Short-run Rigidities and Long-run Adjustments in a Computable General Equilibrium Model of Income Distribution and Development

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SHORT-RUN RIGIDITIES AND LONG-RUN
ADJUSTMENTS IN A COMPUTABLE GENERAL EQUILIBRIUM
MODEL OF INCOME DISTRIBUTION AND DEVELOPMENT

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This paper summarizes the structure of a model of the 'computable general equilibrium' type
which incorporates short-run disequilibrium mechanisms stemming from natural rigidities of the
economic system. Special attention is also given to the macroeconomic implications of the
model. Illustrative simulations based on the Venezuelan economy are reported.

1. Introduction

Several attempts have recently been made to replace the analysis of the
distribution of incomes in developing countries within the framework of
highly disaggregated macroeconomic simulation models of the 'computable
general equilibrium' type [see, for instance, Adelman and Robinson (1977),
Taylor et al. (1980), Dervis and de Melo (1977), and Kervis et al. (1980)].
The practical and analytical interest of such an approach of distributive issues is
obvious. In most countries, a very substantial part of income inequality
comes in fact from 'macroeconomic' sources. In developing countries, for
instance, almost 50% of total inequality is typically explained by the
structure of earnings across sectors and occupational groups, the structure of
employment, and the distribution of wealth.\(^1\) So, a model able to explain the

\(^{1}\)This is a revised version of a paper presented at the Econometric Society World Congress
(Aix-en-Provence, 1980) and at Pr. Malinvaud's Seminar in Paris. We thank the participants to
both seminars as well as L. Taylor, S. Robinson and an anonymous referee for useful comments.

In Venezuela, a decomposition of Theil's statistic according to sectors of economic activity
and occupational status (employee, self-employed, employer) explained 33% of total inequality of
what should roughly correspond to labor-incomes in 1976 [Bourguignon (1980)]. Adding the
strong inequality related to capital-income or wealth distribution should raise that figure
approximately to 50%.

way in which all those parameters may change over time, and react to exogenous shocks, can definitely be of valuable help for policy-making in the field of development and income distribution. On the other hand, that part of income inequality which cannot be so easily explained by macro-economic structural parameters most probably escapes the control of policy-makers and is therefore of less practical interest.  

Computable general equilibrium models permit a consistent endogenous representation of the complex structural circular relationship 'production–distribution–consumption–investment–production'. Those models, however, generally rely on assumptions which may crucially depend on the time horizon that is selected for the analysis. Most of the existing models, for instance, are built along neo-classical assumptions which seem quite appropriate in the long-run — i.e., capital–labor substitution, full-employment, market-clearing prices, etc. — but might be somewhat inadequate in the short- or medium run. This may be a severe drawback for policy-making, since one can easily imagine situations where a given policy-measure would have opposite effects on income distribution in the short run and in the long run and where long-run social benefits could be offset by short-run social costs. A change in the tariff structure of a country, for instance, might well improve its efficiency and its equity in the long-run but it also might generate high short-run adjustment costs in terms of unemployment and income distribution. It seems desirable, therefore, to try to extend the existing computable general equilibrium models of income distribution and development to cover the case of short-run (or medium-run) 'disequilibrium' situations stemming from natural rigidities of the economic system and its dynamic adjustment to equilibrium.

This paper presents such a model applied to Venezuela and the summary results of a few simulations meant to illustrate its ability to account for some disequilibrium situations. Most of the paper, however, is purely theoretical and the practical implications of the model for the Venezuelan economy will not be discussed here.  

2. Main lines of the model

It will be convenient to present the general characteristics of our model as departures from the assumptions underlying the model by Adelman and Robinson (1977). Their model is essentially a sequence of temporary equilibria mainly defined by a fixed structure of sectoral capital stocks and

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2An important part of that 'residual', for instance, is to be found in the age structure of the population and may be of less interest if one has in mind life-cycle incomes. On the other hand, the statement in the text does not deny the general interest of analyzing inequality factors of that type. It simply points out that they certainly are more difficult to control.

3A discussion of the data problems and of the adequation of the model to the evolution of the Venezuelan economy since 1975 is provided in Bourguignon et al (1980).
some exogenous parameters (demographic characteristics of labor supply, inter-sectoral structure of earnings by occupational groups, foreign prices, etc.). In the short run (the unit-period), all markets in that model adjust to equilibrium through price variations. This includes labor-markets where short-run capital–labor substitution ensures well-behaved demand curves so that the only possible source of unemployment is the fixity of wages. From a period to the next, the capital stocks in productive sectors are modified in accordance with the investments decided during the current period and labor-supply changes according to exogenous and endogenous (migrations) demographic mechanisms. A new temporary general equilibrium is found and the whole process goes on generating the dynamic path of the economy.

The main departures that we have introduced in our own model are the following:

(1) Putty-clay production functions prevent capital–labor substitution in the short-run. Thus, productive sectors have a fixed employment and output capacity during the unit-period and their actual employment and output levels are simply proportional to those capacities. The proportion factors are the sectoral 'activity levels' and become crucial endogenous variables of the model. Clearly, this absence of substitution between capital and labor can generate a type of unemployment quite different from that coming from wage rigidities and close to what can be observed in many developing countries. Dynamically, on the other hand, strong changes in the structure of the domestic product is also likely to reproduce in the model some type of 'structural unemployment'.

(2) To be consistent with the preceding assumptions, it seemed logical to define nominal wages during the current period as functions of unemployment rates by labor-categories. The wage-determination mechanism has thus been assumed of the short-run Phillips type. Changing the wage–unemployment elasticities, in an exogenous way, on the other hand, permits to make labor-markets in the model close to the neo-classical instantaneous adjustment case or, on the contrary, to consider situations of perfectly rigid (and exogenous) wages. In the long run, and when the preceding elasticities are neither infinite nor zero, however, labor-markets behave much like they do in the neo-classical theory.

(3) Rationing on the labor-markets is quite possible in the model because changes in money wages may be bounded from above, i.e., wages do not

*In other words unemployment, or under-employment, is largely due in those countries to a limited labor-absorption capacity of productive sectors. This may be the case in the short-run as well as in the long-run if investments are not large enough and/or if they are structurally too rigid.
necessarily tend to infinity when unemployment rates go to zero. With disaggregated labor-markets, this is an interesting and quite realistic feature of the model. Another interesting feature of the model, which is related to labor-markets, is its ability to simulate mechanisms close to the job competition theory through the degree of mobility of the labor-force between different labor-categories (or labor-markets) during the unit-period. This allows us to take into account phenomena like skill-down-grading and voluntary unemployment which may have some importance for income distribution as well as for short-run macroeconomic aggregates.\(^5\)

\(^4\) The model realistically allows for some price-rigidity in various ways. First, some partial downward price-rigidity is assumed in all markets. Secondly, there is a ceiling price on all tradable goods which is defined by foreign competition (including the level of tariffs), so that excess-demand at the ceiling price is met by imports rather than by increases in prices as in conventional general equilibrium models. Finally, the government may also impose ceiling and floor prices on all goods with some endogenous additional measures preventing disequilibria in markets for non-tradable goods.\(^6\)

Of course, all those assumptions do not make our model a 'full disequilibrium model', in the sense that disequilibrium may exist only on labor-markets (as in conventional macro disequilibrium models) and, to some extent, on markets for tradable goods. Computational as well as theoretical choice difficulties, which will clearly appear in the more detailed presentation of the model which follows, prevented us to be more general. We believe, however, that its main departures from conventional general equilibrium mechanisms will allow our model to account for a large number of disequilibrium situations which can be observed in the real world and may perhaps have some substantial impact on some income distribution and development parameters in the short-run.

3. A simplified theoretical presentation of the model

We shall start with a description of the microeconomic behavior of firms and consumers postulated by the model. We shall then see how the decisions of those agents determine the state of the economy in the short run (a given year) and the dynamic links which define the time path of the economy. Finally, we shall briefly study the macroeconomic specificity of the whole model.

\(^5\)Simulations along those lines are reported in Michel and Miqueu (1980).

\(^6\)This is because the model does not allow for rationing in markets for goods and services. For tradable goods, excess-demand at a ceiling price can always be met by imports, but there is no solution of that type for non-tradable goods.
3.1. Microeconomic behavior of economic agents and markets

3.1.1. Productive sectors

All productive sectors are considered as an aggregate firm and a distinction is made between large production units ('formal' sectors) and self-employment or family units ('informal' sectors). Each sector is assumed to produce a specific good or service\(^7\) but there may be some non-zero price cross-elasticity of the demand for the products of two distinct sectors, introducing some inter-sectoral competition.

In order to facilitate the understanding of the model we will first describe the behavior of the representative firm under a simplified set of assumptions. Technology is assumed to be of the putty-clay type, so that it is necessary to differentiate short-run and long-run firms' behavior.

Basic behavior in the short-run

For a given year, each productive sector, \(i\), is assumed to take production decisions, according to the following set of rules:

\[
E_i, K_i, Q_i = F_i(E_i, K_i), \text{ given}
\]

\[
p_i^e = p_i - \sum a_{ij} p_j,
\]

\[
\bar{w}_i = \frac{(E_i/Q_i)}{\sum a_{ik} w_k},
\]

\[
\alpha_i = \frac{Q_i}{Q_i} = E_i/\bar{Q}_i = E_i/E_i
\]

\[
p_i^e > \bar{w}_i \Rightarrow \alpha_i = 1,
\]

\[
p_i^e = \bar{w}_i \Rightarrow 0 \leq \alpha_i \leq 1,
\]

\[
p_i^e < \bar{w}_i \Rightarrow \alpha_i = 0.
\]

\(E, K\) and \(Q\) represent respectively labor-employment, capital and output. The overbar indicates fixed short-run capacities and \(F\) is a conventional production function. The \(a_{ij}\) are fixed intermediate input and non-competitive import coefficients so that \(p_i^e\) is the value-added price. \(\bar{w}_i\) is the variable unit-labor cost. It is derived from the average labor-productivity \((\bar{Q}_i/E_i)\) and a weighted average of the wages corresponding to the various categories of labor \((k)\). The coefficients \(\lambda_{ik}\) represent the structure of

\(^7\)Except agricultural sectors.
employment by types of labor in sector \( i \) and they are assumed to be fixed.\(^8\)

Finally, \( \alpha_i \) is the 'activity level' of sector \( i \) and (1) simply states that each productive sector is maximizing its short-run profits subject to the constraint \( \alpha_i \leq 1 \) and non-negative profits. So, it will operate at full capacity \( (\alpha_i = 1) \) only if the value-added price, \( p_i' \), at least covers the variable unit-labor cost, \( \tilde{w_i} \). If \( p_i' \) just covers \( \tilde{w_i} \), \( \alpha_i \) is determined by the demand side of the market. If \( p_i' \) should be less than \( \tilde{w_i} \), finally, the sector would not operate.\(^9\)

**Additional features of productive sectors' behavior in the short-run**

The actual model is in fact slightly more complicated than what has just been presented for two reasons.

(i) **Price behavior and partial downward price-rigidity.** According to system (1), the activity level of the representative firm of a given productive sector is less than full-capacity only when the output price is so low that its short-run profits are equal to zero. Practically, however, one might expect such behavior is also consistent with a somewhat higher price-level. This is the reason why we have assumed that firms, in the model, are not always pure price-takers but might counteract a too sharp decrease in output prices by reducing their supply. This assumption could probably be more rigorously justified in some type of monopolistic competition framework, but, in any case, it certainly is quite close to the real world.\(^10\)

In accordance with that argument, the two last relationships in system (1) must then be replaced by

\[
\begin{align*}
p_i'' &= \sup (p_i, \tilde{w_i}) \Rightarrow \alpha_i \leq 1, \\
p_i'' &> \sup (p_i, \tilde{w_i}) \Rightarrow \alpha_i = 1. \quad (1')
\end{align*}
\]

So, (1') reflects an asymmetric control on prices by firms. Firms are assumed to be price-takers as long as the price is above some minimum \( (p_0) \) but they will oppose any further reduction below that minimum. This minimum may be defined in a variety of ways, the important requirement being here that it depends only on the past structure of prices and wages.\(^11\)

\(^8\)This assumption might be somewhat restrictive since it implies that adjustments in the structure of employment come only from asymmetrical rates of growth of the various productive sectors. It has been made mostly for the sake of simplicity since there would be no conceptual problems in assuming long-run substitution between labor-categories.

\(^9\)In other words, \( \tilde{w_i} \) is the conventional shut-down price in micro theory. It would also have been possible to change that specification for a minimum strictly positive profit or for a minimum mark-up without modifying the logics of the model.

\(^10\)In that way, the model appears as a mix of price and quantity adjustments although the way in which this is done might seem somewhat heuristic. For a more rigorous discussion of the issue, see Drazen (1980).

\(^11\)Practically we have assumed that prices could not fall by more than 5% between two unit-periods.
(ii) Rationing on the labor-markets. Wages are assumed to be somewhat rigid in the model so that they will be unable to make excess-demand disappear on the labor-markets. In such a situation, rationing employment in productive sectors will become necessary. The rationing scheme is assumed to be such that each sector is rationed proportionally to its share in the total employment in the labor-category in excess-demand.\footnote{Notice that this is not the conventional 'proportional' scheme where the rationing coefficient would be the same for all sectors. The exact formula for this rationing scheme is the following. Let $\rho_i$ be the rationing coefficient (rationed/desired employment) and $\beta_i$ the share of sector $i$ in the total desired employment ($\Sigma_i \rho_i \beta_i = \Sigma_i D_i$). Let $S$ be the labor-supply. Then, we want $\rho_i = \beta_i S$, where $k$ is a constant defined by $\Sigma_i \beta_i S = S$. Solving the latter equation, one finds $\rho_i = (\beta_i / k) (S / D_i)$.) Under those conditions, the full-capacity level, $\alpha_i = 1$, cannot anymore be the reference situation that firms will consider in making their short-run production decisions and (1') must then be changed for

\[
P^*_i = \sup (p_i^*, \tilde{w}_i) \Rightarrow \alpha_i < \bar{\alpha}_i,
\]

\[
P^*_i > \sup (p_i^*, \tilde{w}_i) \Rightarrow \alpha_i = \bar{\alpha}_i,
\]

where $\bar{\alpha}_i$ is the maximum activity level of sector $i$ under rationing in the labor-market, with, of course, $\alpha_i = 1$ if there is no rationing.

**Investment and employment. Long-run behavior**

During a given period, a productive sector is characterized by $E_i, K_i$. In addition, the size of its outstanding debt, $D_i$, is also given as well as the interest rate at which it has been contracted. From a period to the next, those three parameters change in the following way:

\[
\frac{\Delta \tilde{K}_i}{K_i} = A_i (\gamma_i - (1 - \gamma_i)) + \left[ \frac{p^*_i}{\tilde{w}_i} \frac{\delta F_i}{\delta E_i} \right]^{\gamma_i} - 1,
\]

\[
\frac{\Delta \bar{E}_i}{E_i} = A_i (\gamma_i - (1 - \gamma_i)) + \left[ \frac{p^*_i}{\tilde{w}_i} \frac{\delta F_i}{\delta E_i} \right]^{\gamma_i} - 1,
\]

\[
\Delta D_i = \rho_i \left( \Delta \tilde{K}_i + \delta \bar{E}_i \right) - (p^*_i - \tilde{w}_i) Q_i,
\]

where $A_i, A_i', a_i, \sigma_i$ are constants, and $\gamma_i$ is the expected rate of growth of the demand for output $i$ (practically, a moving average of actual growth rates). The first part of the capital equation is a traditional accelerator model of investment which takes into account the level of capacity under-utilisation.\footnote{Notice the stabilizing role of this term for sectors producing non-tradable goods since, in their case, demand growth is necessarily equal to output growth. For tradable goods, however, excess-demand might be met by imports and both rates may differ.}
The second term is of the neo-classical type. It makes the change in capital dependent on the ratio between its marginal revenue-product and its rental cost ($\pi_i r$, with $\pi_i =$average price of capital goods used by sector $i$ and $r =$ interest rate). Again all those prices are assumed to be 'expected' prices and are approximated by moving averages. Together with the employment equation, it can be seen that each sector $i$ is assumed to grow according to the accelerator assumption with a corrective term representing some competitive behavior on the demand side of both the labor and the capital markets as well as capital–labor substitution.

It may be important to notice that (2) is not fully rigorous in the sense that investment and employment decisions may seem artificially separated. The correct specification should be in fact derived from the intertemporal profit maximization of a demand-constrained firms. Actually, (2) has been chosen for convenience and may be interpreted as summarizing the behavior such a theoretical model would imply. Being demand-constrained, on the one hand, the representative firm takes the necessary steps to meet the expected additional demand ($g_i$). This defines its desired level of output for the next period. To produce that output, on the other hand, the firm may consider its current structure of productive factors $(K/E)$ inappropriate in view of expected prices, so that it will adapt progressively that structure to some optimum. In theory, then, the changes in $K$ and $E$ should depend simultaneously on both $\pi_i r$ and $\bar{w}_i$, unlike what is specified in the second part of the first two expressions (2). However, this should not have too much bearing on the general macroeconomic properties of the model. Notice finally that, all other variables being assumed constant, system (2) ensures the convergence toward a long-run conventional equilibrium defined by $\alpha_i = 1$, $p_i'(\delta F_i/\delta K) = \pi_i r$, $p_i'(\delta F_i/\delta E) = \bar{w}_i$.

The last equation in (2) simply describes the need of sector $i$ for investment funds and the resulting change in its outstanding debt. This change is given by the difference between interest payments ($r_{-1}$ is the past value of the interest rate) and investment expenditures ($\delta$, is the depreciation rate of capital), on the one hand, and the cash-flow during the current period, on the other. To make things simpler, we have not introduced the tax system in those formulas and we have assumed a perfect capital market. It is possible to handle imperfect capital markets with the model. In that case the investment process integrates some features of the liquidity model.

14 For instance, a model like

$$
\max_K \int_0^\tau \left( p D_0(p)e^{-\gamma} - w E - qK e^{-\gamma} dt \right) F(K,E) = D_0(p)e^{-\gamma}.
$$

where $D_0(p)$ is the demand function at time 0 and the prices $p, w$ are given.
Self-employment and informal sectors

The same equations as above are postulated for the informal sectors with a few modifications. All the informal sectors are assumed to work at full-capacity during the current period. Wages in the dynamic equations are replaced by self-employment labor opportunity costs which are equal to wages in the formal sector multiplied by the probability of getting the corresponding job (Harris-Todaro hypothesis). Finally, the 'debt' coincides with the personal wealth of firms' owner-operators in that sector. All those assumptions are made to take into account the fact that self-employed workers and family firms do not face the same rigidities on the labor-market as the formal sector but react, nevertheless, to signals in that market.

3.1.2. Labor-markets

Suppose that all prices, \( p_i \), are known, and that the supply of labor by categories \( k \) is fixed. From (1), it is easy to derive the demand for the various types of labor (\( \sum \lambda_i E_i \alpha_i \)). Nominal wages \( w_k \) are assumed to be determined by previous wages (\( w_{k-1} \)) and the rate of unemployment for the labor-category \( k(U_k) \), according to the short-run Phillips' curve,

\[
w_k = (1 + \varepsilon)w_{k-1} + \phi(u_k) \quad \text{with} \quad \phi(0) > 0, \tag{3}
\]

where \( \varepsilon \) is an exogenous productivity factor. Iterating on the sectoral activity levels, \( \alpha_i \), the 'equilibrium' of the labor-markets is defined by (1') and (3). Different cases might occur. First, all sectors operate at full-capacity and there is excess-supply in all labor-markets [see (1')]. Then the \( u_k \)'s are known and so are the \( w_k \)'s through (3). It remains only to check that those \( w_k \)'s are consistent with full capacity in (1'). Secondly, if this latter condition does not hold, some sectors will reduce their activity levels and, thus, unemployment rates will rise whereas wages will fall until both (1') and (3) are satisfied. The third situation corresponds to a situation of excess-demand on one or several labor-markets. \( \phi(0) \) in (3) is reasonably assumed to be finite, which implies some rigidity on wages. So, assume that the full-employment wage-level \( w_k \), corresponding to \( u_k = 0 \) in (3), implies some excess-demand on the labor-market \( k \) because, for instance, all sectors want to operate at full-capacity according to (1'). Then rationing cannot be avoided and all sectors will have to share the existing supply of labor. This is done through the rationing scheme described above and the production decision by firms is not governed by (1') anymore but by (1').

The preceding argument has been made on the assumption of a fixed price, \( p_i \). Practically, however, the problem is far more complex since \( p_i \) depends on the total demand on market \( i \), so that the \( \alpha_i \)'s cannot be determined independently from the \( p_i \)'s. In order to keep this presentation simple,
however, we will not deal with that issue here. Details on that point are
given in the solution algorithm summarized in the appendix. It must be
stressed, finally, that, in the long-run and other things being equal, (3) should
ensure the convergence of the unemployment rates $u_k$ toward their
'equilibrium' level $u_0^0$ defined by $\phi(u_0^0) = 0$.

3.1.3. Income distribution and capital incomes

When wages and activity levels are known for a given set of prices, it is a
simple matter to derive the distribution of labor incomes. First, employment
by categories $k$ is allocated among households. Households are defined by
the category $k$ to which belongs the head of the household, and a household
in a given category has a fixed structure of secondary-members' labor-supply
by types of labor $k$. The number of secondary labor-suppliers in a household
depends, however, on the income of the head. Unemployment is assumed to
be equally distributed among the wage-earners of a category $k$. In other
words, they receive a wage $(1 - u_k)w_k$ instead of $W_k$. Secondly, wage rates by
sector are determined for each category $k$, applying a vector of fixed
coefficients to the 'base wage' of the category ($W_k$). Wage-incomes are then
fully distributed. Self-employment incomes, on the other hand, are simply the
total revenue $p_i Q_i$ of self-employment or informal sectors.

It remains to distribute the capital incomes (other than those coming from
self-employment). It is assumed that those incomes are equal to the wealth of
a household multiplied by the rate of interest of the previous period ($r_{-1}$).
So, everything is as if households had invested all their wealth in a savings
account of a financial intermediary during period ($t-1$). On the other hand,
the interest payments made by the productive sectors on their debt [see (2)]
are also assumed to be collected by the financial intermediary. The national
account identity is ensured by the fact that, initially, the total debt of
productive sectors exactly matches the total assets of all savers in the
economy. Because interest rates may differ between household groups as well
as between productive sectors, there may be some discrepancy between the
receipts and the payments of the financial intermediary. This discrepancy can
only be a surplus, however, and it is assumed to be disposed of through
lending on the capital-market for the current period. In that way, the
financial intermediary may actually be accumulating assets over time.

During the current period, the capital-market works in such a way that
savings by households (and the financial intermediary) match the demand for
funds coming from productive sectors [$AD_i$ in (2)] with, possibly, the help of
the government and borrowing from abroad. The way in which this is done
depends on the specification selected for the interest rate in the macroeconomic
closure of the model (see section 3.3 below). All those assumptions permit in
fact to avoid all portfolio problems. Since all transactions go through the
financial intermediary, there actually is only one asset in the model.
The mechanisms just described permit to determine (for a given vector of prices) households' total incomes classified by the labor-category \( k \), the sector \( i \) and the self-employment status of the head (wealth is the same for all households in a category \( k \)). Within each of those groups, households are further divided in 10 deciles, with a fixed ratio between the income of a given decile and the average income of the group. Mixing all groups, yields then the overall income distribution.

### 3.1.4. Consumption expenditures, foreign trade and government spending

Some simple consumption functions have been estimated by income-brackets. Knowing the income distribution, savings and aggregate consumption demand for the various products may be derived.

Export prices and quantities are fully exogenous. For non-oil products, it is assumed that the government subsidizes exports if the internal price happens to be larger than the foreign price. On the import side, a distinction is made between competing and non-competing foreign goods. The latter are dealt with like any other product in the model. The imports of the former are determined by an eventual excess-demand for the corresponding good at the internal value of the foreign price (including tariffs).

Government revenues are endogenously determined by all direct and indirect taxes. Its expenditures are exogenous for the current period, but a dynamic adjustment permits to satisfy any exogenous budget constraint over a given horizon. Subsidizing operations by the government, on the other hand, may be endogenous to the current period.

### 3.2. Closing the model during the current period. Dynamic linkages

For a given vector of prices, all the operations which have just been described permit to determine the supply and demand for all goods and services, credit and foreign exchange. The state of the economy in the short-run is defined by the set of prices which equilibrate all those markets under alternative constraints. Those constraints are

(a) downward price-rigidity (see (1)'),
(b) foreign competition: ceiling-prices equal to foreign prices plus tariffs,
(c) consumers' protection: ceiling-prices with, eventually, producers' subsidizing,
(d) producers' protection: guaranteed producer prices (or incomes) with, eventually, consumers' subsidizing,
(e) employment protection: producers' subsidizing.

Of course, given the assumptions on the behavior of the productive sectors, prices are not the only determinants of the state of the economy in the short-run. As already seen with (1') or (1''), the activity levels are also
fundamental. When demand and supply on a given market do not match, both $a_i$ and $p_i$ will change. It is only when all sectors operate at full-capacity (with or without rationing) that prices move in accordance with the well-known Walrasian tâtonnement process within the limits of the preceding constraints. In general, however, it can be seen in the appendix that the solution algorithm iterates simultaneously on the $p_i$'s and the $a_i$'s.

When the correct set of prices and activity levels have been found, the state of the economy for the current period is fully determined. It remains then to change all the stock variables to repeat the whole procedure for a new period. Those stock variables include those in (2) but also the wealth distribution among households, the change of which depends on current savings decisions, and all the demographic parameters defining the population of households by categories of labor. The government budget must also be determined in accordance with the exogenous constraints it is subject to.

3.3. The macroeconomic closure of the model in the short run and its long-run behavior

It is not easy to figure out the macroeconomic properties of a disaggregated model of the type we have just described. It is a necessary task, however, to test its consistency and to identify possible macroeconomic constraints on the variables of the model. In the present case, this exercise will also help clarifying the assumptions to be made on the aggregate behavior of prices since money is not explicitly introduced in the model.

Following Taylor and Lysy (1979), let us rewrite the whole model as if there were only one sector producing an aggregate good,

\[ \dot{Q} = F(K, E), \]  
\[ P = \nu P_0 + m(P_0/\tau), \]  
\[ PC = \gamma [w(x)\alpha E + r_{-1} W], \]  
\[ I = I(g, r), \]  
\[ B = mP_0 \alpha \dot{Q} + P_M M(\alpha \dot{Q}, P_M/\tau) - P_x X(\alpha M_x), \]  
\[ F = G - \tau P_x \dot{Q}, \]  
\[ (1-\tau)P_0 \alpha \dot{Q} = PC + PI + F - B/\tau, \]  
\[ P_0 = \min (P_0, \nu w(x)\alpha E/\dot{Q}) \quad \text{if} \quad \alpha < 1, \]
As before, \( \alpha \) is the activity level of this one-sector economy. The total output is decomposed into domestic value-added and intermediate imported inputs \((m_\alpha Q)\) with weights \(v\) and \(m\) \((v + m = 1)\). The output price, \(P_o\), is thus a combination of the value-added domestic price, \(P_v\), and import prices expressed in domestic currencies \((P_\alpha/\tau)\). Private consumption expenditures \((P_C)\) is a constant proportion of households’ income, that is the wage-bill, \(w_\alpha E\) \([w\] depending on \(\alpha\) through \((3)\)], and wealth income, \(r_\alpha W\) (both variables \(r_\alpha\) and \(W\) being given). With a single aggregate output, investment in \((2)\) depends only on the expected growth rate \((g)\) and the cost of capital, \(r\).

Let us momentarily ignore \(M\) in \((8)\) and \((12)\). Exports are then exogenously fixed at \(X\), their foreign unit-price being \(P_x\). \(M\) is the volume of non-competitive final goods imported at the foreign price \(P_M\) and depends on national income \((P \alpha Q)\) and the domestic price of those imports \((P_\alpha/\tau)\).\(^{15}\) \(B\) is then the deficit of the balance of trade expressed in foreign currencies. \(F\) is the fiscal deficit of the government assumed to receive \(t\%\) of the total output and to spend an exogenous amount \(G\) on goods and services. Finally \((10)\) is simply the national account identity, whereas \((11)\) is the analogous of the sectoral behavioral relationship \((1')\) at the aggregate level \(P_v\) being some floor price (exogenous for the current period).

Keeping \(M\) equal to zero and ignoring \((12)\), one can see that, after substitution, the whole system can be reduced to the three eqs. \((8), (10)\) and \((11)\) but that it still contains four unknowns, \(\alpha\), \(P\), \(\tau\) and \(r\). As is well-known, this is simply the consequence of not having explicitly introduced money in the model and the price under-identification in the preceding system can be eliminated only by adding an additional constraint on some of the unknowns or by giving to one of them an arbitrary value. Whatever the solution which is chosen, however, it implicitly is equivalent to assuming some monetary policy rule for the current period.

Table 1 summarizes the main implications of ‘closing’ the model by fixing arbitrarily one of the three unknown prices \((P, r, \tau)\) for the current period. It also shows another type of closure of the model where the exchange-rate, \(\tau\), is taken as fixed in the current period and \((8)\) in the system above is interpreted as the definition of the trade deficit rather than a market-equilibrium constraint. It may be useful, however, to describe with some detail one or two of the specifications presented in table 2.

In view of the present situation of the Venezuelan economy (and also for computational convenience), the specifications which have been selected for the ‘reference’ simulation in the next section are those corresponding to case 2.b: fixed exchange rate and unconstrained trade balance, fixed interest rate.

\[^{15}\text{We ignore here custom duties on imports and subsidies on exports.}\]
Table I
Alternative closures of the model during the current period and their implicit monetary implications.

<table>
<thead>
<tr>
<th>(1) Constraining trade balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1a) Fixed price, P</td>
</tr>
<tr>
<td>Equivalent to monetary policy ensuring an arbitrary absolute domestic price level. A price index must be selected.</td>
</tr>
<tr>
<td>(1b) Fixed rate of interest, r</td>
</tr>
<tr>
<td>Equivalent to 'forced-savings' monetary policy defining the absolute level of domestic prices.</td>
</tr>
<tr>
<td>(1c) Fixed exchange rate, τ</td>
</tr>
<tr>
<td>Equivalent to monetary policy achieving the equilibrium of the trade balance. Defines absolute level of domestic prices.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(2) Non-constraining trade-balance, fixed exchange rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2a) Fixed price, P</td>
</tr>
<tr>
<td>Same as (1a), but the arbitrary absolute price level must be chosen taking into account the price of competitive imports.</td>
</tr>
<tr>
<td>(2b) Fixed interest rate, r</td>
</tr>
<tr>
<td>Same as (1b), but 'foreign savings' replace 'forced savings' when domestic prices reaches foreign prices.</td>
</tr>
</tbody>
</table>

The system (4)-(11) reduces then to the savings-investment eq. (10) and eq. (11) with the two unknowns \( P \) and \( \alpha \). Two regimes are possible. First, the economy may operate at less than full capacity. Then \( \alpha \) is less than one, \( P \) is fixed by (11) and the actual level of \( \alpha \) depends on exogenous demand parameters like \( G \) through eq. (10). It can be seen that (11) implies a situation close to fixed real wage, so that this regime is of the fix-price-flexible-quantity type. The implicit monetary policy is that which ensures price-stability at the level defined by (11) and (5).

As \( G \) increases, \( \alpha \) raises until it reaches the full-capacity limit \( \alpha = 1 \). We find, then, the second regime defined by fixed-quantities (\( Q \)) and flexible prices. The rate of interest being fixed, so is \( I \), and excess-demand on the market for goods and services [eq. (10)] will be met by an increase in \( P \). As the money wage is fixed, this is the well-known forced-savings mechanism and the implicit monetary expansion behind it. Notice, however, that there is an upper limit on the price level coming from competitive imports \( M_r \) through (12). When this limit is reached the balance between savings and investment in eq. (10) is not anymore achieved through the forced-savings mechanism but through the foreign savings corresponding to the deficit of the trade balance caused by competitive imports.\(^{16}\)

\(^{16}\)Actually, both phenomena co-exist in the model since foreign savings may refer only to tradable goods.
<table>
<thead>
<tr>
<th>Year (t = 100)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>100</td>
<td>105.2</td>
<td>110.5</td>
<td>116.7</td>
<td>123.3</td>
<td>130.5</td>
<td>138.2</td>
<td>145.4</td>
<td>154.1</td>
<td>163.6</td>
</tr>
<tr>
<td>Share (%) in GDP of:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>28.0</td>
<td>28.0</td>
<td>27.9</td>
<td>27.8</td>
<td>27.7</td>
<td>27.6</td>
<td>27.4</td>
<td>27.1</td>
<td>26.9</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>5.9</td>
<td>5.8</td>
<td>5.8</td>
<td>6.0</td>
<td>5.9</td>
<td>6.0</td>
<td>6.1</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Manufacturing*</td>
<td>11.3</td>
<td>11.3</td>
<td>11.5</td>
<td>11.6</td>
<td>11.8</td>
<td>11.9</td>
<td>12.0</td>
<td>12.2</td>
<td>12.3</td>
<td>12.5</td>
</tr>
<tr>
<td>Services*</td>
<td>36.6</td>
<td>36.6</td>
<td>36.5</td>
<td>36.3</td>
<td>36.1</td>
<td>36.0</td>
<td>35.9</td>
<td>35.6</td>
<td>35.6</td>
<td>35.5</td>
</tr>
<tr>
<td>Private investment</td>
<td>100</td>
<td>104.2</td>
<td>115.3</td>
<td>121.5</td>
<td>133.5</td>
<td>145.0</td>
<td>150.8</td>
<td>175.0</td>
<td>201.5</td>
<td>213.8</td>
</tr>
<tr>
<td>Imports</td>
<td>100</td>
<td>100.5</td>
<td>103.3</td>
<td>109.4</td>
<td>114.1</td>
<td>118.9</td>
<td>121.1</td>
<td>133.5</td>
<td>149.1</td>
<td>167.5</td>
</tr>
<tr>
<td>Aggregate employment</td>
<td>100</td>
<td>102.5</td>
<td>106.1</td>
<td>111.3</td>
<td>116.8</td>
<td>122.0</td>
<td>127.3</td>
<td>131.5</td>
<td>136.0</td>
<td>140.8</td>
</tr>
<tr>
<td>Aggregate unemployment rate (%)</td>
<td>8.0</td>
<td>8.2</td>
<td>7.7</td>
<td>6.6</td>
<td>5.3</td>
<td>4.3</td>
<td>3.5</td>
<td>3.2</td>
<td>2.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Production price index</td>
<td>100</td>
<td>101.8</td>
<td>105.8</td>
<td>111.7</td>
<td>116.7</td>
<td>120.5</td>
<td>124.7</td>
<td>122.6</td>
<td>142.9</td>
<td>158.0</td>
</tr>
<tr>
<td>Consumption price index*</td>
<td>100</td>
<td>100.6</td>
<td>104.2</td>
<td>110.4</td>
<td>114.2</td>
<td>118.8</td>
<td>121.5</td>
<td>130.8</td>
<td>145.3</td>
<td>168.4</td>
</tr>
<tr>
<td>Nominal wage index*</td>
<td>100</td>
<td>101.9</td>
<td>103.6</td>
<td>107.5</td>
<td>114.8</td>
<td>122.0</td>
<td>132.1</td>
<td>144.2</td>
<td>168.3</td>
<td>210.4</td>
</tr>
<tr>
<td>Real wage index*</td>
<td>100</td>
<td>101.3</td>
<td>99.4</td>
<td>97.4</td>
<td>100.6</td>
<td>103.6</td>
<td>108.9</td>
<td>110.3</td>
<td>115.9</td>
<td>124.9</td>
</tr>
</tbody>
</table>

Gini index for households' income distribution:

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>0.499</td>
<td>0.497</td>
<td>0.494</td>
<td>0.499</td>
<td>0.492</td>
<td>0.486</td>
<td>0.476</td>
<td>0.470</td>
<td>0.460</td>
<td>0.452</td>
</tr>
<tr>
<td>Rural</td>
<td>0.448</td>
<td>0.443</td>
<td>0.446</td>
<td>0.449</td>
<td>0.441</td>
<td>0.432</td>
<td>0.425</td>
<td>0.424</td>
<td>0.419</td>
<td>0.419</td>
</tr>
</tbody>
</table>

*aOil refining is included in the 'oil sector'.
*bIncluding transports but excluding government.
*cThis index is based on the consumption basket of median income urban households in year 1.
*dWeighted average of base wages by labor-categories.
*eNominal wage index deflated by consumption price index.
With those specifications, the model is purely demand-driven in the short-run, which seems to conform rather well with what can be presently observed in Venezuela. In the medium run, however, the nature of the model can be made quite different. Suppose, for example, that the exchange-rate is modified at each inter-period in a direction depending on the sign of the trade balance. Over several years, then, the trade balance constraint would be approximately satisfied and domestic savings would become a constraint for growth. As a matter of fact, one could even model the whole macroeconomic policy decision process by introducing at each inter-period mechanisms which would endogenously determine the traditional policy variables, $G$, $r$, and $τ$ (or, implicitly, the money supply).

The long-run behavior of the model naturally depends on the specifications selected for its macroeconomic closure in the short run and on the way the exogenous parameters, which those specifications rely upon, are changed from a period to the next. In our implementation of the model, we have seen that the short-run closure rule (2b) required to state explicitly the value of the macroeconomic policy variables ($τ$, $r$, and $G$) at the beginning of each period. Choosing the value of those variables, however, depends very much on the objective behind the simulations which are performed. If the goal is to replicate the past evolution of the economy, actual values must be introduced. For short-run forecast or simulation, there is no problem either; any set of arbitrary values can be selected and the model proved sufficiently robust to yield consistent results. In the medium- or the long run, however, things are more complex. It is in the nature of a demand-driven model to exhibit strong cyclical patterns and this may prevent meaningful simulations over a reasonably long period. It is in this case that, as mentioned earlier, the macroeconomic policy parameters must be fixed endogenously at each inter-period, in a way depending on the objective of the simulation which is performed. So, one may study the structural properties of some 'neo-classical' growth process by selecting $τ$, $r$, and $G$ in such a way that the public budget and the trade balance be approximately in equilibrium and the general level of prices be more or less constant over the simulated period. Alternatively, one may think of the conventional policy-mix consisting of a counter-cyclical fiscal policy and a trade-balance fixed exchange-rate monetary policy. The interesting thing is naturally that those different macropolicy assumptions will not necessarily have the same long-run implications and that some of them might even prove inconsistent after several years in the presence of strong changes in the other exogenous parameters of the model.

4. A simple experiment

The preceding theoretical model has been implemented with data taken from Venezuela. The production side of the economy has been disaggregated
into some 65 sectors whereas households have been broken down into some 200 groups defined by the labor-category (professionals, administrative employees, skilled and unskilled urban workers, and agricultural workers) and the employment sector of household heads. As data availability as well as the length of the observation period prevented proper econometric procedures, the behavioral parameters have been estimated by assuming that the Venezuelan economy was near a full-equilibrium situation during the base-year of the simulation period (1975) and trying to replicate the observed evolution of the main economic aggregates over the 1975–1978 period. The algorithm used to solve this rather large model is described in the appendix to the present paper. It proved relatively efficient. On the average, convergence is obtained after 7 iterations which, together, take approximately 20 seconds CPU.

Venezuela has recently been subject to strong macroeconomic policy changes leading to a rather chaotic growth path, and a simulation close to the observed behavior of the economy proved not very convenient as a reference for an experiment aiming to show how the model integrates short-run reactions to some initial exogenous shock. Clearly, the more 'regular' the reference simulation the easier it is to identify the effects of the shock. Given the purely illustrative nature of the experiment we report here, we have thus arbitrarily assumed, for the reference simulation, constant growth rates for all the exogenous variables of the model throughout the period, obtaining then a reasonably steady growth path which, naturally, does not compare at all with the recent swings in the Venezuelan economy.

The figures we have selected ensure nevertheless growth performances consistent with the huge investment potential coming from the 1973 oil-price increase. Exogenous exports (essentially oil), government expenditures and foreign prices are all assumed to grow at 5% every year. Demographic growth is uniform at 3%, whereas technical progress yields a 1.5% increase in productivity every year. Both the exchange rate and the 'base' rate of interest are fixed, which means there is no constraint on investment throughout the simulation period. The economy is thus purely demand-driven and we may expect a sustained growth with a slight acceleration coming from pressures on employment, and consequently, wages and household consumption.

This reference simulation is described, on aggregate terms, in table 2. At the beginning of the period, the economy approximately lies on a 5% growth path. A slight lag in investment in year 2, probably linked to a small discrepancy between expected and actual prices, produces an acceleration of inflation in the subsequent years. Unemployment falls then continuously but, because of inflation, real wages remain more or less

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17The average GNP growth rate has been 6.8% for 1973–1977 but it then falls to 3% in 1978, 0.8% in 1979 and −1.2% in 1980, mostly because of an anti-inflationary fiscal and monetary policy. The inflation rate has risen from 3% before 1977 to 22% in 1980.
constant during the first half of the period. It is only when unemployment is far enough from the 'natural' rate (8%) postulated in the Phillips' relationship that nominal wages start increasing at a very fast speed, becoming then the leading growth factor. There is then a very sharp acceleration of GDP investment and inflation until the end of the simulation period. At the same time, a strong capital-labor substitution develops, possibly announcing some future stabilization of the growth process. On the other hand, that booming situation, which as a matter of fact bears much resemblance with the years 1976–1977 in Venezuela, also implies a strong equalization of the income distribution, essentially because of a fast increase in real wages.

In comparison with the preceding simulation, table 3 reports the results of an experiment consisting of an initial 20% drop in the domestic prices of foreign competitive imports in three manufacturing sectors (machinery and transport equipment). All other exogenous variables are kept at the same level as in the reference simulation, except the rate of interest which is gradually lowered, in order for the capital-market to stay in exactly the same (surplus) situation vis-à-vis the rest of the world as in the first simulation. This clearly is equivalent to imposing an 'equilibrium' condition on the capital-market in the present simulation.

In a static international trade theoretical framework, the effects of the preceding shock are simple to figure out. The fall in competitive import prices will first increase those imports at the expense of domestic production, resulting in a deficit of the trade balance and some devaluation of the domestic currency, which in turn attenuates somewhat the initial drop in prices. Productive resources will nevertheless be reallocated in favor of the other sectors of the economy. Since exports are constrained in our model, those sectors will either be sectors of domestic goods and services or sectors initially subject to foreign competition. This reallocation will depend on the other hand on complex interactions between relative factor intensities in the various sectors and the overall demand patterns in the economy.

This long-run restructuration of the economy occurs in our simulation (table 2). The three sectors hit by the fall in competitive import prices represent in the reference simulation roughly 17.5% of all manufacturing, throughout the period. In the present simulation, their weight in manufacturing is only 11% ten years after the initial shock, but manufacturing as a whole is gradually recovering its share of GDP in the reference simulation, partly through substitution of competitive imports in other manufacturing sectors.

The really interesting phenomenon in table 3, however, is the way in which this restructuration takes place throughout the simulation period. It is quite
Table 3
Simulation (2): Effects of a 20% drop of competitive import prices in three manufacturing sectors.

<table>
<thead>
<tr>
<th>Year (1 in simulation 1 = 100)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>100</td>
<td>104.0</td>
<td>109.3</td>
<td>115.1</td>
<td>121.4</td>
<td>128.1</td>
<td>135.5</td>
<td>143.4</td>
<td>151.4</td>
<td>159.8</td>
</tr>
<tr>
<td>Share (%) in GDP of:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>28.3</td>
<td>28.3</td>
<td>28.4</td>
<td>28.3</td>
<td>28.7</td>
<td>28.0</td>
<td>27.8</td>
<td>27.5</td>
<td>27.3</td>
<td>27.0</td>
</tr>
<tr>
<td>Agriculture</td>
<td>6.0</td>
<td>5.9</td>
<td>5.9</td>
<td>6.1</td>
<td>6.0</td>
<td>6.0</td>
<td>6.1</td>
<td>6.0</td>
<td>5.9</td>
<td>6.0</td>
</tr>
<tr>
<td>Manufacturing*</td>
<td>10.8</td>
<td>10.9</td>
<td>11.1</td>
<td>11.2</td>
<td>11.3</td>
<td>11.5</td>
<td>11.7</td>
<td>11.9</td>
<td>12.1</td>
<td>12.3</td>
</tr>
<tr>
<td>Services*</td>
<td>36.3</td>
<td>36.6</td>
<td>36.6</td>
<td>36.2</td>
<td>36.2</td>
<td>35.9</td>
<td>35.8</td>
<td>35.5</td>
<td>35.4</td>
<td>35.4</td>
</tr>
<tr>
<td>Private investment</td>
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<td>104.6</td>
<td>113.5</td>
<td>117.3</td>
<td>141.9</td>
<td>160.0</td>
<td>161.9</td>
<td>190.0</td>
<td>203.5</td>
</tr>
<tr>
<td>Imports</td>
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<td>105.7</td>
<td>108.0</td>
<td>113.7</td>
<td>115.1</td>
<td>129.2</td>
<td>135.4</td>
<td>139.6</td>
<td>148.1</td>
<td>169.3</td>
</tr>
<tr>
<td>Aggregate employment</td>
<td>98.6</td>
<td>101.1</td>
<td>104.5</td>
<td>109.5</td>
<td>114.5</td>
<td>119.6</td>
<td>124.5</td>
<td>129.6</td>
<td>133.8</td>
<td>139.6</td>
</tr>
<tr>
<td>Aggregate unemployment rate (%)</td>
<td>8.7</td>
<td>9.0</td>
<td>8.6</td>
<td>7.5</td>
<td>6.5</td>
<td>5.6</td>
<td>4.9</td>
<td>4.1</td>
<td>3.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Production price index</td>
<td>97.5</td>
<td>98.6</td>
<td>101.3</td>
<td>106.1</td>
<td>109.4</td>
<td>117.1</td>
<td>120.2</td>
<td>123.8</td>
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</tr>
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<td>Consumption price index'</td>
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<td>96.5</td>
<td>98.9</td>
<td>104.0</td>
<td>104.3</td>
<td>106.7</td>
<td>108.2</td>
<td>110.4</td>
<td>115.5</td>
<td>122.7</td>
</tr>
<tr>
<td>Nominal wage index*</td>
<td>98.4</td>
<td>9.9</td>
<td>101.1</td>
<td>102.5</td>
<td>107.0</td>
<td>109.3</td>
<td>114.2</td>
<td>119.8</td>
<td>127.3</td>
<td>143.0</td>
</tr>
<tr>
<td>Real wage index*</td>
<td>100.5</td>
<td>103.5</td>
<td>102.2</td>
<td>98.6</td>
<td>102.6</td>
<td>102.4</td>
<td>105.5</td>
<td>108.5</td>
<td>110.2</td>
<td>116.5</td>
</tr>
<tr>
<td>Gini index for households' income distribution:</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.501</td>
<td>0.498</td>
<td>0.494</td>
<td>0.499</td>
<td>0.494</td>
<td>0.488</td>
<td>0.482</td>
<td>0.473</td>
<td>0.467</td>
<td>0.454</td>
</tr>
<tr>
<td>Urban</td>
<td>0.503</td>
<td>0.499</td>
<td>0.499</td>
<td>0.504</td>
<td>0.499</td>
<td>0.493</td>
<td>0.487</td>
<td>0.479</td>
<td>0.471</td>
<td>0.456</td>
</tr>
<tr>
<td>Rural</td>
<td>0.448</td>
<td>0.441</td>
<td>0.443</td>
<td>0.445</td>
<td>0.438</td>
<td>0.430</td>
<td>0.426</td>
<td>0.417</td>
<td>0.417</td>
<td>0.409</td>
</tr>
</tbody>
</table>

*Oil-refining is included in the 'oil sector'.
*bIncluding transports but excluding government.
*cThis index is based on the consumption basket of median income urban households in year 1.
*dWeighted average of base wages by labor-categories.
*eNominal wage index deflated by consumption price index.
illustrative of the potentiality and specificity of our model together with the macroeconomic closure rules which have been selected. The initial effect of the fall in import prices is obviously to force the corresponding sectors to the minimum activity level which is allowed (50%), the corresponding demand being met by additional imports. Although minor (1% of GDP) and despite the fact that some investment goods are now cheaper, this disequilibrium situation has deflating multiplier and accelerator effects. After five years GDP has fallen by 1.5% and investment by 12%. More importantly, however, prices and money wages also fall with respect to the reference simulation because of the relative slackness of both the output- and the labor-market. As a consequence, foreign goods become increasingly expensive in comparison with domestic goods, since their price keeps rising at 5% every year as in the reference simulation. Thus, the sectors which were initially exposed to foreign competition are now more effectively protected, whereas the three sectors hit by the initial 20% drop in output prices gradually recuperate. Clearly this deflation is equivalent to a devaluation of the domestic currency re-establishing part of the protection of the three sectors in which foreign competition had increased, and enhancing the protection of the others. An additional factor of recovery is the reduction in interest rates which proves necessary to re-equilibrate the capital-market with respect to the reference simulation. Both factors, together, explain the fast growth of investment expenditures at the end of the period as well as the change in the 'equilibrium' structure of the manufacturing sector. At a slightly more aggregate level, however, both simulations clearly tend to coincide in the long-run.

The same tendency can be observed for the real wage index and inequality figures in tables 1 and 2. In fact, there simply seems to be a one-year lag between both simulations at the end of the period. Over the first years, however, the evolution is quite different. The absence of inflation in the second simulation, as well as the fact that unemployment rates are initially close to their 'equilibrium' values, implying thus little change in money wages, tend to raise real wages over the first half of the simulation period. Households' income inequality is little affected, because this equalizing factor is compensated by a higher rate of unemployment and probably also by changes in the employment structure. At the end of the period, lower real wages and higher unemployment rates naturally increase income inequality for a given year in the second simulation. It may be noticed, however, that this phenomenon is more pronounced for urban or rural households than for the whole population which indicates some differences between both simulations with respect to the urban–rural income differential. This is explained by the fact that the initial shock is directed at the non-agricultural sector and by lags in the migration process.
5. Conclusions

Although we have not modelized the same type of situation in the context of a 'pure' general equilibrium the present model seems a priori to offer a more satisfactory representation of the sequence of short-run effects leading to a structural modification of the economy after some initial exogenous shock. With a pure general equilibrium model, wages would have immediately adjusted to their equilibrium level and labor would have been reallocated across sectors with probably quite different effects. In the present case, the adjustment is more progressive and involves quantity variables (activity levels, unemployment rates) as well as price variables. With the rather realistic macroeconomic specifications we have selected for the preceding experiments, on the other hand, this double adjustment process has spillover effects (on imports and prices for instance) that would not be found so explicitly in pure general equilibrium models. Of course, it would be desirable to perform the comparison with those models in a more rigorous way. The present paper has simply shown that, though not easy, generalizing the available 'computable general equilibrium' models to disequilibrium situations and 'price-quantity' adjustment mechanisms was quite possible.

Appendix: The solution algorithm

If there are $n$ goods and $m$ sectors in the economy and if there were no constraint on prices, the basic problem would be to find a set of $n$ prices, $p_i$, and $m$ sectoral activity levels, $a_j$, such that demand equal supply in all markets and the relationship between $a_j$ and $p_i$ in (1) be satisfied. Wages on the labor-markets being function only of the activity levels $a_j$, they may be ignored. Following Adelman and Robinson (1977), a tâtonnement algorithm for that problem could be

\[
p_i^{(n)} = p_i^{(n-1)}(1 + \lambda^{(n-1)}/ED^{(n-1)/TD^{(n-1)}}),
\]

(A.1)

\[
a_j^{(n)} = a_j^{(n-1)}(1 + \Pi_j^{(n-1)}/R_j^{(n-1)})
\]

(A.2)

with $a_j^{(n)} = 1$ if $a_j^{(n-1)} = 1$ and $\Pi_j > 0$, where the bracketed indices refer to iteration numbers, $ED$ and $TD$ are, respectively, excess-demand and total demand, $\Pi$ and $R$ are profits and total sales. The variables $\lambda^{(n)}$ and $\sigma^{(n)}$ are dampening factors, ensuring that the algorithm will note 'cycle' around the equilibrium. They are initially set to one and halved any time that $ED$ or $\Pi$ change sign from an iteration to the next.

This algorithm must be modified to take into account various possible interdependent constraints on prices and activity levels,
(a) ceiling prices \(\bar{p}_i\) imposed by foreign competitive imports or for policy purposes,
(b) floor prices \(\underline{p}_i\) coming from downward price-rigidity or policy measures, minimum employment constraint \(z_i\), and
(c) rationing on the labor market.

Those constraints imply two major modifications to the simple algorithm (A.1)–(A.2),
(a) Activity levels and prices can not move simultaneously anymore but alternatively under mutual constraints.
(b) Activity levels may, in certain cases, be modified depending on market excess demand and not on sectoral profits as it was initially specified in (A.2).

They also make it necessary to identify products and sectors.\(^{20}\)

The final form of the algorithm is now given by the following conditional system for iteration \(n\):

(a) \(p_i^{(n-1)} > \bar{p}_i\),

\[
p_i^{(n)} = \sup \left\{ p_i, \inf \left[ \bar{p}_i, p_i^{(n-1)} \left( 1 + \frac{ED_i^{(n-1)}}{TD_i^{(n-1)}} \right) \right] \right\},
\]
(b) \(\alpha_i^{(n)} = \alpha_i^{(n-1)} \) if \(ED_i^{(n-1)} \cdot \Pi_i^{(n-1)} < 0\)

However,

\[
\alpha_i^{(n)} = \alpha_i^{(n-1)} \quad \text{if} \quad ED_i^{(n-1)} \cdot \Pi_i^{(n-1)} < 0.
\]

(b) \(p_i^{(n-1)} = \underline{p}_i\), \(p_i^{(n)} = \underline{p}_i\),

\[
\alpha_i^{(n)} = \sup \left\{ z_i, \inf \left[ 1, \alpha_i^{(n-1)} \left( 1 + \frac{\Pi_i^{(n-1)}}{TR_i^{(n-1)}} \right) \right] \right\}.
\]

However,

\[
p_i^{(n)} = \sup \left\{ p_i, \inf \left[ \underline{p}_i, p_i^{(n-1)} \left( 1 + \frac{ED_i^{(n-1)}}{TD_i^{(n-1)}} \right) \right] \right\}.
\]

if \(\alpha_i = \tilde{\alpha}_i\) and \(ED_i > 0\), where \(\tilde{\alpha}_i\) is the rationed activity level of sector \(i\).

Two more points must be stressed. First, this system is valid for all sectors

\(^{20}\)Joint production is assumed only for agricultural sectors, but \(x\) in those sectors is constrained to one, which seems reasonable in view of the lags in the agricultural production process.
and markets, differences between sectors and goods coming from the definition of $\bar{p}_i, p_i$ and $\bar{a}_i$,

(a) for tradable goods $\bar{p}_i =$ foreign price (plus tariff),
(b) for non-tradable goods $\bar{p}_i = \infty$,
(c) in each sector $p_i$ is at least the price imposed by price rigidity described in section 2,
(d) other $\bar{p}_i, p_i$ and $\bar{a}_i$ reflect exogenous policies.

Second, activity levels do not change when $ED_i$ and $\Pi_i$ are of opposite sign. This is only a question of efficiency in the algorithm. When $ED_i$ is positive and $\Pi_i$ negative, for instance, it proved quicker to wait and let the price increase, that process eventually making the profit positive while avoiding unnecessary iterations with a simultaneous increase of the price and decrease of the level of activity, possibly followed by another increase in the level of activity.

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