Would a real depreciation of the euro improve the French economy?

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Abstract

In this paper, we use a Micro-Macro model to evaluate the effects of a real depreciation of the euro on the French economy, both at the macro and micro level. Our Micro-Macro model consists of a Microsimulation model and a CGE model which are integrated using an iterative (or sequential) approach. We find that a 10% real depreciation of the euro stimulates the aggregate demand by increasing exports and reducing imports, which increases real GDP by 0.7% and reduces the unemployment rate in the economy by 2 pp. At the individual level, we find that the macroeconomic shock reduces poverty and, to a lesser extent, income inequality. In particular, the decrease in the equilibrium real wage, determined in the macro model, slightly reduces the available income for people who have already a job, while the reduction in the level of unemployment permits to some individuals to find a job, substantially increasing their income and, in many cases, bringing them out of poverty.

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Highlights

- ▷ We evaluate the effects of a real depreciation of the euro on the French economy.
- ▷ We use a Micro-Macro simulation model combining a Microsimulation and a CGE model.
- ▷ Euro's depreciation stimulates real GDP and reduces unemployment.
- ▷ Euro's depreciation reduces income inequalities and poverty.

Keywords: Exchange rates; Microsimulation; CGE models.

JEL Classification: F40; C63; C68.

1 Introduction

Using a Behavioral Equilibrium Exchange Rate approach on the period 1980-2010, Coudert *et al.* (2013) analyze, among others, real exchange rate misalignments for euro area countries and find that Greece, Ireland, Italy, Portugal, Spain and even France have suffered from increasingly overvalued exchange rates since the mid-2000s. The euro has been criticized given the impossibility for these countries to devaluate their exchange rates in order to improve their international competitiveness. For instance, Paul Krugman advocates on his blog the use of an external devaluation for the Eurozone. Indeed real exchange rate devaluations have long been proposed as a desirable policy response to macroeconomic shocks that improve a country's competitiveness.

The aim of this paper is to analyze the economic consequences for the French economy[1] of a real depreciation of the euro against other currencies. Even if it is evident that a relative price should be determined in general equilibrium, in our paper the real exchange rate is treated as a policy variable, as in Rodrik (2008) among others. Indeed, a real exchange depreciation could be reproduced by a large combination of fiscal policies, such as fiscal devaluation policies[2] which have recently been implemented by France in 2012 and, previously, by Denmark in 1988, Sweden in 1993, and Germany in 2006.

These "beggar-my-neighbor" policies have been implemented by now by single countries in a non-cooperative game. Beside these policies, we propose to investigate what could be the impact of a common shock on a particular country in the Eurozone. We show that despite the intuition related to the fact that for each EU country the majority of international trade is with other EU members, such a shock could have sensitive impacts on euro members economies without modifying the relative prices inside the Eurozone. We consider a real depreciation shock which is modeled like a structural shock in the rest of the world, namely a fiscal or a productivity shock which is exogenous for the Eurozone. Thus, in our paper we quantify the economic consequences that would be produced if a structural real depreciation of the euro occurs. In particular, we focus on the impact of a real depreciation of the euro (i) on macroeconomic variables such as GDP, current account, employment and real wages, the relative competitiveness of domestic firms, and

[1] The French case is particularly interesting since starting from 2005 the current account displayed important deficits.

[2] For a formal analysis of fiscal devaluations, see Farhi *et al.* (2013).

the purchasing power of households, (ii) on sectoral production and on the allocation of production factors across tradable and non-tradable sectors, and (iii) on individual choices and, consequently, on income distribution, inequality and poverty. In particular, our model allows us to investigate how inequalities, both in terms of consumption and incomes, change and to determine who win and loose from a real currency devaluation.

Focusing on redistributive aspects among sectors and among households is particularly relevant because real currency devaluation is by definition an asymmetric shock which affects the relative prices between monetary zones but also between sectors. Concerning the economic consequences at the sectoral level, Gourinchas (1999) states that a variation in the real exchange rate provokes a reallocation of production factors across tradable and non-tradable sectors. Campa and Goldberg (2001) analyze the effects of exchange rate movements on employment and wages for manufacturing industries in the US. They find that for lower markup industries, the effect of a variation of the exchange rate on wages and employment is larger than for higher markup industries. In addition, the size of the real wage elasticities is larger as industries increase their export orientation and smaller as industries rely more heavily on imported inputs. International evidence on the effects of exchange rates on labor markets is provided among others by Burgess and Knetter (1998) who focus on the G7 countries. They confirm differences among industries in employment elasticities with respect to exchange rates, but also across countries.

Beyond the traditional sectoral redistribution, we analyze the impact of real depreciation on income inequalities using an integrated Micro-Macro simulation approach. The integration between microsimulation models and general equilibrium models appears very appealing since, on one side, the drawback of microsimulation models is that the analysis is carried out in a partial equilibrium framework (i.e. the effects on the individual behavior are computed without taking into account for the general equilibrium effects that the change in individual behavior determines at the macro level) and, on the other side, the drawback of general equilibrium models is that they are mainly based on the representative agent paradigm. The integration of these two types of models allows to avoid the previous shortcomings: the individual effects are computed by taking into account for the general equilibrium effects and the macro effects are computed by taking into account for the individual heterogeneity at a very detailed level.

Different procedures are used in the literature to integrate microsimulation and general equilibrium models:[3] (i) The fully integrated approach consists to introduce in the CGE model all the individuals of the micro-data set (Cockburn, 2004). The problem of this approach may be related to the size of the model. (ii) The top-down approach (see for example Bourguignon *et al.*, 2008) consists in transmitting the variations of macro variables computed in the CGE model into the microsimulation model. The problem of this approach is that there is no feedback from the microsimulation model back to the macro CGE model. (iii) The iterative (or sequential) approach, that is used in this paper, consists to transmit the variations of macro variables computed in the CGE model into the microsimulation model and to transmit the variations concerning the individual behavior computed in the microsimulation model into the CGE model, until the fixed point is reached (see for example Savard, 2003). (iv) Another approach consists in using in the macro model several representative agents who aggregate the preferences of individuals who have to make discrete choices (Magnani and Mercenier, 2009).

Our Micro-Macro model, focused on the French economy, consists of a Microsimulation model that includes an arithmetical model for the French fiscal system and two behavioral models used to simulate the individual consumption behavior and the individual labor supply discrete choices, and of a multisectoral and static[4] CGE model with two foreign zones (the Eurozone and the rest of the world). The integration of the two models is made using an iterative (or sequential) approach.

It is important to highlight that the effects of a real currency depreciation, and more generally of any shock, strongly depend on the closure rule used in the macro model.[5] Real devaluation improves the external financial position by increasing exports and reducing imports. In a neoclassical framework in which investments are savings-driven, the effect on real GDP is negligible (the only effects are due to the reallocation of factors across sectors) since (i) the production at the macro level depends on the supply of labor and capital that are supposed to be fully employed and (ii) the increase in one of the components of the aggregate demand is compensated by a strong

[3]For a review concerning the integration of microsimulation and CGE models, see Vaqar and O' Donoghue (2007).

[4]We focus then on a structural shock and do not consider the dynamic effect of a nominal shock in the presence of rigidities. We depart from the dynamic responses of conjunctural nominal exchange rates fluctuations to analyze the long term impact of a structural shock on international world prices.

[5]For a review of the macro closure rules see Löfgren *et al.* (2001), Rattso (1982) and Taylor and Lysy (1979).

reduction in investments and in consumption (Hall, 2009). Thus, real devaluation can stimulate real GDP only if the hypothesis of full-employment of production factors is removed. There are different ways to consider involuntary unemployment. In particular, involuntary unemployment can be explained by the rigidity of wages (or by the presence of a wage bargaining mechanism) or by the weakness of the aggregate demand, according to the keynesian view. In the first case, currency devaluation, which produces a reduction in the demand for imported intermediate goods and then in the marginal productivity of labor, increases the level of unemployment. In the second case, currency devaluation, which stimulates net exports and then the aggregate demand, reduces the level of unemployment. Given that the empirical analysis supports the idea that currency devaluation positively affects the current account and stimulates production, we believe that the keynesian closure is more appropriate than the neoclassical one.[6] However, the keynesian closure rule used in previous works appears extreme since investments are not allowed to react to the shock. In fact, as we show with a sensitivity analysis, the use of the keynesian closure rule induces an extremely positive reaction of the unemployment rate to a real currency devaluation. This is why we chose to modify the approach of Álvarez-Martínez and Polo (2012) by introducing in our CGE model an investment function, estimated on French data, which takes into account for the crowding-out effect on investments produced by a change in the components of the aggregate demand. The introduction of the investment function allows us to build a model which is between the neoclassical and the keynesian ones.

Our main results show that a real depreciation of the euro stimulates the aggregate demand by increasing exports and reducing imports. In particular, using our Micro-Macro model calibrated to the French economy, we find that a 10% euro's devaluation stimulates real GDP (+0.7%) and reduces unemployment (-2 pp). We also find that the real depreciation of the euro induces significant effects at the sectoral level and we observe an important heterogeneity of reactions in terms of employment and production. With the exception of the construction sector, we find an increase in the level of employment for all sectors. The production of tradable sectors is

[6]Rosensweig and Taylor (1990) used a CGE model with a keynesian closure to simulate the effect of currency devaluation in Thailand. They find that a 10% devaluation could increase real GDP by 3.3%. More recently, Álvarez-Martínez and Polo (2012) simulate different external shocks affecting the aggregate demand (among which the reduction of exports) by using a neoclassical closure in which investments are savings-driven and a keynesian closure in which investments are fixed at a given value and the unemployment rate is endogenous. They conclude that using a neoclassical closure the model produces unrealistic changes in the level of investments, while using a keynesian closure the results in terms of GDP and unemployment are closed to empirical data recently observed.

stimulated while only the construction sector is affected by a dramatically job destruction due to the strong fall in investments.[7] At the individual level, given the reduction in the unemployment rate determined at the macro level, some unemployed people find a job and, given the change in real wage and consumption prices determined at the macro level, the individual choices concerning labor supply and consumption demand are affected. We find a significant reduction of poverty and a slight reduction of income inequality. In particular, the decrease in the equilibrium wage determined in the macro model moderately reduces the available income for people who already have a job, while the more conspicuous reduction in unemployment permits to some individuals to find a job, substantially increasing their income.

The paper is organized as follows. In the next section we describe the main characteristics of our Micro-Macro model. Section 3 presents the results of our simulation, while Section 4 presents two sensitivity analyses. The last section concludes.

2 The Micro-Macro model

In this section, we first present our Microsimulation model, which includes an arithmetical model for the French fiscal. Then we present our multisectoral CGE model. Finally, we discuss the procedure used to integrate the two models.

[7] Note that this negative effect is coherent with the evolution of the construction sector in the early years of the introduction of the euro. In fact, between 1999 and 2005, the size of the construction sector has significantly increased in the Eurozone. In particular, in this period, the contribution of the construction sector to the total value added has increased by 11% in the Eurozone and, more specifically, by 13% in France, by 39% in Ireland, by 18% in Italy, and by 72% in Spain. In contrast, it has decreased by 27% in Germany. One interpretation of the observed change in the size of the construction sector could be that the introduction of the euro has represented a currency appreciation for most of the Eurozone countries, excepted for Germany where the introduction of the euro has represented a currency devaluation.

2.1 The SYSIFF 2006 behavioral microsimulation model

SYSIFF 2006 (*Système d'Imposition Fiscale Français*) is an arithmetical microsimulation model for the French fiscal system integrated with two behavioral models concerning consumption and labor supply decisions. It is a microsimulation model since it is based on micro data on a sample of families representative of the French population. The arithmetical part of the model simulates, for each of these families, social contributions, income taxes, VAT, local taxes and social benefits due or to be received by the state. The behavioral part includes two different microeconometric estimations: a quadratic almost ideal demand system for consumption decisions and a discrete-choice labor supply model with involuntary unemployment.

The SYSIFF 2006 model includes a VBA macro that is the heart of the whole Micro-Macro model. The Micro-Macro model is composed by separate independent modules: the arithmetical microsimulation model, the dataset, the consumption module, the labor supply module and the CGE macro model. The VBA macro links all the modules together allowing for the complete micro-macro integration. It is responsible of loading the micro data into SYSIFF 2006, to read the results of the arithmetical microsimulation model and pass them to the labor supply and then consumption modules, that in turns provides the respective behavioral reactions that are passed, together with arithmetic variations, to the CGE that computes macroeconomic variations, that are passed to the arithmetic model, and so on until the variations of all relevant variables are sufficiently stable. In other words, iterations stop when variations of variations are below a certain convergence criterion.

2.1.1 The arithmetical model

The arithmetical model is a collection of algorithms and parameters that allow to compute for each family the amount of social contributions, income taxes, local taxes, and social benefits for a given fiscal system.[8] The micro data set used in our paper is the *Budget de Familles 2006* (from now on BDF2006) by Insee, chosen in virtue of the fact that it is the unique dataset available in France with sufficient information to fulfill all the needs of such a complex fiscal system as the French

[8] A list of fiscal instrument modeled in SYSIFF 2006 is reported in **Table 1**.

one, together with data on family expenditure and labor supply of households members.[9] Given this dataset, the natural choice for the reference fiscal system is the French 2006 one. SYSIFF 2006 allows to simulate all possible reforms, and allows to use any scenario as the baseline for comparisons.

When simulating a scenario, SYSIFF 2006 works with one household at a time, i.e. it computes the value of all the fiscal instruments of that scenario for just one household. The VBA macro is responsible to load, one by one, all the households into SYSIFF 2006 and to save the results in a separate file. The most important result is the total available income after taxes and benefits since variations in the available income affect both the consumption and the labor supply behaviors. Other information that must be included among the results, in order to be passed to the CGE module, are the amounts of social contributions (employer and employee), income taxes, and benefits paid and received by each household.

2.1.2 The consumption module

The estimation of consumption demand is based on the Almost Ideal Demand System proposed by Deaton and Muellbauer (1980) and extended by Banks *et al.* (1997) with the introduction a quadratic income term in the demand functions that fulfill the necessity of having a higher rank demand system (useful when Engel curves are non-linear). Along with the quadratic extension, we also introduce demographic heterogeneity through an income translating function, firstly introduced by Gorman (1976). To comply with homogeneity properties required by consumption theory, i.e. to respect linear homogeneity and Slutsky symmetry, the demand system is subject to a set of *a-priori* restrictions on the parameters. The system of demand equations is estimated simultaneously by Full Information Maximum Likelihood, and a generalized Heckman correction for zero expenditures (Shonkwiler and Yen, 1999) is applied.

The demand of good i, in terms of budget share w_i, is specified as follows:

$$w_i = \alpha_i + t_i(\mathbf{d}) + \sum_j \gamma_{ij} \ln p_j + \beta_i \left(\ln y^* - \ln a(\mathbf{p})\right) + \frac{\lambda_i}{b(\mathbf{p})} \left(\ln y^* - \ln a(\mathbf{p})\right)^2 ,$$

[9] This feature is fundamental for the estimation of the demand system and labor supply functions necessary to integrate micro-level behavioral responses.

with

$$
\begin{aligned}
t_i(\mathbf{d}) &= \sum_r \tau_{ir} \ln d_r \\
\ln y^* &= \ln y - \sum_i t_i(\mathbf{d}) \ln p_i \\
\ln a(\mathbf{p}) &= \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \\
\ln b(\mathbf{p}) &= \sum_i \beta_i \ln p_i.
\end{aligned}
$$

Where $\mathbf{d}$ is the vector of demographic characteristics, $\mathbf{p}$ is the vector of prices, and y is total expenditure in consumption. The preference parameters to be estimated are α_i, β_i, γ_{ij}, λ_i and τ_{ir}. To respect linear homogeneity and Slutsky symmetry the following restrictions must hold:

$$
\sum_i \alpha_i = 1; \sum_i \beta_i = 0; \sum_i \lambda_i = 0; \sum_i \gamma_{ij} = 0 \ \forall j; \sum_j \gamma_{ij} = 0 \ \forall i; \gamma_{ij} = \gamma_{ji} \ \forall i, j; \sum_i \tau_{ir} = 0 \ \forall r.
$$

The dataset used for the estimation is BDF2006. After eliminating a few outliers, families with negative expenditures or negative total expenditure, the sub-sample consists of 10125 families, which is more than 99% of the original sample. To be consistent with the CGE model, consumption goods are aggregated into 11 categories: food, drinks, tobacco, clothing, housing, health care, transport/energy, communication, leisure, food out of home, and other goods. The demographic characteristics included are household size, number of children with less than 3 years, number of children aged between 3 and 6, living in a city with more than 100 thousands inhabitants, age of the household head, if household head is married, if the household head is self-employed and if the household head is a manager.

The estimation results, reported in **Table 2** in the Appendix, show that most parameters of the demand system are significantly different from zero and with expected signs. In addition, self-selection bias due to zero expenditure is detected (and corrected) for almost all goods. The signs of income and uncompensated price elasticities, reported in **Table 3** in the Appendix, for the average family, are as expected and conform to consumption theory requirements. To integrate consumer reaction in the micro-macro model we use family specific elasticities rather than average elasticities. After a shock the quantities consumed by each family are computed according to income and prices variations and then sent to the CGE module for the evaluation of macro reactions and to continue iterations. This allows for a more detailed micro analysis of the behavioral response that accounts for differences in households income and characteristics.

2.1.3 The labor supply module

A standard way to estimate labor supply is to consider that individuals choose the optimal number of hours worked in order to maximize their well-being under a budget constraint. The non-linearity and non-convexity of the budget constraint, due to the characteristics of the tax system, implies the impossibility to derive an explicit solution to this standard utility maximization problem. For this reason, the best option for estimating labor supply behavior is that of discrete choice models *à la* Van Soest (1995). This approach allows to directly estimate the utility function parameters without the need of a Marshallian labor supply function. In particular, discrete choice models have the advance of capturing behavioral change in corner solution, accounting for market rigidities and avoiding the computational and analytical difficulties arising from non-linear and non-convex budget constraints, since the budget constraint is computed by the microsimulation model and introduced directly into the utility function.

The analysis of the distribution of the work alternatives has lead to the choice of four work alternatives: not to work (0 hours), 50% part-time (18 hours), 80% part-time (28 hours), and full time (36 hours). Clearly, not everybody chose one of this options, so we set-up intervals within which the assigned choice is one of the four. 0 hours is reserved to non-working people, 50% part-time is for people working less than 23 hours per week, 80% part-time is for people working 23 to 33 hours per week, and full-time work is for those working more than 33 hours per week. To avoid inconsistencies with the predicted income of the alternatives we recalculate hourly wages of each individual such that the new wage multiplied by the hours of work corresponding to the assigned choice is equal to the observed salary.

The estimates of labor supply are performed on a sub-sample of potential wage earners[10] separately for single men, single women and couples. In particular, for each single (man or woman)

[10] We exclude from the sample self-employed, retired people, individuals with less than 25 years or over 60 years.

we define a utility level for each of the four alternatives depending on individual characteristics and the yearly disposable income associated to each alternative. In contrast, for each couple, we estimate the work decision jointly by considering eight alternatives, four for the woman and two (full time work or not to work) for the man. Then, we define a utility level for each of the eight alternatives depending on families characteristics and the yearly disposable income of the family associated to each alternative. Of course, in order to compute the disposable income for the non-observed alternatives it is necessary to generate a potential salary for the unemployed. Potential salaries are estimated using a Heckman correction model (Heckman, 1979) and the estimation results are reported in **Table 4**.

With respect to the standard model proposed by Van Soest (1995), which implicitly assumes that non-working people choose not to work, we consider that unemployment may be involuntary, as in Magnac (1991), Bingley and Walker (1997), and Haan and Uhlendorff (2007). Our micro data set allow us to identify involuntary unemployed by checking if individuals perceive an unemployment benefit (*Allocation chômage*) that is given only to people who are actively searching for a job. In our sample, 19.7% of individuals do not work and 6.3% of the sample is involuntary unemployed, implying that the unemployment rate is 7.3%. Involuntary unemployment is introduced by randomly assigning (respecting the actual distribution of observed choices) a choice among the work alternatives to involuntary unemployed and estimating the discrete choice labor supply on these fictitious choices. The involuntary unemployment status is then set back according to an estimated probability of being unemployed. The probability of being unemployed has been estimated using a probit model and the predicted probabilities are used to rank individuals. The CDF of predicted probabilities of involuntary unemployment are used to set back the state of involuntary unemployment depending on the macroeconomic equilibrium level of unemployment. For instance, if a shock modifies the unemployment rate computed at the macro level, some individuals may find a job (if the unemployment rate decreases), or lose their job (if the unemployment rate increases), depending on their ranking in the CDF.

The estimation results are as expected since the probability of not being involuntary unemployed significantly increases with age and education,[11] while it decreases if the person is an

[11] We estimate this probability instead of the probability of being unemployed because we need a proper indicator to be compared with the macro unemployment rate. A lower value lowers the position in the CDF.

immigrant or if he has bad health conditions. Living in Paris has a positive but not significant impact on the probability of not being unemployed.

Preference parameters of the labor supply discrete choice model are estimated on the fictitious choice using a Multinomial Logit regression, such that individual chooses the alternative that maximizes his utility. Once the model is estimated the correct prediction is quite large, 88% for single men, 72% for single women and 53% for couples. To ensure that 100% of correct prediction is achieved, 300 extreme-value distributed stochastic terms are extracted for each choice, conditioned on the fact that the prediction corresponds to the observed choice. This error term represents the unobservable characteristics that are not explained by the model. The 300 extractions ensure the statistical properties of labor supply predictions once an exogenous shock or a reform changes the available income of the individuals.

The most relevant parameter in these estimates is the income parameter. We expect it to be positive and significant. This is so for single women and couples, while for men it is not significantly different from zero, probably due to the fact that the vast majority of single men are full time workers. **Tables 5** and **6** report the estimated parameters for singles and couples respectively.

2.2 The CGE model

The CGE model, that represents the macro component of our Micro-Macro simulation model, is a multisectoral and static model with two foreign zones: the Eurozone and the rest of the world. The model is built by using the 2006 French input-output data-set provided by Insee. The input-output table, which includes 118 sectors, is aggregated into 19 sectors, 11 of which correspond to the sectors used in the Microsimulation model concerning the consumption decisions. The construction of the SAM (*Social Accounting Matrix*), necessary to calibrate our CGE model, is completed by using national accounts concerning the government account and the balance of payments. The complete description of the model could be found in the Annex of the paper.

2.2.1 Production side

The sectors of the CGE model are indicated in **Table 7** in the Appendix. For each sector, we use a multi-stage CES production function. In the first stage, the demand of total intermediate goods Z_i, labor L_i and capital K_i is optimally chosen by each sector i in order to maximize his profit given a technological constraint represented by the following production function:

$$Y_i = \left[(\alpha_{Z,i})^{\frac{1}{\sigma_i}} \cdot Z_i^{\rho_i} + (\alpha_{L,i})^{\frac{1}{\sigma_i}} \cdot L_i^{\rho_i} + (\alpha_{K,i})^{\frac{1}{\sigma_i}} \cdot K_i^{\rho_i} \right]^{\frac{1}{\rho_i}}$$

In the second stage, each sector i chooses the repartition of the total intermediate good into different intermediate goods sold by sector j, Z_{ji}. The choice is made in order to minimize the total cost and to respect the following constraint:

$$Z_i = \left[\sum_j (\alpha_{Z_{ji}})^{\frac{1}{\sigma Z_i}} \cdot Z_{ji}^{\rho Z_i} \right]^{\frac{1}{\rho Z_i}}$$

In the third stage, each sector i chooses the repartition of the intermediate goods sold by sector j between the quantity that comes from the domestic market Z_{ji}^h and from abroad Z_{ji}^f. The repartition is made in order to minimize the total cost and to respect the following constraint:

$$Z_{ji} = \left[(\alpha_{ji}^h)^{\frac{1}{\sigma Z_{ji}}} \cdot (Z_{ji}^h)^{\rho Z_{ji}} + (\alpha_{ji}^f)^{\frac{1}{\sigma Z_{ji}}} \cdot (Z_{ji}^f)^{\rho Z_{ji}} \right]^{\frac{1}{\rho Z_{ji}}}$$

In the last stage, each sector i chooses the repartition of the intermediate goods sold by sector j that come from abroad between the quantity that comes from the Eurozone Z_{ji}^{Ez} and from the rest of the world Z_{ji}^{Row}. The repartition is made in order to minimize the total cost and to respect the following constraint:

$$Z_{ji}^f = \left[(\alpha_{ji}^{Ez})^{\frac{1}{\sigma Z_{ji}^f}} \cdot (Z_{ji}^{Ez})^{\rho Z_{ji}^f} + (\alpha_{ji}^{Row})^{\frac{1}{\sigma Z_{ji}^f}} \cdot (Z_{ji}^{Row})^{\rho Z_{ji}^f} \right]^{\frac{1}{\rho Z_{ji}^f}}$$

The optimal repartition depends on the relative price, i.e. the ratio between the price in the Eurozone P_j^{Ez} and the world price expressed in euros $P_j^{Row} \cdot \varepsilon$. In particular, (i) the exchange rate (ε) is assumed to be exogenous (while financial flows are endogenously determined in order to equilibrate the balance of payments) given that it is used to simulate the macroeconomic shock in our model. (ii) The world price of good j expressed in foreign currency (P_j^{Row}) is exogenous. (iii) The price in the Eurozone (P_j^{Ez}) is treated as endogenous since it is reasonable to assume that euro's depreciation would affect prices in the whole Eurozone. In particular, for each sector j, the price in the Eurozone P_j^{Ez} is computed as a weighted average between a domestic price in the Eurozone (which is assumed to vary in the same proportion as the domestic price in France) and the world price expressed in euros. This implies that we consider in our model a symmetric equilibrium in the sense the euro's devaluation does not affect competitiveness within the Eurozone.

A fraction of the production is sold in the domestic market and the complementary fraction is exported. Goods that are exported are supposed to be identical to those sold in the domestic market, implying that the selling price is the same. Exports, towards the Eurozone and the rest of the world, are defined by a demand function that is decreasing in the relative price, i.e. the ratio between the domestic price and the foreign price expressed in domestic currency:

$$\begin{aligned} E_i^{Ez} &= \alpha_i^{Ez} \cdot \left[\frac{P_i^{Ez}}{P_i^h}\right]^{\sigma E_i} \\ E_i^{Row} &= \alpha_i^{Row} \cdot \left[\frac{P_i^{Row} \cdot \varepsilon}{P_i^h}\right]^{\sigma E_i} \end{aligned}$$

Considering that the real devaluation of the euro represents a shock affecting the whole Eurozone, it is reasonable to presume that also real GDP in the Eurozone is affected by the shock. For this reason, the terms α_i^{Ez}, which represent a measure of the purchasing power in the Eurozone, are assumed to be endogenous and to vary in the same proportion as the French real GDP.

2.2.2 Demand side

(a) Consumption

Concerning households, we consider one representative agent who supplies labor and capital and maximizes his well-being by choosing the consumption level of different goods and services. In particular, the quantity of labor that people want to supply is determined by the Microsimulation model, while the unemployment rate can be exogenous or endogenous in the CGE model depending on the choice of the macro closure. Concerning the consumption of goods and services by the representative agent, as indicated in **Table 7**, we consider 11 "microsimulation sectors", the consumption level of which is fixed at the level determined by the Microsimulation model; and 8 "CGE sectors", the consumption level of which is determined in the CGE model.

Even if the labor supply and the consumption demand for some sectors are treated as exogenous in the CGE model, it is important to highlight that this does not mean that these variables are exogenous in our Micro-Macro model. In fact, the value of these variables is computed in the Microsimulation model by taking into account for the individual behavior. The variations determined at the individual level are then aggregated and introduced into the CGE model as an exogenous shock.

Preferences of the representative agent are modeled using a multi-stage utility function. In the first stage, the representative agent determines the level of total consumption for the "CGE goods" C^{cge} as a fraction of the total disposable income. In the second stage, he decides, for each "CGE good" i, the optimal consumption C_i^{cge}. In the third stage, he chooses the optimal repartition of the consumption demand of good i between domestic goods C_i^h and foreign goods C_i^f. In the last stage, the consumption demand of the foreign good i is divided into foreign goods coming from the Eurozone C_i^{Ez} and from the rest of the world C_i^{Row}.

(b) Investments

The second component of the aggregate demand is given by the investment. As for consumption, we use a multi-stage structure. In the first stage the aggregate investment I is allocated into different sectors I_i. Then, we determine the repartition of the investment of good i between investment coming from the domestic market I_i^h and the foreign market I_i^f. In the last stage, the investment of the foreign good i is divided into foreign investment goods coming from the Eurozone I_i^{Ez} and from the rest of the world I_i^{Row}.

(c) Government expenditure

The third component of the aggregate demand is given by the government expenditure. Here, we also use a multi-stage structure. In the first stage the total government expenditure G, that is determined in the model by assuming that the ratio with respect to real GDP remains constant, is allocated into different sectors (G_i). Then we determine the repartition of the government expenditure of good i between goods coming from domestic and foreign markets (respectively G_i^h and G_i^f). In the last stage, the government expenditure of the foreign good i is divided into foreign goods coming from the Eurozone G_i^{Ez} and from the rest of the world G_i^{Row}.

(d) Total demand

For each sector i, the total quantity demanded depends on the demand of the domestic good (that is given by the difference between the domestic production and exports) and on the demand of the foreign good. In particular, for each sector i, the total domestic demand of the domestic good X_i^h is given by the sum of domestic intermediate goods, private and public consumption and investments. For each sector i, the total imports respectively from the Eurozone M_i^{Ez} and from the rest of the world M_i^{Row} are given by the sum of intermediate goods, private and public consumption and investments imported respectively from the Eurozone and the rest of the world:

$$\begin{aligned} X_i^h &= \sum_j Z_{ij}^h + C_i^h + I_i^h + G_i^h \\ M_i^{Ez} &= \sum_j Z_{ij}^{Ez} + C_i^{Ez} + I_i^{Ez} + G_i^{Ez} \\ M_i^{Row} &= \sum_j Z_{ij}^{Row} + C_i^{Row} + I_i^{Row} + G_i^{Row} \end{aligned}$$

2.2.3 Budget constraints

(a) Household budget constraint

The gross income earned by the representative agent is given by the sum of labor and capital incomes earned in France and abroad, and of transfers from the government:

$$\begin{aligned} Y_{gross} &= w \cdot (1 - \text{cot}_{empl}) \cdot L_{Fr-Fr} \cdot (1-u) + w^{Ez} \cdot L_{Fr-Ez} \\ &+ r \cdot PI \cdot A_{Fr-Fr} + r^{Row} \cdot \varepsilon \cdot A_{Fr-Row} + \Gamma_{ms} + \Gamma \end{aligned}$$

In particular, the labor incomes earned in France depend on the endogenous domestic wage w, on the contribution rate paid by the employees cot_{empl} and the quantity of labor supplied by French people who work in France $L_{Fr-Fr} \cdot (1-u)$. The latter variable depends on the quantity of labor that people decide to supply L_{Fr-Fr} that is fixed at the level determined in the Microsimulation model, and on the unemployment rate u which can be exogenous or endogenous according to the macro closure that is chosen in the CGE model. By assuming that French people who work abroad work in the Eurozone, labor incomes earned abroad depend on the exogenous foreign wage rate w^{Ez} and the exogenous quantity of labor supplied by French people who work abroad L_{Fr-Ez}. The capital incomes earned in France depend on the endogenous domestic interest rate r and the value of assets owned by French people in France A_{Fr-Fr}, while the capital incomes earned abroad depend on the exogenous world interest rate r^{Row}, the exchange rate ε and the value of assets owned by French people in the rest of the world A_{Fr-Row}. We consider two types of transfers from the government: transfers Γ_{ms} that affect the labor incomes (and thus the labor market choices), the value of which is fixed at the level determined in the Microsimulation model, and transfers Γ that do not affect individual labor choices that are treated as exogenous.

The disposable income is computed as the difference between the gross income and taxes on labor and capital incomes:

$$Y_{disp} = Y_{gross} - Tax_{lab} - \tau_{cap} \cdot r \cdot PI \cdot A_{Fr-Fr}$$

In particular, the value of the taxes on labor incomes Tax_{lab} is fixed at the level determined in the Microsimulation model, while taxes on capital incomes are supposed to be proportional to the capital incomes earned, where τ_{cap} is the tax rate on capital incomes.

The budget constraint states that the difference between the disposable income and the consumption of goods and services represents private savings S_H:

$$S_H = Y_{disp} - \sum_i PC_i \cdot C_i$$

(b) Government budget constraint

Government revenues come from direct taxes on labor and capital incomes, indirect taxes on production and on the value added, and social contributions on employers and employees, while government expenditures are represented by the total public expenditure G, interests on the public debt B and transfers to households (Γ_{ms} and Γ). The difference between government revenues and expenditures determines public savings S_G:

$$
\begin{aligned}
S_G &= \sum_i \tau_{y,i} \cdot P_i^h \cdot Y_i \\
&+ \sum_i \tau_{VAT_i} \cdot \left[P_i^h \cdot \left(C_i^h + I_i^h + G_i^h \right) + P_i^{Ez} \cdot \left(C_i^{Ez} + I_i^{Ez} + G_i^{Ez} \right) + P_i^{Row} \cdot \varepsilon \cdot \left(C_i^{Row} + I_i^{Row} + G_i^{Row} \right) \right] \\
&+ Tax_{lab} + \tau_{cap} \cdot r \cdot PI \cdot A_{Fr-Fr} + \sum_i w \cdot (cot_{patr} + cot_{empl}) \cdot L_i \\
&- (P_g \cdot G + r \cdot B + \Gamma_{ms} + \Gamma)
\end{aligned}
$$

(c) Balance of payments

The balance of payments states that the current account surplus plus the capital account surplus must be equal to zero. In particular, the current account surplus is given by the net exports plus the net factor incomes from the rest of the world, while the capital account surplus is given by the net capital inflows, i.e. the difference between the flow of foreign assets to France ΔA_{Row-Fr} and the flow of domestic assets to the rest of the world ΔA_{Fr-Row}:

$$
\begin{aligned}
& \left[\sum_i P_i^h \cdot (E_i^{Ez} + E_i^{Row}) \right] - \left[\sum_i \left(\sum_j PZ_i^f \cdot Z_{ij}^f \right) + PC_i^f \cdot C_i^f + PI_i^f \cdot I_i^f + PG_i^f \cdot G_i^f \right] \\
+ & \left[w^{Ez} \cdot L_{Fr-Ez} + r^{Row} \cdot \varepsilon \cdot PI \cdot A_{Fr-Row} \right] - \left[w \cdot (1 - cot_{empl}) \cdot L_{Row-Fr} + r \cdot PI \cdot A_{Row-Fr} \right] \\
+ & PI \cdot (\Delta A_{Row-Fr} - \Delta A_{Fr-Row}) \\
= & \; 0
\end{aligned}
$$

Given that the real exchange rate is assumed to be exogenous and given that the flow of domestic assets to the rest of the world ΔA_{Fr-Row} is determined by the optimal asset allocation (see infra), the balance of payments determines the flow of foreign assets to France ΔA_{Row-Fr}.

2.2.4 Optimal asset allocation

We assume that the representative agent has to choose, at the beginning of the period, how to allocate his (exogenous) initial wealth A_{Fr} between investments in France A_{Fr-Fr} and abroad A_{Fr-Row}. We suppose that the two alternatives are not perfect substitutes and that the optimal allocation depends on the ratio between the rates of return on the two assets. In particular, the rate of return on assets invested in France is the (net of depreciation) marginal productivity of capital r, while the rate of return on assets invested abroad is given by the sum between the foreign interest rate r^{Row} and the percentage variation of the exchange rate $\frac{\varepsilon-\varepsilon_{-1}}{\varepsilon_{-1}}$.

The total wealth owned by the representative agent at the beginning of the next period $A_{Fr_{+1}}$, that is given by the initial total wealth A_{Fr} plus private savings S_H, must be also allocated between assets invested in France $A_{Fr-Fr_{+1}}$ and abroad $A_{Fr-Row_{+1}}$, on the basis of the anticipated ratio between the rates of return. We consider extrapolative expectations implying that the anticipated rate of return on assets invested in France is fixed at the (net of depreciation) marginal productivity of capital of the first period; the anticipated foreign interest rate is fixed at the level of the first period; and the anticipated percentage variation of the exchange rate is fixed to zero.

The allocation of the total wealth in the two periods allows us to determine the flow of domestic assets to the rest of the world ΔA_{Fr-Row}.

2.2.5 Equilibrium conditions

For each sector i, domestic prices P_i^h adjust in order to guarantee the equilibrium between the quantity produced Y_i and the domestic and foreign demands:

$$Y_i = X_i^h + E_i^{Ez} + E_i^{Row}$$

In the labor market, the total labor demanded by all the sectors $\sum_i L_i$ must be equal to sum between the quantity of labor supplied by French people (that depends on the quantity of labor, determined in the Microsimulation model, that French people want to supply L_{Fr-Fr}, and on the unemployment rate u) and the (exogenous) quantity of labor supplied by foreign people L_{Row-Fr}:

$$\sum_i L_i = L_{Fr-Fr} \cdot (1-u) + L_{Row-Fr}$$

In the capital market, the total capital demanded by all the sectors $\sum_i K_i$ and by the government B must be equal to sum between the capital supplied by French people A_{Fr-Fr} (that depends on the optimal asset allocation choice) and the (exogenous) capital supplied by foreign people A_{Row-Fr}:

$$\sum_i K_i + B = A_{Fr-Fr} + A_{Row-Fr}$$

This equation determines the equilibrium domestic rate of remuneration of capital r.

Finally, the *numéraire* chosen is the domestic price index. Thus, the exchange rate ε represents the real exchange rate and the macroeconomic shock simulated in this paper is a depreciation of the real exchange rate.

2.2.6 Macro closure

The macroeconomic equilibrium condition states that aggregate investments must be equal to aggregate savings (i.e. the savings of the representative agent, of the government and with respect to the rest of the world):

$$PI \cdot I = S_H + S_G + PI \cdot (\Delta A_{Row-Fr} - \Delta A_{Fr-Row})$$

The neoclassical closure, that is the most frequently used in general equilibrium models, implies that investments are then savings-driven, i.e. the macroeconomic equilibrium condition determines the aggregate investment. The use of the neoclassical closure implies that a shock which increases the value of a component of the aggregate demand (for example, an increase in the current account induced by currency devaluation) produces a strong and unreasonable effect on investments, while the effect on the GDP is negligible since GDP is determined by the supply of productive factors that are supposed to be fully employed in the economy. Thus, currency devaluation can stimulate real GDP only if the hypothesis of full-employment of production factors is removed, i.e. by introducing in the model the involuntary unemployment provoked, according to the keynesian view, by the weakness of the aggregate demand.

With respect to the neoclassical closure, the keynesian closure consists to introduce fix the level of investments at a predetermined level (see Álvarez-Martínez and Polo, 2012) and to endogenize the unemployment rate. The unemployment rate is then determined in order to satisfy the macroeconomic equilibrium condition between investments and aggregate savings, implying that aggregate production is demand-driven. In particular, and in contrast to neoclassical models, the macroeconomic equilibrium may be an under-unemployment equilibrium, implying that unemployment appears in the case in which the level of the aggregate demand is insufficient.

However, even the keynesian closure presents a major shortcoming since the reduction in the unemployment rate produced by the currency devaluation simulated in our paper would be excessively high. This is why we chosen to use in our CGE model a closure rule which is between the neoclassical and the keynesian ones. The idea is the following: with a neoclassical closure, in which investments are savings-driven, an increase in the current account, or in any other component of the aggregate demand, produces a crowding-out effect on investments; in contrast, with a keynesian closure, the same shock produces no effects on investments (if investments are fixed at a given value) or just an indirect effect via the interest rate. Our idea is to introduce in our model an investment function which takes into account for the (partial) crowding-out effect on investments produced by a change in the components of the aggregate demand. In particular, using yearly French data from 1946 to 2012 provided by Insee, we estimate the following investment function:

$$I = \alpha_0 + \alpha_1 \cdot GDP_{real} + \alpha_2 \cdot \Delta C + \alpha_3 \cdot \Delta G + \alpha_4 \cdot \Delta CA$$

The previous equation implies that investments depend on the real GDP, the change in aggregate consumption (ΔC), the change in total public expenditures (ΔG), and the change in the current account (ΔCA). The detrended variables ΔC, ΔG, and ΔCA are constructed using a HP filter with a smoothing parameter equal to 100. The results, reported in **Table 8**, show that an increase in each of the components of the aggregate demand produces a crowding-out effect on investments. However, the crowding-out effect is only partial, i.e. is lower than the effect obtained using a neoclassical closure. Thus, the introduction of this investment function allows us to build a CGE model with a macro closure that is between the neoclassical and the keynesian ones.

2.3 Integration of the two models

Our Micro-Macro model works as follows. First, the CGE model simulates a shock (that can be a macroeconomic or a microeconomic shock) and determines the macroeconomic effect, in particular the percentage variations of (i) the equilibrium domestic wage, (ii) the equilibrium consumer prices of the goods and services, (iii) the consumer price index, and (iv) the equilibrium unemployment rate.

The percentage variations are then sent to the Microsimulation model in order to compute, for each individual, the effects on (i) the labor supply, (ii) the demand of goods and services, (iii) the employees' and employers' contributions, (iv) the taxes on incomes, and (v) the transfers from the government.

The individual effects are then aggregated and the percentage variations computed in the Microsimulation model allow us to determine the new values, used in the CGE model, of the following exogenous variables: (i) the total quantity of labor that people want to supply, (ii) the total demand of goods and services, (iii) the total contributions paid by the employees and the employers, (iv) the total taxes on incomes, and (v) the total transfers paid by the government.

The CGE model is then solved by considering the new values of the exogenous variables determined in the Microsimulation model. The solution obtained with the CGE model (i.e. the percentage variations of the equilibrium prices) is then introduced in the Microsimulation model again. And so on. We developed an algorithm in which the iterations are stopped when the fixed point is reached, i.e. when all the percentage variations remain (sufficiently) unchanged from one iteration to another.

3 The effects of a macroeconomic shock: a real depreciation of the euro

3.1 Macroeconomic effects

In this section we analyze the effects of a real depreciation of the euro by 10%. We first analyze the macroeconomic effects, both on the whole economy and at the sectoral level, and then the microeconomic effects.

3.1.1 Macroeconomic effects on the whole economy

The direct effect of the real depreciation of the euro concerns international trade. In particular, **Table 9** shows that exports, at constant prices, increase by 3.3% while imports, at constant prices, decrease by 6.8%. The effects in nominal terms, i.e. in terms of the *numéraire*, are obviously less positive since the euro's depreciation implies an increase in the price of imports from the non-Eurozone. In nominal terms, imports decrease by 1.9%, while exports increase by 3.5%. The impact on the current account at constant prices is positive and quite important: with respect to GDP, the current account passes from a deficit of 0.5% before the shock to a surplus of 2.2% after the depreciation. Thus, the ratio of the current account to GDP increases, in real terms, by 2.7 pp.

Table 10 shows the main macroeconomic results. The increase of the current account in real terms stimulates the aggregate demand. Given the keynesian closure, the overall macroeconomic equilibrium between investments and savings is guaranteed by a change in the unemployment rate. In particular: (i) Private consumption in constant prices is negatively affected by the increase in the consumer price index (+0.5%), but positively affected by the reduction in the unemployment rate. The private saving rate increases by 1.3 pp. (ii) Government savings decrease, at constant prices, and the ratio between the public deficit and GDP increases by 0.7 pp given that (a) the aggregate public expenditure, that is supposed to be proportional to real GDP, increases by 0.7%, (b) total direct taxation decreases by 0.5%,[12] and (c) VAT revenues decrease by 2.3% due to the reduction in imports from the rest of the world. (iii) Savings with respect to the rest of the world are affected by (a) the flow of domestic assets to the rest of the world (+2.4%) determined by the portfolio decision made by French people to invest in France or abroad and (b) the flow of assets from the rest of the world that equilibrates the balance of payments (-3.5%). (iv) Investments, determined by a specific investment function, are negatively affected by the increase in consumption, in government expenditures and in the current account (-10.8%). Nevertheless, it is important to note that the crowding-out effect on investments is less important than it could be by using a standard neoclassical closure. The macroeconomic equilibrium between investments and savings needs an important reduction in the unemployment rate from 8.8% to 6.8% (-2 pp).

Labor supply increases by 2.2% thanks to the reduction in the unemployment rate, even if the quantity of labor that workers want to supply decreases by 0.04% given the reduction in the

[12] This result is explained by the reduction in wages expressed in terms of the *numéraire*. Due to the progressivity of the French fiscal scheme, this negative effect dominates the positive effect coming from the increase in employment.

real wage (-2%). The economic mechanisms in the labor market are depicted in **Figure 1**. In particular, the labor demand function is determined such that the labor marginal productivity is equal to the real wage, while the quantity of labor supplied is positively related to the real wage. Before the shock, the economy is situated in point A in **Figure 1**. The weakness of the aggregate demand and production implies that the quantity of labor demanded is lower than the quantity of labor that is voluntary supplied at the initial real wage. The difference between people who want to work and people who find a job represents the involuntary unemployment, while the difference between the working-age population and people who want to work represents the non-participating population or voluntary unemployment. The real depreciation of the euro reduces the demand for intermediate inputs coming from the rest of the world. This reduces the marginal productivity of labor and causes a shift to the left of the labor demand function. Given that the shock increases exports and reduces imports, the aggregate demand for goods and services increases from Y_1 to Y_2 in the figure, and the demand of labor increases from L_1^d to L_2^d. After the shock, the economy is situated in point B, with a lower real wage, a greater level voluntary unemployment due to the reduction of the real wage, and a lower level of involuntary unemployment due to the increase in the aggregate demand.

Finally, the decrease in the unemployment rate produces a positive effect on the real GDP that increases by 0.7%.

3.1.2 Macroeconomic effects on the sectors

As we have already said, the direct effect of depreciation concerns imports and exports. Obviously, the effect at the sectoral level depends on its exposure to international trade. **Table 11** presents, for each sector, the size of imports (with respect to the total demand of domestic and foreign goods) and the size of exports (with respect to the total production). Seven sectors (energy, mineral products, textile, mechanic industry, electric industry, metallurgy, and transports) are exposed to international trade, while three sectors are completely closed to international trade (construction, hotels and restaurants, and public administration).[13] The table also indicates the part of imports and exports with respect to the Eurozone and to the rest of the world. In the

[13] A sector is defined as exposed to international trade if imports represent more than 25% of total demand *or* exports represent more than 25% of total production.

last column, we indicate the weight of each sector in terms of production with respect to the production at the national level.

Table 12 shows that the real depreciation of the euro strongly reduces imports of tradable sectors from the rest of the world (energy -12.2%, mineral products -16.3%, textile -19.4%, mechanic industry -23%, electric industry -17.5%, metallurgy -22%, and transports -13.9%), that are only partially replaced by imports from the Eurozone, and stimulates exports toward the rest of the world.

Table 13 indicates other macroeconomic effects at the sectoral level, concerning the production level, labor and capital demand, consumption and investment. In particular, the real depreciation of the euro induces a significant increase in the production of tradable sectors (energy +2%, mineral products +2.6%, textile +4.7%, electric industry +3.1%, metallurgy +1.3%). The production level of the construction sector is dramatically reduced (-8.9%) due to the strong fall in investments.

The effect on sectoral prices are reported in **Table 14**. In particular the domestic price, for each sector, is endogenously determined to guarantee the equilibrium in the domestic market, while the foreign price is computed as the weighted average between the price in the Eurozone and the price in the rest of the world, both affected by the real depreciation of the euro. We also compute the total effect on the price level for each sector, computed as the weighted average between the domestic and the foreign prices, that is then sent to the Microsimulation model and affects the individual consumer behavior. The most important increases in prices are observed in sectors that are more exposed to international trade: energy +2%, mineral products +1.8%, textile +2.3%, electric industry +3.3%, and transports +3.1%.

3.2 Microeconomic effects

The change in the real wage affects the disposable income earned by each family and then the labor-market choices. The change in consumer prices and the change in the disposable income earned by each family affect the consumption choices concerning the different goods and services. Moreover, a certain number of involuntary unemployed find a job, since the equilibrium unemployment rate decreases. This implies that the real depreciation of the euro, which is a pure macroeconomic shock, produces significant effects at the individual level, both in terms of individual choices and of income distribution.

Table 15 reports poverty and inequality measures for the whole population before and after the 10% depreciation of the euro, together with the percentage variation.[14] The overall effects of the shock is rather limited. The most notable result is a reduction in the number of the poor[15] of about 1%, accompanied by a similar reduction in the intensity of poverty[16] (-1.2%). Inequality reduction is small: the Gini index reduces by 0.3%, while the average income increases for the first decile and reduces for the last, reducing the interdecile ratio by 0.7%.

These figures are substantially driven by a significant reduction of involuntary unemployment. **Tables 16** and **17** report the change in the labor supply for singles and couples. 1.4% of previously unemployed singles finds a full time job, while 0.3% find a part time job. Similarly, for couples, the families in which at least one member find a full time job are 1.2%, while in the 0.4% of families a previously unemployed member finds a part-time job. The number of families that reduce the labor supply due to the decline of the salary is negligible.

These results imply that the number of families that gain from the shock is limited, but their gain is quite substantial. **Table 18** reports the number of winners and losers in terms of disposable income and their gain by family type. In general, results confirm that who wins obtains substantial gains but that a rather large part of the population suffers from a moderate loss, due to the slight decrease in equilibrium wages. It is worth noting that the shock benefits mostly the poor. Almost 9% of the poor win and their gain in terms of available income represents more than 34%. Another group that benefit from the shock is that composed by singles with children, although their gain is lower than for the poor, about 10% of single with children gain from the shock. The group that is less affected by the shock is that composed by the elderly. Since there is no behavioral variation in the labor supply and their pension is not affected by the shock, there is no variation in their conditions.[17]

[14]Poverty and inequality analysis is carried out by computing equivalent incomes using the OECD equivalence scale.

[15]Defined as the percentage of families with an equivalized disposable income below a poverty line corresponding to the 60% of the median equivalized disposable income.

[16]Defined as the mean distance separating the population from the poverty line, with the non-poor being given a distance of zero.

[17]In France pension benefits and subsidies are indexed with inflation, implying that the increase in prices obtained in the macro model has no effect on their real income.

Thus a first look at the aggregate poverty and inequality measures hides a quite substantial improvement. This is particularly true for poor people, since the reduction in the unemployment rate permits to some individuals to find a job. On the other side, the situation deteriorates - but very slightly - for people who have already a job since the wage level decreases after the shock. The average gain in terms of disposable income is very important (+34.1%) for the winners, while the average loss is quite limited (-1.1%) for the losers.

Finally, **Table 19** reports the effects concerning consumption for each category by family type. Clearly, part of the variation is driven by price increase, especially for tobacco and clothing, that had the sharpest price increase, while large income increases beef up consumption of the poor.

4 Sensitivity analysis

In this section, we present two sensitivity analyses to explore the role of two key elements in the simulation of currency devaluation: the choice of the macro closure rule and the choice of the value of the elasticity used to model international trade.

The first sensitivity analysis compares the results of our base scenario presented above with the ones obtained using different macro closure rules. As we have already said, in our base scenario we used a macro closure which can be considered as between the neoclassical and the Keynesian ones. Here we consider simulate the effects of a 10% real devaluation of the euro using a neoclassical closure, in which investments are determined by aggregate savings, and a Keynesian closure, in which investments are fixed at a predetermined value.

As **Table 20** shows, using a neoclassical closure, a 10% real devaluation of the euro would produce a negative effect on real GDP (-0.6%). This negative result is explained by the reduction in the stock of capital available in the economy (-0.9%) which, in turns, is related to the choice of French people to invest abroad. Clearly, without this effect due to the optimal asset allocation, the effect on the real GDP would be negligible since, if aggregate labor and capital are constant, real GDP is affected only by the reallocation of the production factors across sectors. Thus, in real terms, the positive effect on the current account (exports increase by 2.6% and imports decrease by 8%) is more than compensated by the small decrease in consumption and government expenditures and by the strong fall in investments (-14.4%).

Instead, using a Keynesian closure rule, a 10% real devaluation of the euro produces a strongly positive effect on the real GDP. Even if the stock of capital decreases by 0.8%, real GDP increases by 4.6% thanks to the strong increase in the labor endowment (+8.6%) and the reduction in the unemployment rate (which passes from 8.8% to 0.9%). Concerning the elements of the aggregate demand, the shock produces a positive effect on the current account (exports increase by 5.4% and imports decrease by 3.4%), investments do not change since, with the Keynesian closure rule, are fixed at the initial level, consumption and government expenditures increase. To resume, we think that both the neoclassical and the Keynesian closures determine an unrealistic effect on real GDP. In particular, with the neoclassical closure the unrealistic effect is related to the excessively high reduction in investments, while with the Keynesian closure the unrealistic effect is related to the excessively high reduction in the unemployment rate. In contrast, in our base scenario, the real devaluation of the euro produces a quite positive effect on real GDP combined with an important reduction in investments (even if the crowding-out effect on investments is less important than that obtained with the neoclassical closure rule) and with a reduction in the unemployment rate (which is less important than what that obtained with the keynesian closure rule).

The second sensitivity analysis concerns the elasticities used to model international trade. While in our base scenario we used the elasticities coming from the GTAP model, here we consider two scenarios in which these elasticities are multiplied by 0.75 and by 1.25. As **Table 21** shows, in the first case the positive effect on the current account is less important than what obtained in the base scenario (exports increase by 2.3% vs. 3.3% in the base scenario, while imports decrease by 6.3% vs. 6.8% in the base scenario), while in the second case the effect is more important. Consequently, the effect on the real GDP and on the unemployment rate are less important in the first case (and more important in the second case) with respect to the base scenario. In particular, the positive effect on real GDP of a 10% real devaluation of the euro would be between 0.2% and 1% using elasticities between 0.75 and 1.25 times the GTAP elasticities.

5 Conclusions

In our paper, we use a Micro-Macro model to evaluate the effects of a pure macroeconomic shock represented by a 10% real depreciation of the euro, both at the macro and micro level. We find that the real depreciation of the euro stimulates the aggregate demand by increasing exports and reducing imports. The increase in aggregate demand stimulates the real GDP and reduces the unemployment rate in the economy from 8.8% to 6.8%. At the sectoral level, the real depreciation of the euro induces a significant increase in the production of tradable sectors (energy, mineral products, textile, mechanic industry, electric industry, metallurgy, and transports). As found by Davis and Haltiwanger (2001), currency devaluation induces important effects on job creation in tradable sectors, while the global effect on non-tradable sector is marginal. It is also interesting to note that currency devaluation does not produce a transfer of the workforce from non-tradable to tradable sectors. In fact, the strong job destruction produced in the construction sector seems to profit to all the other sectors, especially mineral products, textile and electric industry.

At the individual level, we find that the macroeconomic shock induces significant consequences on poverty and a slight reduction of income inequality. The decrease in the equilibrium wage determined in the macro model moderately reduces the available income for people who have already a job, while the reduction in unemployment permits to some individuals to find a job, substantially increasing their income. The average income of the first decile increases while a rather large part of the population suffers from a moderate loss, due to the decrease in equilibrium wages. Finally, about 9% of the poor win and their gain in terms of available income represents more than 34%.

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Table 1: Fiscal instruments simulated in SYSIFF 2006

Social contributions and VAT	**Income tax, local taxes and public benefits**
Employer social contributions	**Deductions**
Assurance Maladie/Solidarité	Retraites complémentaire volontaire
Assurance Vieillesse Plafonnée	Frais réels
Assurance Vieillesse Déplafonnée	Abattement général
Allocation Familiales	Déductions Enfant
FNAL	Déductions Ascendants
Allocation Chômage	Pertes en capital
Retraites Complémentaire	
AGFF	**Income tax**
Régime de Prévoyance Cadres	Foyer fiscal
Versement Transport	Impôt sur le Revenu
Réduction Fillon	
	Tax credits
Employee Social contributions	Contribution non profit
Assurance Maladie/Solidarité	Assurance décès-sante
Assurance Vieillesse Plafonnée	Prestation compensatoire
Assurance Vieillesse Déplafonnée	Personnes âgées dépendantes
Allocation Chômage	Salarié à domicile
Retraites Complémentaires	Garde d'enfants
AGFF	Frais de scolarisation
Assurance Santé extra/complémentaire	Comp. Taxe Carbone
CAPS (Capital)	Réduction d’impôts DOM
Prélèvement Social (Capital)	Prime pour l'emploi
Allocations Familiales (self empl.)	
Formation professionnelle (self empl.)	**Local Taxes**
Assurance Maladie (self empl.)	Taxe Habitation
Assurance Invalidité décès (self empl.)	Taxe Foncière sur le non-bâti
Assurance Vieillesse (self empl.)	Taxe Foncière sur le bâti
Régime d’Indemnités Journalières (self empl.)	
	Public Benefits
Special contributions	AF - Allocations Familiales
CSG	PAJE - Prestation d'Accueil du Jeune Enfant
CRDS	a) child born before 01-01-2004
	APE (Allocation Parental d'Education)
VAT	APJE (Allocation Pour Jeune Enfants)
Food	AAM (Aide Assistant Maternelle)
Beverages	b) child born after 01-01-2004
Clothing	Prime à la Naissance
Energy	AB (Allocation de Base)
Furniture	CLCA (Complément de Libre Choix d'Activité)
Household appliance	Paje Emploi
Housing (products)	CFAM - Complément Familial
Health	API - Allocation Parent Isolée
Transports	ARS - Allocation Rentrée Scolaire
Communications	Prime de Déménagement
Amusements	Minimum Vieillesse
Books and newspapers	Aide au Logement
Cinema	RMI (Revenu Minimum d'Insertion)
Museums	RSA (Revenu de Solidarité Active)
Leisure	
Teaching	
Meals	
Beauty	
Other goods	

Table 2: FIML estimation of the AIDS system

Parameters		Drink	Tobacco	Clothing	Housing	Health	Transport / Energy	Communication	Leisure	Meals	Other	Food
	α	0.165***	0.070***	0.129***	-1.059***	0.166***	0.058***	0.054***	0.356***	0.288***	0.247***	0.526***
Drink		0.012***	0.000	-0.006***	0.011***	-0.002***	-0.002***	0.002***	-0.008***	-0.001***	-0.007***	0.000
Tobacco			0.040***	-0.004***	-0.011***	-0.007***	0.006***	0.013***	-0.012***	-0.007***	-0.008***	-0.011***
Clothing				0.036***	0.044***	-0.020***	-0.001*	-0.003***	-0.031***	-0.007***	-0.003***	-0.005***
Housing					-0.149***	0.024***	-0.003***	-0.002**	0.033***	0.009***	0.012***	0.032***
Health						0.049***	0.000	0.002***	-0.013***	-0.011***	-0.002***	-0.021***
Transport / Energy	γ						0.035***	0.002***	-0.003***	-0.003***	-0.005***	-0.028***
Communication								0.007***	-0.004***	-0.003***	-0.001***	-0.012***
Leisure									0.075***	-0.013***	-0.009***	-0.016***
Meals										0.055***	-0.008***	-0.012***
Other											0.050***	-0.019***
Food												0.093***
	β	-0.018***	0.009***	-0.074***	0.248***	-0.035***	0.000	0.000	-0.053***	-0.018***	-0.019***	-0.041***
	λ	0.001***	-0.003***	0.009***	-0.013***	0.003***	0.000**	0.001***	0.004***	0.000**	-0.001***	0.000**
Hh. size		-0.006***	0.011***	0.003***	-0.007***	-0.006***	-0.001**	-0.004***	-0.006***	-0.004***	0.006***	0.015***
N. child 0-2		0.002***	-0.023***	0.011***	0.010***	0.026***	-0.002	0.012***	-0.015***	-0.023***	-0.001	0.004
N. child 3-6		-0.002***	-0.003**	0.005***	0.003***	0.013***	0.005***	0.013***	0.002***	-0.011***	-0.001*	-0.025***
City > 100.000		-0.004***	0.007***	0.009***	-0.012***	-0.006***	-0.006***	0.001*	0.006***	-0.002***	0.003***	0.003
Age of the hh. Head		0.002***	-0.006***	-0.004***	0.006***	0.006***	0.005***	0.005***	0.001***	-0.010***	-0.001***	-0.005***
Hh. head is married		0.001***	-0.024***	-0.023***	0.014***	-0.020***	-0.006***	-0.020***	-0.017***	-0.033***	0.012***	0.116***
Hh. head is self-employed		0.003***	0.003*	-0.013***	-0.005***	0.005***	0.006***	0.042***	0.020***	0.007***	-0.019***	-0.050***
Hh. head is manager		-0.005***	-0.011***	-0.005***	-0.017***	-0.006***	-0.013***	-0.011***	-0.007***	0.018***	-0.004***	0.061***
	σ	0.004	0.081***	0.139***	0.305***	0.007*	0.041***	-0.058***	0.017***	0.011***	0.050***	0.000

Table 3: Price and income elasticities from the estimation of the AIDS system

	Drink	Tobacco	Clothing	Housing	Health	Transport / Energy	Communication	Leisure	Meals	Other	Food
Income elasticities	**0.988**	**0.648**	**1.321**	**1.344**	**1.134**	**1.074**	**1.153**	**0.982**	**0.910**	**0.731**	**0.755**
Uncompensated price elasticities											
Drink	**-0.794**	0.045	-0.037	-0.100	0.004	-0.014	0.032	-0.072	-0.019	-0.056	0.021
Tobacco	0.055	**-0.453**	-0.078	-0.089	-0.005	0.074	0.096	-0.084	-0.083	-0.062	-0.019
Clothing	-0.040	-0.057	**-0.484**	-0.123	-0.081	-0.046	-0.036	-0.149	-0.082	-0.066	-0.156
Housing	-0.081	-0.078	-0.140	**-0.270**	-0.105	-0.079	-0.049	-0.166	-0.122	-0.117	-0.137
Health	-0.007	-0.031	-0.063	-0.078	**-0.529**	-0.019	-0.004	-0.084	-0.083	-0.021	-0.213
Transport / Energy	-0.012	0.017	-0.003	-0.027	-0.007	**-0.786**	0.007	-0.027	-0.002	-0.033	-0.200
Communication	0.028	0.116	-0.024	-0.044	0.002	0.014	**-0.741**	-0.110	-0.099	-0.036	-0.260
Leisure	-0.035	-0.092	-0.110	-0.107	-0.056	-0.017	-0.035	**-0.336**	-0.066	-0.053	-0.076
Meals	-0.005	-0.100	-0.045	-0.074	-0.054	0.021	-0.027	-0.063	**-0.466**	-0.041	-0.057
Other	-0.024	-0.106	-0.046	-0.100	0.016	-0.005	0.011	-0.047	-0.035	**-0.355**	-0.041
Food	0.023	-0.051	-0.057	-0.031	-0.088	-0.109	-0.043	-0.026	-0.020	-0.023	**-0.329**

Table 4: Heckman estimation for salaries

	Single		Married	
	Female	Male	Female	Male
Log of hourly wage				
Age	0.025*	0.037**	0.046***	0.035***
Age squared	0.000	0.000	0.000***	0.000***
Primary education	0.020	-0.090	-0.050	-0.023
Secondary education	0.059	0.128	0.075	0.150***
Cap/Bep	0.051	0.110*	0.101**	0.135***
University	0.196**	0.253***	0.266***	0.235***
Superior education	0.246***	0.248***	0.351***	0.246***
Stranger	-0.027	-0.133**	-0.094**	-0.063**
Ile-de-France	0.095	0.051	0.066	0.110**
Public sector	0.101***	0.084*	0.126***	0.011
White collar	0.342***	0.406***	0.307***	0.406***
Constant	1.344***	1.200***	0.791***	1.171***
Selection				
Age	0.121***	0.027	0.073***	-0.001
Age squared	-0.001***	0.000	-0.001***	0.000
Primary education	0.552**	-0.055	0.237	-0.042
Secondary education	0.704***	0.105	0.147	0.476**
Cap/Bep	0.675***	0.622***	0.303***	0.184
University	1.231***	0.194	0.686***	0.276**
Superior education	1.358***	0.423	0.726***	0.468***
Stranger	-0.344*	-0.609***	-0.656***	-0.580***
N. children [0,2]	-0.347	-1.493	-0.459***	-0.206**
N. children [3-6]	-0.243***	2.961	-0.255***	0.027
Bad health	-0.977***	-1.297***	-0.425***	-0.764***
Non-labor incomes	-0.081***	-0.077***	-0.015***	-0.044***
Ile-de-France	0.498	0.371	-0.086	0.083
Constant	-1.694*	1.397	-0.238	2.000**
ρ	-0.018	0.008	0.236***	-0.027

Table 5: Discrete choice labor supply estimation for singles

	Single females				Single males			
	Not working	50% Part time	80% Part time	Full Time	Not working	50% Part time	80% Part time	Full Time
Ln of disposable income	Ref. cat	0.444**	0.444**	0.444**	Ref. cat.	0.012	0.012	0.012
Part time 1		4.248	-8.716	-13.233**		-17.508	-2.692*	-2.620**
Part time 2		0.643	13.905***	-0.846		-28.445	-26.597	-10.203
Domestic worker		-1.630*	-2.571**	-1.833***		1.024	43.158*	46.652**
Baby sitter		-0.590	-0.226	0.222		-4.720	-55.798*	-58.848**
Age		16.179	52.136***	31.865***		0.588	1.261	0.952
Age squared		-21.995	-65.668***	-40.839***		-0.123	0.444	0.603
Primary education		0.956	0.432	1.183*		-0.107	1.463	0.864
Secondary education		1.075	1.811***	1.393**		-0.828	0.423	0.033
Cap/bep		0.412	0.537	0.995**		3.472***	3.873***	3.083**
University		1.937***	1.701***	2.435***		0.457	-0.719	-0.151
Superior education		2.231***	1.953***	2.482***		27.561	24.387	23.462
Stranger		0.443	0.323	-0.284		6.360	6.020	5.558
N. Children [0-2]		-0.078	-0.247	-1.399**		-1.974***	-1.890***	-3.501***
N. Children [3-6]		-0.247	-0.341	-0.684***		-0.114**	-0.209***	-0.192***
Bad health		-2.096***	-1.828***	-2.421***		0.523	0.064	0.486
Non-labor incomes		-0.024	-0.061**	-0.062***		-1.778	3.909	3.611
Rent		1.176***	1.031***	1.284***		0.122	-0.016	-0.035
Museums		-5.942	-0.237	-0.203		0.078	0.060	0.098
Books		0.091	0.007	0.033		0.870	-6.748	-4.295
Amusements		-0.030	0.101*	0.050		0.000	0.000	0.000
Constant		-3.984	-10.827***	-4.316*		0.000	0.000	0.000

Table 6: Discrete choice labor supply estimation for couples

Husband	Not working				Full time			
Wife	Not working	50% Part time	80% Part time	Full Time	Not working	50% Part time	80% Part time	Full Time
Ln of disposable income	ref cat.	2.401***	2.401***	2.401***	2.401***	2.401***	2.401***	2.401***
Age wife		108.876	112.073*	76.146**	7.236	20.030	42.130*	46.001**
Age squared wife		-108.164	-133.696*	-91.670**	-5.080	-23.861	-50.852*	-56.638**
Cap/bep wife		-0.147	0.592	0.409	-0.350	-0.014	0.062	-0.231
University wife		-1.509	-15.533	0.332	-0.183	0.209	0.530	0.345
Superior education wife		-1.273	-15.412	0.543	-0.731	-0.473	-0.314	-0.427
Stranger wife		0.771	-16.678	-0.057	0.398	0.323	-0.436	-0.352
Bad health wife		-0.724	-18.028	-1.139*	-0.298	-1.019*	-0.636	-1.141**
Age husband		-5.975	-47.364	5.005	-26.819	-22.964	-29.254	-35.180
Age squared husband		-13.638	46.666	-7.243	25.663	20.958	28.465	33.523
Cap/bep husband		0.806	-0.309	0.270	-0.730	-0.732	-0.386	-0.489
University husband		0.782	1.047	0.861	-0.501	-0.282	-0.017	0.116
Superior education husband		-0.336	-14.322	-0.130	-0.716	-0.769	-0.428	-0.264
Stranger husband		-1.091	0.455	0.234	-0.272	-0.180	-0.313	-0.192
Bad health husband		0.679	0.716	1.180**	-1.513***	-1.531***	-1.355***	-1.441***
Part-time 1		25.456*	11.706	17.557**	7.210	15.523**	6.507	4.120
Part-time 2		-8.738	-1.448	-6.806	-4.783	-2.856	1.891	-5.125
Non-labour income		0.752**	0.240	0.346	-0.610***	-0.563***	-0.598***	-0.579***
Rent		-0.414	0.353	0.175	0.251	0.253	0.525	0.472
Leisure		0.009	-0.068	0.116	0.119	0.252**	0.215*	0.272**
Number of children		-0.103	-0.807	-0.554*	0.329	-0.070	-0.156	-0.525**
Constant		-25.640*	-13.958	-18.781***	6.585	2.082	-0.897	3.067

Table 7: List of the sectors in the CGE model

		CGE	MS
1 Food	Agriculture, hunting, forestry, fishing. Food		X
2 Beverage	Beverages		X
3 Tobacco	Tobacco		X
4 Energy	Mining and quarrying. Coke, refined petroleum products and nuclear fuel. Production, collection and distribution of electricity. Manufacture of gas; distribution of gaseous fuels through mains. Steam and hot water supply. Collection, purification and distribution of water	X	
5 Mineral products	Chemicals excluding pharmaceuticals. Rubber and plastics products. Other non-metallic mineral products	X	
6 Textile	Textiles, textile products, leather and footwear		X
7 Housing	Wood and products of wood and cork		X
8 Mechanic industry	Machinery and equipment, nec	X	
9 Electric industry	Office, accounting and computing machinery. Electrical machinery and apparatus. Medical, precision and optical instruments	X	
10 Metallurgy	Iron and steel. Non-ferrous metals. Fabricated metal products, except machinery and equipment	X	
11 Health	Health and social work. Pharmaceuticals. Education		X
12 Construction	Construction	X	
13 Transports	Motor vehicles, trailers and semi-trailers. Building and repairing of ships and boats. Aircraft and spacecraft. Railroad equipment and transport equip nec. Manufacturing nec; recycling. Land transport; transport via pipelines. Water transport. Air transport. Supporting and auxiliary transport activities. Activities of travel agencies		X
14 Hotels et restaurants	Hotels and restaurants		X
15 Leisure	Pulp, paper, paper products, printing and publishing. Radio, television and communication equipment. Other community, social and personal services. Private households with employed persons and extra-territorial organisations and bodies		X
16 Communications	Post and telecommunications		X
17 Public administration	Public admin. and defence; compulsory social security	X	
18 Non-financial services and R&D	Real estate activities. Renting of machinery and equipment. Computer and related activities, Research and development. Other Business Activities	X	
19 Financial services	Finance and insurance		X

Table 8: Estimation results of the investment function

Dependent Variable: INV
Method: Least Squares
Sample: 1949 2012
Included observations: 64

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-116.7686	10.22002	-11.42548	0.0000
GDP	0.580564	0.041725	13.91396	0.0000
Detrended CONS	-0.428466	0.184598	-2.321076	0.0240
Detrended G	-0.315125	0.156875	-2.008761	0.0495
Detrended CA	-0.909974	0.187228	-4.860240	0.0000

R-squared	0.997651	Mean dependent var	190.4531
Adjusted R-squared	0.997309	S.D. dependent var	97.54353
S.E. of regression	5.060240	Akaike info criterion	6.210405
Sum squared resid	1408.331	Schwarz criterion	6.513998
Log likelihood	-189.7330	Hannan-Quinn criter.	6.330005
F-statistic	2919.334	Durbin-Watson stat	0.499086
Prob(F-statistic)	0.000000		

Source: Insee. French data from 1949 to 2012.

Table 9: Aggregate effects of a 10% real depreciation of the euro on international trade

		constant prices / real terms	current prices / nominal terms
Exports	(% var)	3.3	3.5
Exports (Eurozone)	(% var)	1.3	1.6
Exports (Rest of the world)	(% var)	5.5	5.7
Imports	(% var)	-6.8	-1.9
Imports (Eurozone)	(% var)	2.7	4.3
Imports (Rest of the world)	(% var)	-16.5	-8.2
Current Account / GPD	(% in p.p.)	2.7	1.4

Table 10: Aggregate effects of a 10% real depreciation of the euro on the main macroeconomic variables

Real GDP	(% var)	0.7
Unemployment rate	(% in p.p.)	-2.0
Labor	(% var)	2.2
Capital	(% var)	-0.8
Real wage	(% var)	-2.0
Real rate of remuneration of capital	(% in p.p.)	0.0
Consumer Price Index	(% var)	0.5
Private consumption	(% var)	0.2
Investments	(% var)	-10.8
Government expenditure	(% var)	0.7
Private saving rate	(% in p.p.)	1.3
Public deficit / GDP	(% in p.p.)	0.7
Flow of domestic assets to RoW	(% var)	2.4
Flow of foreign assets to France	(% var)	-3.5

Figure 1: The labor market with voluntary and involuntary unemployment

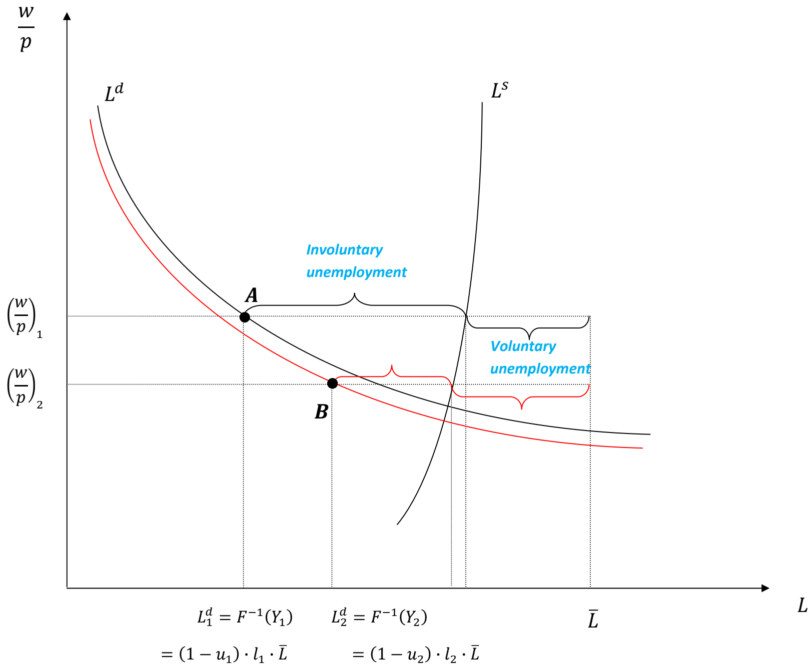

Table 11: Size of imports and exports (total, vs. Eurozone, vs. rest of the world)

		M / (M+X)	MEU / M	MROW / M	E / (E+X)	EEU / E	EROW / E	Y / GDP
1	Food	13.9%	63.0%	37.0%	14.5%	66.8%	33.2%	6.8%
2	Beverage	9.0%	53.8%	46.2%	24.5%	37.9%	62.1%	2.2%
3	Tobacco	13.1%	83.3%	16.7%	3.3%	51.8%	48.2%	0.4%
4	Energy	29.5%	27.0%	73.0%	11.2%	56.7%	43.3%	5.5%
5	Mineral products	46.5%	57.7%	42.3%	45.7%	48.7%	51.3%	3.2%
6	Textile	45.5%	38.5%	61.5%	37.1%	47.5%	52.5%	1.7%
7	Housing	22.5%	53.3%	46.7%	18.9%	47.4%	52.6%	2.8%
8	Mechanic industry	34.9%	53.7%	46.3%	36.6%	46.7%	53.3%	3.0%
9	Electric industry	54.6%	34.5%	65.5%	51.3%	47.7%	52.3%	2.9%
10	Metallurgy	34.0%	69.1%	30.9%	32.4%	61.4%	38.6%	3.2%
11	Health	6.5%	51.1%	48.9%	9.9%	50.5%	49.5%	10.1%
12	Construction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.1%
13	Transports	40.0%	51.1%	48.9%	43.2%	50.5%	49.5%	7.5%
14	Hotels and restaurants	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%
15	Leisure	17.3%	72.7%	27.3%	18.8%	59.2%	40.8%	7.7%
16	Communications	3.0%	51.2%	48.8%	5.1%	54.2%	45.8%	1.8%
17	Public administration	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%
18	Non-financial services and R&D	3.8%	51.2%	48.8%	3.6%	54.2%	45.8%	21.9%
19	Financial services	2.8%	51.2%	48.8%	3.9%	54.2%	45.8%	5.0%

Source: Insee and OECD

Table 12: Sectoral effects of a 10% real depreciation of the euro on international trade

		Exports	Exports (Eurozone)	Exports (Rest of the World)	Imports	Imports (Eurozone)	Imports (Rest of the World)
1	Food	2.3	1.0	4.8	-5.2	2.7	-18.6
2	Beverage	3.5	1.1	5.0	-6.1	0.8	-14.1
3	Tobacco	3.0	0.8	5.2	-1.3	1.2	-13.6
4	Energy	2.4	1.2	4.1	-7.2	6.1	-12.2
5	Mineral products	3.0	1.5	4.4	-5.3	2.7	-16.3
6	Textile	3.6	2.0	5.2	-9.2	6.9	-19.4
7	Housing	3.2	1.3	5.0	-9.1	-0.5	-19.0
8	Mechanic industry	3.2	1.4	4.8	-10.8	-0.3	-23.0
9	Electric industry	3.4	1.9	4.8	-9.9	4.6	-17.5
10	Metallurgy	2.6	1.2	4.7	-5.1	2.4	-22.0
11	Health	3.1	0.9	5.2	-2.8	9.0	-15.1
12	Construction						
13	Transports	2.7	1.4	4.1	-6.5	0.6	-13.9
14	Hotels et restaurants						
15	Leisure	2.7	1.0	5.1	-3.6	2.1	-18.6
16	Communications	2.8	1.0	4.8	-7.3	2.0	-17.0
17	Public administration						
18	Non-financial services and R&D	2.8	0.9	5.0	-7.4	3.4	-18.9
19	Financial services	2.8	0.9	5.1	-7.6	3.1	-18.8

Table 13: Sectoral effects of a 10% real depreciation of the euro on macro variables

		Production	Labor	Capital	Consumption (MS sectors)	Consumption (CGE sectors)	Investments
1	Food	0.7	2.5	0.7	0.0		-10.5
2	Beverage	0.2	2.2	-0.2	-1.7		
3	Tobacco	0.6	2.2	-0.2	0.5		-10.3
4	Energy	2.0	6.3	3.6		0.3	-12.6
5	Mineral products	2.6	5.7	3.3		0.5	-11.1
6	Textile	4.7	6.6	3.9	0.5		
7	Housing	-1.0	1.1	-1.4	-1.4		-10.5
8	Mechanic industry	-1.1	1.4	-1.1		0.5	-11.1
9	Electric industry	3.1	5.8	3.1		0.8	-11.9
10	Metallurgy	1.3	4.1	1.4		-1.0	-10.7
11	Health	0.8	2.5	-0.1	-0.5		-10.2
12	Construction	-8.9	-6.3	-8.8		1.1	-10.6
13	Transports	0.6	5.5	2.4	0.2		-11.9
14	Hotels et restaurants	-0.3	2.1	-0.4	-2.7		
15	Leisure	0.6	2.5	-0.1	-0.1		-10.6
16	Communications	-0.3	2.3	-0.3	-0.2		
17	Public administration	0.8	2.5	-0.1		1.9	
18	Non-financial services and R&D	-0.8	1.3	-1.3		2.9	-10.4
19	Financial services	-0.4	1.4	-1.1	0.4		

Table 14: Sectoral effects of a 10% real depreciation of the euro on prices

		Domestic prices	Foreign prices			Total
			Eurozone	Rest of the world	Total	
1	Food	0.1	0.7	10.0	3.8	0.4
2	Beverage	-0.2	0.6	10.0	4.8	0.2
3	Tobacco	-0.7	-0.5	10.0	1.2	-0.5
4	Energy	1.6	2.5	10.0	7.8	2.0
5	Mineral products	0.8	2.3	10.0	5.4	1.8
6	Textile	-0.5	2.0	10.0	6.6	2.3
7	Housing	-0.2	0.9	10.0	4.9	0.6
8	Mechanic industry	0.1	1.5	10.0	5.1	1.4
9	Electric industry	0.1	2.4	10.0	7.1	3.3
10	Metallurgy	0.3	1.3	10.0	3.7	1.1
11	Health	-0.7	-0.3	10.0	4.4	-0.6
12	Construction	0.3	0.8	10.0	0.0	0.3
13	Transports	1.5	2.9	10.0	6.3	3.1
14	Hotels et restaurants	0.0	0.5	10.0	0.0	0.0
15	Leisure	-0.5	0.1	10.0	2.6	-0.2
16	Communications	0.1	0.7	10.0	5.0	0.1
17	Public administration	-0.6	-0.2	10.0	0.0	-0.6
18	Non-financial services and R&D	-0.3	0.0	10.0	4.6	-0.3
19	Financial services	-0.4	-0.1	10.0	4.5	-0.4

Table 15: Microeconomic effects of a 10% real depreciation of the euro on income inequality and income distribution

	Baseline	Shock	variation
Headcount ratio	9.05%	8.96%	-1.0%
Poverty gap ratio	2.53%	2.50%	-1.2%
Gini index	0.2909	0.2899	-0.3%
10th percentile	6867	6893	0.4%
50th percentile	13363	13345	-0.1%
90th percentile	24750	24677	-0.3%
90th / 10th perc.	3.60	3.58	-0.7%

Table 16: Singles' labor supply reaction

		Prediction				
		0	18	24	36	Total
Choice	0	14.1	**0.1**	**0.2**	**1.4**	15.7
	18	0.0	6.7	0.0	0.0	6.7
	24	0.0	0.0	8.2	0.0	8.2
	36	0.0	0.0	0.0	69.4	69.4
	Total	14.1	6.7	8.4	70.8	100

Table 17: Couples' labor supply reaction

		Prediction								
		0-0	0-18	0-24	0-36	36-0	36-18	36-24	36-36	Total
Choice	0-0	2.8	0.0	0.0	0.0	**0.2**	0.0	0.0	0.0	3.1
	0-18	0.0	0.8	0.0	0.0	0.0	**0.1**	0.0	0.0	0.9
	0-24	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.7
	0-36	0.0	0.0	0.0	2.5	0.0	0.0	0.0	**0.4**	2.9
	36-0	0.0	0.0	0.0	0.0	17.8	**0.2**	**0.2**	**0.5**	18.7
	36-18	0.0	0.0	0.0	0.0	0.0	9.9	0.0	0.0	9.9
	36-24	0.0	0.0	0.0	0.0	0.0	0.0	14.5	0.0	14.5
	36-36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.3	49.4
	Total	2.8	0.8	0.7	2.6	18.1	10.3	14.7	50.2	100

Table 18: Percentage of winners, average percentage gain and percentage of losers and average loss

Family type	Winners	Gain	Losers	Loss	Net gain
All families	2.5%	24.1%	36.9%	-1.1%	0.2%
Poor	8.7%	34.2%	11.6%	-0.3%	2.9%
Single males	3.9%	33.0%	48.3%	-1.1%	0.8%
Single females	2.8%	14.3%	29.2%	-1.1%	0.1%
Singles w/children	10.2%	18.2%	63.6%	-0.7%	1.4%
Couples w/o children	1.8%	28.6%	40.3%	-1.1%	0.1%
Couples w/1 child	3.3%	18.8%	59.4%	-1.2%	-0.1%
Couples w/2 children	2.9%	37.9%	65.5%	-1.1%	0.4%
Couples w/3 or more children	2.3%	20.2%	61.3%	-0.9%	-0.1%
Elderly (more than 60)	0.0%	0.0%	0.0%	0.0%	0.0%

Table 19: Consumption reaction

Family type	Income	Food	Beverages	Tobacco	Clothing	Housing	Health	Transports	Comm.	Recreation	Hotels	Fin. serv.
All families	0.2%	-1.8%	0.4%	-1.4%	-0.7%	0.2%	-2.7%	0.3%	-0.2%	-0.3%	0.0%	-0.1%
Poor	2.9%	1.5%	2.5%	2.0%	4.1%	7.3%	-0.3%	10.6%	4.7%	2.9%	2.1%	2.2%
Single males	0.8%	-1.6%	1.5%	0.1%	-0.5%	1.9%	-1.9%	0.7%	1.9%	0.2%	0.4%	0.1%
Single females	0.1%	-1.8%	0.1%	-1.5%	-0.7%	0.1%	-2.9%	-0.4%	-0.4%	-0.5%	0.0%	-0.1%
singles w/children	1.4%	-0.9%	1.6%	0.8%	0.1%	-0.6%	-3.0%	3.8%	0.6%	-0.2%	0.4%	0.5%
Couples w/o children	0.1%	-2.0%	0.3%	-1.7%	-0.8%	-0.1%	-2.8%	-0.4%	-0.6%	-0.2%	-0.2%	-0.1%
Couples w/1 child	-0.1%	-2.1%	0.0%	-2.0%	-1.2%	-0.6%	-3.0%	0.0%	-0.7%	-0.5%	-0.5%	-0.4%
Couples w/2 children	0.4%	-1.8%	0.1%	-2.0%	-0.2%	1.1%	-3.0%	2.5%	-0.4%	-0.5%	0.0%	0.1%
Couples w/3+ children	-0.1%	-2.1%	-0.1%	-1.5%	-1.0%	-0.3%	-2.5%	-0.7%	-0.5%	0.3%	-0.1%	-0.2%
Elderly (more than 60)	0.0%	-1.7%	0.3%	-1.1%	-0.6%	0.0%	-2.6%	-0.3%	-0.3%	0.0%	0.0%	0.0%
Price variation		0.2%	-0.5%	2.3%	0.6%	-0.6%	3.1%	0.0%	-0.2%	0.1%	-0.4%	0.4%

Table 20: Sensitivity analysis - Macro closures

		Base scenario	Neoclassical closure	Keynesian closure
Real GDP	(% var)	0.7	-0.6	4.6
Unemployment rate	(% in p.p.)	-2.0	0.0	-7.9
Labor	(% var)	2.2	0.0	8.6
Capital	(% var)	-0.8	-0.9	-0.8
Real wage	(% var)	-2.0	-1.5	-3.9
Real rate of remuneration of capital	(% in p.p.)	0.0	-0.1	0.2
Consumer Price Index	(% var)	0.5	0.5	0.5
Private consumption	(% var)	0.2	-0.5	2.0
Investments	(% var)	-10.8	-14.4	0.0
Government expenditure	(% var)	0.7	-0.6	4.6
Exports	(% var)	3.3	2.6	5.4
Imports	(% var)	-6.8	-8.0	-3.4
Private saving rate	(% in p.p.)	1.3	0.9	2.6
Public deficit / GDP	(% in p.p.)	0.7	0.8	0.4
Flow of domestic assets to RoW	(% var)	2.4	2.4	2.3
Flow of foreign assets to France	(% var)	-3.5	-3.8	-2.8

Table 21: Sensitivity analysis - Trade elasticities

		Base scenario	Elasticities x 0.75	Elasticities x 1.25
Real GDP	(% var)	0.7	0.2	1.0
Unemployment rate	(% in p.p.)	-2.0	-1.2	-2.5
Labor	(% var)	2.2	1.3	2.7
Capital	(% var)	-0.8	-0.8	-0.8
Real wage	(% var)	-2.0	-1.8	-2.2
Real rate of remuneration of capital	(% in p.p.)	0.0	-0.1	0.0
Consumer Price Index	(% var)	0.5	0.5	0.5
Private consumption	(% var)	0.2	-0.1	0.3
Investments	(% var)	-10.8	-9.9	-12.2
Government expenditure	(% var)	0.7	0.2	1.0
Exports	(% var)	3.3	2.3	4.2
Imports	(% var)	-6.8	-6.3	-7.6
Private saving rate	(% in p.p.)	1.3	1.2	1.3
Public deficit / GDP	(% in p.p.)	0.7	0.8	0.6
Flow of domestic assets to RoW	(% var)	2.4	2.4	2.4
Flow of foreign assets to France	(% var)	-3.5	-3.4	-3.8

Would a euro's depreciation improve the French economy?

Technical description of the CGE model

February, 2014

A.1 Introduction

In this technical document, we describe in details the CGE model that represents the macro component of our Micro-Macro simulation model. Our CGE model is a static and multisectoral model with two foreign zones: the Eurozone and the Rest of the World. The CGE model is built by using the French input-output data-set of 2006 provided by Insee which includes 118 sectors. We aggregate these sectors into 19 sectors, 11 of which correspond to the sectors used in the Microsimulation model concerning the consumption decisions. The construction of the SAM (*Social Accounting Matrix*), necessary to calibrate our CGE model, is completed by using national accounts concerning the government account and the balance of payments. Elasticities come from the GTAP model.

The sectors of the CGE model are indicated in Table A.1 which also indicates whether the consumption level is determined in the CGE model or in the Microsimulation (MS) model.

Table A.1: List of the sectors

		CGE	MS
1 Food	Agriculture, hunting, forestry, fishing. Food		X
2 Beverage	Beverages		X
3 Tobacco	Tobacco		X
4 Energy	Mining and quarrying. Coke, refined petroleum products and nuclear fuel. Production, collection and distribution of electricity. Manufacture of gas; distribution of gaseous fuels through mains. Steam and hot water supply. Collection, purification and distribution of water	X	
5 Mineral products	Chemicals excluding pharmaceuticals. Rubber and plastics products. Other non-metallic mineral products	X	
6 Textile	Textiles, textile products, leather and footwear		X
7 Housing	Wood and products of wood and cork		X
8 Mechanic industry	Machinery and equipment, nec	X	
9 Electric industry	Office, accounting and computing machinery. Electrical machinery and apparatus. Medical, precision and optical instruments	X	
10 Metallurgy	Iron and steel. Non-ferrous metals. Fabricated metal products, except machinery and equipment	X	
11 Health	Health and social work. Pharmaceuticals. Education		X
12 Construction	Construction	X	
13 Transports	Motor vehicles, trailers and semi-trailers. Building and repairing of ships and boats. Aircraft and spacecraft. Railroad equipment and transport equip nec. Manufacturing nec; recycling. Land transport; transport via pipelines. Water transport. Air transport. Supporting and auxiliary transport activities. Activities of travel agencies		X
14 Hotels et restaurants	Hotels and restaurants		X
15 Leisure	Pulp, paper, paper products, printing and publishing. Radio, television and communication equipment. Other community, social and personal services. Private households with employed persons and extra-territorial organisations and bodies		X
16 Communications	Post and telecommunications		X
17 Public administration	Public admin. and defence; compulsory social security	X	
18 Non-financial services and R&D	Real estate activities. Renting of machinery and equipment. Computer and related activities, Research and development. Other Business Activities	X	
19 Financial services	Finance and insurance		X

A.2 The equations of the model

A.2.1 Sectors

For each sector, we use a multi-stage CES production function. In the first stage, the production level of a sector i (Y_i) depends on the total quantity of intermediate goods (Z_i), labor (L_i) and capital (K_i) used:

$$Y_i = \left[(\alpha_{Z,i})^{\frac{1}{\sigma_i}} \cdot Z_i^{\rho_i} + (\alpha_{L,i})^{\frac{1}{\sigma_i}} \cdot L_i^{\rho_i} + (\alpha_{K,i})^{\frac{1}{\sigma_i}} \cdot K_i^{\rho_i}\right]^{\frac{1}{\rho_i}}$$

The first order conditions in order to maximize profit given the technological constraint are:

$$Z_i = \alpha_{Z,i} \cdot \left[\frac{P_i^h \cdot (1-\tau_{y,i})}{PZ_i}\right]^{\sigma_i} \cdot Y_i \quad (1)$$

$$L_i = \alpha_{L,i} \cdot \left[\frac{P_i^h \cdot (1-\tau_{y,i})}{w \cdot (1+cot_{patr})}\right]^{\sigma_i} \cdot Y_i \quad (2)$$

$$K_i = \alpha_{K,i} \cdot \left[\frac{P_i^h \cdot (1-\tau_{y,i})}{r+\delta}\right]^{\sigma_i} \cdot Y_i \quad (3)$$

$$P_i^h \cdot (1-\tau_{y,i}) \cdot Y_i = PZ_i \cdot Z_i + w \cdot (1+cot_{patr}) \cdot L_i + (r+\delta) \cdot K_i \quad (4)$$

Equations (1), (2), (3) and (4) determine Z_i, L_i, K_i and Y_i. P_i^h is the home price of the good produced by sector i. w and $r+\delta$ represent respectively the equilibrium remuneration of one unit of labor and capital that are both supposed to be unique given the hypothesis of perfect mobility of the production factors across sectors. The parameters cot_{patr} and $\tau_{y,i}$ represent respectively the social contributions rate paid by the employers and the tax rate on production. $P_i^h \cdot (1-\tau_{y,i})$ represents the average net price on sales earned by the firm. $w \cdot (1+cot_{patr})$ represents the total cost paid by a firm to hire one unit of labor. PZ_i represents the aggregate price of intermediate goods used by sector i, defined later.

In the second stage, each sector i chooses the repartition of the total intermediate good into different intermediate goods sold by j (Z_{ji}). The choice is made in order to minimize the total cost and to respect the following constraint:

$$Z_i = \left[\sum_j (\alpha_{Z_{ji}})^{\frac{1}{\sigma Z_i}} \cdot Z_{ji}^{\rho Z_i} \right]^{\frac{1}{\rho Z_i}}$$

The first order conditions are:

$$Z_{ji} = \alpha_{Z_{ji}} \cdot \left[\frac{PZ_i}{PZ_{ji}} \right]^{\sigma Z_i} \cdot Z_i \tag{5}$$

$$PZ_i \cdot Z_i = \sum_j PZ_{ji} \cdot Z_{ji} \tag{6}$$

These equations determine respectively Z_{ji} and PZ_i.

PZ_{ji} is the average price of the intermediate goods of type j that sector i buys, defined later.

Z_{ji} represents the quantity of good j that sector i buys. This quantity can be produced in the domestic market (h) or abroad (f). The repartition is made in order to minimize the total cost and to respect the following constraint:

$$Z_{ji} = \left[(\alpha_{ji}^h)^{\frac{1}{\sigma Z_{ji}}} \cdot (Z_{ji}^h)^{\rho Z_{ji}} + (\alpha_{ji}^f)^{\frac{1}{\sigma Z_{ji}}} \cdot (Z_{ji}^f)^{\rho Z_{ji}} \right]^{\frac{1}{\rho Z_{ji}}}$$

The first order conditions are:

$$Z_{ji}^h = \alpha_{ji}^h \cdot \left[\frac{PZ_{ji}}{P_j^h} \right]^{\sigma Z_{ji}} \cdot Z_{ji} \tag{7}$$

$$Z_{ji}^f = \alpha_{ji}^f \cdot \left[\frac{PZ_{ji}}{PZ_j^f} \right]^{\sigma Z_{ji}} \cdot Z_{ji} \tag{8}$$

$$PZ_{ji} \cdot Z_{ji} = P_j^h \cdot Z_{ji}^h + PZ_{ji}^f \cdot Z_{ji}^f \tag{9}$$

These equations determine Z_{ji}^h, Z_{ji}^f and PZ_{ji}.

PZ_{ji} is the average price of the intermediate goods of type j that sector i buys computed as the weighted average between the equilibrium domestic price (P_j^h) and the foreign price (PZ_{ji}^f), defined later.

Z_{ji}^f represents the quantity of good j that sector i buys abroad. This quantity can be produced in the Eurozone (Ez) or in the rest of the world (Row). The repartition is made in order to minimize the total cost and to respect the following constraint:

$$Z_{ji}^{f} = \left[(\alpha_{ji}^{Ez})^{\frac{1}{\sigma Z_{ji}^{f}}} \cdot (Z_{ji}^{Ez})^{\rho Z_{ji}^{f}} + (\alpha_{ji}^{Row})^{\frac{1}{\sigma Z_{ji}^{f}}} \cdot (Z_{ji}^{Row})^{\rho Z_{ji}^{f}} \right]^{\frac{1}{\rho Z_{ji}^{f}}}$$

The first order conditions are:

$$Z_{ji}^{Ez} = \alpha_{ji}^{Ez} \cdot \left[\frac{PZ_{ji}^{f}}{P_{j}^{Ez}} \right]^{\sigma Z_{ji}^{f}} \cdot Z_{ji}^{f} \quad (10)$$

$$Z_{ji}^{Row} = \alpha_{ji}^{Row} \cdot \left[\frac{PZ_{ji}^{f}}{P_{j}^{Row} \cdot \varepsilon} \right]^{\sigma Z_{ji}^{f}} \cdot Z_{ji}^{f} \quad (11)$$

$$PZ_{ji}^{f} \cdot Z_{ji}^{f} = P_{j}^{Ez} \cdot Z_{ji}^{Ez} + P_{j}^{Row} \cdot \varepsilon \cdot Z_{ji}^{Row} \quad (12)$$

These equations determine Z_{ji}^{Ez}, Z_{ji}^{Row} and PZ_{ji}^{f}.

PZ_{ji}^{f} represents the average price of the intermediate goods of type j that sector i buys abroad which is computed as the weighted average between the price in the Eurozone P_{j}^{Ez} and the world price expressed in euros $P_{j}^{Row} \cdot \varepsilon$. In particular, ε is the exchange rate that is assumed to be exogenous (while financial flows are endogenously determined in order to equilibrate the balance of payments) and is used to simulate the macroeconomic shock in our model. The world price of good j expressed in foreign currency P_{j}^{Row} is exogenous, while the price in the Eurozone P_{j}^{Ez} is treated as endogenous since it is reasonable to assume that euro's depreciation would affect prices in the whole Eurozone. For each sector j, the price in the Eurozone P_{j}^{Ez} is computed as a weighted average between a domestic price in the Eurozone (which is assumed to vary in the same proportion as the domestic price in France) and the world price expressed in euros.

A.2.2 Exports

A fraction of the production is sold in the domestic market and the complementary fraction is exported. Goods that are exported are supposed to be identical to those sold in the domestic market, implying that the selling price P_{i}^{h} is the same.

Exports are defined by a decreasing function of the relative price, i.e. the ratio between the foreign price expressed in Euros and the domestic price. Exports towards the Eurozone (E_i^{Ez}) and the rest of the world (E_i^{Row}) are given by:

$$E_i^{Ez} = \alpha_i^{Ez} \cdot \left[\frac{P_i^{Ez}}{P_i^h}\right]^{\sigma E_i} \tag{13}$$

$$E_i^{Row} = \alpha_i^{Row} \cdot \left[\frac{P_i^{Row} \cdot \varepsilon}{P_i^h}\right]^{\sigma E_i} \tag{14}$$

These equations determine respectively E_i^{Ez} and E_i^{Row}.

In particular, as we have already said, prices in the Eurozone are assumed to be endogenous in order to take into account that Euro's devaluation represents a shock affecting the whole Eurozone. Consequently, it is reasonable to presume that real GDP in the Eurozone is affected by the shock as in France. For this reason, the terms α_i^{Ez} are assumed to be endogenous and to vary in the same proportion as the French real GDP.

A.2.3 Consumption

In our Micro-Macro simulation model, the labor supply depends on the quantity of labor that people want to supply (that is determined by the Microsimulation model) and on the unemployment rate (that can be exogenous or endogenous depending on the macro closure used in the CGE model). Thus, in the CGE model, utility does not depend on leisure but only on consumption of goods and services.

In particular, the consumption level for 11 (over 19) sectors is determined by the Microsimulation model. Therefore, in the CGE model, the representative agent has to decide the optimal level of consumption for the 8 "CGE sectors" ($i^{cge} = 4, 5, 8, 9, 10, 12, 17, 18$).

First, the representative agent determines the level of total consumption for the "CGE goods" (C^{cge}). We assume that the value of total consumption for the "CGE goods" is equal to a fraction of the total disposable income:

$$PC^{cge} \cdot C^{cge} = \alpha_C \cdot Y_{disp} \tag{15}$$

This equation determines C^{cge}.

PC^{cge} is the price index of the "CGE goods", while Y_{disp} indicates the disposable income, both defined later.

Starting from the total consumption for the "CGE goods", the representative agent chooses, for each "CGE goods" i, the optimal quantity C_i^{cge}, by maximizing the following CES utility function:

$$C^{cge} = \left[\sum_{i=i_{cge}} (\alpha_{C_i^{cge}})^{\frac{1}{\sigma C}} \cdot (C_i^{cge})^{\rho C} \right]^{\frac{1}{\rho C}}$$

The first order conditions are:

$$C_i^{cge} = \alpha_{C_i^{cge}} \cdot \left[\frac{PC}{PC_i^{cge}} \right]^{\sigma C} \cdot C \quad (16)$$

$$PC^{cge} \cdot C^{cge} = \sum_{i=i_{cge}} PC_i^{cge} \cdot C_i^{cge} \quad (17)$$

The previous equations determine respectively the consumption level and the price index for the "CGE goods" (C_i^{cge} and PC^{cge}). The consumption level for the "microsimulation goods" (C_i^{ms}) is fixed at the level determined by the Microsimulation model.

Households can consume, for each sector i, domestic goods C_i^h and foreign goods C_i^f and the optimal repartition, is chosen in order to minimize the total cost and to respect the following constraint:

$$C_i = \left[(\alpha_{C_i}^h)^{\frac{1}{\sigma C_i}} \cdot \left(C_i^h \right)^{\rho C_i} + (\alpha_{C_i}^f)^{\frac{1}{\sigma C_i}} \cdot \left(C_i^f \right)^{\rho C_i} \right]^{\frac{1}{\rho C_i}}$$

The first order conditions are:

$$C_i^h = \alpha_{C_i}^h \cdot \left[\frac{PC_i}{P_i^h \cdot (1 + \tau_{VAT_i})} \right]^{\sigma C_i} \cdot C_i \quad (18)$$

$$C_i^f = \alpha_{C_i}^f \cdot \left[\frac{PC_i}{PC_i^f} \right]^{\sigma C_i} \cdot C_i \quad (19)$$

$$PC_i \cdot C_i = P_i^h \cdot (1 + \tau_{VAT_i}) \cdot C_i^h + PC_i^f \cdot C_i^f \quad (20)$$

These equations determine C_i^h, C_i^f and PC_i.

In particular, PC_i represents the average consumption price of good i, computed as the average between the domestic consumption price $P_i^h \cdot (1+\tau_{VAT_i})$ and the foreign consumption price PC_i^f, defined later. The parameter τ_{VAT_i} indicates the VAT rate in sector i.

Households can consume foreign goods coming from the Eurozone C_i^{Ez} and from the rest of the world C_i^{Row}. The optimal composition is chosen in order to minimize the total cost and to respect the following constraint:

$$C_i^f = \left[(\alpha_{C_i}^{Ez})^{\frac{1}{\sigma C_i^f}} \cdot (C_i^{Ez})^{\rho C_i^f} + (\alpha_{C_i}^{Row})^{\frac{1}{\sigma C_i^f}} \cdot (C_i^{Row})^{\rho C_i^f} \right]^{\frac{1}{\rho C_i^f}}$$

The first order conditions are:

$$C_i^{Ez} = \alpha_{C_i}^{Ez} \cdot \left(\frac{PC_i^f}{P_i^{Ez} \cdot (1+\tau_{VAT_i})} \right)^{\sigma C_i^f} \cdot C_i^f \tag{21}$$

$$C_i^{Row} = \alpha_{C_i}^{Row} \cdot \left(\frac{PC_i^f}{P_i^{Row} \cdot \varepsilon \cdot (1+\tau_{VAT_i})} \right)^{\sigma C_i^f} \cdot C_i^f \tag{22}$$

$$PC_i^f \cdot C_i^f = P_i^{Ez} \cdot (1+\tau_{VAT_i}) \cdot C_i^{Ez} + P_i^{Row} \cdot \varepsilon \cdot (1+\tau_{VAT_i}) \cdot C_i^{Row} \tag{23}$$

These equations determine C_i^{Ez}, C_i^{Row} and PC_i^f.

In particular, PC_i^f represents the average foreign consumption price of good i computed as the average between the (endogenous) Eurozone consumption price $P_i^{Ez} \cdot (1+\tau_{VAT_i})$ and the (exogenous) world consumption price $P_i^{Row} \cdot \varepsilon \cdot (1+\tau_{VAT_i})$.

A.2.4 Investment

The repartition of the aggregate investment I, which is defined later, into the sectors of our CGE model (I_i) is made in order to minimize the total cost and to respect the following constraint:

$$I = \left[\sum_i (\alpha_{I_i})^{\frac{1}{\sigma I}} \cdot (I_i)^{\rho I} \right]^{\frac{1}{\rho I}}$$

The first order conditions are:

$$
\begin{aligned}
I_i &= \alpha_{I_i} \cdot \left[\frac{PI}{PI_i}\right]^{\sigma I} \cdot I && (24) \\
PI \cdot I &= \sum_i PI_i \cdot I_i && (25)
\end{aligned}
$$

These equations determine I_i and the price index of investments PI.

In particular, investment goods can come from the domestic market, indicated respectively I_i^h and I_i^f. The optimal repartition is made by minimizing the total cost and by respecting the following constraint:

$$
I_i = \left[(\alpha_{I_i}^h)^{\frac{1}{\sigma I_i}} \cdot \left(I_i^h\right)^{\rho I_i} + (\alpha_{I_i}^f)^{\frac{1}{\sigma I_i}} \cdot \left(I_i^f\right)^{\rho I_i}\right]^{\frac{1}{\rho I_i}}
$$

The first order conditions are:

$$
\begin{aligned}
I_i^h &= \alpha_{I_i}^h \cdot \left[\frac{PI_i}{P_i^h \cdot (1+\tau_{VAT_i})}\right]^{\sigma I_i} \cdot I_i && (26) \\
I_i^f &= \alpha_{I_i}^f \cdot \left[\frac{PI_i}{PI_i^f}\right]^{\sigma I_i} \cdot I_i && (27)
\end{aligned}
$$

$$
PI_i \cdot I_i = P_i^h \cdot (1+\tau_{VAT_i}) \cdot I_i^h + PI_i^f \cdot I_i^f \qquad (28)
$$

These equations determine I_i^h, I_i^f and PI_i.

In particular, PI_i represents the average investment price of good i, computed as the average between the domestic investment price $P_i^h \cdot (1+\tau_{VAT_i})$ and the foreign investment price PI_i^f, defined later.

Foreign investment goods can come from the Eurozone and from the rest of the world, indicated respectively I_i^{Ez} and I_i^{Row}. The optimal repartition is chosen by minimizing the total cost and by respecting the following constraint:

$$I_i^f = \left[(\alpha_{I_i}^{Ez})^{\frac{1}{\sigma I_i^f}} \cdot \left(I_i^{Ez}\right)^{\rho I_i^f} + (\alpha_{I_i}^{Row})^{\frac{1}{\sigma I_i^f}} \cdot \left(I_i^{Row}\right)^{\rho I_i^f} \right]^{\frac{1}{\rho I_i^f}}$$

The first order conditions are:

$$I_i^{Ez} = \alpha_{I_i}^{Ez} \cdot \left[\frac{PI_i^f}{P_i^{Ez} \cdot (1 + \tau_{VAT_i})} \right]^{\sigma I_i^f} \cdot I_i^f \quad (29)$$

$$I_i^{Row} = \alpha_{I_i}^{Row} \cdot \left[\frac{PI_i^f}{P_i^{Row} \cdot \varepsilon \cdot (1 + \tau_{VAT_i})} \right]^{\sigma I_i^f} \cdot I_i^f \quad (30)$$

$$PI_i^f \cdot I_i^f = P_i^{Ez} \cdot (1 + \tau_{VAT_i}) \cdot I_i^{Ez} + P_i^{Row} \cdot \varepsilon \cdot (1 + \tau_{VAT_i}) \cdot I_i^{Row} \quad (31)$$

These equations determine I_i^{Ez}, I_i^{Row} and $P_{I,i}^f$.

In particular, $P_{I,i}^f$ represents the average foreign investment price of good i, computed as the average between the (endogenous) Eurozone price $P_i^{Ez} \cdot (1 + \tau_{VAT_i})$ and the (exogenous) world price $P_i^{Row} \cdot \varepsilon \cdot (1 + \tau_{VAT_i})$.

A.2.5 Government expenditure

The total government expenditure, denoted by G, is determined in the model by assuming that the ratio with respect to real GDP is constant:

$$\frac{G}{GDP_{real}} = const_G \quad (32)$$

This equation determines G, while $const_G$ is calibrated in order to reproduce the 2006 value of the total government expenditure.

The repartition of the total government expenditure (G) into different sectors is made in order to minimize the total cost and to respect the following constraint:

$$G = \left[\sum_i (\alpha_{G_i})^{\frac{1}{\sigma G}} \cdot (G_i)^{\rho G} \right]^{\frac{1}{\rho G}}$$

The first order conditions are:

$$G_i = \alpha_{G_i} \cdot \left[\frac{PG}{PG_i}\right]^{\sigma G} \cdot G \quad (33)$$

$$PG \cdot G = \sum_i PG_i \cdot G_i \quad (34)$$

These equations determine G_i and the government price index PG.

In particular, the government can consume domestic and foreign goods. The optimal repartition is made by minimizing the total cost and by respecting the following constraint:

$$G_i = \left[(\alpha^h_{G_i})^{\frac{1}{\sigma G_i}} \cdot \left(G^h_i\right)^{\rho G_i} + (\alpha^f_{G_i})^{\frac{1}{\sigma G_i}} \cdot \left(G^f_i\right)^{\rho G_i}\right]^{\frac{1}{\rho G_i}}$$

The first order conditions are:

$$G^h_i = \alpha^h_{G_i} \cdot \left[\frac{PG_i}{P^h_i \cdot (1+\tau_{VAT_i})}\right]^{\sigma G_i} \cdot G_i \quad (35)$$

$$G^f_i = \alpha^f_{G_i} \cdot \left[\frac{PG_i}{PG^f_i}\right]^{\sigma G_i} \cdot G_i \quad (36)$$

$$PG_i \cdot G_i = P^h_i \cdot (1+\tau_{VAT_i}) \cdot G^h_i + PG^f_i \cdot G^f_i \quad (37)$$

These equations determine G^h_i, G^f_i and PG_i.

In particular, PG_i represents the average price of good i, computed as the average between the domestic price $P^h_i \cdot (1+\tau_{VAT_i})$ and the foreign price PG^f_i, defined later.

Foreign goods demanded by the government can come from the Eurozone and from the rest of the world. The optimal repartition is chosen by minimizing the total cost and by respecting the following constraint:

$$G^f_i = \left[(\alpha^{Ez}_{G_i})^{\frac{1}{\sigma G^f_i}} \cdot \left(G^{Ez}_i\right)^{\rho G^f_i} + (\alpha^{Row}_{G_i})^{\frac{1}{\sigma G^f_i}} \cdot \left(G^{Row}_i\right)^{\rho G^f_i}\right]^{\frac{1}{\rho G^f_i}}$$

The first order conditions are:

$$G_i^{Ez} = \alpha_i^{Ez} \cdot \left[\frac{PG_i^f}{P_i^{Ez} \cdot (1 + \tau_{VAT_i})} \right]^{\sigma G_i^f} \cdot G_i^f \tag{38}$$

$$G_i^{Row} = \alpha_i^{Row} \cdot \left[\frac{PG_i^f}{P_i^{Row} \cdot \varepsilon \cdot (1 + \tau_{VAT_i})} \right]^{\sigma G_i^f} \cdot G_i^f \tag{39}$$

$$PG_i^f \cdot G_i^f = P_i^{Ez} \cdot (1 + \tau_{VAT_i}) \cdot G_i^{Ez} + P_i^{Row} \cdot \varepsilon \cdot (1 + \tau_{VAT_i}) \cdot G_i^{Row} \tag{40}$$

These equations determine G_i^{Ez}, G_i^{Row} and PG_i^f.

In particular, PG_i^f represents the average foreign price of good i, computed as the average between the (endogenous) Eurozone price $P_i^{Ez} \cdot (1 + \tau_{VAT_i})$ and the (exogenous) world price $P_i^{Row} \cdot \varepsilon \cdot (1 + \tau_{VAT_i})$.

A.2.6 Domestic demand of goods and services

For each sector i, the total domestic demand in the domestic market (X_i^h) is given by the sum of domestic intermediate goods, consumption (private and public) and investments:

$$X_i^h = \sum_j Z_{ij}^h + C_i^h + I_i^h + G_i^h \tag{41}$$

This equation determines X_i^h.

A.2.7 Imports of goods and services

For each sector i, the total imports from the Eurozone and from the rest of the world are given by:

$$M_i^{Ez} = \sum_j Z_{ij}^{Ez} + C_i^{Ez} + I_i^{Ez} + G_i^{Ez} \tag{42}$$

$$M_i^{Row} = \sum_j Z_{ij}^{Row} + C_i^{Row} + I_i^{Row} + G_i^{Row} \tag{43}$$

These equations determine M_i^{Ez} and M_i^{Row}.

A.2.8 Household budget constraint

First, we define the gross income perceived by the representative agent as the sum of labor and capital incomes and transfers from the government:

$$\begin{aligned} Y_{gross} &= w \cdot (1 - \text{cot}_{empl}) \cdot L_{Fr-Fr} \cdot (1-u) + w^{Ez} \cdot L_{Fr-Ez} \\ &+ r \cdot PI \cdot A_{Fr-Fr} + r^{Row} \cdot \varepsilon \cdot A_{Fr-Row} + \Gamma_{ms} + \Gamma \end{aligned} \tag{44}$$

The first component in the RHS represents the labor incomes earned in France which depend on the domestic wage w, the contribution rate paid by the employees cot_{empl} and the number of French people who work in France $L_{Fr-Fr} \cdot (1-u)$. The latter variable depends on the quantity of labor that people decide to supply L_{Fr-Fr} that is fixed at the level determined in the Microsimulation model, and on the unemployment rate u which can be exogenous or endogenous in the CGE model according to the macro closure rule that is chosen. The second component is the labor incomes earned abroad which depend on the exogenous foreign wage rate w^{Ez} and the exogenous number of French people who work abroad L_{Fr-Ez}. We assume that French people who work abroad work in the Eurozone. The capital incomes earned in France (third component) depend on the domestic interest rate r and the value of assets owned by French people in France A_{Fr-Fr}, while the capital incomes earned abroad (fourth component) depend on the exogenous world interest rate r^{Row}, the exogenous exchange rate ε and the value of assets owned by French people in the rest of the world A_{Fr-Row}. The last two elements in the RHS represent the transfers paid by the government. We consider two types of transfers: (i) Γ_{ms} represents transfers that affect the labor incomes (and thus the labor market choices), the value of which is fixed at the level determined in the Microsimulation model.[1] (ii) Γ represents other (exogenous) transfers from the government that do not affect individual labor choices (that include, for example, pension benefits).

The disposable income is computed as the difference between the gross income and taxes on labor and capital incomes:

[1] Γ_{ms} includes *Allocations familiales, Allocations parents isolés, Allocation de rentrée scolaire, Complément familial, Aide au logement, Prestation d'accueil du jeune enfant, Prime à la naissance, Allocation de base, Complément de libre choix d'activité, Allocation parentale d'éducation, Aide assistante maternelle, Allocations pour jeune enfant, Prime pour l'emploi, Revenu minimum d'insertion, Minimum vieillesse.*

$$Y_{disp} = Y_{gross} - Tax_{lab} - \tau_{cap} \cdot r \cdot PI \cdot A_{Fr-Fr} \tag{45}$$

In particular the value of the taxes on labor incomes (Tax_{lab}) is fixed at the level determined in the Microsimulation model. τ_{cap} is the tax rate on capital incomes.

The budget constraint states that the difference between the disposable income and the consumption of goods and services is saved:

$$S_H = Y_{disp} - \sum_i PC_i \cdot C_i \tag{46}$$

This equation determines private savings S_H, implying that the propensity to save is endogenous.[2]

A.2.9 Government budget constraint

Government savings are given by the difference between revenues (that come from direct and indirect taxes and social contributions) and expenditures (represented by the total public expenditure, interests on the public debt B and transfers to households):

$$\begin{aligned} S_G &= \sum_i \tau_{y,i} \cdot P_i^h \cdot Y_i \\ &+ \sum_i \tau_{VAT_i} \cdot \left[P_i^h \cdot \left(C_i^h + I_i^h + G_i^h\right) + P_i^{Ez} \cdot \left(C_i^{Ez} + I_i^{Ez} + G_i^{Ez}\right) + P_i^{Row} \cdot \varepsilon \cdot \left(C_i^{Row} + I_i^{Row} + G_i^{Row}\right)\right] \\ &+ Tax_{lab} + \tau_{cap} \cdot r \cdot PI \cdot A_{Fr-Fr} + \sum_i w \cdot (cot_{patr} + cot_{empl}) \cdot L_i \\ &- (P_g \cdot G + r \cdot B + \Gamma_{ms} + \Gamma) \end{aligned} \tag{47}$$

This equation determines the public savings S_G.

A.2.10 Balance of payments

The balance of payments states that the current account surplus plus the capital account surplus must be equal to zero. In particular, the current account surplus is given by the net exports plus

[2] The propensity to save is endogenous since the total consumption of the "microsimulation goods" is fixed at the level determined in the Microsimulation model and the total consumption of the "CGE goods" is determined as a fraction of the disposable income (see Equation 15).

the net factor incomes from the rest of the world, while the capital account surplus is given by the net capital inflows, i.e. the difference between the flow of foreign assets to France ΔA_{Row-Fr} and the flow of domestic assets to the rest of the world ΔA_{Fr-Row}.

$$\begin{aligned} & \left[\sum_i P_i^h \cdot (E_i^{Ez} + E_i^{Row})\right] - \left[\sum_i \left(\sum_j PZ_i^f \cdot Z_{ij}^f\right) + PC_i^f \cdot C_i^f + PI_i^f \cdot I_i^f + PG_i^f \cdot G_i^f\right] \\ + & \quad \left[w^{Ez} \cdot L_{Fr-Ez} + r^{Row} \cdot \varepsilon \cdot PI \cdot A_{Fr-Row}\right] - \left[w \cdot (1 - cot_{empl}) \cdot L_{Row-Fr} + r \cdot PI \cdot A_{Row-Fr}\right] \\ + & \quad PI \cdot (\Delta A_{Row-Fr} - \Delta A_{Fr-Row}) \\ = & \quad 0 \end{aligned}$$

Given that the exchange rate ε is assumed to be exogenous and the flow of domestic assets ΔA_{Fr-Row} to the rest of the world is determined by the optimal asset allocation (see infra), the balance of payments determines the flow of foreign assets to France ΔA_{Row-Fr}.

A.2.11 Optimal asset allocation

The (exogenous) initial wealth owned by French households (A_{Fr}) must be invested, at the beginning of the period, in France or abroad. We suppose that domestic and foreign assets are not perfect substitutes and that the optimal allocation depends on the ratio between the rates of return on the two assets. In particular, the rate of return on the domestic assets is the (net of depreciation) marginal productivity of capital r and the rate of return on the foreign assets is given by the sum between the foreign interest rate r^{Row} and the percentage variation of the exchange rate $\frac{\varepsilon - \varepsilon_{-1}}{\varepsilon_{-1}}$.

The optimal allocation of the initial wealth, that depends on the anticipated ratio between the two rates of return, is given by:

$$\frac{A_{Fr-Fr}}{A_{Fr-Row}} = \alpha_{Fr} \cdot \left(\frac{r}{r^{Row} + \frac{\varepsilon - \varepsilon_{-1}}{\varepsilon_{-1}}}\right)^{\sigma_r} \tag{48}$$

$$A_{Fr} = A_{Fr-Fr} + A_{Fr-Row} \tag{49}$$

The previous equations determine A_{Fr-Fr} and A_{Fr-Row}.

The total wealth owned by the representative agent at the beginning of the next period $A_{Fr_{+1}}$ must also be allocated between domestic assets and foreign assets. The households total wealth available at the beginning of the next period depends on the private savings and is given by:

$$PI \cdot A_{Fr_{+1}} = PI \cdot A_{Fr} + S_H \tag{50}$$

The optimal allocation of $A_{Fr_{+1}}$ between domestic assets and foreign assets is made on the basis of the (anticipated) ratio between the rates of return. In particular, the anticipated rate of return on the domestic assets is the anticipated (net of depreciation) marginal productivity of capital $E[r_{+1}]$ and the anticipated rate of return on the foreign assets is given by the sum between the anticipated foreign interest rate $E[r_{+1}^{Row}]$ and the anticipated percentage variation of the exchange rate $E[\frac{\varepsilon_{+1}-\varepsilon}{\varepsilon}]$. We consider extrapolative expectations, implying that $E[r_{+1}] = r$, $E[r_{+1}^{Row}] = r^{Row}$ and $\frac{E[\varepsilon_{+1}]-\varepsilon}{\varepsilon} = \frac{\varepsilon-\varepsilon}{\varepsilon} = 0$. Thus:

$$\frac{A_{Fr-Fr_{+1}}}{A_{Fr-Row_{+1}}} = \alpha_{Fr} \cdot \left(\frac{r}{r^{Row}}\right)^{\sigma_r} \tag{51}$$

$$A_{Fr_{+1}} = A_{Fr-Fr_{+1}} + A_{Fr-Row_{+1}} \tag{52}$$

The previous equations determine $A_{Fr-Fr_{+1}}$ and $A_{Fr-Row_{+1}}$. The flow of assets to the rest of the world is then given by:

$$\Delta A_{Fr-Row} = A_{Fr-Row_{+1}} - A_{Fr-Row} \tag{53}$$

A.2.12 Equilibrium conditions

A.2.12.1 Markets of goods and services

At the equilibrium, the quantity produced in each sector Y_i must be equal to the domestic and foreign demands:

$$Y_i = X_i^h + E_i^{Ez} + E_i^{Row} \tag{54}$$

This equation determines the domestic equilibrium price in each sector P_i^h.

A.2.12.2 Labor market

In the labor market, the total labor demanded by all the sectors must be equal to sum between the quantity of labor supplied by French people (that depends on the quantity of labor, determined in the Microsimulation model, that French people want to supply L_{Fr-Fr}, and on the unemployment rate u) and the (exogenous) quantity of labor supplied by foreign people L_{Row-Fr}:

$$\sum_i L_i = L_{Fr-Fr} \cdot (1-u) + L_{Row-Fr} \tag{55}$$

This equation determines the equilibrium domestic wage w.

A.2.12.3 Capital market

At the equilibrium, the total capital demanded by all the sectors and by the government must be equal to the capital supplied by French people (that depends on the quantity that is endogenously determined in order to optimally allocate the initial wealth) and by foreign people (that is exogenous):

$$\sum_i K_i + B = A_{Fr-Fr} + A_{Row-Fr} \tag{56}$$

This equation determines the equilibrium domestic rate of remuneration of capital r.

A.2.13 Numéraire

The Walras Law implies that one equation of the model is redundant and one price must be chosen as *numéraire*. We chosen the domestic price index as the *numéraire*. Thus, the exchange rate ε represents the real exchange rate and the macroeconomic shock simulated in this paper is a depreciation of the real exchange rate.

A.2.14 Macro closure

In our CGE model us use a closure rule which is between the neoclassical and the keynesian ones. In particular, we introduce in our model an investment function which takes into account for the (partial) crowding-out effect on investments produced by a change in the components of the aggregate demand. The investment function introduced in our CGE model is the following:

$$I = \alpha_0 + \alpha_1 \cdot GDP_{real} + \alpha_2 \cdot \Delta C + \alpha_3 \cdot \Delta G + \alpha_4 \cdot \Delta CA \tag{57}$$

where the parameters have been estimated using yearly French data from 1946 to 2012 provided by Insee. The results, reported in Table A.2, show that an increase in each of the components of the aggregate demand produces a crowding-out effect on aggregate investments, but this crowding-out effect is only partial, i.e. is lower than the effect obtained using a neoclassical closure. The introduction of this investment function allows us to build a CGE model with a macro closure that is between the neoclassical and the keynesian ones.

Table A.2: Estimation results of the investment function

Dependent Variable: INV
Method: Least Squares
Sample: 1949 2012
Included observations: 64

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-116.7686	10.22002	-11.42548	0.0000
GDP	0.580564	0.041725	13.91396	0.0000
Detrended CONS	-0.428466	0.184598	-2.321076	0.0240
Detrended G	-0.315125	0.156875	-2.008761	0.0495
Detrended CA	-0.909974	0.187228	-4.860240	0.0000

R-squared	0.997651	Mean dependent var	190.4531
Adjusted R-squared	0.997309	S.D. dependent var	97.54353
S.E. of regression	5.060240	Akaike info criterion	6.210405
Sum squared resid	1408.331	Schwarz criterion	6.513998
Log likelihood	-189.7330	Hannan-Quinn criter.	6.330005
F-statistic	2919.334	Durbin-Watson stat	0.499086
Prob(F-statistic)	0.000000		

Source: Insee. French data from 1946 to 2012.

The macroeconomic equilibrium condition states that aggregate investments must be equal to aggregate savings (i.e. the savings of the representative agent, of the government and with respect to the rest of the world):

$$PI \cdot I = S_H + S_G + PI \cdot (\Delta A_{Row-Fr} - \Delta A_{Fr-Row}) \tag{58}$$

This equation determines the equilibrium unemployment rate u.

A.3 Interactions with the Microsimulation model

Our Micro-Macro model works as follows. First, the CGE model simulates a shock (that can be a macroeconomic or a microeconomic shock) and determines the macroeconomic effects, in particular the percentage variations of (i) the equilibrium domestic wage, (ii) the equilibrium consumer prices of the goods and services, (iii) the consumer price index, and (iv) the unemployment rate.

$$\begin{aligned} \Delta\% w &= \frac{w(new) - w(0)}{w(0)} \\ \Delta\% PC_i &= \frac{PC_i(new) - PC_i(0)}{PC_i(0)} \\ \Delta\% CPI &= \frac{CPI(new) - CPI(0)}{CPI(0)} \\ \Delta\% u &= \frac{u(new) - u(0)}{u(0)} \end{aligned}$$

where $w(0)$ and $w(new)$ indicate respectively the initial value (i.e. before the simulation of a shock) and the final value (i.e. the solution value obtained in the CGE model) of the domestic wage rate; $PC_i(0)$ and $PC_i(new)$ are respectively the initial value and the final value of the average consumption price of good i (computed as the average between the domestic consumption price and the foreign consumption price); $CPI(new)$ and $CPI(0)$ are respectively the initial value and the final value of the consumer price index; $u(new)$ and $u(0)$ are respectively the initial value and the final value of the unemployment rate.

The variations of the equilibrium prices are then introduced in the Microsimulation model in order to compute the effects on (i) the total quantity of labor that French people want to supply L_{Fr-Fr}, (ii) the consumption demand of goods and services C_i^{ms}, (iii) the total tax on labor incomes Tax_{lab}, (iv) the total contributions paid by the employees and the workers, and (v) the total transfers paid by the government to households Γ_{ms}.

The percentage variations computed in the Microsimulation model allow us to determine the new value of the exogenous variables in the CGE model as follows:

$$\begin{aligned}
L_{Fr-Fr}(new) &= (1+\Delta\%L_{Fr-Fr}) \cdot L_{Fr-Fr}(0) \\
C_i^{ms}(new) &= (1+\Delta\%C_i^{ms}) \cdot C_i^{ms}(0) \\
Tax_{lab}(new) &= (1+\Delta\%Tax_{lab}) \cdot Tax_{lab}(0) \\
cot_{patr}(new) &= (1+\Delta\%TotCot_{patr}) \cdot cot_{patr}(0) \cdot \frac{w(0) \cdot [L_{Fr-Fr}(0) \cdot (1-u(0)) + L_{Row-Fr}]}{w \cdot [L_{Fr-Fr}(new) \cdot (1-u(new)) + L_{Row-Fr}]} \\
cot_{empl}(new) &= (1+\Delta\%TotCot_{empl}) \cdot cot_{empl}(0) \cdot \frac{w(0) \cdot [L_{Fr-Fr}(0) \cdot (1-u(0)) + L_{Row-Fr}]}{w \cdot [L_{Fr-Fr}(new) \cdot (1-u(new)) + L_{Row-Fr}]} \\
\Gamma_{ms}(new) &= (1+\Delta\%\Gamma_{ms}) \cdot \Gamma_{ms}(0)
\end{aligned}$$

where $L_{Fr-Fr}(0)$, is the initial value (i.e. before the simulation of a shock) of the number of French people who want to work in France, $C_i^{ms}(0)$ is the initial value of the consumption level for the "microsimulation goods", $\Gamma_{ms}(0)$ is the initial value of the transfers from the government to the households, $Tax_{lab}(0)$ is the initial value of the total labor income taxes, $w(0)$ is the initial value of the domestic wage, $cot_{patr}(0)$ and $cot_{empl}(0)$ are the initial values of the contribution rates paid respectively by the employers and the employees.

The CGE model is then solved by considering the new values of the exogenous variables determined in the Microsimulation model. The solution obtained in the CGE model (i.e. the percentage variations of the equilibrium prices and the unemployment rate) is then introduced in the Microsimulation model. And so on. We developed an algorithm in which the iterations are stopped when the fixed point is reached, i.e. when all the percentage variations remain (sufficiently) constant from one iteration to another.