ANNALES D'ÉCONOMIE ET DE STATISTIQUE. – N° 32 — 1993

On the Modelling of Quantity Constraints: An Empirical Point of View

Bénédicte MAILLARD, Henri SNEESSENS*

ABSTRACT. – Business surveys suggest that firms are more often than not quantity-constrained, either by the demand for their output or by the availability of the inputs. Until the late seventies, macro-modellers used to put most of the emphasis on sales constraints, dealing with supply-side quantity constraints in a fairly ad-hoc fashion, simply adding "tension variables" in various parts of an otherwise demand-driven (at least in the short run) model. Over the last ten years however, models have been developed that allow an explicit and rigorous representation of these phenomena. In their most sophisticated versions, these models allow time-varying proportions of sales-, capacity- and labor-supply-constrained firms. Although from a theoretical viewpoint this last approach is clearly superior to the initial one, one may wonder whether empirically the initial procedure does not provide a convenient and much more tractable approximation to the "true" model. This paper aims at answering this question by using Monte-Carlo experiments. The answer is that not introducing quantity constraints in a rigorous way may well alter significantly the parameter estimates and the dynamic properties of the model when the proportion of demand-constrained firms is low, as it was during most of the sixties and early seventies. When the proportion of demand-constrained firms is high (as observed after 1975), the simplified model provides quite a correct approximation.

Point de vue empirique sur la modélisation des contraintes quantitatives

RÉSUMÉ. – Les enquêtes de conjoncture suggèrent que les entreprises sont systématiquement confrontées à des contraintes quantitatives d'importance et de nature variables au fil de la conjoncture, soit contraintes de débouchés, soit tensions dues à des contraintes de capacité ou de disponibilité en main-d'œuvre. Depuis un peu plus de dix ans, des modèles macro-économiques empiriques ont été construits et estimés qui prennent en compte de façon rigoureuse et explicite l'existence de telles contraintes. Le gain en rigueur a cependant un coût non négligeable en termes de facilité d'utilisation. La procédure utilisée dans les années soixante-dix était beaucoup plus simple. Elle supposait la prédominance des contraintes de débouchés et introduisait les effets de tensions par la simple addition de quelques variables ad hoc (traditionnellement un degré d'utilisation des capacités) dans les équations de prix et de commerce extérieur. La question posée est de savoir si cette prodécure n'offre pas en fait, d'un point de vue empirique, un bon compromis entre rigueur et réalisme. Cette question est examinée dans cet article à l'aide d'expériences de Monte-Carlo. On montre que la procédure ad hoc est dangereuse et susceptible de conduire à des biais importants dans les résultats d'estimation et de simulation. Ce type de problèmes pourrait expliquer les difficultés rencontrées en pratique pour l'obtention d'équations de commerce extérieur stables.

* B. MAILLARD : Faculté libre de Sciences Economiques, Lille; H. SNEESSENS : Université Catholique de Louvain, Faculté libre de Sciences Economiques, Lille.

This research was part of a SPES research programme, covered by contract No. SPES-CT91-0079. A previous version – MAILLARD-SNEESSENS [1990] – was presented at the conference on "Macro- and Micro-Economic Forecasting", UFSIA, Antwerpen, in May 1991. We are grateful to Michel Lubrano, Pierre Malgrange, Daniel Weiserbs and anonymous referees for their comments on previous drafts. The usual disclaimer of course applies.

1 Introduction

Business surveys suggest that firms are more often than not quantity-constrained, either by the demand for their output or by the availability of the inputs. Macro-modellers have always been aware of the existence of such quantity constraints. Short of a satisfactory theoretical framework, they used for a long time to put most of the emphasis on sales constraints, dealing with supply-side quantity constraints in a fairly ad-hoc fashion, simply adding "tension variables" in various parts of an otherwise demand-driven Keynesian (at least in the short run [1]) model. Tensions were usually proxied by an index of capacity utilization; this variable was introduced in the price and foreign trade equations along with the usual Keynesian variables, in order to catch the effects that excess demand episodes could have on markups, exports and imports. This kind of specification was used, for example, in the DMS model at INSEE (FOUQUET *et al.* [1978]), and in the COMET model built for the EEC Commission (BARTEN *et al.* [1976]). We shall call these models **Standard Keynesian Macroeconomic models** (henceforth SKM models).

Since Barro-Grossman's seminal work on so-called "disequilibrium models" (BARRO-GROSSMAN [1971, 1976]) more attention has been paid to the modelling of quantity constraints. Over the last ten years, models have been developed that allow an explicit and rigorous representation of these phenomena, and treat demand and supply constraints symmetrically. Early empirical quantity rationing models can be found in ARTUS *et al.* [1984, 1985], KOOIMAN-KLOEK [1985], SNEESSENS [1983 a], VILARÈS [1981]. In these models, aggregate output is at any time determined by the minimum of supply and demand. This approach was later extended so as to distinguish a large number of firms experiencing different quantity constraints. By explicitly aggregating over firms and micromarkets (see LAMBERT [1988]), aggregate output becomes a smooth function of both demand and supply quantity constraints, with the relative importance of each changing over the cycle. Demand constraints are relatively more important in the trough of a recession, supply constraints at the peak of an expansion. Such a formulation was used by LAMBERT *et al.* [1984] on French data and SNEESSENS-DRÈZE [1986] on Belgian data. More recently, it has been used to analyze and compare the determinants of unemployment in ten industrialized countries (see DRÈZE *et al.* [1990]). These models include endogenous wage and price behaviors, with prices set by monopolistically competitive firms on the goods market, and wages set by trade unions (or by negotiation between the firm and the union) on the labor market (see SNEESSENS [1987], ARNSPERGER-DE LA CROIX [1990], LUBRANO *et al.* [1993]). We shall call these models **Quantity Rationing Macroeconomic models** (henceforth QRM models).

1. It is now well-understood that, even in these Keynesian models, output is supply-determined in the long run (see for instance DELEAU *et al.* [1981, 1984]).

From a theoretical point of view, QRM models are clearly superior to SKM ones, because they are more rigorous and more general in the handling of quantity constraints. From an empirical point of view, things are not so clear however. Introducing quantity constraints in a rigorous way has its costs and usually forces us to simplify drastically other features of the model (dynamics, representation of demand behaviors, etc.) in order to keep it tractable. One may then wonder whether the initial modelling strategy could not actually provide a much more convenient approximation to the "true" model; one may wonder whether models with seemingly ad-hoc tension variables could not be interpreted as loose log-linearized versions of the true model that can successfully track most of the short run supply-side influences on output.

There surely can be no clearcut and definite answer to such a question. A specification that proved to be a convenient approximation for a given range and behavior of the explanatory variables may well turn out to be a very awful one for another economic environment. Our purpose in this paper is merely to investigate by the means of a Monte-Carlo experiment what, if anything, might be lost by not representing rigorously the effects of quantity constraints. To this end, we shall construct a QRM model and use it to generate a set of artificial macroeconomic data; we then look at the consequences of using an approximate SKM model rather than the true QRM one to interpret these data. It appears that not introducing quantity constraints in a rigorous way may well alter significantly the parameter estimates and the dynamic properties of the model when the proportion of demand-constrained firms is low, as it was during most of the sixties and early seventies. When the proportion of demand-constrained firms is high (as observed most of the time after 1975, except in the short-lived expansion of the late eighties), the simplified model provides quite a correct approximation.

The next section is devoted to the specification of the QRM and SKM models. The chosen specification for the QRM model is essentially the same as to the one used in many existing empirical macroeconometric models with quantity constraints (see DRÈZE *et al.* [1990], e. g.) [2]. This setup is in line with recent developments on price-wage formation and real rigidities; it differs from usual specifications by allowing for quantity constraints. The corresponding SKM specification is very close to those used until the late seventies; it is essentially the same as the core-model of DELEAU-MALGRANGE-MUET [1981, 1984], slightly modified to make it compatible with our QRM model. It differs from the latter only in the way supply-side quantity constraints are taken into account. Each model (QRM and SKM) is made of some twenty-five equations; differences appear only in four of them, namely the exports, imports, output and price equations.

Sections 3 and 4 are then devoted to a comparison of the results obtained with each formulation. In section 3, we use the QRM model

2. Other authors have made different specificational choices. It seems reasonable to think that our main conclusion (quantity constraints should be dealt with explicitly, rather than by simply adding ad hoc tension variables) is fairly robust, and would also have been obtained if we had started from one of these alternative setups.

to construct the data set and to compare the parameter estimates obtained by using the true (QRM) specifications to those obtained with the SKM specifications; this is done for the three key-equations: exports, imports and prices. We also compare the quality of the adjustment by computing dynamic simulations over the estimation sample. In section 4, we use these parameter estimates to simulate the effects of demand, supply and structural shocks in the two formulations. We close with a few words of conclusion in section 5.

2 Specification of the QRM and SKM Models

We present in this section the QRM model that we use below to generate the data and make the simulation experiments, and its SKM counterpart. To economize on space, we shall not repeat here the detailed analysis of the behavior of the monopolistically competitive firm or of the trade-union under quantity constraints, and contend ourselves with simple intuitive explanations. The interested reader is referred to SNEESSENS [1987, 1992], MEHTA-SNEESSENS [1990] and LUBRANO-MEHTA SNEESSENS [1993] for more details. There will also be no attempt to derive the dynamics from an explicit intertemporal optimization programme. It is fair to say that our understanding of actual expectation processes, intertemporal price and wage behaviors, and of all kinds of adjustment costs (to give only a few examples) remains fairly limited, so that the ideal, fully-rigorous macro-model remains, at present, beyond our reach. As we want to put all the emphasis on the appropriate way of handling quantity constraints, we shall have to sacrifice other aspects and satisfy ourselves with simple backward-looking dynamic specifications [3]. This simplification will hopefully not affect too much our conclusions. It is now well-understood that nominal disturbances may have transitory real effects, even when people hold rational expectations, provided there are adjustment costs, and that the corresponding dynamics may take simple backward-looking forms (see for instance BLANCHARD [1990]).

We first consider the QRM version of the model, and discuss briefly its specification long run properties. We next turn to the SKM alternative.

3. See LAFFARGUE-MALGRANGE-PUJOL [1992] for an attempt to introduce rational expectations and intertemporal behaviors in a macroeconomic model with monopolistic competition, without quantity constraints. An alternative strategy would be to dispense with empirical work and construct simplified computable general-equilibrium intertemporal models, as it is done for real business cycle models.

2.1. The Equations of the QRM Model

The equations of the QRM model are presented in Table 1. They are grouped into six categories, respectively 1-goods demands, 2-supply-side quantity constraints, 3-output and employment, 4-realized transactions, 5-prices and wages, and finally 6-the definition of consumers'disposable income and the exogenous variables.

1. The demand for private consumption CD, for exports XD, and for imports MD are specified in fairly traditional terms. CD is a dynamic function of net disposable income DI, with both the long-run elasticity and the long run marginal propensity to consume set equal to 1. XD and MD are the usual functions of world or domestic output and of relative prices. The demand for domestic goods YD is obtained by difference between the total final demand and the demand for imports.

The aggregate gross investment rate is a positive function of the pure profit rate (r). The latter is positively related to the following three factors (see MEHTA-SNEESSENS [1990]): (i) the markup rate on marginal cost π; (ii) the adequacy of the existing production technology (represented by the output-labor ratio A and the output-capital ratio B; see below) at the prevailing labor and capital costs (W and V respectively); (iii) the degree of capacity utilization DUC. These three effects are introduced separately, with coefficients i_1, i_2 and i_3, respectively. These three coefficients plus coefficient i_4, associated to the lagged dependent variable, determine together the speed at which the aggregate production capacity will adjust to its equilibrium value after a change in the pure profit rate [4]. The constant term i_0 must be defined in such a way that the **net** investment rate becomes zero when the pure profit rate reaches its stationary equilibrium value. If the latter is assumed to be zero ($r^* = 0$, i. e., the price set by the firm is equal to the average production cost), i_0 will thus be defined as:

$$i_0 \equiv \delta - i_1 \ln \pi^* - i_2 \ln \left(\frac{\mathrm{A}^{-1}\mathrm{W}}{\mathrm{B}^{-1}\mathrm{V}} \right)^* - i_3 \ln \mathrm{DUC}^*,$$

where δ is the depreciation rate; a star over a variable indicates a stationary equilibrium value.

2. The production technology is described by the two technical coefficients A and B. Rather than using the standard putty-putty framework (which is too unrealistic when it implies that the capital-labor ratio can be adjusted at will) or a putty-clay vintage model (which leads either to untractable formulations or to simplistic representations),. we use the mixed Leontief-Cobb-Douglas model found in many empirical QRM models (see for instance SNEESSENS [1983a], LAMBERT *et al.* [1984] and DRÈZE *et al.* [1990]), and which was also implicit in many SKM models. The capital stock is homogeneous. The installed technology (the prevailing capital-labor ratio) is rigid in the short run and does not dependent on input levels; in the longer run, it is progressively adjusted to relative factor cost changes. In this way, we keep

4. This specification has been used with some succes on French and Belgian data; see for instance SNEESSENS-MAILLARD [1988].

empirically tractable formulations while avoiding the undesirable feature that every change in the output level should simultaneously imply a change in the prevailing capital-labor ratio. The optimal capital-labor ratio is obtained by cost minimization, subject to a Cobb-Douglas technological constraint. The technical coefficient equations are then obtained by substituting the optimal capital-labor ratio into the Cobb-Douglas function [5]; the coefficient of labor in the latter is represented by α_1. At given available labor force LF and capital stock KA, these technical coefficients determine the full-employment output level YL and the production capacity YC.

3. The aggregate output equation takes into account the fact that different firms may face different quantity constraints. By explicit aggregation over individual Min conditions, one obtains, under some restrictions, a smooth CES function of aggregate demand YD, aggregate production capacity YC and aggregate full-employment output YL [6]. Parameter ρ can be interpreted as a mismatch parameter; the lower the value of ρ, the greater the mismatches. The proportions of firms in each category of constraint are given by Π_D, Π_C and Π_L respectively. These proportions are related to the tension variables RED (rate of excess demand for goods), DUC (degree of capacity utilization) and UR (unemployment rate) respectively.

4. The fourth group of equations determines actual goods transactions. Despite the capacity and labor supply constraints, we assume (in line with most empirical QRM models) that there is no rationing of the **domestic** demand for goods. There is however a spillover effect on exports and imports. The larger the excess demand for domestic goods, the lower the exports. Actual imports are then determined as a residual by the national account identity [7].

5. Prices are a markup on unit labor costs. The markup rate π is positively related to the rate of excess demand for goods, as suggested by the monopolistic competition framework (see SNEESSENS [1987]). The wage equation implies that nominal wages are fully indexed on prices and labor productivity, with a negative impact of the unemployment rate; this relationship is meant to represent the optimal tradeoff between real wages and employment obtained by maximization of a trade-union objective function. The constant term ω_0 measures (the logarithm of) the share of output that would be claimed by workers in the limit case with zero unemployment, what we shall call **basic wage claims**. Dynamic adjustments are given the form of an error correction mechanism. We assume the indexation of prices to unit labor costs to be slow, while the indexation of wages to prices is instantanteous, an asymmetry obtained in many empirical

---

5. To keep the model as simple as possible, we assume no exogenous technical progress.

6. LAMBERT [1988] has shown that the CES function is a valid approximation of the expected values of the minimum of two variables, when the latter are log-normally distributed; GOURIEROUX *et al.* [1984] obtained an exact result with Weibull distributions. SNEESSENS [1983 b] has extended Lambert's result to the case of three variables.

7. To keep the model as simple as possible, we do not introduce inventories, which should clearly play the role of buffer stock assumed here by imports (see for instance BLEUZE *et al.* [1988]). Introducing inventory behaviors explicitly is unlikely to change our main conclusions.

works and which allows the wage share to be pro-cyclical. Because of this nominal price rigidity, a nominal disturbance will have transitory real effects.

6. The exogenous variables are taxes T, public consumption GD, world output YW, world prices PW, real capital usage cost V/P, and the labor force LF. Assuming an exogenous world price level and real capital usage cost amounts to assuming a fixed exchange rate system with perfect capital mobility; in this setup, the nominal anchor is given by the world price level, and the supply of money adjusts automatically to the desired level via foreign exchange market operations.

TABLE 1

The QRM model

---

1. Demand for goods

$$\Delta \ln \mathrm{CD} = \gamma_0\, \Delta \ln \mathrm{DI} + \gamma_1 \{\ln \mathrm{DI}_{-1} - \ln \mathrm{CD}_{-1}\} + \varepsilon_1\,;$$

$$\frac{\mathrm{ID}}{\mathrm{KA}_{-1}} = (1 - i_4)\left\{ i_0 + i_1 \ln \pi + i_2 \ln \frac{\mathrm{A}^{-1}\,\mathrm{W}}{\mathrm{B}^{-1}\,\mathrm{V}} + i_3 \ln \mathrm{DUC} \right\} + i_4\, \frac{\mathrm{ID}_{-1}}{\mathrm{KA}_{-2}} + \varepsilon_2\,;$$

$$\ln \mathrm{XD} = \xi_0 + \xi_1 \ln \mathrm{YW} - \xi_2 \ln \frac{\mathrm{P}}{\mathrm{PW}} + \varepsilon_3\,;$$

$$\ln \mathrm{MD} = \mu_0 + \mu_1 \ln \mathrm{YD} + \mu_2 \ln \frac{\mathrm{P}}{\mathrm{PW}} + \varepsilon_4\,;$$

$$\mathrm{YD} \equiv \mathrm{CD} + \mathrm{GD} + \mathrm{ID} + \mathrm{XD} - \mathrm{MD}.$$

2. Technical coefficients and supply-side constraints

$$\ln \mathrm{YL} = \ln \mathrm{A} + \ln \mathrm{LF} + \varepsilon_5\,;$$

$$\ln \mathrm{A} \equiv \alpha_0 + (1 - \alpha_1) \ln \frac{1 - \alpha_1}{\alpha_1} + (1 - \alpha_1)\, \Theta(\Lambda) \ln \frac{\mathrm{W}}{\mathrm{V/DUC^*}}\,;$$

$$\mathrm{LF} \equiv \mathrm{LF}_0\,;$$

$$\ln \mathrm{YC} = \ln \mathrm{B} + \ln \mathrm{KA} + \varepsilon_6\,;$$

$$\ln \mathrm{B} \equiv \alpha_0 - \alpha_1 \ln \frac{1 - \alpha_1}{\alpha_1} - \alpha_1\, \Theta(\Lambda) \ln \frac{\mathrm{W}}{\mathrm{V/DUC^*}}\,;$$

$$\mathrm{KA} \equiv (1 - \delta)\, \mathrm{KA}_{-1} + \mathrm{I}\,;$$

$$\Theta(\Lambda) \equiv \frac{1 - \theta}{1 - \theta \Lambda}\,, \text{ lag polynomial function.}$$

3. Output, employment, tension variables

$$\mathrm{Y} = \{\mathrm{YD}^{-\rho} + \mathrm{YC}^{-\rho} + \mathrm{YL}^{-\rho}\}^{-\frac{1}{\rho}}, \qquad \text{with } \rho \geq 0\,;$$

$$\ln \mathrm{L} = \ln \mathrm{Y} - \ln \mathrm{A} + \varepsilon_7$$

$$\Pi_{\mathrm{D}} \equiv \left\{\frac{\mathrm{Y}}{\mathrm{YD}}\right\}^{\rho}; \qquad \mathrm{RED} \equiv \frac{\mathrm{YD}}{\mathrm{Y}} - 1 \equiv \{\Pi_{\mathrm{D}}\}^{-\frac{1}{\rho}} - 1\,;$$

$$\Pi_{\mathrm{C}} \equiv \left\{\frac{\mathrm{Y}}{\mathrm{YC}}\right\}^{\rho}; \qquad \mathrm{DUC} \equiv \frac{\mathrm{Y}}{\mathrm{YC}} \equiv \{\Pi_{\mathrm{C}}\}^{\frac{1}{\rho}}\,;$$

$$\Pi_{\mathrm{L}} \equiv \left\{\frac{\mathrm{Y}}{\mathrm{YL}}\right\}^{\rho}; \qquad \mathrm{UR} \equiv 1 - \frac{\mathrm{Y}}{\mathrm{YL}} \exp(\varepsilon_5 + \varepsilon_7),$$

$$\equiv 1 - \{\Pi_{\mathrm{L}}\}^{\frac{1}{\rho}} \exp(\varepsilon_5 + \varepsilon_7).$$

4. Realized goods transactions and foreign trade

$C \equiv CD; \quad G \equiv GD; \quad I \equiv ID;$

$\ln X \equiv \ln XD - \xi_3 \ln(1 + RED);$

$M \equiv (C + G + I + X) - Y.$

5. Prices and wages

$$\Delta \ln P = p_1 \Delta \ln(1+\pi) + p_2 \Delta \ln(A^{-1} W) + p_3 \{\ln(1+\pi_{-1}) + \ln(A^{-1} W)_{-1} - \ln P_{-1}\} + \varepsilon_8,$$

with $\ln(1+\pi) \equiv k_0 + k_1 \ln(1 + RED);$

$$\Delta \ln W = \Delta \ln P - v_0 \cdot \omega_1 \Delta UR + v_1 \Delta \ln A + v_2 \{\omega_0 - \omega_1 UR_{-1} + \ln A_{-1} + \ln P_{-1} - \ln W_{-1}\} + \varepsilon_9.$$

6. Exogenous variables and accounting identities

$DI \equiv Y - \delta KA_{-1} - T,$	disposable income ;
$T = T_0,$	taxes ;
$GD = T_0 + \varepsilon_{10},$	public consumption ;
$\ln YW = \ln YW_0 + \varepsilon_{11},$	world output ;
$\ln PW = \ln PW_0 + \varepsilon_{12},$	world prices ;
$\ln \frac{V}{P} = \ln v_0 + \varepsilon_{13},$	real capital usage cost ;
$LF = LF_0,$	labor force.

2.2. The Long Run Stationary Equilibrium in the QRM Model

The stationary equilibrium is a situation where, by definition, all the real variables remain constant [8]. We shall assume the equilibrium pure profit rate to be zero ($r^* = 0$), and define the constant term of the investment function accordingly, so that net investment becomes zero when the price of goods is equal to the total average production cost. In the QRM model, this stationary equilibrium can easily be shown to have the following characteristics:

(i) with a Cobb-Douglas technology, labor's share of output is in the long run equal to α_1, the coefficient of labor in the production function (this need not be the case in the short run);

(ii) it then immediately follows from the wage equation that the equilibrium unemployment rate is a function of the discrepancy between basic wage claims and labor's equilibrium share of output:

$$UR^* = \frac{1}{\omega_1}(\omega_0 - \ln \alpha_1),$$

8. Remember that we assumed no exogenous technical progress and no population growth.

which in turn determines the equilibrium proportion of labor-constrained firms Π_L^* ; note that the equilibrium unemployment rate does not depend on the mismatch parameter ρ;

(iii) from the price equation, it is seen that the equilibrium markup rate is equal to the ratio of the capital and labor Cobb-Douglas coefficients, that is:

$$\pi^* = \frac{1 - \alpha_1}{\alpha_1},$$

which in turn determines the equilibrium proportion of demand-constrained firms Π_D^* (via RED*, at given k_0 and k_1);

(iv) knowing Π_D^* and Π_L^*, one obtains directly the equilibrium proportion of capacity-constrained firms Π_C^*, which determines the equilibrium degree of capacity utilization DUC* [9]. It is easily seen that the latter is equal to:

$$\begin{aligned} \mathrm{DUC}^* &= \{1 - \Pi_D^* - \Pi_L^*\}^{\frac{1}{\rho}}, \\ &= \left\{1 - [\alpha_1 \exp(k_0)]^{\frac{\rho}{k_1}} - \left[1 - \frac{\omega_0 - \ln \alpha_1}{\omega_1}\right]^{\rho}\right\}^{\frac{1}{\rho}} \end{aligned}$$

The equilibrium degree of capacity utilization is linked positively to the mismatch parameter ρ (i.e., the greater the mismatches, the lower the value of ρ and as a consequence DUC*) and to the basic wage claim parameter ω_0.

These properties imply that, in the long run, a nominal demand disturbance (a change in world prices e. g.) is compensated by a change in the domestic price level, while the output level, the unemployment and capacity utilization rates, the proportion of firms in each "regime" (Π_D, Π_C, Π_L), all these real variables remain unaffected. The equilibrium values of the real variables is affected by supply-side disturbances only. Note finally that the equations have been modelled in such a way (long-run marginal propensity to consume equal to 1, public expenditures equal on average to tax revenues) such that there is no systematic and permanent accumulation of wealth or debt, and the trade balance is on average equal to zero.

2.3. A Simplified Setup: The SKM Model

In the SKM model (see Table 2), supply shortages are taken into account in a simplified manner, by simply adding a capacity utilization effect in the exports, imports and price equations. Because supply constraints are not explicitly modelled, there is also no explicit measure of the excess demand

9. The equilibrium degree of capacity utilization can be smaller than 1 because this setup assumes a large number of monopolistically competitive firms, each firm having the same exogenously given size.

for goods RED; the degree of capacity utilization DUC is used as a proxy [10]. Note that, as a consequence, the national account identity is now used to determine output, rather than imports.

The stationary equilibrium properties of the SKM model remain similar to those of the QRM model, except for the capacity utilization rate. Because the capacity utilization rate DUC has been used as a proxy for the rate of excess demand for goods, its equilibrium value becomes in the SKM model:

$$\mathrm{DUC}^{**} = [\alpha_1 \exp(k_0')]^{-\frac{1}{k_1'}}.$$

It is worth pointing out that the equilibrium capacity utilization rate no longer depends on the mismatch parameter ρ (which has no equivalent in the SKM model) nor on the basic wage claim parameter ω_0.

TABLE 2

The SKM model

1. Demand for goods: as in QRM
2. Technical coefficients and supply-side constraints: as in QRM
3. Output, employment and tension variables:

$$\mathrm{Y} \equiv \mathrm{C} + \mathrm{G} + \mathrm{I} + \mathrm{X} - \mathrm{M};$$

$$\ln \mathrm{L} = \ln \mathrm{Y} - \ln \mathrm{A} + \varepsilon_7;$$

$$\mathrm{DUC} = \frac{\mathrm{Y}}{\mathrm{YC}}; \qquad \mathrm{UR} = 1 - \frac{\mathrm{L}}{\mathrm{LF}}.$$

4. Realized goods transactions and foreign trade

$$\mathrm{C} \equiv \mathrm{CD}; \qquad \mathrm{G} \equiv \mathrm{GD}; \qquad \mathrm{I} \equiv \mathrm{ID};$$

$$\ln \mathrm{X} \equiv \ln \mathrm{XD} - \xi_3' \ln \mathrm{DUC};$$

$$\ln \mathrm{M} \equiv \ln \mathrm{MD} - \mu_1 (\ln \mathrm{YD} - \ln \mathrm{Y}) + \mu_3' \ln \mathrm{DUC},$$

$$\equiv \mu_0 + \mu_1 \ln \mathrm{Y} + \mu_2 \ln \frac{\mathrm{P}}{\mathrm{PW}} + \mu_3' \ln \mathrm{DUC} + \varepsilon_4.$$

5. Prices, wages and capital usage costs: as in QRM, except for π which is now defined as: $\ln(1+\pi) \equiv k_0' + k_1' \ln \mathrm{DUC}$.
6. Exogenous variables and accounting identities: as in RQM

10. Many empirical QRM models presented in DRÈZE *et al.* [1990] have actually DUC as a proxy for RED in the foreign trade equation, as in our SKM model. This simplifies a lot the estimation burdens (because YD and RED are unobserved latent variables) but, as we shall see, may lead to serious biases.

3 How Good is the SKM Approximation?

Our objective in the next two sections is to check what, if anything, is lost by using the SKM model as an approximation to the QRM model. We do this from two different points of views. Section 3 is devoted to a comparison of the parameter estimates obtained with the two formulations and to a comparison of the quality of the fits over the estimation sample. Section 4 uses the parameter estimates of section 3 to make simulation experiments and compare the consequences of demand, supply or structural shocks in the two formulations. This exercice is also the opportunity to illustrate the dynamic properties of a QRM model. It is repeated twice, with slightly different parameter values. In the first case, the parameter values are chosen so as to reproduce a situation typical of the sixties and early seventies, with a low equilibrium unemployment rate and a low equilibrium proportion of demand-constrained firms. In the second case, the parameter values are changed (the change can be interpreted as a supply shock) so as to imply a high equilibrium unemployment rate and a high proportion of demand-constrained firms, as it was the case most of the time after 1975 (except in the late eighties). One may expect that the SKM model will provide a better approximation to the true QRM model in this second case, where the proportion of demand-constrained firms is high.

3.1. True Parameter Values and Data Set

The chosen parameter values are reproduced in Table 3. Parameters k_0 (which determines the markup rate in the price equation) and ω_0 (which determines basic wage claims) take different values in the two series of experiments, the low (resp. high) values implying a low 33% (resp. high 59%) proportion of demand-constrained firms and a low 3.00% (resp. high 7.88%) unemployment rate. These changes in k_0 and ω_0 leave the equilibrium degree of capacity utilization unchanged [11]. In order to keep the same equilibrium output level in the two cases, we also change μ_0

11. We thus look at a situation where the increase in the proportion of demand-constrained firms is matched by a decrease in the proportion of labor-constrained firms, at unchanged degree of capacity utilization. Alternatively, one could examine the case where the increase in the proportion of demand-constrained firms is matched by a decrease in the proportion of capacity-constrained firms (lower DUC*). The former case is clearly closer to the situation observed in our economies, as shown by business survey results in the manufacturing sector and by the econometric estimates reported in DRÈZE *et al.* [1990]. It is worth noting that ARTUS *et al.* [1987, 1990, 1991] obtain, in a two-sector setup, a somewhat different result. These authors explain the poor export performance of French manufacturing industries during the eighties by a shortage of profitable production capacities and demand rationing. It is not clear yet how the two results can be reconciled. See however in section 5 the analysis of the effect of structural changes on foreign trade estimates.

(import equation) and LF_0 (labor force). There is much disagreement about the sensitivity of markups to excess demand (k_1) and of wages to unemployment (ω_1). The value $k_1 = 1$ implies that the desired markup increases by 2 percentage points when the proportion of demand-constrained firms decreases from 59 to 33%; the value of $\omega_1 = 1$ implies that the desired wage share decreases by 4 percentage points when unemployment increases from 3 to 7.9%. If one period represents one quarter, the values of the dynamic coefficients in the price and wage equations imply that, after one year, about 90% of an increase in wage costs is passed on to prices, while 75% of a productivity increase is passed on to wages. These values are in line with the empirical estimates reported in DRÈZE *et al.* [1990] (reported estimates range from .5 to 1. for the former, from .4 to .9 for the latter).

TABLE 3

The Parameter Values

Consumption:	stationary state value: $C^* = 1142.75$;
	$\gamma_0 = \gamma_1 = .5$; $\varepsilon_1 \sim N(0, .009)$.
Investment:	stationary state value: $I^* = 242.40$; $K^* = 3462.9$;
	$i_0 = .0195$; $i_1 = .01$; $i_2 = .05$; $i_3 = .025$; $i_4 = .5$;
	$\delta = .07$; $\varepsilon_2 \sim N(0, .009)$.
Exports:	stationary state value: $X^* = 360.00$;
	$\xi_0 = -3.06$; $\xi_1 = 1.0$; $\xi_2 = .25$; $\xi_3 = 2.0$;
	$\varepsilon_3 \sim N(0, .009)$.
Imports:	stationary state value: $M^* = 360.00$;
	$\mu_0 = -1.68$ or -1.591; $\mu_1 = 1.0$; $\mu_2 = .25$;
	$\varepsilon_4 \sim N(0, .009)$.
Technical coeff.:	stationary state value: $A^* = 85.0$; $B^* = 0.513$; $\alpha_0 = 3.42$; $\alpha_1 = .8$; $\theta = .8$;
	$\varepsilon_5 \sim N(0, .003)$, $\varepsilon_6 \sim N(0, .003)$.
Output-employment:	stationary state values: $Y^* = 1731.45$;
	$L^* = 20.37$;
	$\rho = 40$; $\varepsilon_7 \sim N(0, .003)$.
Prices:	stationary state value: $P^* = 1.0$;
	$p_1 = .8$; $p_2 = .6$; $p_3 = .4$;
	$k_0 = .1957$ or $.21$; $k_1 = 1.0$; $\varepsilon_8 \sim N(0, .003)$.
Wages:	stationary state value: $W^* = 68.0$;
	$v_0 = v_1 = .5$; $v_2 = .2$;
	$\omega_0 = -.1931$ ou $-.145$; $\omega_1 = 1$; $\varepsilon_9 \sim N(0, .009)$.
Exogenous variables:	$T_0 = 346.29$; $GD = T_0$; $\varepsilon_{10} \sim N(0, 5)$;
	$YW_0 = 8103.1$; $\varepsilon_{11} \sim N(0, .01)$;
	$PW_0 = 1.00$; $\varepsilon_{12} \sim N(0, .005)$;
	$v_0 = .10$; $\varepsilon_{13} \sim N(0, .005)$;
	$LF_0 = 21.00$ or 22.105.

These parameter values are next used to generate observations on the endogenous variables. We drew to this end one sample of 66 observations for the exogenous variables and 100 samples of 66 observations for each of the residuals, and generated in this way 100 samples of 66 observations for each endogenous variable. The values of the exogenous variables were chosen so as to obtain relative orders of magnitude between the macro-variables similar to those observed in large European economies.

3.2. Parameter Estimates

We computed, for each sample, the instrumental variable estimates of the parameters of the three equations that are different in the QRM and the SKM models, namely the export, import and price equations. The sample mean and standard deviations of these estimates, computed over the 100 replications, are reproduced in Table 4. Note that we estimated an import equation for the QRM model as well, with the spill-over effect from the domestic goods market approximated by a log-linear term in the rate of excess demand for goods (RED). In the correct QRM model, imports are given by the national account identity.

The results suggest the following comments:

(i) As one would expect, the estimates obtained with the true QRM specifications are better than the others. The QRM estimates are never significantly different from the true value and are usually fairly precise, except in the import equation where we approximated the spillover effect with RED instead of using the national account identity. The estimates are of similar quality in the low and in the high Π_D^* cases.

(ii) Proxying the demand pressure effect with the capacity utilization variable, as is done in the SKM model, gives quite different results in the low and the high Π_D^* cases. While there are substantial biases and efficiency losses in the former case, there seem to be little losses in the latter. Note that the degree of capacity utilization variable remains significant even in the high Π_D^* case (i. e. with little demand pressure), which indicates that it provides an acceptable approximation to the rate of excess demand only when tensions are not too important.

(iii) The parameters most affected by the approximation in the low Π_D^* case are the price elasticities of exports and imports (strongly underestimated) and the output elasticity of imports (strongly overestimated). This is the sort of strange result that applied econometricians find in practice. In the present context, the bias is easily explained: because of the positive correlation between the rate of excess demand for goods and the level of output, the latter plays in part the role of a proxy for RED.

(iv) Other experiments (not detailed on Table 4) have shown that the demand pressure effect on prices can be strongly underestimated, even with the correct QRM specification. This is the case for example when the standard error of the residual in the wage equation is lowered to the same value as that in the price equation (0.003 instead of 0.009); it is then more difficult to disentangle the effects that wage and demand shocks can have on prices. It is also worth noting that the SKM estimates of the foreign trade equations become worse and worse when the relative importance of supply shocks is increased (i. e., when the variance of the residuals of the technical coefficients and wage equations is increased).

TABLE 4

Parameter Estimates (Averages over 100 Replications; Sample Standard Deviations between Parentheses)

Coefficient of	Low Π_D^* (0.33)			High Π_D^* (0.59)		
	True coeff.	QRM est.	SKM est.	True coeff.	QRM est.	SKM est.
1. *Exports eq.*						
constant (ξ_0)	−3.06	−3.02	−2.51	−3.06	−2.99	−3.10
		(1.17)	(1.34)		(1.15)	(1.30)
ln YW (ξ_1)	1.00	0.99	0.83	1.00	0.99	0.97
		(0.13)	(0.15)		(0.12)	(0.14)
ln $\frac{P}{PW}$ ($-\xi_2$)	−0.25	−0.25	−0.12	−0.25	−0.25	−0.23
		(0.03)	(0.05)		(0.03)	(0.04)
ln (1 + RED) ($-\xi_3$) .	−2.00	−1.90	–	−2.00	−1.89	–
		(0.25)			(0.26)	
ln DUC ($-\xi_3'$)	–	–	−1.63	–	–	−1.17
			(0.70)			(0.24)
ln X_{-1}	0.00	−0.006	0.16	0.00	0.002	0.04
		(0.08)	(0.11)		(0.08)	(0.09)
D.W.		2.07	1.90		2.08	1.95
S.E.R.		0.009	0.011		0.009	0.010
2. *Imports eq.*						
constant (μ_0)	−1.68	0.085	−15.39	−1.59	−1.60	−2.64
		(3.98)	(6.04)		(1.42)	(2.11)
ln Y (μ_1)	1.00	0.75	2.74	1.00	0.98	1.10
		(0.55)	(0.85)		(0.20)	(0.32)
ln $\frac{P}{PW}$ (μ_2)	0.25	0.21	0.09	0.25	0.22	0.20
		(0.03)	(0.07)		(0.035)	(0.048)
ln (1 + RED)	–	3.76	–	–	3.49	–
		(0.35)			(0.42)	
ln DUC (μ_3')	–	–	2.72	–	–	2.01
			(0.95)			(0.42)
ln M_{-1}	0.00	0.03	0.15	0.00	0.029	0.065
		(0.05)	(0.11)		(0.061)	(0.092)
D.W.		2.05	2.06		2.08	1.82
S.E.R.		0.008	0.015		0.009	0.011
3. *Price equation*						
Δln (1 + RED) (π_0) .	0.80	0.70	–	0.80	0.70	–
		(0.13)			(0.15)	
Δln DUC (π_0') . . .	–	–	0.56	–	–	0.43
			(0.26)			(0.13)
Δln (A_{-1} W) (π_1) .	0.60	0.64	0.72	0.60	0.63	0.65
		(0.03)	(0.04)		(0.03)	(0.03)
constant ($k_0\ \pi_2$) . . .	0.078	0.077	0.077	0.084	0.083	0.092
		(0.008)	(0.01)		(0.008)	(0.01)
ln (1 + RED_{-1}) ($k_1\ \pi_2$)	0.40	0.35	–	0.40	0.35	–
		(0.08)			(0.09)	
ln DUC_{-1} ($k_1'\ \pi_2$) . .	–	–	0.36	–	–	0.22
			(0.25)			(0.07)
ln $\left(\frac{A^{-1} W}{P}\right)_{-1}$ (π_2)	0.40	0.39	0.30	0.40	0.39	0.38
		(0.04)	(0.05)		(0.04)	(0.04)
D.W.		2.04	2.05		2.04	2.05
S.E.R.		0.003	0.004		0.003	0.003

(v) Table 4 suggests that, with the SKM formulation and when there are strong demand pressure effects (low Π_D^*), the lagged dependent variable may become significant in the foreign trade equations. We indeed obtained significant and large values (0.40) of the corresponding parameters in some replications. The SKM model may thus suggest more dynamics than is actually true.

3.3. Dynamic Simulation over the Estimation Sample

Table 5 below reproduces the results of a dynamic (non-stochastic) simulation over the estimation sample. Whatever the model used, the largest root mean squared error is always observed in the price equation. The SKM results are slightly inferior to the QRM ones only in the low Π_D^* case; they are sometimes even better in the high Π_D^* case. On this criterion, the SKM model thus seems to be able to mimic fairly well the properties of the QRM one.

TABLE 5

Dynamic Simulation; Root Mean Squared Errors

	Low Π_D^* (0.33)		High Π_D^* (0.59)	
	QRM	SKM	QRM	SKM
Y	0.08%	0.18%	0.15%	0.13%
I	0.26%	0.47%	0.39%	0.39%
WR	0.20%	0.22%	0.22%	0.19%
P	0.75%	1.76%	1.08%	1.72%
X	0.14%	0.28%	0.14%	0.20%
M	0.25%	0.43%	0.27%	0.32%

4 Effects of Demand, Supply and Structural Shocks

In this section, we compare the dynamic effects in the QRM and SKM models respectively, first of a demand shock, next of a supply shock, and also examine briefly the consequences of structural shocks. We use the true parameter values, except of course in the import, export and price equations, where there are no "true" values in the SKM model. For these three equations, we thus use the parameter estimates obtained in the previous section. We do the same for both models, in order to have as fair as possible a comparison [12].

12. Imports are however obtained as a residual in the QRM model, so as to satisfy the national account identity. This difference is largely unconsequential, at least in our numerical examples.

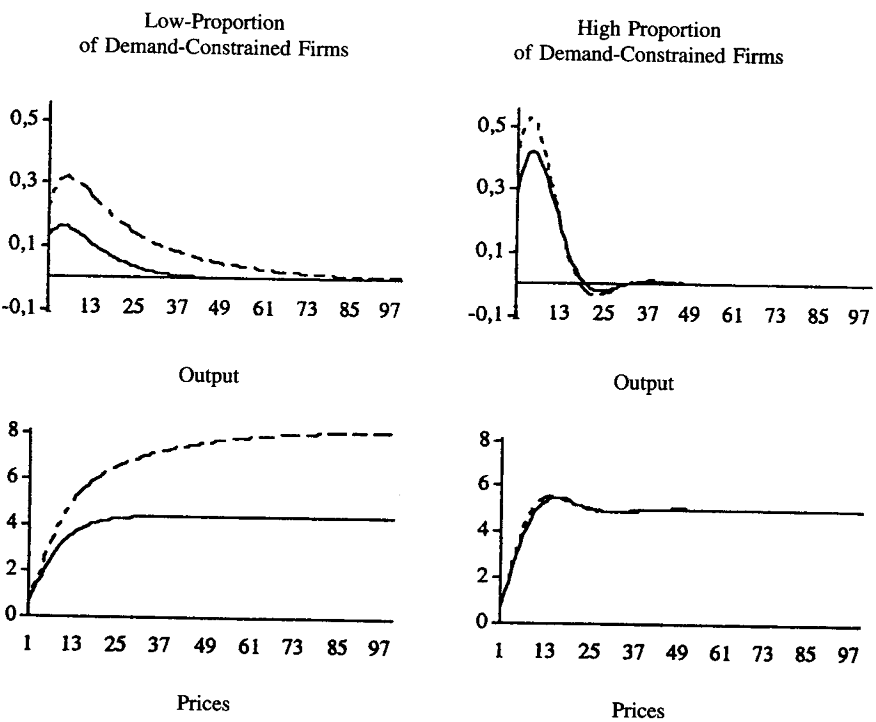
4.1. Dynamic Effects of a Demand Shock

The shock takes the form of a permanent, unanticipated 2% increase in world activity. There is no long run effect on the real variables neither in the QRM nor in the SKM models. There may however be transitory effects, resulting from the slow adjustment of prices and wages. Figure 1 illustrates the dynamic consequences of the shock on output and prices in the two models. Time is measured along the horizontal axis. The change in the value of the endogenous variables compared to the reference path (the initial stationary equilibrium) is measured in percentage points along the vertical axis. The continuous and the dashed lines represent the effects of the shock in the QRM and SKM models respectively. The left-hand-side panels correspond to the low Π^*_D case, the right-hand-side ones to the high Π^*_D case.

While the two models yield similar predictions in the latter case, the SKM model strongly overestimates the short run output effects in the former; this again emphasizes that the DUC variable is not a good proxy for demand pressure when the latter is important. Because it strongly underestimates the import and export price elasticities, the SKM model also strongly overestimates the long run price effects of the demand shock.

FIGURE 1

Effects of a permanent unanticipated 2% increase in world activity in the QRM (–) and SKM (---) models, when the proportion of demand-constrained firms is low (left panels) or high (right panels).



Some experiments (not reproduced here) have also revealed the tendency for the SKM formulation to generate artificial oscillatory dynamics, either as a result either of wrong dynamics in the foreign trade equations or of too large an accelerator effect created by the overestimation of output.

4.2. Dynamic Effects of a Supply Shock

The shock takes the form of an increase in the basic wage claim parameter ω_0, such that basic wage demands in percent of total value-added [exp. (ω_0)] increase by one percentage point. We know from section 2 that such a shock does affect the long run equilibrium values of the real variables. There is in this respect a substantial difference between the QRM and SKM models. An increase in ω_0 increases the equilibrium capacity utilization rate (DUC) in the former, while it leaves it unchanged in the latter.

The dynamic effects of the shock are illustrated in Figure 2, which displays the behavior of four key variables, namely investment, real wages, the unemployment rate and the degree of utilization of production capacities. As before, left-hand-side panel s reproduce the low Π_D^* case, right-hand-side ones the high Π_D^* case. In both the QRM and the SKM models, the shock leads to a larger equilibrium unemployment rate. As with the demand shock, the SKM formulation seems to provide quite an acceptable approximation when the proportion of demand-constrained firms is high, despite the fact that it does not incorporate the effect of ω_0 on the equilibrium capacity utilization rate. This is no longer true when the proportion of demand-constrained firms is low; the SKM formulation then strongly underestimates the effects of profitability on the investment behavior of the firms. Note also that the SKM formulation underestimates the long run real wage effect (which mirrors the change in DUC).

4.3. Structural Change and Foreign Trade

The structural change we consider takes the form of increased mismatches between the demand and the supply of goods, because either the production capacity or the supply of labor are not where the demand for goods is. This increased mismatch can be taken into account in the QRM model, where the output equation was obtained by explicit aggregation over micromarkets. In this framework, an increased mismatch is represented by a lower value of parameter ρ. The available empirical evidence with QRM models does suggest a slowly but steadily decreasing value of ρ in both Europe and the USA (see DRÈZE *et al.* [1990]). A lower value of ρ leaves unchanged the equilibrium rates of unemployment (UR*) and of excess demand for goods (RED*), although it affects negatively the equilibrium degree of capacity utilization (DUC*) and, by this channel, affects the relative labor cost, factor productivities, etc. (see section 2). None of these effects can be accounted for in the SKM model.

The failure of the SKM model to account for increased mismatches may lead to substantial biases when the true model is the QRM one and the SKM model is used as a convenient approximation to make forecasts. Our aim here is not to analyze in details all these consequences. We shall instead

FIGURE 2

Effects of a Permanent increase in Basic Wage Claims (ω_0) in the QRM (–) and SKM (---) Models.

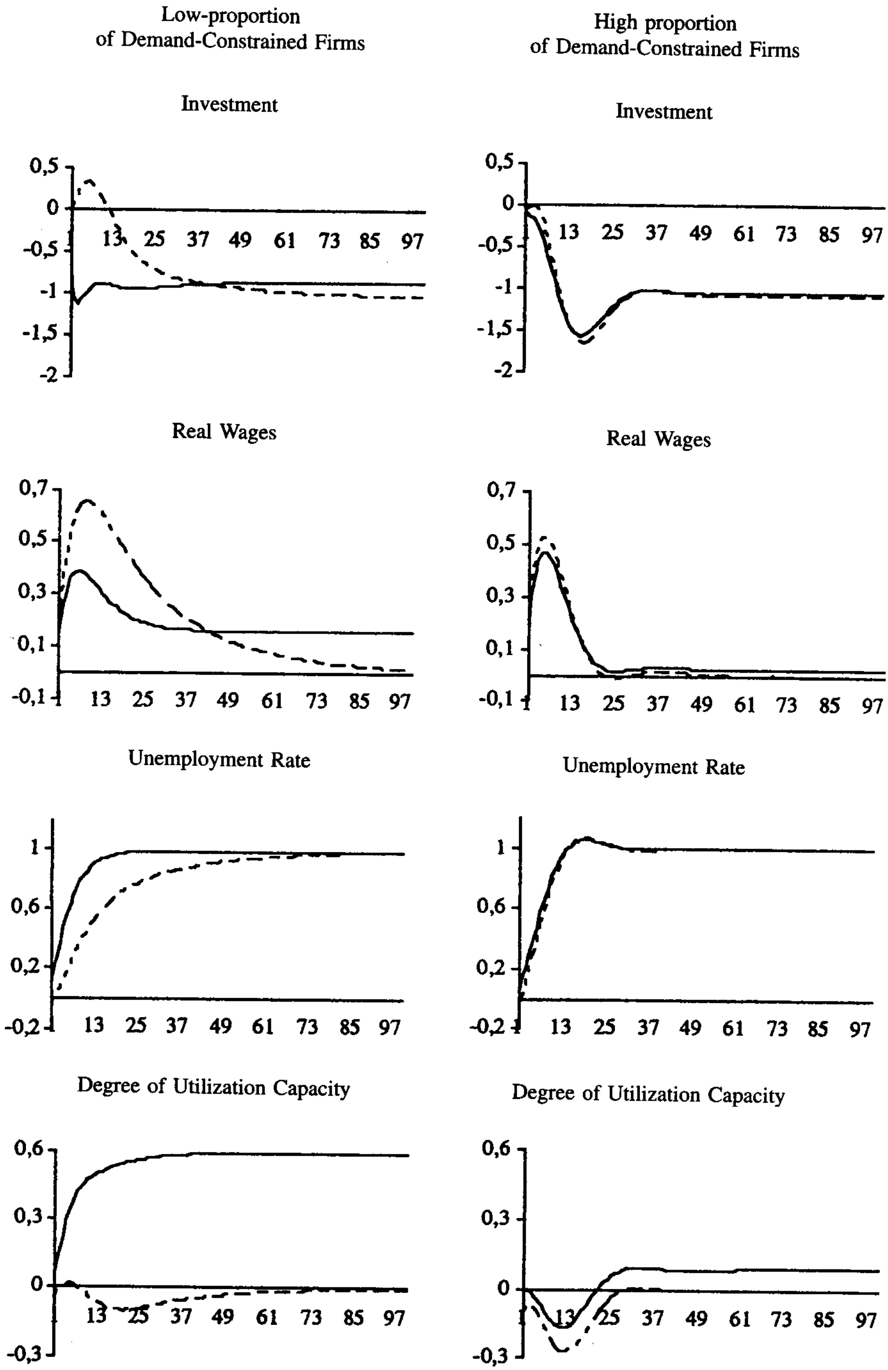
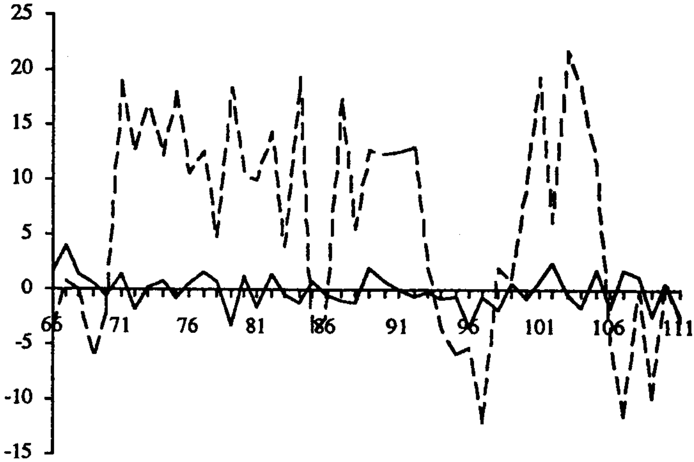


FIGURE 3

Average error of one-period-ahead forecasts of net exports, in the QRM (solid) and the SKM (dashed) models respectively, when structural mismatches are increasing over time.



focus on the foreign trade equations, where error forecasts are likely to be most blatant. In the SKM model, the degree of capacity utilization DUC is used in the foreign trade equation as a proxy for the excess demand for goods RED. Structural changes affects differently the two variables: DUC is affected negatively, while RED remains unchanged. One should thus expect, in the case of rising mismatches, a systematic overestimation of net exports in the SKM model.

To illustrate this point, we generated 110 observations with the QRM model in the low Π_D^* case. During the first 65 periods, the value of the mismatch parameter ρ remains fixed at 50; during the last 45 periods, ρ decreases steadily from 50 to 30. These orders of magnitude are those suggested by the empirical estimates reported in DRÈZE *et al.* [1990]. A decrease in ρ from 50 to 30 leads to a 5 percentage points decrease in the equilibrium degree of capacity utilization (from 98.76% to 94.23%), while the equilibrium rate of excess demand for goods remains constant at 2.84% and the equilibrium unemployment rate at 3%. Figure 3 shows the error forecasts obtained when the QRM (solid line) and the SKM (dashed line) models respectively are used to make one period-ahead forecasts of net exports over the second sub-period (66-110). Each forecast is based on the export and import equations estimated on all previous observations. Parameter estimates are thus revised recursively as more and more observations become available [13]. Figure 3 shows that the average forecast error is zero with the QRM foreign trade equations and is, as expected, positive and fairly large with the SKM ones.

---

13. It may be worth pointing out that in this experiment, the coefficients associated to DUC in the SKM equations progressively go to zero and become insignificant in both equations, while at the same time the long term coefficient of GDP in the import equation increases to 3.

5 Conclusions

The Monte-Carlo experiments constructed around the QRM and the SKM models emphasize the importance that non-linearities due to quantity constraints may have for the analysis of demand, supply or structural shocks and the determination of a macroeconomic equilibrium. When the unemployment rate is large (around 8%) and the proportion of demand-constrained firms is high (around 60%), i. e., in a situation similar to the one observed in many European countries during most of the post 1975 period (until the short-lived recovery of the late eighties), approximating the effects of supply constraints by a log-linear function of the degree of capacity utilization is acceptable and does not distort the results. In other cases, for example when the unemployment rate and especially the proportion of demand-constrained firms are low (the latter around 33% in our example), the degree of capacity utilization will no longer be a good proxy for supply constraints and the role of non-linearities may become quite important. Simply using log-linear terms in the degree of capacity utilization will then yield misleading results, for both short-run and long-run analyses. The problem is due partly to the non-linearities, partly to the changing relationship between the degree of capacity utilization and the rate of excess demand when the equilibrium unemployment rate changes after a supply or a structural shock. The numerical examples used in this paper suggest that some of the difficulties traditionally met when estimating foreign trade and price equations on post-war data could be due to this problem. The explicit and rigorous representation of the effects of quantity constraints will thus, in general, be worth while doing, both in theoretical and empirical works.

• References

ARNSPERGER, C., de la CROIX, D. (1990). – "Union Power and Price Fixation. A General Equilibrium Perspective", IRES Discussion Paper 9015, Département des Sciences Économiques, Université Catholique de Louvain.

ARTUS, P., LAROQUE, G., MICHEL, G. (1984). – "Estimation of a Quartely Econometric Model with Quantity Rationing", *Econometrica*, 52, pp. 1387-1414.

ARTUS, P., AVOUYI-DOVI, S., LAFFARGUE, J.-P. (1987). – "Un modèle économétrique de déséquilibre à deux secteurs et son apport à l'analyse des politiques économiques", *Revue de l'OFCE*, 21, pp. 211-236.

ARTUS, P., AVOUYI-DOVI, S., LAFFARGUE, J.-P. (1990). – "Un modèle économétrique en déséquilibre de l'économie française à deux secteurs avec prix et investissement endogènes", *Economie et Prévision*, pp. 94-95.

ARTUS P., AVOUY-DOVI, S., LAFFARGUE, J.-P. (1991). – "Déséquilibre, investissement et désagrégation sectorielle: une application au cas français", *Annales d'économie et de statistique*, 23, pp. 137-158.

ARTUS, P., AVOUY-DOVI, S., LAROQUE, G. (1985). – "Estimation d'une maquette macroéconomique trimestrielle avec rationnements quantitatifs", *Annales de l'INSEE*, 57, pp. 3-24.

BARRO, R. J., GROSSMAN, H. I. (1971). – "A General Disequilibrium Model of Income and Employment", *American Economic Review,* 61, pp. 82-93.

BARRO, R. J., GROSSMAN, H. I. (1976). – "Money Employment and Inflation", Cambridge University Press, London and New York.

BARTEN, A. P, d'ALCANTARA, G., CARRIN, G. J. (1976). – "COMET. A Medium-Term Macroeconomic Model for the European Economic Community", *European Economic Review,* 7, pp. 63-115.

BLANCHARD, O. J. (1990). – "Why Does Money Affect Output?", in Friedman, B.M., Hahn, F.H., eds, *Handbook of Monetary Economics,* North- Holland.

BLEUZE, E., LEROUX, V., MUET, P. (1988). – "Offre, demande et compétitivité industrielle: Les apports d'un modèle économétrique de déséquilibre intégrant les données d'enquête", *Revue de l'OFCE,* 23, pp. 175-191.

DELEAU, M., MALGRANGE, P., MUET, P. A. (1981). – "Une maquette représentative des modèles macroéconomiques", *Annales de l'INSEE,* 42, pp. 53-91.

DELEAU, M., MALGRANGE, P., MUET, P. A. (1984). – "A Study of Short-run and Long-run Properties of Macroeconometric Dynamic Models by Means of an Aggregative Core Model", in Malgrange, P., Muet, P.A., eds, *Contemporary Macroeconomic Modelling,* Basil Blackwell, Oxford.

DRÈZE, J. H., BEAN, Ch., LAMBERT, J. P., MEHTA, F., SNEESSENS, H. R., eds. (1990). – "Europe's Unemployment Problem", MIT Press.

FOUQUET, D., CHARPIN, J. M., GUILLAUME, H., MUET, P. A., VALLET, D. (1978). – "DMS, Modèle dynamique multisectoriel", *Les Collections de l'INSEE,* série C, Nos. 64-65.

GOURIEROUX, C., LAFFONT, J.-J., MONFORT, A. (1984). – "Econométrie des modèles d'équilibre avec rationnement: une mise à jour". *Annales de l'INSEE.* 55/56, pp. 5-38.

KOOIMAN, P., KLOEK, T. (1985). – "An Aggregate Two-Market Disequilibrium Model for Dutch Manufacturing", *European Economic Review,* 29, pp. 323-354.

LAFFARGUE, J. F., MALGRANGE, P., PUJOL, T. (1992). – "Une maquette trimestrielle de l'économie française avec anticipations rationnelles et concurrence monopolistique", *L'actualité économique,* 68, pp. 225-261.

LAMBERT, J.- P. (1988). – Disequilibrium Macroeconomic Models, Cambridge University Press, Cambridge.

LAMBERT, J.-P., LUBRANO, M., SNEESSENS, H. R. (1984). – "Emploi et Chômage en France de 1955 à 1982: Un modèle macroéconomique annuel avec rationnements", *Annales de l'INSEE,* 55/56, pp. 39-76.

LUBRANO, M., MEHTA, F., SNEESSENS, H. R. (1993). – "Wage and Price Setting in a Macroeconomic Model with Quantity Constraints", IRES Discussion Paper, 9311, Département des Sciences Économiques, Université Catholique de Louvain.

MAILLARD, B., SNEESSENS, H. R. (1990). – "Introducing Supply-side Quantity Constraints into Keynesian Macroeconometric Models: An Evaluation", IRES, Département des Sciences Economiques, Université Catholique de Louvain, *mimeo.*

MEHTA, F., SNEESSENS, H. R. (1990). – "Belgian Unemployment: The Story of a Small Open Economy Caught in a Worlwide Recession", in DRÈZE *et al.* [1990].

SNEESSENS, H. R. (1983a). – "A Macroeconomic Rationing Model of the Belgian Economy", *European Economic Review,* 20, pp. 193-215.

SNEESSENS, H. R. (1983b). – "Aggregation in Quantity Rationing Models", unpublished manuscript, Département des Sciences Économiques, Université Catholique de Louvain.

SNEESSENS, H. R. (1987). – "Investment and the Inflation-Unemployment Trade-off in a Quantity Rationing Model with Monopolistic Competition", *European Economic Review,* 31, pp. 781-808.

SNEESSENS, H. R. (1992). – "Contraintes de débouchés, capacités de production et chômage dans un modèle macroéconomique avec concurrence imparfaite", *L'actualité économique*, 68, pp. 140-174.

SNEESSENS, H. R., DRÈZE, J. H. (1986). – "A Discussion of Belgian Unemployment, Combining Traditional Concepts and Disequilibrium Econometrics", *Economica*, 53, S89-S119.

SNEESSENS, H. R., MAILLARD, B. (1988). – "Investment, Sales Constraints and Profitability in France 1957-1985", *Recherches Économiques de Louvain*, 54, pp. 151-168.

VILARÈS, M. J. (1981). – "Macroeconometric Model with Structural Change and Disequilibrium", *mimeo*, INSEE, Paris.