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# Non-competitive CGE model: microeconomic foundations, equations and calibration

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# Non-competitive CGE model: microeconomic foundations, equations and calibration

by

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## Abstract:

This paper proposes a non-competitive CGE model with microeconomic foundations as clear as those of the Walrasian CGE model. Drawn essentially from the General Theory of the Firm, the microeconomic foundations developed make it possible: (i) to take into account the imperfections in the computable general equilibrium modeling without opting for a specific theoretical framework of imperfect competition (monopoly, duopoly, oligopoly, etc. .), (ii) that employment is a result of the CGE model and that unemployment does not result from the choice of the modeler to force or not the existence of unemployment through the introduction of specific equations in the model, ( iii) to better understand the behavior of economic agents in terms of foreign trade and to limit the level of arbitrariness in the calibration of the parameters of the import and export functions; (iv) to determine the investment demand function of firms in each branch of activity considered in the model; it depends, among other things, on economic performance, financing constraints, user cost of capital and transaction costs of the branch of activity; (v) to determine the expressions of the price of each product and the average wage of each branch of activity. Thus, this non-competitive CGE model is more suitable for understanding the effects of public policies and other shocks on labor market, employment, household income, investment, economic growth and foreign trade, as well as prices.

## Résumé : Modèle EGC non concurrentiel : les fondements microéconomiques, les équations et la calibration

Ce papier propose un modèle EGC non concurrentiel (MEGC-NC) avec des fondements microéconomiques aussi clairs que ceux du modèle EGC walrasien. Tirés essentiellement de la Théorie générale de la firme, les fondements microéconomiques développés permettent : (i) de prendre en compte les imperfections dans la modélisation en équilibre général calculable sans opter pour un cadre théorique spécifique de concurrence imparfaite (monopole, duopole, oligopole, etc.), (ii) que l'emploi soit un résultat du modèle EGC et que le chômage ne découle pas du choix du modélisateur de forcer ou pas l'existence du chômage à travers l'introduction d'équations spécifiques dans le modèle, (iii) de mieux appréhender les comportements des agents économiques en matière de commerce extérieur et de limiter le niveau de l'arbitraire dans la calibration des paramètres des fonctions d'importation et d'exportation ; (iv) de déterminer la fonction de demande d'investissement des entreprises de chaque branche d'activités du modèle ; elle dépend, entre autres, des performances économiques, des contraintes de financement, du coût d'usage du capital et des coûts de transaction de la branche d'activités ; (v) de déterminer les expressions du prix de chaque produit et du salaire moyen de chaque branche d'activités. Le modèle EGC non concurrentiel ainsi développé est plus adapté, notamment pour appréhender les effets des politiques publiques et autres chocs sur le marché du travail, l'emploi, les revenus des ménages, l'investissement, la croissance économique et le commerce extérieur, ainsi que sur les prix.

**Keywords:** Non-competitive Computable General Equilibrium Model, CGEM, imperfections
**Mots clés :** Modèle d'équilibre général calculable non concurrentiel, MEGC, imperfections,

**JEL classification:** B21, C68

## *Summary*

## 1. Introduction

The Computable General Equilibrium Model (CGEM) remains one of the most widely used models by economists and experts in other social and environmental science disciplines. This is partly explained by the fact that the MEGC makes it possible to consider the economy as a whole by reconciling macroeconomic approaches and microeconomic approaches, all within a coherent framework (Gérard et al. 2011), and thus, to apprehend the complexity of the impacts of the phenomena studied. Indeed, for a given economy at a given period, CGEMs make it possible to identify the opportunity of the various economic policies and, thus, to replace macro-econometric models, especially in contexts where the statistical series are incomplete (Cogneau and Roubaud , 1994). However, the use of CGEMs comes up against difficulties related to their basic theoretical framework.

CGE models are first based on the Walrasian equilibrium framework. In these models (i) competition is pure and perfect in the markets, (ii) wages and prices are flexible, (iii) goods and labor markets are in equilibrium, (iv) labor is mobile between sectors of activity, (v) total amount of investment is determined by savings (I=S). Obviously, these first models received numerous criticisms for the lack of realism not only of the hypotheses, but also of the simulation results (Cogneau and Roubaud 1994, Hérault 2003).

To represent the real characteristics of the economies studied, modelers introduce models of imperfect competition and wage rigidities in the CGE models. However, there are many possible specifications of imperfect competition which have a considerable impact on the macroeconomic results of CGE models. Also, many models favor the hypothesis of a margin rate on production prices and/or wage rigidity without developing the underlying microeconomic behaviors (Cogneau and Roubaud 1994, Marouani 2002). As a result, neoclassical authors are quite reluctant towards these non-competitive CGE models whose microeconomic foundations are not as clear as the Walrasian equilibrium and whose optimality properties are even more difficult to explore.

Thus, as much as the idealistic microeconomic foundations of competitive CGE models weaken their use as a decision support tool, the use of non-competitive CGE models as a decision support tool is weakened due to the lack of clear microeconomic foundations. Therefore, even if they claim to provide important results for economic policies, many CGE studies retain an experimental character.

Faced with this observation, this paper aims to build a non-competitive CGE model based on clear microeconomic foundations and whose optimality properties can be explored. More specifically, it involves building a CGE model based on the general theory of the firm and its recent developments (Zerbo 2016, 2018a, 2018b, 2020, 2022; Zerbo and Hien 2019, 2020a, 2020b). Indeed, for the general theory of the firm (GTF), the markets are characterized by imperfections that influence the decisions of economic agents and move them away from the neoclassical optimum. Because of imperfections, the search for "mutually advantageous" compromise is the markets operating rule. Thus, economic relations between agents are characterized by compromise functions determined, among other things, by their institutional, legal, social and human environment, as well as by their individual and/or collective capabilities and preferences. The decisions of economic agents corresponding to the mutually advantageous compromises result from the maximization of compromise functions under constraints.

Thus, this paper is structured in three sections: (i) a review of CGE models, (ii) the microeconomic foundations of the non-competitive CGE model, (iii) the presentation of the non-competitive CGE model and an approach of its calibration.

## 2. Review of computable general equilibrium models

The literature review proposed in this section includes two subsections: (i) genesis of modeling in CGE and (ii) presentation of the basic structure of competitive CGE model.

### 1. *From the Walrasian CGE model to neo-structuralist CGE models*

According to the specialized literature, the model developed by Johansen on Norway in 1960 is the precursor model of computable general equilibrium models. However, the first generation of CGE models is best represented by the work of Shoven and Whalley (1984), which proposed disaggregated models at firm and household level and whose framework is purely Walrasian (Schubert 1993).

These first CGE models are static models of temporary equilibrium, written in real terms, equipped with a simple Walrasian kernel, based on the assumptions of pure and perfect competition. Supply and demand functions are derived from the first-order conditions of the maximization of corporate profit and of consumer utility function in a framework of pure and perfect competition. Prices and wages are flexible, investment is determined by savings (Cogneau and Roubaud 1994).

The assumptions of pure and perfect competition limit the realism of these first computable general equilibrium models. Indeed, one of their major shortcomings is due to their usual paradigm, namely the assumption of profit maximization by firms. It implicitly assumes in particular that there is no room for negotiation on the markets, that employees have no ability to claim and to adopt opportunistic strategies, and that they can be replaced at will; therefore demand for labor is equal to supply for labor. As a result, standard CGE model cannot account for the persistent underemployment or unemployment observed in many countries because it ignores labor market imperfections. So, the literature is characterized by virulent debates between general equilibrium modelers.

According to Cogneau and Roubaud (1994), the hottest debates between modelers in computable general equilibrium oppose neoclassical and “neo-structuralist” schools. These debates focus on the consideration of rigidities in CGE models. Neo-structuralist CGE models consider a whole series of rigidities or structural specificities that lead economy away from full employment of production factors and lead to adjustment problems radically different from the neoclassical CGE. Although some neoclassical modelers agree with their neo-structuralist counterparts on the need to consider rigidities, they remain opposed to the extent or quantity of acceptable rigidities.

In developing countries where knowledge of microeconomic behaviors and economic constraints is still limited, neo-structuralist authors put forward two types of justification for integrating rigidities into the CGE model: (i) a mode of polemical justification which consists in propose alternative thought experiments to the neo-classical conception, (ii) a positive mode of justification which consists in making an institutional description of the economy studied (Cogneau and Roubaud 1994). However, neo-structuralist works are most often only literary and are not based on irrefutable demonstrations. So, they do not provide clear microeconomic foundations with behavioral functions that can help build a more realistic alternative model. Faced with this situation of uncertainty described by the neoclassical authors as "absence of decisive proof of the existence of insurmountable rigidities", they put forward the argument of parsimony to support the idea that a CGE model less constrained should be preferred to neo-structuralist models which would err on the side of ad hoc rigidities. This argument based on the absence of decisive evidence of the speed of adjustments in the economy can also be addressed to the neoclassical CGE model, because as Cogneau and Roubaud (1994) said, it seems just as difficult to justify the neoclassical assumptions of flexibility.

About these debates, Boyer (1986) points out that “just like nature, macroeconomists abhor a vacuum! In this case, we cannot fight the new classic models by objecting to the unrealism of their founding hypotheses. In fact, the game is not so much to compare reality to a model, but to compare various models by reference to what they teach us about concrete economies”. So, alongside these debates, modelers have sought since the mid-1980s to introduce imperfect competition into the CGE model to arrive at alternative CGE models that are more realistic than the Walrasian CGE model. Depending on the objectives of the modelers and their respective choice of the imperfect framework, the introduction of imperfect competition is done in various ways.

From the middle of the 1980s, some modelers (Harris 1984, Cox and Harris 1985) sought to introduce a more realistic way of prices formation into the CGE models. These authors introduced a fixed mark-up to describe the formation of prices in a monopoly situation and increasing returns to scale by the presence of fixed costs.

Other modelers have sought to replace the competition framework of the CGE model with a Cournot-like oligopolistic analysis framework to determine supply, and horizontal product differentiation to determine demand (Decreux, Guérin and Jean, 2002) or by an oligopolistic structure with conjectural variations (Elbehri and Hertel 2004), with consideration or not of the heterogeneity of the products (Burniaux and Waelbroeck 1992).

To consider labor market imperfections, modelers adopted various approaches: (i) introduction of a global or sectoral minimum wage allowing unemployment to be incorporated into the model (Taylor 1980, Dervis et al. 1982, Maechler and Roland-Host 1995, Decaluwé, Dissou and Robichaud 1999, Lemelin and Robichaud 2018), (ii) taking into account of inter-sector wage differentials (De Melo 1977, Thierfelder and Shiells 1997), (iii) adoption of a segmentation of labor market between the formal sector and the informal sector (Maechler and Roland-Host 1995), (iv) introduction of an expensive matching process in the labor market (Maechler and Roland-Host 1995, Cahuc and Zulberberg 1996, Balistreri 2002), (v) consideration of unions or union negotiations in the CGE models (De Melo and Tarr 1992, Thierfelder and Shiells 1997, Devarajan et al. 1997, Bontout et John 1998).

These approaches of coupling imperfection models with the competition CGE model make it possible to increase the realism of these applied models. Nevertheless, there are several models of imperfections, each relating to specific aspects. Thus, as Marouani (2002) indicates, one of the difficulties lies in the choice of the operating model of the labor market to be retained. Moreover, the difficulty of empirical validation of the working model of the labor market adopted weakens the use of these models for decision-making purposes. Also, according to Marouani (2002), "the assumption of intersectoral labor mobility used in all models constitutes an aberration from the point of view of stylized facts". Also, works on general equilibrium incorporating labor market imperfections deal only with wage setting mechanisms. The issues of hiring/firing rules, labor standards and other elements of labor regulation, which significantly influence the functioning of labor market, are not explicitly modeled in CGE models (Marouani 2002).

The greatest fragility of CGE models with imperfections comes from the fact that they couple the neoclassical behavior equations of economic agents with imperfections models. Yet neoclassical behavior equations derive from the assumption of markets of pure and perfect competition. And if the markets are imperfect, corporate behavior is no longer neoclassical: the entrepreneur can not maximize his profit in the neoclassical way because employees no longer have the same status as production equipment; as the employer, they too have expectations of the company.

In the coupling of competition CGE models and imperfection models, it is implicitly supposed that economic agents ignore market imperfections and behave in a neoclassical manner (ex-ante); it is after determining their strategies that they try to consider certain market imperfections (ex-post). However, taking imperfections into account is inherent in the decision-making process of economic agents. For example, the imperfections of information on the labor market, the delays and costs of hiring and dismissal, the rigidity of wages, the existence of monopoly or oligopoly are not neutral in the business decision-making process; they shape the behavior of entrepreneurs and workers.

Also, CGE models with labor market imperfections consider wage rigidities and/or the matching problem as the cause of the observed imbalance on labor market. This confirms the fact that these models are based on the neoclassical paradigm of labor market which considers that the wage is the adjustment variable allowing unemployment to be eliminated unless rigidities prevent it. It is a very restricted vision of the labor market which, among other things, (i) reduces the goal sought by the employer in his relationship with the labor market and (ii) ignores the specificity of the labor factor – a living and intelligent factor, capable of claiming and adopting opportunistic behavior, unlike capital.

Thus, despite the efforts of neo-structuralist modelers, the observation is that there is not yet a standard heterodox CGE or macroeconomic model based on microeconomic foundations as clear and decisive as those of the Walrasian CGE model. Neo-structuralist modelers attempted to couple the competitive CGE model with imperfect competition models in order to obtain a more realistic CGE model, rather than building a non-competitive CGE model based on new clear and realistic microeconomic foundations, which would result in more realistic behavior functions.

Therefore, in this paper, we first develop the microeconomic foundations and derive the behavior functions before building the non-competitive CGE model based on these new microeconomic foundations. Before addressing these microeconomic foundations in the coming section, the review of CGE models is completed by the presentation of the basic structure of competitive CGE models.

## 2. *Basic structure of competitive CGE models*

In general, the CGE model includes several equations organized into various blocks: (i) production, (ii) income and savings of agents, (iii) domestic demand, (iv) foreign trade, (v) prices and (vi) conditions of balance. The economic agents generally considered are companies, households, the State and similar, the rest of the world.

### *a. Production*

The production volume ($XS_b$) of a branch of activity is determined as being the sum of the value added in volume ($VA_b$) of the branch and the intermediate consumption ($CI_{bp}$) by product (relation 2.1). Intermediate consumption by branch of activity and by product is determined as being a fixed proportion $a_{bp}$ of value added (relation 2.2). Value added is a function of capital and labor (relation 2.3). Constant elasticity substitution (CES) functions in general or Cobb-Douglas functions, in particular, remain the most used in CGE moels. For this presentation, we use Cobb-Douglas production technology.

$$XS_b = VA_b + \sum_p CI_{bp} \quad (2.1)$$

$$CI_{bp} = a_{bp} VA_b \quad (2.2)$$

$$VA_b = A_b {K_b}^{\beta_b} {L_b}^{\alpha_b} \quad (2.3)$$

The labor and capital demands of a branch of activity are derived from the maximization of the profit of the branch whose expression is given by the relation (2.4). The respective demands for labor and capital are therefore given by relations (2.5) and (2.6).

$$\pi_b = P_{VA_b} VA_b - w_b L_b - r_b K_b \quad (2.4)$$

$$L_b = \frac{\alpha_b \, P_{VA_b} VA_b}{w_b} \quad (2.5)$$

$$K_b = \frac{\beta_b \, P_{VA_b} VA_b}{r_b} \quad (2.6)$$

### *b. Agent income and savings*

**Household income and savings**: taking modeling needs into account, households can be subdivided into several categories according to residence place, professional category, gender of household or standard of living. The gross income ($GY_h$) of households is composed mainly of labor income paid by each branch of activity, capital income which represents the share of the gross operating surplus (GOS) of each branch of activity which goes to households, net income from property and dividends received by households ($DIV_h$), net transfers received by households ($NTR_h$). Thus, the household income equation is given by relation (2.7).

$$GY_h = \sum_{b=1}^{B} W_b\, L_{hb} + \sum_{b=1}^{B} \lambda_{hb} GOS_b + DIV_h + NTR_h \qquad (2.7)$$

Household disposable income ($DY_h$) is equal to gross household income minus taxes on household income (relation 2.8). Household savings ($S_h$) is determined as a fixed proportion of disposable household income (relation 2.9).

$$DY_h = GY_h - ITR_h \qquad (2.8)$$

$$S_h = \theta_h DY_h \qquad (2.9)$$

**Enterprise income and savings**: Like households, enterprises can also be subdivided into several categories (formal/non-formal, financial/non-financial, large enterprises/SMEs/Micro-enterprises, etc.). Business income is mainly made up of the sum of gross operating surplus (GOS) of the branches of activity minus the shares paid respectively to households and to the rest of the world. Thus, the business income equation is given by relation (2.10).

$$Y_{ent} = \sum_b (1 - \lambda_{hb} - \lambda_{ROWb}) GOS_b \qquad (2.10)$$

Based on this income, companies pay direct taxes and duties on their income (ITRe), pay dividends to households and the rest of the world ($DIV_{ROW}$) and generate savings (relation 2.11).

$$S_{ent} = Y_{ent} - DIV_h - DIV_{ROW} - ITR_{ent} \qquad (2.11)$$

**Government income and savings**: some models distinguish between the central State and local authorities. Government revenue consists mainly of taxes and duties paid by the branches of activity ($ITB_b$), taxes on products ($TP_p$), duties and taxes on imports ($DTM_p$) and exports ($DTEX_p$), direct taxes paid by households ($ITR_h$) and by businesses ($ITR_{ent}$), as indicated by relation (2.12). The amount of the different types of taxes and duties is calculated by applying fixed levy rates.

$$Y_G = \sum_b ITB_b + \sum_p (TP_p + DTM_p + DTEX_p) + ITR_{ent} + ITR_h \qquad (2.12)$$

Government spends an amount G on goods and services for consumption, makes transfers to households of an amount $TG_h$, as well as to the rest of the world of an amount $TG_{ROW}$ and releases savings ($S_G$) as the relation (2.13) indicates.

$$S_G = Y_G - G - TG_h - TG_{ROW} \qquad (2.13)$$

### *c. Domestic demand*

Domestic demand is made up of final household consumption by product ($CF_{hp}$) and the government consumption (G), investment by product ($INV_p$) and intermediate consumption by branches of activity ($CI_p$).

**Volume of final household consumption by product ($CF_{hp}$)**: it is defined as a fixed proportion of the amount of total final household consumption ($CF_h$), divided by the market price of the product concerned ($PC_p$), as indicated the relation (2.14). The amount of total household final consumption is equal to 1 minus the propensity to save multiplied by disposable income (relation 2.15).

$$CF_{hp} = \upsilon_{hp} \frac{CF_h}{PC_p} \quad (2.14)$$

$$CF_h = (1 - \theta_h) DY_h \quad (2.15)$$

**Volume of the investment by product ($INV_p$)**: it is defined as a fixed proportion of the total amount of the investment (TINV), divided by the market price of the product concerned ($PC_p$) as indicated by the relation (2.16).

$$INV_p = \sigma_p \frac{TINV}{PC_p} \quad (2.16)$$

**Volume of intermediate consumption by product ($CI_p$):** it is equal to the sum of the intermediate consumption of the branches of activity for the product concerned (relation 2.17).

$$CI_p = \sum_b CI_{bp} \quad (2.17)$$

Final consumption of the government (G) is exogenous.

### *d. Foreign trade*

The foreign trade block establishes the export and import functions by product. To determine the volumes of product exports and imports, the approach proposed by Armington (1969) remains the most widely used to avoid extreme specialization of production. It considers that there is imperfect substitutability between the same goods of different geographical origin. Thus, for each product category i, the demand for a composite good Q (fictitious) is defined as a constant elasticity of substitution function of the domestic good and the imported good or of the good sold at home and the exported good.

**Volume of exports by product**: to determine the volume of exports of the product, companies maximize their total revenue which is equal to the sum of domestic sales $P_{Lp}DS_p$ and the value of exports of the product $P_{Ep}EX_p$, under constraint of the distribution function of the composite good given by relation (2.18). Solving this maximization program gives the relation (2.19) which indicates that the ratio of the volume of exports of the product and the volume of sales of the product at home is a function of the relative export price with respect to the local price.

$$Q_p^E = q_p^E \left[\beta_p^E EX_p^{\rho_p^E} + (1 - \beta_p^E) DS_p^{\rho_p^E}\right]^{\frac{1}{\rho_p^E}} \quad (2.18)$$

$$\frac{EX_p}{DS_p} = \left[\frac{P_{Ep}}{P_{Lp}} \frac{1-\beta_p^E}{\beta_p^E}\right]^{\frac{1}{\rho_p^E - 1}} \quad (2.19)$$

**Volume of imports by product:** to determine the volume of imports of the product, it is considered that the buyers minimize their expenditure dedicated to the purchase of this product which is equal to the sum of the purchases of the local product $P_{Dp}DD_p$ and purchases of the imported good $P_{Mp}IMP_p$, under the constraint of the distribution function of the composite good given by relation (2.20). The resolution of this minimization program gives the relation (2.21) which indicates that the ratio of the volume of imports of the product and the volume of purchases of the local product is a function of their relative price.

$$Q_p^M = q_p^M \left[\beta_p^M IMP_p^{-\rho_p^M} + (1-\beta_p^M) DD_p^{-\rho_p^M}\right]^{\frac{1}{-\rho_p^M}} \quad (2.20)$$

$$\frac{IMP_p}{DD_p} = \left[\frac{P_{Dp}}{P_{Mp}} \frac{\beta_p^M}{1-\beta_p^M}\right]^{\frac{1}{\rho_p^M+1}} \quad (2.21)$$

**Current account balance (CAB):** it is equal to export earnings, minus the amount of imports, minus all net transfers paid to the rest of the world by resident agents as indicated by the relation (2.22) .

$$CAB = e\sum_p P_{WEp} EX_p - e\sum_p P_{WMp} IMP_p - TRANS_{ROW} \quad (2.22)$$

### *e. Prices of goods and services*

Several relative prices are calculated in relation to the price of a good considered as cash: the price of value added by branch of activity ($P_{VAb}$), the price of intermediate consumption of the branch ($P_{CIb}$), the price to the producer of the branch ($P_b$), the producer price per product ($P_p$), the local production price including indirect taxes ($P_{Dp}$) or excluding indirect taxes ($P_{Lp}$), the producer price of the exported product ($P_{Ep}$), the price of the imported product including import duties and taxes ($P_{Mp}$) and the GDP deflator (PINDEX).

The price of value added by branch is equal to the difference between the production of the branch in value and the intermediate consumption of the branch in value, divided by the volume of value added (relation 2.23).

$$P_{VAb} = \frac{P_b XS_b - P_{CIb} CI_b}{VA_b} \quad (2.23)$$

The price of intermediate consumption of a branch of activity is equal to the weighted average price of intermediate consumption of the branch (relation 2.24).

$$P_{CIb} = \sum_p \frac{CI_{bp}}{CI_b} P_{pc} \quad (2.24)$$

The price of the local product sold on the national market including indirect taxes ($P_{Dp}$) is equal to the price excluding taxes of the local product on the market multiplied by 1 plus the rate of indirect taxes on the product (relation 2.25).

$$P_{Dp} = (1 + txs_p) P_{Lp} \quad (2.25)$$

The price of the imported product ($P_{Mp}$) is equal to the foreign price in foreign currencies of the imported product multiplied by the exchange rate e, by 1 plus the rate of indirect taxes on the product ($txs_p$) and by 1 plus the rate of customs duties on imports ($tim_p$) of the product (relation 2.26). With this relationship, the standard CGE model does not provide a margin on imported products. Thus, the price of the imported product is equal to its unit cost plus the indirect taxes on the products.

$$P_{Mp} = (1 + txs_p)(1 + tim_p) e P_{WMp} \quad (2.26)$$

The price of the exported product ($P_{Ep}$) is equal to the foreign price in foreign currencies of the exported product multiplied by the exchange rate e, divided by 1 plus the tax rate on the exported product (relation 2.27).

$$P_{Ep} = \frac{e P_{WEp}}{(1 + tex_p)} \quad (2.27)$$

The price of the composite product is equal to the sum of the demand for the local product and the imported product values, divided by the volume of the composite product (relation 2.28).

$$P_{pC} = \frac{P_{Dp}DD_p + P_{Mp}IMP_p}{Q_p^M} \quad (2.28)$$

The producer price of the product is equal to the sum in value of the production sold locally and the production exported, divided by the volume of production (relation 2.29).

$$P_p = \frac{P_{Lp}DS_p + P_{Ep}EX_p}{XS_p} \quad (2.29)$$

The producer price per branch is equal to the weighted average price of the branch's products (relation 2.30).

$$P_b = \sum_p \frac{XS_{pb}}{XS_b} P_p \quad (2.30)$$

The GDP deflator is equal to the weighted average price of the added values of the branches of activity (relation 2.31).

$$PINDEX = \sum_b \frac{VA_b}{\sum_b VA_b} P_{VAb} \quad (2.31)$$

### *f. Equilibrium conditions*

On the market for production factors, on the one hand, the total supply of labor (LS) is equal to the sum of the labor demands of the branches of activity and, on the other hand, the supply of capital of each branch of activity is equal to its demand for capital. Thus, in the competitive CGE model, the economy is in a situation of full employment of labor and physical production capacities. Moreover, the supply of labor and the supply of capital are exogenous.

$$LS = \sum_b L_b \quad (2.32)$$

$$KS_b = K_b \quad (2.33)$$

On the market for goods and services, we have the following equilibria: (i) the supply of each local product on the domestic market is equal to the demand for the local product on the domestic market (relation 2.34), (ii) the global supply of each market product is equal to its global demand (relation 2.35); (iii) the supply of a non-market product is equal to its demand (relation 2.36).

$$DS_p = DD_p \quad (2.34)$$

$$XS_p + IMP_p = EX_p + CF_{mp} + CI_p + INV_p \quad (2.35)$$

$$XS_{nm} = \frac{G}{P_G} \quad (2.36)$$

In the capital market, saving is equal to total investment (relation 2.37).

$$TINV = S_m + S_e + S_G - CAB \quad (2.37)$$

In summary, the standard CGE model presented above has the merit of having microeconomic foundations and a series of relatively consistent behavior functions. However, as many critics of the model have pointed out: (i) the assumptions of pure and perfect competition and prices flexibility are difficult to justify; (ii) the behaviors of economic agents underlying the Armingtonian approach to international trade are not sufficiently clear; (iii) the impossibility for the economy to be in a situation of underemployment of the factors of production does not correspond to the stylized facts; (iv) the non-existence of commercial margin on products (local or imported) does not correspond to the facts; (v) the fact that investment is determined by savings in the standard CGE model means that the contribution of foreign direct investment (FDI), loans and other investment funds in the accumulation process is ignored.

Thus, one of the major challenges of building the non-competitive CGE model is to be able to remove these points of inadequacy of the standard CGE model, while avoiding the trap of coupling this model with specific models of imperfect competition. Hence the importance of first developing new solid and more realistic microeconomic foundations.

## 3. Microeconomic foundations of non-competitive CGE model

According to Sand-Zantman (1995), any general equilibrium model can be characterized by (i) the categories of agents taken into account, (ii) the rules of behavior which reflect the supposed motivations of these agents, (iii) the choice of signals that determine the arbitrages, (iv) the institutional context in which the transactions take place or the structures that determine the functioning of the markets and (v) the system constraints or the equilibrium conditions that must be satisfied, but not taken into account by the agents when making their decision.

In the non-competitive CGE model, the agents considered are households, companies, the government and the rest of the world. The rules of behavior of these agents are dominated by compromise/negotiation because transactions take place in imperfect markets characterized in particular by the existence of regulatory institutions, by imperfect information and by the limited capacities of the agents to perform rational calculations in real time. So, the non-competitive CGE model is mainly based on the General Theory of the Firm (Zerbo 2016, 2018b, 2020). So, this section presents the microeconomic foundations relating to (i) the production behavior of companies, (ii) the exchange and formation of prices on the market for goods and services, (iii) the export behavior of companies, (iv) the behavior of demand for imported products and (v) the investment behavior of companies.

### 1. *Production behavior of firms*

The general theory of the firm considers that companies operate based on the compromise between the stakeholders: employers, employees, shareholders and lenders.

Thus, they optimize a compromise function U (under production constraint) so that each stakeholder “feels satisfied” as given by the program (3.1). The compromise function U depends on the expected real gross profit π, the employment level L and the real wage level w/p. The parameter p denotes the price level and F denotes the production technology.

$$\begin{cases} Max\ U(\pi,\ L,\ w/p) \\ u/c \quad \pi + (w/p)L - F(K,\ L) \leq 0 \end{cases} \tag{3.1}$$

The first-order conditions given by the system of equations (3.2) indicate that the optimal compromise ($\pi^*$; L*; (w/p)*) on the labor market is such that (i) the marginal productivity of labor plus the marginal labor market transaction costs ($MRS_{\pi/L}$) equals the real wage, (ii) the employer's desire to earn an extra penny of gross profit equals the desire per worker to earn an extra penny on the salary, (iii) the technical constraint of distribution of the income generated is respected.

$$\begin{cases} \frac{\partial F}{\partial L} + MRS_{\pi/L} = w/p \\ \frac{1}{L}\frac{\partial U}{\partial w} = \frac{\partial U}{\partial \pi} \\ \pi + (w/p)L = F(K,\ L) \end{cases} \tag{3.2}$$

Thus, the level of labor demand is determined by the confrontation between conventional labor demand (1st equation) and technical labor demand (3rd equation). It depends on the gross profit or the gross operating surplus (GOS), the level of wages, the degree of flexibility/quantitative security of the labor market and labor productivity.

To specify the model, we adopt Cobb-Douglas functions for the compromise function and the production technology as given by relations (3.3) and (3.4). As a reminder, the parameters $\delta_1$, $\delta_2$ and $\delta_3$ depend on the level at which the institutional, legal and social environment is favorable respectively to relatively higher gross profits, to relatively higher wages and to job security. For example, the more the labor legislation protects the jobs, the more $\delta_3$ will be relatively high; or even the higher the relative wage bargaining power of workers, the relatively higher $\delta_2$ will be.

$$U(\pi;\ w;\ L) = \pi^{\delta_1}(w/p)^{\delta_2}L^{\delta_3} \tag{3.3}$$

$$F(K,L) = AL^{\alpha}K^{\beta} \tag{3.4}$$

Concerning the production function (relation 3.4), it is assumed in the following that the returns to scale are diminishing, namely: $0 < \alpha + \beta < 1$.

Based on specifications (3.3) and (3.4), the expressions for average wage, gross profit, labor demand are given respectively by relations (3.5), (3.6), (3.7) and (3.8). In these relations, Y designates the added value, $\eta$ is a parameter equal to $\delta_3/\delta_1$ which measures the level of job security on the labor market. [1]

$$w/p \ = \frac{\delta_2}{\delta_1+\delta_2}\frac{Y}{L} \tag{3.5}$$

$$\pi = (1-\alpha)\left[A\frac{(\alpha+\eta)^{\alpha}}{(1+\eta)(w/p)^{\alpha}}\right]^{\frac{1}{1-\alpha}} K^{\frac{\beta}{1-\alpha}} \tag{3.6}$$

$$LD = \frac{(\alpha+\eta)}{(1-\alpha)}\frac{\pi}{(w/p)} \tag{3.7}$$

$$LD = \left[\frac{A(\alpha+\eta)}{(1+\eta)(w/p)}K^{\beta}\right]^{1/(1-\alpha)} \tag{3.8}$$

The relation (3.5) expresses the real wage as a function of the apparent productivity of labor. The ratio $\delta_2/(\delta_1+\delta_2)$ reflects the share of the wealth created intended for labor compensation. It is determined by the degree of imperfection of information on wages, the relative wage bargaining power of workers, and prevailing wage regulations. Thus, the degree of wage flexibility/rigidity depends on the variability of labor productivity and the relative wage bargaining power of employees.

Relations (3.7) and (3.8) express the demand for labor of firms as a function of the gross operating surplus on the one hand and of the level of capital employed on the other. The relation (3.7) indicates that for a fixed level of gross profit, the demand for labor increases with the parameter $\eta$ which accounts for the level of job security. However, as shown in relation (3.6), gross profit declines with job security, namely the parameter $\eta$. Ultimately, according to relation (3.8), the demand for labor of companies

[1] For more details on this specification consult Zerbo & Hien (2020b).

decreases with job security, which depends in particular on the rules and procedures for hiring and dismissal provided for by labor legislation. The more these rules and procedures tend to secure employment, the more restrictive they are for employers and the less they will hire.

Thus, in addition to the technical-economic characteristics, the non-competitive labor demand function depends on the state of operation of the labor market: among other things, the degree of imperfection of the information on the labor market and the hiring and firing regulations. This constitutes a first fundamental difference with the labor demand function of the standard CGE model, as well as with the labor demand functions of alternative CGE models which focus only on wage rigidities.

### 2. *Exchange and formation of prices of goods and services*

The microeconomic foundations of price formation are drawn from the theory of exchange and price formation developed by Zerbo (2022), which considers that exchange is the result of a compromise process between producers/sellers and the buyers. In a given transaction, the seller wishes to sell a quantity Q of the good desired by the buyer and generate a unit margin m; while the buyer wishes to acquire a certain quantity Q of this good and make a saving S in the transaction compared to the amount of his willingness to spend (VD) for the purchase of this good. Obviously, there is an asymmetry of information between the seller and the buyer: the buyer knows exactly neither the unit margin desired by the seller nor the unit cost of the good; nor does the seller know how much the buyer is willing to spend, nor how much he wants to save.

Then, for the exchange of a given good, the rapport between the seller and the buyer can be apprehended by an implicit compromise function (denoted V), which depends on the unit margin m, the quantity Q of the good exchanged and the amount S of the saving that the buyer wishes to make in the transaction, as expressed by relation (3.9).

$$V = V(m\,;Q\,;S) \qquad (3.9)$$

The structure of the compromise function of the exchange is determined by (i) the institutional, economic and social environment in which the transaction takes place, (ii) the social and human capacities and characteristics of the buyer and the seller, as well as (iii) the characteristics of the concerned good.

In relation to the exchange they are trying to conclude between them, the seller and the buyer come to an agreement only if they are mutually satisfied. Therefore, the mutually advantageous transaction is the result of the maximization of the compromise function of the exchange with respect to the unit margin m, the quantity Q of the good and the amount S of the saving to be made, under constraint the buyer's willingness to spend. Let $C_u$ be the unit cost of the good; then the compromise program of the exchange is given by relation (3.10).

$$\begin{cases} \underset{m;\,Q;\,S}{\text{Max}}\; V(m\,;Q\,;S) \\ u/c \quad (C_u + m)Q + S \leq VD \end{cases} \qquad (3.10)$$

As a reminder, given that the principle of bargaining is to converge positions, intermediate solutions are preferred by the stakeholders over extreme solutions. This implies that the set of possible compromise points is convex and, thus, the compromise function of the exchange is concave. This characteristic of the compromise function guarantees the mathematical existence of an optimal compromise point which may or may not be within reach of the stakeholders.

The first-order conditions of this compromise program are given by the system of equations (3.11), where p denotes the unit price of the good and is equal to $C_u$ + m.

$$\begin{cases} \frac{\partial V}{\partial m} = Q\frac{\partial V}{\partial S} \\ \frac{\partial V}{\partial Q} = p\frac{\partial V}{\partial S} \\ pQ + S = VD \end{cases} \tag{3.11}$$

The first-order conditions (system of equations 3.11) indicate that the mutually beneficial transaction (m*, Q*, S*) is such that, on the one hand, the capacitive desire of the seller to earn an additional unit on the margin unit is equal to the capacitive desire of the buyer to save on the volume of the transaction (1st equation) and, on the other hand, the capacitive desire of the seller to increase the volume of the transaction by an additional unit is equal to the capacitive desire of the buyer to save on the price of the good (2nd equation). The last equation simply indicates the saturation of the buyer's willingness to spend constraint.

For the model, we adopt a specification of the Cobb-Douglas form for the trade-off function as given by relation (3.12) where the parameters $\theta_m$, $\theta_Q$ and $\theta_S$ are positive and their sum is equal to 1.

$$V(m; Q\ ;\ S) = m^{\theta_m} Q^{\theta_Q} S^{\theta_S} \tag{3.12}$$

With such a specification of the compromise function of exchange, the price is proportional to the ratio of the willingness to spend VD with respect to the quantity of the supply of goods and services Q (relation 3.13). The unit margin rate (Tm = unit margin/unit cost) depends on the degree of desirability of the product ($\theta_Q$) and the capabilities of companies to make the margin ($\theta_m$) as indicated by relationship (3.14). The saving realized in the purchase of the product is proportional to the willingness to spend (relation 3.15).

$$p = \left(\frac{\theta_Q}{\theta_Q+\theta_S}\right)\frac{VD}{Q} \tag{3.13}$$

$$p = (1 + Tm)C_u\ , \quad \text{with } \mathrm{Tm} = \frac{\theta_m}{\theta_Q-\theta_m} \tag{3.14}$$

$$S = \left(\frac{\theta_S}{\theta_Q+\theta_S}\right)VD \tag{3.15}$$

A buyer's willingness to spend to acquire a given product results from the maximization of his utility function, under income constraint. Indeed, let $(x_i)_{i=1 \text{ to } I}$, the vector of all goods sold and purchased in the country, $(p_i)_{i=1 \text{ to } I}$, the associated price vector and U the utility function of representative buyer defined by relation (3.16).[2]

$$U(x_1, \dots, x_I) = \prod_{i=1}^{I} x_i^{v_i} \tag{3.16}$$

For a given total income R of the buyer and for a given price $p_i$ of good i, the willingness of the buyer to spend to acquire good i is equal to $p_i x_i^*$ where $x_i^*$ is the quantity of good i which maximizes buyer utility, under income constraint. Thus, the buyer determines his willingness to pay for each product by maximizing his utility function under the budget constraint as indicated by relation (3.17).

$$\begin{cases} \underset{x_1 \dots x_I}{\text{Max}}\ U(x_1, \dots, x_I) \\ \sum_{i=1}^{I} p_i x_i \le R \end{cases} \tag{3.17}$$

[2] The consumer utility function is considered to have the form of a Cobb-Douglas function. On reminder, $\sum_i v_i = 1$.

The first order conditions give the system of equations (3.18). The resolution of these first-order conditions allows us to obtain the relation (3.19) which expresses the maximum expenditure $p_i x_i^*$ to acquire each good i according to the income R of the buyer and his relative preference for good i.

$$\begin{cases} \frac{v_j}{v_i}\frac{x_i}{x_j} = \frac{p_j}{p_i} \ \ pour\ i \neq j \\ \sum_{i=1}^{I} p_i x_i = R \end{cases} \quad (3.18)$$

We therefore deduce that the willingness to spend to acquire each product i is a function of the relative preference of the buyer for this product and his level of income as indicated by relation (3.20).

$$p_i x_i^* = v_i R \quad (3.19)$$

$$VD_i = v_i R \quad (3.20)$$

By combining relations (3.13) and (3.20), the price of product i is given by relation (3.21) where $Q_i$ is the volume of supply of product i and R is the total amount of revenue of buyers. Thus, the price of a good is a function of (i) the level of intrinsic desirability of this product ($\theta_{Qi}$), (ii) the relative preference of buyers for this product compared to other goods ($v_i$), (iii) the desire capacity of the buyers to save in the transaction ($\theta_{Si}$) and (iv) the ratio of the financial capacity of the buyers to the volume of supply of this product.

$$p_i = \left(\frac{\theta_{Qi}}{\theta_{Qi}+\theta_{Si}}\right) v_i \frac{R}{Q_i} \quad (3.21)$$

In continuation of this work, in order to simplify the writing of the equations, we pose: $\left(\frac{\theta_{Qi}}{\theta_{Qi}+\theta_{Si}}\right) v_i = \gamma_i$. Then, the relationship between the price of product i and the ratio of financial capacity to the volume of supply of product i takes the form of the relationship (3.21bis).

$$p_i = \gamma_i \frac{R}{Q_i} \quad (3.21bis)$$

Also, note that the difference between the willingness to spend and the saving realized in the purchase of the product ($VD_i - S_i$) is equal to $\gamma_i R$. On the other hand, the saving realized in a transaction relating to a product i is proportional to the financial capacity of the buyers (relation 3.22).

$$S_i = (1 - \gamma_i) R \quad (3.22)$$

From relations (3.21bis and 3.22), we deduce that final consumption expenditure and savings of household are respectively proportional to their income. Let $DY_h$ be the household disposable income, then household consumption expenditure for product i is given by relation (3.23), total household final consumption expenditure is given by relation (3.24), savings generated by households is given by relation (3.25). The average household propensity to consume is therefore equal to $(\sum_i \gamma_{hi})$.

$$p_i Q_{hi} = \gamma_{mi} DY_h \quad (3.23)$$

$$DPCF_h = \sum_i p_i Q_{hi} = (\sum_i \gamma_{hi}) DY_h \quad (3.24)$$

$$S_h = \sum_i S_{hi} = (1 - \sum_i \gamma_{hi}) DY_h \quad (3.25)$$

### 3. *Firm export behavior*

For a given good, companies produce an XS quantity. This good can be sold on the domestic market and/or exported. Let DS be the quantity sold on the domestic market and EX the quantity exported. The question is how companies distribute their supply of goods XS between domestic market and foreign market. This question finds its answer in the theory of exchange and price formation briefly presented above.

For a product destined both for the domestic market and for export, the collective compromise function of exchange is not only characterized by the domestic environment, but also by the external environment. Also, two variables are added to the arguments of the exchange compromise function: (i) the margin becomes a composite margin including the local margin ($m_L$) and the export margin ($m_E$) and (ii) the quantity exchanged is now shared between the local market (DS) and the external market (EX) according to a distribution function determined by the requirements, constraints and opportunities of the national and international trading environment. Indeed, at the scale of a nation, one wants both (i) an abundant supply of the product, (ii) more foreign currencies via exports and (iii) extending its economic power through a high volume of export. Also, on the external market, there are opportunities and/or constraints/threats to exporting the product. All these requirements, opportunities and constraints shape the distribution of the product supply of companies between the local market and the external market. As a result, these distributions of product supply and unit margin obey distribution functions.

Let $G_{xs}$ and $G_m$ be the respective distribution functions of product supply and unit margin. Then, the exchange compromise function given by relation (3.12) now takes the general form given by relation (3.26).

$$V(m_L; m_E; DS; EX; S) = [G_m(m_L; m_E)]^{\theta_m}[G_{xs}(DS\,; EX)]^{\theta_Q} S^{\theta_S} \qquad (3.26)$$

We consider in the following that $G_{xs}$ is a function with constant elasticity of substitution. Thus, the collective exchange compromise function is given by relation (3.27) where the parameter $\rho_E$ translates the capabilities (ease and acceptability) of exporting more of the product when the price relative to the export of the product increases by one unity. Then, $\rho_E$ is positive.

$$V = [G_m(m_L; m_E)]^{\theta_m}\left[a_L(DS)^{(1+1/\rho_E)} + a_E(EX)^{(1+1/\rho_E)}\right]^{\theta_Q/(1+1/\rho_E)} S^{\theta_S} \qquad (3.27)$$

Faced with national requirements, the constraints and opportunities of the environment apprehended by the function of collective compromise of exchange, companies want to export more and satisfy local demand in order to achieve more total receipts. The expression of the total receipts of companies is given by the relation (3.28) where $P_L$ and $P_E$ designate respectively the price of the product on the domestic market and the price of the product for export.

$$R(DS; EX) = P_L DS + P_E EX \qquad (3.28)$$

Companies export policy consists of maximizing their total receipts while considering the requirements imposed by the nation. In other words, companies maximize their total receipts under the constraint that the level of collective compromise of exchange is at the level required by the nation, and regarding all national and international constraints and opportunities. Let $\bar{V}$ be the level of collective compromise of exchange required at the national level for the concerned good, then the program of companies exporting said product is given by the relation (3.29).

$$\begin{cases} \underset{EX,\ DS}{\text{Max}} (P_E EX + P_L DS) \\ \quad u/c \qquad V(m_L; m_E; DS; EX; S) = \bar{V} \end{cases} \qquad (3.29)$$

The first-order conditions give equation (3.30) which expresses the relative price of the good on the external market as a function of the ratio of the quantity of the product exported (EX) compared to the quantity sold on domestic market (DS). Knowing that $DS + EX = XS$, the relation (3.30) makes it possible to express the volume of exports (relation 3.31) and the volume of sales on domestic market (3.32) according to the relative price and the quantity of production.

$$\frac{P_E}{P_L} = \frac{a_E}{a_L}\left[\frac{EX}{DS}\right]^{1/\rho_E} \qquad (3.30)$$

We observe with relation (3.31) that the volume of exports increases with the relative price on the external market ($P_E/P_L$) and the total supply XS. Similarly, it is observed that the volume of domestic sales is increasing with the relative price on the domestic market ($P_L/P_E$) and the total supply XS.

$$EX = \frac{\left(\frac{a_L}{a_E}\frac{P_E}{P_L}\right)^{\rho_E}}{1+\left(\frac{a_L}{a_E}\frac{P_E}{P_L}\right)^{\rho_E}} XS \qquad (3.31)$$

$$DS = \frac{1}{1+\left(\frac{a_L}{a_E}\frac{P_E}{P_L}\right)^{\rho_E}} XS \qquad (3.32)$$

### 4. *Behavior of demand for local and imported product*

For a given good, economic agents can buy the locally produced good and/or the imported good. Thus, in the compromise function of exchange of a given good (relation 3.12): (i) the quantity to be exchanged is a combination of the local good (DD) and the imported good (IMP) and (ii) the margin unit is made up of the margin on the local product ($m_D$) and the margin on the imported product ($m_M$).

The distribution of the quantity of a product purchased between local product and imported product depends on several factors regardless of the relative price, in particular: (i) policies promoting the consumption of local product, (ii) the degree of preference of resident buyers for local products compared to imported products, (iii) the quality and physical characteristics of the local product compared to the imported product, (iv) the relative level of physical accessibility/availability of the local product compared to the imported product, (v) the legal rules, requirements and standards in force with regard to importation. All these factors shape the distribution of the demand for the product between the quantity of the local product and the quantity of the imported product independently of the relative price. As a result, it is considered that the distributions of product demand and unit margin are made according to distribution functions.

Let $H_m$ and $H_Q$ be the respective distribution functions of the unit margin and of the demand between the domestic and foreign markets. The compromise function of exchange given by relation (3.12) takes the form given by relation (3.33).

$$V(m_D; m_M; DD; IMP; S) = [H_m(m_D; m_M)]^{\theta_m}\left[H_Q(DD\,; IMP)\right]^{\theta_Q} S^{\theta_S} \qquad (3.33)$$

We suppose in the following that $H_D$ is a distribution function with constant elasticity of substitution. Thus, the compromise function is given by relation (3.34) where the parameter $\rho_M$ measures the elasticity of the ratio of the quantity of the imported product to the quantity of the local product with respect to the relative price of the local product. Thus, ρ_M measures the increase in the relative quantity of the imported product when the relative price of the local product compared to the imported product increases by 1%. Thus, $\rho_M$ is positive.

$$V = [H_m(m_D; m_M)]^{\theta_m}\left[a_D(DD)^{(1-1/\rho_M)}+a_M(IMP)^{(1-1/\rho_M)}\right]^{\theta_Q/(1-1/\rho_M)} S^{\theta_S} \qquad (3.34)$$

Thus, the arbitration between the purchase of the local good and the purchase of the imported good consists in maximizing the compromise function of exchange under the constraint of the will to spend. Let $P_D$ be the price of the local product and $P_M$ the price of the imported product. Then, the maximization program is given by the relation (3.35).

$$\begin{cases} \underset{DD,\ IMP}{\text{Max}}\ V\,(m_D,\ m_M,\ DD,\ IMP,\ S) \\ \\ P_D DD + P_M IMP + S \leq VD \end{cases} \qquad (3.35)$$

The first order conditions of this program are given by the system of equations (3.36).

$$\begin{cases} \frac{P_D}{P_M} = \frac{a_D}{a_M}\left[\frac{IMP}{DD}\right]^{\frac{1}{\rho_M}} \\ \\ P_D DD + P_M IMP = VD - S \end{cases} \qquad (3.36)$$

Knowing that $(VD - S)$ is proportional to the financial capacity R of buyers (cf. previous subsection), with $\gamma$ the proportionality coefficient, the resolution of the first order conditions gives the expressions of the respective volumes of the imported product (relation 3.37) and the local product (3.38).

$$IMP = \frac{\left(\frac{a_M}{a_D}\right)^{\rho_M}\left[\frac{P_D}{P_M}\right]^{\rho_M - 1}}{\left[1 + \left(\frac{a_M}{a_D}\right)^{\rho_M}\left[\frac{P_D}{P_M}\right]^{\rho_M - 1}\right]P_M}\gamma R \qquad (3.37)$$

$$DD = \frac{1}{\left[1 + \left(\frac{a_M}{a_D}\right)^{\rho_M}\left[\frac{P_D}{P_M}\right]^{\rho_M - 1}\right]P_D}\gamma R \qquad (3.38)$$

### 5. ***Corporate investment behavior***

In the general theory of the firm, the investment decision of companies is the result of the capital compromise process that takes place between the stakeholders (manager, shareholders, lenders) under the constraints of profitability and financing (Zerbo and Hien 2019, 2020b). Let V be the capital compromise function of the firms. Its arguments are: G, the net profit; r, the interest rate; I, the investment volume; B; the amount of the financial guarantees. Let K be the stock of capital; $\phi$, the financing supply function; $\tau$, the direct tax rate on corporate profits; $\pi$, the gross profit function of firms; $\delta$, the rate of capital depreciation. The compromise program of capital is given by relation (3.39).[3]

$$\begin{cases} \underset{G,\,r,\ I,\,B}{Max}\ V(G\ ;\ r\ ;I\ ;\ B) \\ u/c \\ \quad G \leq (1-\tau)[\pi(K) - (r+\delta)(K)] \\ \quad I \leq \phi(r; B) \\ \quad B \leq B(I) \end{cases} \qquad (3.39)$$

In this work, we adopt the specifications below for the compromise function of capital (relation 3.40), the supply function of financing (relation 3.37), the supply function of financial guarantees (relation 3.42) , the profit function (relation 3.43) which is obtained by applying relation (3.6).

$$V(G\ ;\ r\ ;I\ ;\ B) = G^{\theta_1} r^{\theta_2} I^{\theta_3} B^{\theta_4} \qquad (3.40)$$

$$\phi(r; B) = \varphi_0 r^{a_1} B^{a_2} \qquad (3.41)$$

$$B(I) = B_0 I^{\sigma_B} \qquad (3.42)$$

$$\pi(K) = \pi_0 K^{\alpha_\pi} \qquad (3.43)$$

[3] For simplicity, the sources of financing are not distinguished.

Thus, solving the program (3.39) with the above specifications allows to express the rate of investment (relative to the stock of capital) as a function of the interest rate, the rate of capital depreciation and the ratio of the gross profit relative to capital stock (π/K).[4]

$$\frac{I}{K} = \frac{\left(\frac{(\theta_3+\sigma_B\theta_4)}{\theta_1} + \frac{(1-\sigma_B a_2)\theta_2}{a_1\theta_1}\right)\left[\frac{\pi}{K} - (r+\delta)\right] - \frac{(1-\sigma_B a_2)}{a_1} r}{(r+\delta) - \alpha_\pi \frac{\pi}{K}} \qquad (3.44)$$

Relation (3.44) indicates that the investment rate depends on gross profit per unit of capital (π/K), capital profitability ($\alpha_\pi$ ), guarantee system (i.e. $1 - \sigma_B a_2$), rate of use of capital (i.e. r+δ), transaction costs on the capital market $\left(i.e.\ \frac{\theta_3+\sigma_B\theta_4}{\theta_1}\right)$.

The expression of the demand for investment (relation (3.45)) is deduced from the relation (4.44) by multiplying it by K. According to this relation (3.45), the demand for investment increases with the net profit ($\pi - (r+\delta)K$), the marginal profitability of capital ($\alpha_\pi \frac{\pi}{K}$) and transaction costs on the capital market.

$$I = \frac{\left(\frac{(\theta_3+\sigma_B\theta_4)}{\theta_1} + \frac{(1-\sigma_B a_2)\theta_2}{a_1\theta_1}\right)[\pi - (r+\delta)K] - \frac{(1-\sigma_B a_2)}{a_1} rK}{(r+\delta) - \alpha_\pi \frac{\pi}{K}} \qquad (3.45)$$

The main feature of this section on the microeconomic foundations relates to the realism of the assumptions and the major differences it presents with respect to the foundations of the neoclassical model. First, unlike the neoclassical model, there is a wage setting function that depends on labor productivity and is influenced by the relative wage bargaining power of stakeholders, the degree of information sophistication, as well as regulation in terms of remuneration. Second, the labor demand function increases with gross profit and is influenced by, among other things, the hiring and firing regulations, as well as the unions power to defend the employment of their members. Third, the price of a good is determined by the financial capacity of the buyers, the level of desirability of the good, the desire-capacity of the sellers to make the unit margin, the quantity of the supply of good and the desire-ability of buyers to save in the purchase of this good. Fourth, the functions of foreign trade are better understood: (i) the export function of a product results from the maximization of the total receipts realized on this product under the constraint of the level of collective compromise of exchange required for this product and (ii) the import function results from the maximization of the compromise function of exchange, constrained by buyers' willingness to spend. Fifth, unlike the neoclassical model, there is an investment function of firms that depends on, among other things, profit and is influenced by transaction costs and financing constraints.

Based on these new microeconomic foundations, the static non-competitive CGE model is developed in the next section.

[4] Noted that if the markets were perfect, the program (3.35) would boil down to the maximization of $G = (1-\tau)[\pi(K) - (r+\delta)K]$, then the demand for investment would be such that $\alpha_\pi \frac{\pi}{K} - (r+\delta) = 0$. However, with transaction costs linked to market imperfections, the investment demand is such that $\alpha_\pi \frac{\pi}{K} - (r+\delta) < 0$. Therefore, the denominator of the relation (3.40) is positive. For more details see Zerbo & Hien (2019).

## 4. The Non-competitive Computable General Equilibrium Model

The non-competitive computable general equilibrium model is structured in six blocks: (i) Production, wages, employment and unemployment; (ii) Income and expenditure of institutional agents, (iii) Domestic demand, (iv) Trade, (v) Prices of goods and services, (vi) Equilibrium conditions. Besides these six blocks, the last subsection proposes a model calibration approach.

### 1. *Production, wages, employment and unemployment*

The economy is subdivided into branches of activity b (=1, …, B). Each branch of activity offers goods and services and creates added value $VA_b$ by using labor and capital. To determine the optimal levels of wages and labor demand, firms in each branch of activity optimize their compromise function, under-constraint of their production capacity. In this presentation we consider that the production technology and the primary compromise function of each branch of activity are Cobb-Douglass functions (relations 4.1 and 4.2).

$$U(\pi_b\ ;\ (w/p)_b\ ;\ L_b) = \pi_b^{\delta_{1b}}(w/p)_b^{\delta_{2b}}L_b^{\delta_{3b}} \tag{4.1}$$

$$F_b(L_b;\ K_b) = A_b L_b^{\alpha_b} K_b^{\beta_b} \tag{4.2}$$

#### a. *Wage rates of branches of activity*

Based on the compromises and production functions, the wage compromise process makes it possible to determine the real wage rate (compared to the previous period) for each branch of activity according to relationship (3.5). The real wage rate ( $w_b^r$ ) is determined according to the labor productivity observed in the previous period, as expressed by the relation (4.3), where $\omega_b$ $(= \delta_{2b}/(\delta_{1b} + \delta_{2b}))$ accounts for the relative power of collective wage bargaining of employees in branch of activity b, with regard to the regulations and collective agreements in terms of labor compensation in force.

$$w_b^r = \omega_b \frac{P_{VAbt-1} VA_{bt-1}}{L_{bt-1}} \tag{4.3}$$

The nominal wage rate is set by indexing the real wage rate to the inflation rate. Thus, the nominal wage rate is given by relation (4.4), where $\varepsilon_b$ denotes the coefficient of indexation of wage rate to inflation rate i in the branch of activity.

$$W_b = w_b^r(1 + \varepsilon_b i) \tag{4.4}$$

#### b. *Production of branches of activity*

Labor demand ($LD_b$) is derived from the maximization of the primary compromise function, subject to the production capacity constraint of the branch of activity. It is given by relation (4.5) where the parameter $\eta_b = \delta_{3b}/\delta_{1b}$ and measures the degree of employment security.

$$LD_b = \left[\frac{A_b(\alpha_b + \eta_b)}{(1+\eta_b)w_b^r} K_b^{\beta_b}\right]^{1/(1-\alpha_b)} \tag{4.5}$$

The labor demand of the branch of activity being determined, the added value is given by relation (4.6) and the nominal value of the gross operating surplus is given by relation (4.7).

$$VA_b = A_b LD_b^{\alpha_b} K_b^{\beta_b} \tag{4.6}$$

$$GOSno_b = P_{VAb}VA_b - W_bLD_b \qquad (4.7)$$

The volume of intermediate consumption of a branch in product p is determined by relation (4.8) and the volume of production is given by relation (4.9).

$$CI_{bp} = a_{bp}VA_b \qquad (4.8)$$

$$XS_b = VA_b + \sum_p CI_{bp} \qquad (4.9)$$

### *c. Total employment and unemployment*

For each branch of activity, the level of employment is given by relation (4.5). Thus, total employment is equal to the sum of demand for labor in the branches of activity (relation 4.10).

$$Emtot = \sum_{b=1}^{B} LD_b \qquad (4.10)$$

The unemployment in the economy is equal to the difference between total supply of labor (LS) and total employment (relation 4.11).

$$U = LS - Emtot \qquad (4.11)$$

## 2. *Income and Expenses of Institutional Agents*

### *a. Households*

Households derive their gross income from labor compensation, from the share of gross operating surplus paid to them, and from dividends paid by companies to them. Thus, the nominal value of income of households is given by relation (4.12).

$$GY_h = \sum_{b=1}^{B} W_b\, LD_b + \sum_{b=1}^{B} \lambda_{hb} GOSno_b + DIV_m \qquad (4.12)$$

Households pay income tax ($ITR_h$), receive net transfers from the State ($TG_h$) and from the rest of the world ($TROW_h$), after which they generate disposable income (relation 4.13). The net transfers paid by the rest of the world to households is a fixed proportion ($\varphi_{hROW}$) of their income ($GY_h$).

$$YD_h = GY_h - ITR_h + TG_h + TROW_h \qquad (4.13)$$

Based on disposable income and by applying relations (3.24 and 3.25), final consumption expenditure ($DPCFT_h$) is given by relation (4.14), where $\varphi_h$ designates the average propensity to consume. This final consumption expenditure is broken down into final consumption expenditure of specific products p ($DPCF_{hp}$) given by relation (4.15). Thus, households generate savings given by relation (4.16). Household investment expenditure is considered equal to household savings (relation 4.17).

$$DPCFT_h = \varphi_h DY_h \qquad (4.14)$$

$$DPCF_{hp} = \upsilon_{hp} DPCFT_h \qquad (4.15)$$

$$S_h = (1 - \varphi_h) DY_h \qquad (4.16)$$

$$DPINV_h = S_h \qquad (4.17)$$

### b. Companies

Companies' income comes mainly from their activities. This income is made up of the gross operating surplus minus the respective shares paid to households and to the rest of the world. The nominal value of business income is by the relation (4.18).

$$Y_{ent} = \sum_{b=1}^{B}(1 - \lambda_{hb} - \lambda_{ROWb})GOSno_b \tag{4.18}$$

Companies pay taxes to government, pay dividends to households and the rest of the world, and release savings (relation 4.19). The nominal values of dividends paid to households and to the rest of the world are given by relations (4.20) and (4.21).

$$S_{ent} = Y_{ent} - DIV_h - DIV_{ROW} - ITR_{ent} \tag{4.19}$$

$$DIV_h = \phi_h Y_{ent} \tag{4.20}$$

$$DIV_{ROW} = \phi_{ROW} Y_{ent} \tag{4.21}$$

The volume of investment demand from firms in branch of activity b (relation 4.22) is determined by applying relation (3.41) where $h_{tcb}$ and $h_{fcb}$ are positive parameters depending on the level of market imperfections and financing constraints branch of activity b.

$$INV_b = \frac{(h_{tcb})[GOS_b - (r+\delta_b)K_b] - (h_{fcb})\, rK_b}{(r+\delta_b) - \alpha_{\pi b}\frac{GOS_b}{K_b}} \tag{4.22}$$

Thus, the total volume of business investment demand is equal to the sum of the volumes investment demand of the branches of activity of the economy as indicated by the relation (4.23).

$$INV_{ent} = \sum_b INV_b \tag{4.23}$$

### c. Government

Government revenue consists mainly of taxes and duties paid by the branches of activity ($ITB_b$), taxes on products ($TP_p$), duties and taxes on imports ($DTM_p$) and exports ($DTEX_p$), direct taxes paid by households ($ITR_h$) and paid by companies ($ITR_{ent}$), as indicated by relation (4.24).

$$Y_G = \sum_b ITB_b + \sum_p (TP_p + DTM_p + DTEX_p) + ITR_{ent} + ITR_h \tag{4.24}$$

Each category of taxes and duties is obtained by applying a fixed levy rate as indicated by relations (4.25) to (4.30).

$$ITB_b = txb_b P_b XS_b \tag{4.25}$$

$$TP_p = tx_p P_{htp} DT_p \tag{4.26}$$

$$DTM_p = tim_p[e.P_{WMp}.IMP_p] \tag{4.27}$$

$$DTEX_p = txe_p[e.P_{WEp}.EXP_p] \tag{4.28}$$

$$ITR_{ent} = t_{ent}.Y_{ent} \tag{4.29}$$

$$ITR_h = t_h.GY_h \tag{4.30}$$

The total amount of government expenditure is exogenous ($DPT_G$). It is mainly made up of final consumption expenditure on goods and services (G), public investment expenditure ($DPINV_G$), public debt service ($PDS_G$), and net transfers to households ($TG_h$). From its revenues and expenditures, the government generates a public deficit ($DF_G$) given by the relation (4.31) which is mainly financed by loans.

$$DF_G = -(Y_G - G - TG_h - SDP_G - DPINV_G) \quad (4.31)$$

Debt service depends on the amounts (at the beginning of the period) of domestic public debt ($DPD_G$) and external debt denominated in foreign currencies ($DROW_G$), interest rates and amortization rates of the domestic debt and the foreign debt (in foreign currencies), as well as the exchange rate e, as expressed by the relation (4.32).

$$PDS_G = (r_{iG} + \delta_{iG})DPD_G + (r_{rowG} + \delta_{rowG}).e.DROW_G \quad (4.32)$$

Final consumption expenditure, investment expenditure and transfers to households are defined respectively as fixed proportions of total government budgetary expenditure minus the amount of debt service (relationships 4.33 to 4.35).

$$G = (g_G)(DPT_G - PDS_G) \quad (4.33)$$

$$TG_h = (tg_h)(DPT_G - PDS_G) \quad (4.34)$$

$$DPINV_G = (1 - g_G - tg_h)(DPT_G - PDS_G) \quad (4.35)$$

The expenditure made by the government for the final consumption of a product p is given by the relation (4.36).

$$DPCF_{Gp} = \upsilon_{Gp}G \quad (4.36)$$

### 3. *Domestic demand*

Total domestic demand ($DT_p$) for each product p (relation 4.37) is made up of the final consumption demand from households (relation 4.38) and the government (relation 4.39), the intermediate consumption demand (relation 4.40) and the demand for investment. In these relations, $P_{ttcp}$ designates the price including tax of the product p.

$$DT_p = CF_{hp} + CF_{Gp} + CI_p + INV_p \quad (4.37)$$

$$CF_{hp} = \frac{DPCF_{hp}}{P_{ttcp}} \quad (4.38)$$

$$CF_{Gp} = \frac{DPCF_{Gp}}{P_{ttcp}} \quad (4.39)$$

$$CI_p = \sum_b CI_{pb} \quad (4.40)$$

The volume of total investment demand of the economy is equal to the sum of the investment volumes of institutional agents (relation 4.41). The respective investment volumes of households and the government are equal to the ratio between their respective investment expenditures and the price of goods and services (relationships 4.42 and 4.43). Thus, the volume of investment in product p is defined as a fixed proportion of the total investment (relation (4.44).

$$TINV = INV_{ent} + INV_h + INV_G \quad (4.41)$$

$$INV_h = \frac{DPINV_h}{P_{INV}} \quad (4.42)$$

$$INV_G = \frac{DPINV_G}{P_{INV}} \quad (4.43)$$

$$INV_p = \sigma_p TINV \quad (4.44)$$

### 4. *Trade and current account balance*

The trade of each product p is characterized by four types of functions: (i) the export function of the local product p, (ii) the domestic supply function of the local product p; (iii) the import function of product p and (iv) the domestic demand function of local product p.

By applying the relations (3.20) and (3.21), the volume of exports of the local product p is given by the relation (4.45) and the volume of the supply of the local product p on the domestic market is given by the relation (4.46 ).

$$EX_p = \frac{\left(\frac{a_{Lp}}{a_{Ep}}\frac{P_{Ep}}{P_{Lp}}\right)^{\rho_{Ep}}}{1+\left(\frac{a_{Lp}}{a_{Ep}}\frac{P_{Ep}}{P_{Lp}}\right)^{\rho_{Ep}}} XS_p \quad (4.45)$$

$$DS_p = \frac{1}{1+\left(\frac{a_{Lp}}{a_{Ep}}\frac{P_{Ep}}{P_{Lp}}\right)^{\rho_{Ep}}} XS_p \quad (4.46)$$

Applying relations (3.37) and (3.38) and knowing that the total resources available to meet the demand for goods and services is equal to the total value of the local supply of goods and services, the volume of demand for the imported product p is given by relation (4.47) and the volume of domestic demand for local product p is given by relation (4.48) where $P_j$ denotes the producer price of product j.

$$IMP_p = \frac{\left(\frac{a_{Mp}}{a_{Dp}}\right)^{\rho_{Mp}}\left[\frac{P_{Dp}}{P_{Mp}}\right]^{\rho_{Mp}-1}\gamma_p \sum_j P_j XS_j}{\left[1+\left(\frac{a_{Mp}}{a_{Dp}}\right)^{\rho_{Mp}}\left[\frac{P_{Dp}}{P_{Mp}}\right]^{\rho_{Mp}-1}\right]P_{Mp}} \quad (4.47)$$

$$DD_p = \frac{\gamma_p \sum_j P_j XS_j}{\left[1+\left(\frac{a_{Mp}}{a_{Dp}}\right)^{\rho_{Mp}}\left[\frac{P_{Dp}}{P_{Mp}}\right]^{\rho_{Mp}-1}\right]P_{Dp}} \quad (4.48)$$

The current account balance (CAB) is equal to export earnings minus the amount of imports, plus net transfers received from the rest of the world as indicated by the relationship (4.49).

$$CAB = e\sum_p P_{WEp}EX_p - e\sum_p P_{WMp}IMP_p + TROW_m + TROW_G + TNROW_{ent} \quad (4.49)$$

### 5. *Prices of goods and services*

The price inclusive of all taxes of the product p ($P_{ttcp}$) is calculated by applying the relation (3.21) which indicates that the price is proportional to the ratio between all the potential resources available for the purchase of the product p and the volume of the product p (relation (4.50)). Knowing that $XS_p - EX_p = DS_p$ and that $DS_p = DD_p$, the calculation of the expression (4.50) using the relations (4.47) and (4.48) gives the price including tax of the product p according to the price of the local product and that of the imported product as indicated by the relation (4.51).

$$P_{ttcp} = \gamma_p \frac{\sum_j P_j XS_j}{XS_p + IMP_p - EX_p} \quad (4.50)$$

$$P_{ttcp} = \frac{\left[1 + \left(\frac{a_{Mp}}{a_{Dp}}\right)^{\rho_{Mp}} \left[\frac{P_{Dp}}{P_{Mp}}\right]^{\rho_{Mp}-1}\right] P_{Dp}}{\left[1 + \left(\frac{a_{Mp}}{a_{Dp}} \frac{P_{Dp}}{P_{Mp}}\right)^{\rho_{Mp}}\right]} \quad (4.51)$$

The producer price of product p is equal to the weighted average of the local price ($P_{Lp}$) and the export price of product p ($P_{Ep}$) (relation 4.52). Thus, we obtain the relation (4.53) which expresses the producer price of product p as a function of the export price and the local price.

$$P_p = \frac{P_{Lp} DS_p + P_{Ep} EX_p}{XS_p} \quad (4.52)$$

$$P_p = \frac{\left[1 + \left(\frac{a_{Lp}}{a_{Ep}}\right)^{\rho_{Ep}} \left(\frac{P_{Ep}}{P_{Lp}}\right)^{\rho_{Ep}+1}\right] P_{Lp}}{1 + \left(\frac{a_{Lp}}{a_{Ep}} \frac{P_{Ep}}{P_{Lp}}\right)^{\rho_{Ep}}} \quad (4.53)$$

The domestic price $P_{Dp}$ of the local product including indirect taxes is equal to the domestic price excluding taxes $P_{Lp}$ of the local product on the domestic market multiplied by 1 plus the rate of indirect taxation on the product p (relation (4.54)).

$$P_{Dp} = (1 + t_{xp}) P_{Lp} \quad (4.54)$$

By applying relation (3.14), the price excluding taxes of the imported product ($P_{htMp}$) is equal to the unit cost of the imported product ($Cu_{Mp}$) multiplied by 1 plus the mark-up rate (relation 4.55). The unit cost of the imported product p is equal to its foreign price (in foreign currency) multiplied by the exchange rate (e) and by 1 plus the rate of customs duties on imports ($tim_p$) of the product p as indicated by the relationship (4.56). Thus, the price including tax of the imported product ($P_{Mp}$) is given by relation (4.57). Thus, the mark-up rate on the imported product is calculated based on the reference period

$$P_{htMp} = (1 + Tm_{Mp}) Cu_{Mp} \quad (4.55)$$

$$Cu_{Mp} = (1 + tim_p) e P_{WMp} \quad (4.56)$$

$$P_{Mp} = (1 + t_{xp}) P_{htMp} \quad (4.57)$$

The price of the exported product ($P_{Ep}$) is equal to the foreign price of the exported product multiplied by the exchange rate (e), divided by 1 plus the tax rate on the exported product (relation 4.58).

$$P_{Ep} = \frac{e P_{WEp}}{(1 + txe_p)} \quad (4.58)$$

The price of added value by branch is equal to the difference between the nominal values of production and intermediate consumption of the branch, divided by the added value of the branch (relation 4.59).

$$P_{VAb} = \frac{P_b XS_b - P_{CIb} CI_b}{VA_b} \quad (4.59)$$

The price of intermediate consumption of a branch of activity is equal to the weighted average price of intermediate consumption of the branch (relation 4.60) where $c_{bp}$ is the proportion of product p in the total of intermediate consumption of branch of activity b. The price of the output of industry b is given by relation (4.61) where $b_{bp}$ is the proportion of product p in the output of industry b.

$$P_{CIb} = \sum_p c_{bp} P_{ttcp} \qquad (4.60)$$

$$P_b = \sum_p b_{bp} P_p \qquad (4.61)$$

The GDP deflator is equal to the weighted average price of the added values of the branches of activity (relation 4.62); the price of the investment is equal to the weighted average of the prices of the products used for investment (4.63); the general price level is equal to the weighted average of product prices (relation 4.64).

$$PINDEX = \sum_b \frac{VA_b}{\sum_b VA_b} P_{VAb} \qquad (4.62)$$

$$P_{INV} = \sum_p \sigma_p P_{ttcp} \qquad (4.63)$$

$$P_{ttc} = \sum_p \frac{DD_p + IMP_p}{\sum_j (DD_j + IMP_j)} P_{ttcp} \qquad (4.64)$$

### 6. *Equilibrium conditions*

On the market for goods and services, we have the following equilibria: (i) the supply of each local product on the national market is equal to the demand for the local product on the national market (relation 4.65), (ii), the real value of total resources is equal to the real value of total uses (relation 4.66).

$$DS_p = DD_p \qquad (4.65)$$

$$XS_p + IMP_p = EX_p + CF_p + CI_p + INV_p \qquad (4.66)$$

$$K_b \leq KS_b \qquad (4.67)$$

The equilibrium conditions (4.65) make it possible to determine the producer price of each local product p, as well as the level of capital employed by each branch of activity b.

The equilibrium conditions (4.66) make it possible to determine the level of capital $K_b$ actually employed by each branch of activity; this level of capital is then compared to the total available capital stock $KS_b$. If the $K_b$ obtained through solving the equilibrium conditions equations is such that $K_b \leq KS_b$, then the level of capital employed is equal to the found value $K_b$. Conversely, if the $K_b$ obtained through solving the equilibrium conditions equations is such that $K_b > KS_b$, then the level of capital employed is equal to the total value of the capital stock $KS_b$; i.e. the constraint (4.67) is saturated and the concerned branch of activity is in a situation of full employment of its physical production capacities. If $K_b > KS_b$; there is strong pressure on the prices of the concerned branch of activity.

On the capital market, we have: (i) the financing need of companies, namely $INV_{ent} - S_{ent}$ is equal to foreign direct investment (FDI) which corresponds to transfers paid by the rest of the world to companies (relation (4.68)).

$$INV_{ent} - S_{ent} = FDI = TROW_{ent} \qquad (4.68)$$

The public deficit is financed by external borrowing; thus, the public deficit is equal to the net transfers paid by the rest of the world to the government (relation 4.69).

$$DF_G = TROW_G \quad (4.69)$$

## 7. *Calibration of non-competitive CGE model*

The calibration of the model parameters is made from the data of the base year t. These parameters are calibrated to obtain the values of the base year aggregates. Table 4.1 proposes calibration formulas for each parameter of the model. The index t indicating the period is mentioned only when necessary.

Table 4.1: Calibration of non-competitive CGEM

| Param. | Label | Calibration | Observations |
|---|---|---|---|
| $\omega_b$ | Coefficient of relative wage bargaining power of employees in branch of activity b | $\frac{L_b W_b}{VA_b}$ | |
| $\varepsilon_b$ | Indexation coefficient of the salary to the inflation rate of the branch of activity b | $\frac{(L_{bt-1}W_{bt} - \omega_b VA_{bt-1})}{i_{t-1}\omega_b VA_{bt-1}}$ | |
| $\eta_b$ | Coefficient of job security level of industry b | $(1-\alpha_b)\frac{L_b W_b}{GOS_b} - \alpha_b$ | |
| $\alpha_b$ | Elasticity coefficient of the labor factor of the branch of activity b | $\frac{\ln(VA_{bt}/A_b) - \frac{\ln(VA_{bt-1}/A_b)}{\ln(K_{bt-1})}\ln(K_{bt})}{\ln(L_{bt}) - \frac{\ln(L_{bt-1})}{\ln(K_{bt-1})}\ln(K_{bt})}$ | An econometric regression would be better. |
| $\beta_b$ | Capital elasticity coefficient of the branch b | $\frac{\ln(VA_{bt}/A_b)}{\ln(K_{bt})} - \alpha_b \frac{\ln(L_{bt})}{\ln(K_{bt})}$ | |
| $A_b$ | Production technology scale parameter of branch b | $A_b$ is such as $\frac{1}{2}(\alpha_b + \beta_b) = \frac{\Delta\ln(VA_b)}{\Delta\ln(K_b)+\Delta\ln(L_b)}$ | |
| $a_{bp}$ | Leontief coefficient of intermediate consumption of branch b in product p | $\frac{CI_{bp}}{VA_b}$ | |
| $\varphi_h$ | Average household propensity to consume | $\frac{CF_h}{DY_h}$ | |
| $\vartheta_{hp}$ | Proportion of product p in final household consumption | $\frac{CF_{hp}}{CF_h}$ | |
| $\phi_h$ | Proportion of dividends paid to households in business income | $\frac{DIV_h}{Y_{ent}}$ | |
| $\phi_{ROW}$ | Proportion of dividends paid to the rest of the world in business income | $\frac{DIV_{ROW}}{Y_{ent}}$ | |
| $\lambda_{hb}$ | Proportion of the GOS of branch of activity b paid to households | $\frac{GOS\ of\ branch\ b\ paid\ to\ households}{GOS_b}$ | |
| $\lambda_{ROWb}$ | Proportion of the GOS of branch of activity b paid to the rest of the world | $\frac{GOS\ of\ b\ paidto\ the\ rest\ of\ world}{GOS_b}$ | |
| $txb_b$ | Tax rate on branch b activities | $\frac{ITB_b}{P_b XS_b}$ | |
| $tx_p$ | Indirect tax rate of the product p | $\frac{TP_p}{P_{htp}DT_{pt}}$ | |
| $tim_p$ | Rates of customs duties and taxes on imports of the product p | $\frac{DTM_p}{eP_{WMp}IMP_p}$ | |
| $txe_p$ | Tax rates on exports of product p | $\frac{DTEX_p}{eP_{WEp}EXP_p}$ | |
| $t_h$ | Direct tax rate on household income | $\frac{ITR_h}{GY_h}$ | |

| Param. | Label | Calibration | Observations |
|---|---|---|---|
| $t_{ent}$ | Direct tax rate on business income | $\frac{ITR_{ent}}{Y_{ent}}$ | |
| $tg_h$ | Share of public expenditure intended for transfers to households | $\frac{TG_h}{G}$ | |
| $Tm_{Mp}$ | Margin rate on the imported product p | $\frac{P_{htMp}}{(1+tim_p)eP_{WMp}} - 1$ | |
| $\sigma_p$ | Proportion of product p in total investment | $\frac{INV_p}{TINV}$ | |
| $\rho_{Ep}$ | Coefficient of exchange compromise function related to export of product p | $\frac{\Delta\ln(EX_p/DS_p)}{\Delta\ln(P_{Ep}/P_{Lp})}$ | An econometric regression would be better |
| $\frac{a_{Lp}}{a_{Ep}}$ | Ratio of the coefficients of the exchange compromise function related to export of product p | $\frac{P_{Lp}}{P_{Ep}}\left[\frac{EX_p}{DS_p}\right]^{1/\rho_{Ep}}$ | |
| $\rho_{Mp}$ | Coefficient of exchange compromise function related to import of product p | $\frac{\Delta\ln(IMP/DD)}{\Delta\ln(P_D/P_M)}$ | An econometric regression would be better |
| $\frac{a_{Mp}}{a_{Dp}}$ | Ratio of the coefficients of the exchange compromise function related to import of product p | $\frac{P_{Mp}}{P_{Dp}}\left[\frac{IMP_p}{DD_p}\right]^{\frac{1}{\rho_{Mp}}}$ | |
| $\gamma_p$ | Proportionality coefficient between the price of product p and the financial capacity/supply ratio of product p | $\frac{XS_p + IMP_p - EX_p}{\sum_j P_j XS_j} P_{ttcp}$ | |
| $\alpha_{\pi b}$ | Capital profitability coefficient of branch b | $\frac{\Delta\ln(GOS_b)}{\Delta\ln(K_b)}$ | An econometric regression would be better |
| $h_{tcb}$ | Coefficient relating to transaction costs on the capital market of branch b | $\frac{\left(r_t + \delta_b - \alpha_{\pi b}\frac{GOS_{bt}}{K_{bt}}\right)INV_{bt} - \left(r_{t-1} + \delta_b - \alpha_{\pi b}\frac{GOS_{bt-1}}{K_{bt-1}}\right)\frac{INV_{bt-1}}{r_{t-1}K_{bt-1}}}{GOS_{bt} - (r_t + \delta_b)K_{bt} - \frac{GOS_{bt-1} - (r_{t-1} + \delta_b)K_{bt-1}}{r_{t-1}K_{bt-1}}}$ | |
| $h_{fcb}$ | Coefficient relating to financing constraints on the capital market of branch b | $\frac{h_{tcb}[GOS_{bt} - (r_t + \delta_b)K_{bt}] - \left(r_t + \delta_b - \alpha_{\pi b}\frac{GOS_{bt}}{K_{bt}}\right)INV_{bt}}{r_t K_{bt}}$ | |

## Conclusion

This paper aimed to develop a non-competitive computable general equilibrium model with microeconomic foundations as clear as the Walrasian computable general equilibrium model. Thus, drawn essentially from the General Theory of the Firm, the microeconomic foundations have been developed for different aspects of the non-competitive CGE model, namely: (i) production and labor demand of companies, (ii) wage setting, (iii) exchange and market price formation of goods and services, (iv) export behavior, (v) import demand for goods and services, (v) investment demand of companies. These microeconomic foundations bring major positive changes in computable general equilibrium modeling.

First, these microeconomic foundations make it possible to consider market imperfections in computable general equilibrium modeling without opting for a specific theoretical framework of imperfections (monopoly, duopoly, oligopoly, etc.). Indeed, the characteristics and the level of the imperfections are directly translated into the parameters of the behavior functions of the agents resulting from the compromise process and, thus, the results of the simulations are no longer influenced by the choice of the modeler about the model of imperfections integrated into the CGE model. Thus, regarding the labor market, the degree of information imperfection, as well as the rules and procedures for hiring, firing and compensation are considered in the functions of labor demand and wages. Also, the degree of wage rigidity does not depend on the choice of the modeler; it depends on the variability of labor productivity, relative wage bargaining power of unions and wage regulations.

Secondly, employment is a result of the CGE model in the same way as economic growth for example, and not an input of the model. Thus, unemployment does not result from the choice of the modeler to force or not the existence of unemployment through the introduction of specific unemployment equations in the model. Unemployment is notably the consequence of a relatively low level of activity, which can result from several factors. Also, the level of use of the capital stock is endogenous. So, economy can be in a situation of underemployment or full employment of physical production capacities depending on the level of aggregate demand.

Third, the behavior of economic agents in terms of foreign trade is now better understood and, thus, the calibration of the parameters of the import and export functions is no longer an arbitrary matter. Indeed, the export function of a product stems from the maximization of the companies' total receipts under constraint of the level of exchange compromise required by the national community for the said product. The import function of a product results from the maximization of the exchange compromise function constrained by the willingness of buyers to spend on this product. Therefore, the parameters of the import function of each good depend on : (i) policies promoting the consumption of local product, (ii) degree of preference of residents for imported products compared to local products, (iii) quality and physical characteristics of the imported product compared to the local product, (iv) level of physical accessibility/availability of the imported product compared to the local product, (v) the legal rules, requirements and standards in force with regard to importation. The parameters of the export function of each good depend on the opportunities and capacities of the compagnies, local and external requirements, and constraints on the external market.

Fourth, the demand for investment function of each branch of activity is determined based on microeconomic foundations. It considers, among other things, the imperfections on the markets and the financing constraints of the branch of activity. Therefore, the demand for investment of the non-competitive CGE model depends on the economic performance, financing constraints and transaction costs of each branch of activity.

Fifthly, the price of a product is not only the result of the supply and demand confrontation, it also depends on the level of desirability of the product, the respective desire-capacity (capability) of the producers to make the margin and of the buyers to save on the purchase of the product, as well as the relative preference of buyers for this product compared to other products. The price of a product is therefore proportional to the ratio between the financial capacity of buyers and the volume of product supply. Thus, the degree of price flexibility or rigidity depends on the variability (i) of the ratio of demand and supply, (ii) of the level of desirability of the product, (iii) of the respective capacities of the producers to make the unit margin and of the buyers to save on the purchase of the product.

Thus, the present non-competitive CGE model is more suitable for identifying the effects of economic policies, particularly on the labor market, employment, labor income, investment, economic growth and foreign trade, as well as on prices. However, the static nature of the non-competitive CGE model does not make it possible to understand all the medium-term effects of public policies and shocks. Therefore, in addition to the implementation of this static non-competitive CGE model, it would be relevant to develop a dynamic non-competitive CGE by referring to the present static non-competitive computable general equilibrium model.

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