usually adopted as the "closure rule" and it is often used for evaluating investment. Such a restrictive assumption is necessary because in these models there is no financial/monetary sector. In traditional econometric models which formulate the IS-LM scheme, the savings-investment identity is implicitly induced by the flow-of-funds identity which equalizes demand and supply of money.

The macro-framework, as it will be presented below in a simple manner, is used in our CGE model to integrate the real and the monetary/financial sectors of the economy and overcome the closure rule limitation. A similar approach is also followed by Bourguignon, Branson and de Melo (1989).

The national income identity may be written as:

[Equation: C+I+G+(X-M) = Y + T] while [Equation: Y = C + S]

where C, I, G, X, M, T and S denote private consumption, investment, government expenditure, exports, imports, net tax receipts and savings. The balance of payment identity is written as:

[Equation: X - M = Ex (Delta [A sub f] + Delta [B sub R]- Delta [B sub f])]

which represents the financing of deficits (or the allocation of surplus) by changes in net foreign assets [Equation: [A sub f]] , bank reserves [Equation: [B sub R]] and foreign borrowing [Equation: [B sub f]] , depending on the exchange rate [Equation: Ex] . The public budget identity also represents financing of deficit through bank borrowing [Equation: [B sub g]] , private domestic borrowing [Equation: [P sub g]] and foreign borrowing, as follows:

[Equation: G - T = Delta [B sub g] + Delta [P sub g] + Ex Delta [B sub f]]

The strict equality of savings and investments, which is used in traditional CGE models, is expanded in a way that any difference between them is financed through changes in money supply [Equation: [M sub s]] , private domestic borrowing of government, net foreign assets and private lending from banks [Equation: [B sub p]] , as follows:

[Equation: S - I = Delta [M sub s] + Delta [P sub g] + Ex Delta [A sub f] - Delta [B sub p]]

The Walrasian closure, which may be further interpreted as flow-of-funds identity, is re-written as follows:

[Equation: - (G - T) + (S -I) - (X-M) = 0] which implies:

[Equation: - (Delta [B sub g] + Delta [P sub g] + Ex Delta [B sub f]) + (Delta [M sub s] + Delta [P sub g] + Ex Delta [A sub f] - Delta [B sub p]) - Ex (Ex (Delta [A sub f] + Delta [B sub R]- Delta [B sub f])) = 0]

and : [Equation: Delta [M sub s] = Delta [B sub R] + Delta [B sub g] + Ex Delta [B sub p]]

The last equation is the monetary identity and constitute the expansion of the "closure rule" when incorporating a financial sector into the CGE framework.

The above macro-framework, i.e. the set of accounting identities, is able to cover a large spectrum of financial market conditions and institutional characteristics. Alternative situations may be represented by choosing the appropriate set of endogenous variables to be solved by these identities.

The two following subsections present the real and the monetary sectors of the model, while section 3 gives the corresponding equations. In this presentation, we make abstraction of implementation details concerning both the accounting system and the particular formulation of econometric equations.

The Real Sector

The real sector of the economy, as represented by the modelling framework, comprises four sectors (agriculture, energy, industry and services) and four corresponding commodities. There are three economic agents, namely producers, consumers and government. Consumers supply labour force to producers who employ it as production factor together with capital. The four commodities are traded, thus imported and exported. The real sector of the economy comprises then five markets: four commodity markets and one labour market. Government's behaviour is assumed exogenous.

Demand of commodities is formed by private consumption, investment in dwellings, government expenditure and investment, private investment, stock variation and exports. These demand elements are allocated over the set of commodities.

A basic behavioural equation determines the distribution of gross private income in consumption and gross savings. Equation (1) determines private consumption by using the Davidson, Hendry, Srba and Yeo (1978) approach, which applies an error correction mechanism on the difference between consumption and real income. Adjustment depends also on unemployment, inflation and the real interest rate.

Equation (2) allocates total private consumption over a set of consumption categories (food, housing, durables, etc.). Among the various allocation systems that have been proposed in the literature, equation (2) implements the Houthakker, Taylor (1970) approach, which links demands with the change in total consumption, a "state" variable and relative prices. Equation (2) corresponds to a system of econometric equations estimated simultaneously with constraints in the parameters. A transformation matrix is used in equation (3) to pass from consumption by category to consumption by commodity.

Investment in dwellings is modelled in equation (4) as a function of real income, inflation and real interest rate. Equations (5) and (6) allocate government expenditure, public investment, investment in dwellings and private investment over the set of commodities by employing fixed coefficients. This is not a restrictive assumption given the aggregate level of commodity classification used by the model. Total private investment by sector is determined as derived factor demand, while government expenditure and public investment are both exogenous.

Supply of commodities has to be represented in a way to determine intermediate consumption and production factor demand by sector. Production possibilities frontiers, used for this purpose, must provide also for the evaluation of potential production by sector. Among the various approaches, we present here a simple one based on CES technology for primary production factors and Leontieff technology for intermediate consumption.

Equation (7) represents a matrix equation (16 equations in our classification) that constitute the basic relation of the Input/Output system. Intermediate consumption of commodity i by sector k is a constant function of the level of production of sector k. Technical coefficients are independently projected over time.

Flexibility of production is assumed for the use of capital and labour as production factors. By defining a CES production function, we derive from profit maximization the demand for labour and capital [equations (11) and (12)], as well as potential production [equation (13)]. The derived demand for production factors depends on relative factor prices, which are determined in equations (9) and (10). The cost of labour depends on the wage rate determined in the labour market, while the cost of capital is evaluated by an Ando, Modigliani, Rasche, Turnofsky (1974) formula. Factor demand equations are simultaneously estimated for each sector by imposing constraints on the parameters. These equations determine the demand for capital and labour in the latest vintage, thus evaluate investment and the labour demand variation. Investment accumulation forms the capital stock, in equation (8).

Equation (13) relates potential production by sector with effective production and the rate of capacities utilization. In the case of competitive equilibrium (market type M1), the rate of capacities utilization is fixed at a pre-determined level and (14) is used to evaluate effective production, which in this case corresponds to supply behaviour. If the market is imperfectly competitive (of type M3), then equation (14) serves to evaluate the rate of capacities utilization and effective production, being demand-driven, is evaluated in equations (20) to (23).

Value added per sector is evaluated in equation (15) from Input/Output relations.

Trading sectors are assumed neither price takers nor price makers in exports, but price takers in imports. Prices of exports and imports are evaluated in equations (16) and (17) as functions of foreign prices (exogenous), the exchange rate and domestic prices. Demand functions are used to evaluate exports and imports of commodities [see equations (18) and (19)]. Exports depend on foreign demand (exogenous), competitiveness measured by relative prices, profitability factors and the rate of capacities utilization. Imports depend on domestic demand and competitiveness.

All components of supply and demand of commodities being evaluated, equation (20) determines equilibrium in the commodity markets.

If a commodity market is assumed to be perfectly competitive, then the rate of capacities utilisation is fixed (=1) and effective production is determined by (14), as equal to potential production, so it is supply-driven. In this case, equilibrium equation (20) corresponds to the determination of the commodity prices in domestic supply, i.e. p_i^F .

If a commodity market is not perfectly competitive, we assume that excess supply prevails. Then, equation (14) is solved for the capacities utilisation rate and effective production is evaluated from equation (20), so it is demand-driven. Hence, we need one more equation (per sector) to evaluate commodity prices, i.e. p_i^F . In excess supply situations and imperfect markets, it is natural to assume cost-driven markup pricing, as it is usually done in traditional econometric models (which because of this assumption are often called neo-Keynesian models). Such a price equation is represented by (20A), which is eliminated from the model in the case of perfectly competitive markets (and it is not used in the CGE model variant we are using for policy analysis in this paper).

Notice that it is quite possible to mix market clearing situations across commodities. That is, one commodity may be formulated in a way that its price is determined by the equilibrium of demand and supply, equation (20), while another may employ equation (20A) for cost-based pricing.

Equations (21) to (24) concern the labour market. Labour supply depends on exogenous population and expected real wages, in equation (21). The corresponding function is derived simultaneously with the consumption function (1) from utility maximization under budget constraint. Labour demand, in equation (22), is the sum of sectoral labour demands, derived from production functions, and exogenous public sector employees.

The labour market can clear under two alternative regimes. The perfectly competitive case is represented by equation (23) which corresponds to the evaluation of the average wage rate ([Equation: w]). In this case the rate of unemployment is fixed to zero (or at an exogenous predetermined level). In the imperfectly competitive case, excess labour supply is assumed to prevail, and the rate of unemployment is determined by (23A) and the wage rate is evaluated by some price indexation mechanism. Equation (23B) proposes a Philips curve formulation extended with the incorporation of productivity effects. Notice, again, that equations (23A) and (23B) are not used in the full CGE variant of the model, and in fact they are not used in the variant employed for policy analysis in this paper. Sectoral wage rates are indexed to the average wage rate, in equation (24).

Derived prices depend on commodity prices in domestic supply, i.e. [Equation: [p super F sub i]] and the prices of imported goods. The corresponding equations weight these prices by means of shares of domestic production and imports. Exogenous tax rates are applied on the formation of these derived prices.

Equations (33) and (34) determine total, net tax revenues. Equations (35) to (40) are accounting identities that determine income and savings.

Private income from salary and non-salary revenues depends on the value of production and labour payments. Total private income, evaluated in (37), enters the consumption equation (1). Net savings of the private sector, the government and the rest-of-the-world, which are determined by equations (38) to (40), constitute the starting point of the financial/monetary sector of the model.

The Financial/Monetary Sector

As in most macro-econometric models, the financial behaviour of economic agents is based on a portfolio model which is derived by maximizing expected utility. The model allocates financial wealth among various assets. The allocation is made on the basis of expected yields and other determining factors [see Erp et alii (1989), van der Beken and van der Putten (1989)]. Such an approach avoids reduced form models of financial mechanisms and uses relative interest rates as explanatory variables. Depending on whether liberalised capital markets are represented in the model, these interest rates together with the exchange rate can be derived from the equilibrium of financial supply and demand flows.

The structure of our financial/monetary model is based on the above approach. Regarding its accounting structure, the model is based on a matrix of flows of funds, involving four economic agents, namely the private, government, banking[1] and foreign sectors.

A simplified form of the flow-of-funds matrix is given in sub-section 3.2, together with the equations of the financial/monetary model. In our model we do not use a full-scale matrix of flows of funds. This is due to the lack of statistical data and the particular needs of the model design. In fact, we adopt a hybrid approach where the flow of funds approach is mixed with a "deficit financing approach". More specifically, the foreign and public sectors are represented only with respect to the financing of their surpluses, while the banking and private sectors are represented following an "assets-liabilities balance" approach.

[1] The banking system, as defined in this model comprises, beside the central bank, all commercial banks and specialised credit institutions.

The equations presented in section 3.2 correspond to the variant of the model which has been used in the present paper. This variant is not a general one, but it corresponds to the particular institutional characteristics, we have admitted as representative of the present status of financial markets and policy, in Greece.

On the assets side of the private sector, total wealth (W) is evaluated by private net savings, a variable coming from the real part of the model; see equation (41).

The allocation of total wealth of the private sector is described as "risk averse investment behaviour". Private agents are assumed to maximize the utility of the return from a portfolio. In this respect future returns are uncertain and the risk aversion is formalised as diminishing marginal utility. It is also assumed that changes in the composition of the portfolio in relation to the starting point entail costs. This portfolio model is based on Parkin (1970) and used in the Freia-Kompas model of the Dutch economy and has also been applied to Belgium [see Van Erp et alii (1989) and Van de Beken and Van der Putten (1989)].

The basic model, expanded with a number of sector-specific variables, determines the optimum portfolio composition, in terms of cash, time deposits, saving deposits, government bonds, bank bonds and treasury bills; see equation (42). The allocation mainly depends on the relative rates of return (assimilated to interest rates) from the above assets. The corresponding equations are simultaneously estimated and a set of restrictions on parameters are imposed. Restrictions include symmetry and additivity conditions, the latter implying that one of the equations is redundant. Also, adjustment costs and dynamic behaviour are incorporated in these equations. Equations (43) determine the changes (flows) of assets allocation.

Foreign exchange deposits, in equation (44), are explained by the evolution of the exchange rate, the foreign to domestic interest rate differential and the capital and transfer inflow which enters the country.

The demand of credit by the private sector, equation (45), bears the influence of the real interest rate, the profit rate and the volume of total investments of the sector.

The "assets-liabilities" balance of the private sector, equation (46), is used to determine the change in saving deposits, which is left out from equations (42) and (43), so as to respect additivity condition.

The approach to modelling the public sector behaviour is drawn by the concern of financing the public deficit. Although in many respects the financing of the public sector is often a matter of political decision, some behavioural equations are introduced in the specification of the model to mimic such decisions.

The financing of the public sector's deficit can be effected by borrowing from the domestic sectors (from the private sector and the commercial banks), the foreign sector[2], and from the central bank (Bank of Greece). The share of public deficit covered by foreign loans depends mainly on the interest rates differential and on the PSBR as a % of GDP; see equation (48). The amount of total foreign debt could be considered as an additional explanatory variable however the existing data are generally not reliable and this effect was not included in the model. Similarly, the share of public deficit covered by borrowing from the central bank is a function of PSBR as a % of GDP, the interest

[2] EEC grants, NATO contribution and transfers from abroad constitute a very small part of the total financing and are not discussed.

rates differential; see equation (49). These two equations are used just to mimic current policies, and could be replaced by simpler forms involving exogenous rates.

Domestic borrowing of government is divided into two parts: the treasury bills and the government bonds. Both can be acquired by the private sector and by commercial banks. Concerning the private sector, investment in these two assets emanates from portfolio allocation. For the banking sector, we retain a formulation, see equations (52) and (53), which explicitly reflects the current institutional regime, in which commercial banks are obliged to buy treasury bills and government bonds at a rate proportional to their total liabilities. By substituting equation (47), which determines total domestic borrowing, into equation (51), we derive the demand/supply equilibrium in financing public deficits. This equilibrium serves to determine the rate of interest of government lending, i.e. [Equation: r sub g] , which further leads the interest rates of bonds and treasury bills in equations (62) and (64).

Equations (54) and (55) represent the assets-liabilities balance in the banking sector. In our model, this serves to evaluate the capacity of banks to lend the private sector, i.e. variable [Equation: Delta [B sub p]] . This formulation also is in accordance with Greek institutional characteristics and reflect the leakage in capital supply to the private sector induced by the imperative financing of public deficit.

Equation (56) represents demand/supply equilibrium of the capital flows addressed to the private sector. This serves to determine the private lending interest rate, i.e. [Equation: r sub l] , which is used in both the real and the monetary sectors of the model, and further leads the interest rates of assets; see equations (59), (60), (61) and (63).

Modelling of the foreign sector is oriented towards determining the ways for covering the current account deficit. Foreign capital inflow is an independent variable and is a function of relative profitability of investment assets in Greece. This is reflected in equation (57). Equation (58), corresponds to the financing of current account deficit. In the present model variant, we assume that changes in bank reserves are maintained at some predetermined level. Thus, balance in equation (58) is achieved through movements of the nominal exchange rate.

Equation (65) evaluates total public debt by accumulating deficits. Public debt further influences interests and annuities which enter the equation (38), which determines net savings of the public sector. This effect is not explicitly showed in the simplified presentation of the model, in section 3.

In summary, the present model variant, of the financial/monetary sector, determines endogenously three equilibrium prices: (i) the private sector lending interest rate, (ii) the government lending interest rate and the (iii) exchange rate.

The above specification does not excludes, however, the possibility to include different structural or institutional changes that may occur in the economy. This may be effected by some other selection of endogenous and exogenous variables. For example, it is possible is to consider that the exchange rate is exogenously determined by the authorities. In this case foreign exchange reserves should be endogenous and be estimated as a residual variable.

Furthermore, if the lending interest rate is fixed by the central bank, a credit rationing regime would occur. In this case, demand for credits will be rationed by supply and equation (45), which determines credit demand, must be eliminated from the model.

Equations

The Real Sector

Demand

[Equation: [C super p] = [Phi super c] { [Y sub h]/[p sub c], [U sub R], Delta [p sub c], [r sub l]-Delta [p sub c] } right (1)]

[Equation: Delta [C super c sub j] = [Phi super c sub j] {Delta [C sub p], Delta ([p super c sub j]/[p sub c]),... }, #4 all j right (2)]

[Equation: [C super p sub i] = Sum below j [[ct] super c sub [ij]] #. [C super c sub j], #4 all i right (3)]

[Equation: [I super R] = [Phi super R] { [Y sub h]/[p super R sub I], Delta [p super R sub I], [r sub l]-Delta[p super R sub I] } right (4)]

[Equation: [C super G sub i] = [[tc] super G sub i]#. [C super G],#4 all i #4 ([C super G] #4 exogenous) right (5)]

[Equation: [C super I sub lambda] = [[tc] super I sub lambda] #. [I sub lambda], #4 all lambda = i, ... , R , G #4 ([I super G] exogenous) right (6)]

[Equation: [C super k sub i] = [[tc] super k sub i] #. [Q super F sub k], #4 all i, #4 all k right (7)]

Supply

[Equation: [K sub k] = (1-[d sub k])[K sub [k,-1]]+[I sub [k,-1]], #4 all k right (8)]

[Equation: [p super w sub k] = [Phi super w sub k] {[w sub k],[w sub [k,-1]],...,[h sub k]}, #4 all k right (9)]

[Equation: [p super K sub k] = [p super I sub k] #. (1+Delta [w sub k]-[r sub l]), #4 all k right (10)]

[Equation: [I sub k]/[K sub k] = [Phi super I sub k] {-[g sub k]t,[p super w sub k]/[p super K sub k],[Q super P sub k] }, #4 all k right (11)]

[Equation: Delta [N sub k]/[N sub [k,-1]] = [Phi super N sub k] {-[g sub k]t,[p super w sub k]/[p super K sub k],[Q super P sub k] }, #4 all k right (12)]

[Equation: [Q super P sub k] = [q sub k] [e super [[g sub k]t]] #.[#[[delta sub k] [[K sub k] super [[sigma sub k]/([sigma sub k]-1)]] + (1-[delta sub k]) [[N sub k] super [[sigma sub k]/([sigma sub k]-1)]] #]] super [([sigma sub k]-1)/[sigma sub k]], #4 all k right (13)]

[Equation: [Q super F sub k] = [U super c sub k] #. [Q super P sub k], #4 all k right (14)]

[Equation: [Q super V sub k] = [Q super F sub k] - Sum below i [C super k sub i], #4 all k right (15)]

Foreign Trade

[Equation: [p super X sub i] = (1-[t sub e]) #. [Phi super [p sub X] sub i] { [p super * sub i] [Ex], [p super F sub i] }, #4 all i right (16)]

[Equation: [p super M sub i] = (1+[t sub m]) #. [Phi super [p sub M] sub i] { [p super * sub i] [Ex] }, #4 all i right (17)]

[Equation: [X sub i] = [Phi super X sub i] { [D super * sub i],([p super * sub i] [Ex])/[p super X sub i],[p super X sub i]/[p super F sub i], [U super c sub i]}, #4 all i right (18)]

[Equation: [M sub i] = [Phi super M sub i] { [Q super T sub i]+[X sub i], [p super M sub i]/[p super D sub i], ... }, #4 all i right (19)]

Demand-Supply Equilibrium

[Equation: [Q super F sub i] +[M sub i] = Sum below k [C super k sub i]+[C super p sub i]+[C super G sub i]+[C super I sub i]+[C super S sub i]-[X sub i]-[T sub i], #4 all i #4 ([C super S sub i] #4 exog.) right (20)]

Prices of domestic goods in the case of non-competitive commodity markets

[Equation: [p super F sub i] = Phi [([p super w sub i][[N sub i] over [Q super F sub i]]) super [mu sub i]] [([p super K sub i][[K sub i] over [Q super F sub i]]) super [nu sub i]] Product below k [([p super k sub i][[C super k sub i] over [Q super F sub i]])] super [l sub [k,i]] [([U super c sub i]) super [tau sub i]], #4 all i right (20A)]

Labour Market

[Equation: [N super S] = [Phi super S] { [POP], [w sub i]/[p sub c] } right (21)]

[Equation: [N super D] = Sum below k [N sub k] + [N sub G] right (22)]

[Equation: [N super S] = [N super D] #4 and #4 [U sub R] = 0 right (23)]

[Equation: [U sub R]=[[N sub S]-[N sub D]] over [N sub s] right (23A)]

[Equation: [[Delta w] over [w sub [-1]] = [lambda sub o] + [lambda sub 1] [[Delta [p sub c]] over [p sub [c,-1]]] + [lambda sub 2] [U sub R] + [lambda sub 3] Sum below i [[Delta ([Q super V] over [N sub i])] over ([[Q super V sub [i,-1]] over [N sub [i,-1]]])] right (23B)]

[Equation: [w sub k] = [[ct] super w sub k] w , #4 all k right (24)]

Derived Prices

[Equation: [p super c sub j] = proport (Sum below i [[ct prime] super [i] sub [ij]] [p super c sub i]), #4 all j right (25)]

[Equation: [p super c sub i] = proport (1+[t super c sub i]) #[[[Q super F sub i] over [[Q super F sub i]+[M sub i]]] [p super F sub i] + [[M sub i] over [[Q super F sub i]+[M sub i]]] [p super M sub i] #], #4 all i right (26)]

[Equation: [p sub c] = sum below i [[C super p sub i] over [C super p] [p super c sub i] right (27)]

[Equation: [p super G sub i] = proport (1+[t super G sub i]) #[[[Q super F sub i] over [[Q super F sub i]+[M sub i]]] [p super F sub i] + [[M sub i] over [[Q super F sub i]+[M sub i]]] [p super M sub i] #], #4 all i right (28)]

[Equation: [p super I sub lambda] = proport (1+[t super I sub lambda]) #[[[Q super F sub lambda] over [[Q super F sub lambda]+[M sub lambda]]] [p super F sub lambda] + [[M sub lambda] over [[Q super F sub lambda]+[M sub lambda]]] [p super M sub lambda] #], #4 all lambda = i, ... , R, G right (29)]

[Equation: [p super I sub k] = Sum below i [[tc] super k sub i] [p super I sub i], #4 all k right (30)]

[Equation: [p super k sub i] = proport (1+[t super k sub i]) #[[[Q super F sub i] over [[Q super F sub i]+[M sub i]]] [p super F sub i] + [[M sub i] over [[Q super F sub i]+[M sub i]]] [p super M sub i] #], #4 all k #4 all i right (31)]

[Equation: [p super V sub k] = #[[p super F sub k] [Q super F sub k] - Sum below i [p super k sub i] [C super k sub i] #] / [Q super V sub k], #4 all k right (32)]

Tax Revenues

[Equation: [T sub i] = [t super C sub i] [C super p sub i] + ..., #4 all i right (33)]

[Equation: T = Sum below i [T sub i] right (34)]

Income and Savings

[Equation: R sub w = Sum below i [w sub i] [N sub i] (1 - [t sub w]) right (35)]

[Equation: R sub K = (Sum below k [p super V sub k] [Q super V sub k] - Sum below i [w sub i] [N sub i]) (1 - [t sub k]) right (36)]

[Equation: [Y sub h] = [R sub w] + [R sub K] right (37)]

[Equation: S sub p = [R sub w] + [R sub K] + [R sub f] + Sum below i [p super X sub i] [X sub i] [t sub e] - [p sub c] [C super p] - T - Sum below k [p super I sub k][I sub k] - Sum below k [p super F sub i][C super S sub i] right (38)]

[Equation: [S sub g] = #^ Sum below i [w sub i] [N sub i] [t sub w] + (Sum below k [p super V sub k] [Q super V sub k] - Sum below i [w sub i] [N sub i]) [t sub k] + T + Sum below i [p super M sub i] [M sub i] [t sub m] left #^ - Sum below i ([p super G sub i] [C super G sub i] + [p super I sub i] [I super G] + [p super X sub i] [X sub i] [t sub e]) right (39)]

[Equation: [S sub w] = Sum below i ([p super X sub i] [X sub i] - [p super M sub i] [M sub i]) + [R sub f] right (40)]

Symbol Table

Index i :	products (agriculture, industry, energy, services)
Index k :	sectors (agriculture, industry, energy, services)
Index j :	consumption categories (food, housing, durables, consumption goods, services, ...)
Index t or -1:	time
[Equation: Phi]	function that applies an error correction or other adjustment process
[Equation: proport]	proportional to
[Equation: Delta]	variation in time [Equation: Delta x = [x sub t] - [x sub [t-1]]]

	VOLUME	DEFLATOR
total private consumption	[Equation: C super p]	[Equation: p sub c]
consumption by category	[Equation: C super c sub j]	[Equation: p super c sub j]
consumption by product	[Equation: C super p sub i]	[Equation: p super c sub i]
investment in dwellings	[Equation: I super R]	[Equation: p super R sub I]
public investment (exogenous)	[Equation: I sub G]	[Equation: p super G sub I]
investment by sector	[Equation: I sub k]	[Equation: p super I sub k]
government expenditure (exogenous)	[Equation: C super G]	[Equation: p super G]
gov. expend. by product	[Equation: C super G sub i]	[Equation: p super G sub i]
investment by product	[Equation: C super I sub i]	[Equation: p super I sub i]
intermediate consumption by product and sector	[Equation: C super k sub i]	[Equation: p super k sub i]
capital stock by sector	[Equation: K sub k]	[Equation: p super K sub k]
employment by sector	[Equation: N sub k]	[Equation: [p super w sub k], [w sub k]]
potential production by sector	[Equation: Q super P sub k]	[Equation: [p super F sub k]]
effective production by sector	[Equation: Q super F sub k]	[Equation: [p super F sub k]]
value added by sector	[Equation: Q super V sub k]	[Equation: [p super V sub k]]
stock variation by product (exogenous)	[Equation: C super S sub i]	[Equation: [p super S sub i]]
exports of good i	[Equation: X sub i]	[Equation: [p super X sub i]]
imports of good i	[Equation: M sub i]	[Equation: [p super M sub i]]
international demand by product (exogenous)	[Equation: D super * sub i]	[Equation: p super * sub i]
labour supply	[Equation: N super S]	[Equation: w]
labour demand	[Equation: N super D]	[Equation: w]

Other variables

government employees (exogenous)	[Equation: N sub G]	capacity utilization rate of sector k	[Equation: U super c sub k]
population (exogenous)	[Equation: POP]	unemployment rate	[Equation: U sub R]
income of households	[Equation: Y sub h]	exchange rate	[Equation: Ex]
salary income	[Equation: R sub w]	interest rate in lending	[Equation: r sub l]
non salary income	[Equation: R sub k]	export subsidies rate	[Equation: t sub e]
tax receipts by product	[Equation: T sub i]	import tariff rate	[Equation: t sub m]
total indirect taxes	[Equation: T]	consumption tax rates	[Equation: t super c sub i]
private net savings	[Equation: S sub p]	investment tax rates	[Equation: t super I sub i]
government savings (balance of the public budget)	[Equation: S sub g]	intermediate consumption tax rates	[Equation: t super k sub i]

balance of payments	[Equation: S sub w]	salary income tax rate	[Equation: t sub w]
net transfers from abroad	[Equation: R sub f]	non salary income tax rate	[Equation: t sub k]

Miscellaneous

consumption transformation coefficients	[Equation: [[ct] super c sub [ij]]]	technical coefficients	[Equation: [tc] super G sub i]
technical coefficients of intermediate consumption	[Equation: [tc] super k sub i]	technical coefficients	[Equation: [tc] super I sub i]
technical progress	[Equation: g sub k]	replacement rate	[Equation: d sub k]
CES elasticities	[Equation: [delta sub k],[sigma sub k]]	constants	[Equation: [q sub k]]
elasticities	[Equation: lambda, mu, nu, l, tau]	technical coefficients	[Equation: [ct] super w sub k]

The Financial/Monetary Sector

The Flow-of-Funds Matrix

Private Sector (P)	Government (G)	Banks (B)	Foreign Sector (F)
Cash [Equation: Delta [A sub [cs]]]]]	Foreign Capital	Private Loans [Equation: Delta [B sub p] Inflow [Equation: Delta [A sub f]	
Saving Deposits [Equation: Delta [A sub [sd]]]]]	Loans [Equation: Delta [B sub g] loans [Equation: Delta [B sub f]	Bank of Greece	Foreign exchange
Time Deposits [Equation: Delta [A sub [td]]]]]	Other Transfers [Equation: [O sub g]	Treasury Bills [Equation: Delta [B sub [tb]]	
Bank Bonds [Equation: Delta [A sub [bb]]]]]	Bank Reserves [Equation: Delta [B sub R]	Government Bonds [Equation: Delta [B sub [gb]]	
Government Bonds [Equation: Delta [A sub [gb]]]			
Treasury Bills [Equation: Delta [A sub [tb]]]			

Foreign Exch. Deposits [Equation: Delta [A sub f super p]]			
Total Assets [Equation: Delta [As sub p]]]		Total Assets [Equation: Delta [[As] sub b]	
Credits [Equation: Delta [L sub p]]] Loans [Equation: Delta [B sub f]]	Foreign Exchange	Cash [Equation: Delta [A sub [cs]]	
Foreign Capital]] Inflow [Equation: Delta [A sub f]]	Domestic Borrowing [Equation: Delta [B super g sub p] Saving Deposits [Equation: Delta [A sub [sd]]		
Bank of Greece] Loans [Equation: Delta [B sub g]]	Time Deposits [Equation: Delta [A sub [td]]		
Other Transfers [Equation: [O sub g]]]	Bank Bonds [Equation: Delta [A sub [bb]]		
]	Foreign Exch. Deposits [Equation: Delta [A sub f super p]		
]	Bank Reserves [Equation: Delta [B sub R]		
Net Savings [Equation: [S sub p]]]]	Net Savings [Equation: [S sub g]	Net Savings [Equation: [S sub w]	
Total Liab. [Equation: Delta [Li sub p]]]		Total Liab. [Equation: Delta [Li sub b]	

Equations

Private Sector

[Equation: W= [W sub [-1]] + (S sub p) right (41)]

[Equation: [[A sub mu] over W] = [alpha sub mu] + Sigma below [nu=/mu] beta sub [mu nu] [phi sub [mu nu]] ([r sub nu] - [r sub mu]) + [Sigma below lambda] [gamma sub [mu lambda]] [[X sub lambda] over W], #4 all mu, nu = cs,td,gb,bb,tb #4 except #4 sd right (42), scale: 1.000]

[Equation: Delta [A sub mu] = [A sub mu] - [[([A sub mu])] sub [-1]], #4 all mu=cs,td,gb,bb,tb, #4 except #4 sd right (43)]

[Equation: Delta [A sub f super p] = Phi ([r super *] - [r sub l], Ex Delta [A sub f], [[p dot] sub c] - Ex, ...) right (44)]

[Equation: Delta [L sub p] = Phi ([Sum [I sub i], [r sub l] - [w dot], [R sub K] / Sum [p super F sub i][Q super F sub i], ...]) right (45)]

[Equation: Delta [L sub p] + Ex Delta [A sub f] + [S sub p] = Sum below mu Delta [A sub mu] + Delta [A sub f super p], #4 all mu = cs,sd,td,gb,bb,tb right (46)]

Government Sector

[Equation: Delta [B super g sub p] = Delta [A sub [gb]] + Delta [A sub [tb]] + Delta [B sub [gb]] + Delta [B sub [tb]] right (47)]

[Equation: [Delta B super g sub f] = Phi ([S sub g] , [r super *] - [r sub l], [r sub g] - [r sub l], [[p dot] sub c] - Ex, ...) right (48)]

[Equation: [Delta B super g sub p] = Phi ([S sub g] , [r super *] - [r sub l], [r sub g] - [r sub l], [[p dot] sub c] - Ex, ...) right (49)]

[Equation: Delta [B sub f] = Delta [B super g sub f] / Ex right (50)]

[Equation: [Delta B super g sub f] + Delta [B super g sub p] + Delta [B sub g] + Ex [O sub g] + [S sub g] = 0 #4 #4 ([O sub g] #4 exogenous) right (51)]

Banks

[Equation: Delta [B sub [tb]] = [rho sub [tb]] Delta [Li sub b] right (52)]

[Equation: Delta [B sub [gb]] = [rho sub [gb]] Delta [Li sub b] right (53)]

[Equation: Delta [[Li] sub b] = Delta [A sub [cs]] + Delta [A sub [sd]] + Delta [A sub [td]] + Delta [A sub [bb]] + Delta [A sub f super p] + Ex Delta [B sub R] right (54)]

[Equation: Delta [B sub p] + Delta [B sub [tb]] + Delta [B sub [gb]] + Delta [B sub g] = Delta [[Li] sub b] right (55)]

[Equation: Delta [L sub p] = Delta [B sub p] right (56)]

Foreign sector

[Equation: Delta [A sub f] = Phi ([r super *]-[r sub l], [[p dot] sub c] - Ex, ...) right (57)]

[Equation: Delta [A sub f] + Delta [B sub f] + Delta [B sub R] + [O sub g] = [S sub w] / Ex #4 #4 (Delta [B sub R] #4 exogenous) right (58)]

Derived Interest Rates

(the private lending interest rate [Equation: [r sub l]] and the government lending interest rate [Equation: [r sub g]] are leading)

[Equation: [r sub [cs]] = Phi sub [cs] ([r sub l]) right (59)]

[Equation: [r sub [td]] = Phi sub [td] ([r sub l]) right (60)]

[Equation: [r sub [sd]] = Phi sub [sd] ([r sub l]) right (61)]

[Equation: [r sub [bb]] = Phi sub [bb] ([r sub l]) right (63)]

[Equation: [r sub [gb]] = Phi sub [gb] ([r sub g]) right (62)]

[Equation: [r sub [tb]] = Phi sub [tb] ([r sub g]) right (64)]

Public Debt

[Equation: [B super g] = [[([B super g])] sub [-1]] + Delta [B super g sub p] + Delta [B super g sub f] right (65)]

Policy Results

The CGE model, presented in the above sections, is further used in scenario analysis. Scenarios aim at studying the efficiency and the impacts of several public policy measures, which have in common the concern to reduce public deficit.

The analysis is done separately for each measure, so as to facilitate the interpretation of results and, in the same time, to test the behaviour of the CGE model. For all scenarios, the model is running dynamically over a period of five years.

The CGE model presents a clear advantage, over other approaches: in quantifying a scenario, the model ensures equilibrium in all markets and balances all agents' accounts; thus, the model can support a normative interpretation of scenario impacts. The latter are quantified as usually, by comparing scenario results to a baseline simulation. (see Tables 1 to 5)

Increase of Direct Tax Rate by 10%

In this scenario, public policy aims at reducing deficits by increasing revenues from direct (income) taxation. This results in a transfer of wealth from households to the public sector and induces changes in demand and supply in the various markets, which are simultaneously clearing in the model at a new equilibrium point.

The main effect emanates from the financial markets, in which capital supply constraints are relaxed, due to the reduction of public deficit. The new equilibrium point is characterized by lower interest rates, which then have several second order effects. The decrease of interest rates induce factor substitutions in production, namely in favour of capital. Demand for labour being reduced, wage rates are readjusting downwards to maintain full employment.

On the other hand, increased income taxation implies a reduction of disposable income, hence of private consumption. Demand in the commodity markets is then shifted downwards and supply is readjusted. The new equilibrium point corresponds, in general, to declining commodity prices.

The effects through wage rates, interest rates and commodity prices contribute to a deflationary process, which improves competitiveness in foreign markets and increases demand of commodities through exports, decreased imports and investment. However, the net result on GDP remains slightly negative. The improvement in the balance of trade implies a further readjustment of exchange rates (towards re-evaluation in the longer term), to maintain a constant level of Bank's reserves.

In summary, the direct taxation policy measure complies with the aim of reducing public deficits and is beneficial for current account. However, households' income and, at a lower degree, economic growth are repressed.

Increase of Indirect Tax Rates by 5%

This policy measure results in a transfer of wealth mainly from firms and secondarily from households to the public sector. In the financial markets, this releases capital supply possibilities and induces a reduction of interest rates. The increase of indirect tax rates has also a direct effect on consumer prices of commodities which are increasing. On the other hand, wages are shifting downwards to balance labour substitution pressures, so real wages, disposable income and private consumption are reduced. Firms are baring profit losses because they are obliged to sell at lower prices to adjust their supply to decreasing demand. GDP in market prices (as reported in Table 2) is increasing, because indirect tax receipts, included in GDP in market prices, counterbalance the slight reduction of both final demand and sectoral value added.

In summary, the second order effects are similar to the case of direct taxation. However, the distributional effects differ, since in this case firms bare the main costs.

Reduction of Public Sector Employees by 2%

In this scenario, public deficits are reduced through the decrease of public expenses.

The reduction of public sector employees decreases total demand for labour, so wage rates are readjusted downwards to achieve full employment. The reduction of public sector deficits induce, as in the previous cases, a release of capital supply and substantially decreases interest rates. The resulting decrease of capital cost is, however, lower than that of wage rates, so substitutions in favour of labour occur in production. Given that, within an one year perspective, the capital stock is fixed, commodity supply constraints are relaxed by increasing the use of labour. This induces lower equilibrium prices of commodities, so a deflationary process is launched.

Exports are decreasing mainly because of higher profitability in the domestic markets. The potential losses in current account are counterbalanced by a re-evaluation of national currency.

In summary, the reduction of public sector employees contributes to the objective of diminishing public deficits and has beneficial impacts to the current account, the employment, the domestic demand and the profitability of firms. Households bare the costs because of the reduction of their real wages.

Increase of Social Security Contribution Rate by 10%

This measure concerns contributions both by workers and firms. It aims at reducing public deficits by focusing on the Social Security domain, which in Greece present high losses.

As in the previous case, this measure induces a relaxation of public sector borrowing requirements and diminishes interest rates. This has further effects on capital costs and induces substitutions in favour of capital. Wages are then decreasing to obtain full employment and contribute to the reduction of disposable income. The reduction of the latter is further aggravated by the increase payments for social security. Consequently, private consumption is reduced. However, total demand of commodities is maintained, through investment and exports and total supply is slightly reduced, because of the decline of imports. The changes on foreign trade are due to the devaluation of national currency, which is required to maintain financing of the balance of payments. The new equilibrium in the market of commodities corresponds, in the short term, to higher commodity prices, a situation which changes in the longer term.

The social security measure achieves high decreases of public deficits, but it is detrimental to mainly households and secondarily firms. It creates also inflationary pressures in the short term, but it is beneficial to current account.

Decrease of Public Investment by 1 billion annually

This scenario aims also at reducing public expenses. As previously, interest rates are decreasing and induce substitutions detrimental to labour. Again, wage rates readjust downwards.

In contrast with the previous scenario, the decrease in public investment induces a deflationary process. This is due to the fact that profitability is maintained in the domestic market, private consumption is not decreased and exports are reduced. The latter effect is supported by a re-evaluation of national currency.

In this case, firms' savings are positively affected and only households bare some costs. In contrast with the previous cases, the current account obtains much lower gains.

Conclusions

In the present paper, we specified and implemented an empirical CGE model of the Greek economy, which has a number of distinguishing features, such as the integration of a financial/monetary sector, the flexibility to represent different clearing regimes in markets and the econometric estimation of all behavioural equations.

We applied the model to a number of case studies which have in common the aim to reduce public deficits. The model supported a normative interpretation of scenario assessment, since it quantifies impacts while ensuring equilibrium of markets, full employment and balance of all accounts.

All public policy measures we studied, correspond to a transfer of wealth from households and firms to the public sector. This transfer is unequal across the types of measures, so that the measures can be normatively evaluated according to distributional analysis. All measures induce diminishing interest rates of equilibrium, but their effects on production differ. The one repressing private income and consumption generally launch a deflationary process, which is further beneficial to current account but provoke important losses of wealth to households. The one repressing public expenses seem to exhibit more equity in distributional effects, but are less effective in the reduction of public deficits.

The purpose of the paper was not to analyse in depth those public policy issues, but rather to test and qualify the model's behaviour. To this respect, results are encouraging to pursue research in this direction and further improve the model.

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