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Article — Digitized Version

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Vierteljahrshefte zur Wirtschaftsforschung

Provided in Cooperation with:

German Institute for Economic Research (DIW Berlin)

Suggested Citation: Henry, Jérôme (1991) : Price systems in 5 European multinational models, Vierteljahrshefte zur Wirtschaftsforschung, ISSN 0340-1707, Duncker & Humblot, Berlin, Vol. 60, Iss. 3/4, pp. 131-134

This Version is available at:

<https://hdl.handle.net/10419/141014>

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Price Systems in 5 European Multinational Models¹

by Jérôme Henry*

The modelling of prices in the models which are here considered will be shortly presented and discussed along the following lines:

- the choice the different teams made to model a full price system or not;
- the theoretical background of their key equation;
- the dynamics of this main equation and its long-run properties;
- the estimation procedures.

Finally will be summed up the main long-run properties of the price key equation in the European 'big four'.

1. With or without a full price system?

In MIMOSA, INTERLINK, QUEST and the OEF models a full system of deflators is included. Generally there exists some key or 'core' domestic price econometric equation which models the behaviour of -according to the data available or the model-maker's choice- either a production price, a wholesale price or an output price. The combination of domestic output prices and import prices gives the whole set of expenditure deflators, through linking equations which sometimes include fixed coefficients from the input-output tables (MIMOSA and INTERLINK). Consequently, those equations which give the expenditure deflators are very much like accounting identities. The balance between nominal expenditure and income is then achieved either by the inventories-stockbuilding deflator (INTERLINK and QUEST) or some industry output price (like the trade and other business output deflator in MIMOSA²).

Such systems are obviously heavier but also much richer in terms of simulations properties, namely through relative prices effects, such as in the investment equations for instance. They also offer a wider range of tax-policy simulations, in terms of VAT (MIMOSA or QUEST) for instance.

In GEM, on the contrary, only some of the prices are modelled. Four prices are considered: the consumption expenditure deflator, the Consumption Price Index — which might be quite different from the latter, due to structural effects such as the part of the short-term interest rates in the UK, the manufactured goods or wholesale price and the

GDP deflator. The consistency between nominal and real accounting identities is thus not imposed or rather, not accounted for.

2. A 'core' equation: some production, wholesale or value added price

No matter whether that equation which leads the price behaviours in all models is estimated in terms of production, output, value added or wholesale price³; whether it is for non-energy (INTERLINK) or manufacturing (MIMOSA) sectors; it is always designed as a mark-up on unit costs, the base of which is the assumed oligopolistic behaviour of the companies. There seems to be a general agreement on that precise -and maybe only one- point.

Starting with the apparently mainstream $P=(1+m).UC$ specification, one actually can find as many variations as there are models, or even as there are models and countries modelled.

Firstly, much varied definitions of the relevant unit cost can be found: measured strictly in terms of Labor Cost (GEM, OEF and QUEST), or including all factor costs (INTERLINK with the energy and investment costs, consistent with its three-factor production function) or even adding up a large range of components like shadow wages for non-employees, direct taxes, interest expenses, intermediate consumption and investment (MIMOSA).

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¹ The five models are: MIMOSA (CEPII-OFCE, Paris), OEF (Oxford), GEM (NIESER-LBS, London), INTERLINK (OECD, Paris) and QUEST (DIW, Berlin), the paper is based on the available versions of these models in march 1991.

² The MIMOSA model also considers a behavioural equation for this deflator, but it is only used as an index of commercial margins when computing the expenditure deflators consistent with the benchmark input-output table.

³ The noticeable exception is the consumption price equation in GEM's France; due to a lack of reliable data source the team judged relevant to take rather this price as a key variable instead of the wholesale price, yet the specification is similar (see table 1).

Moreover the Unit Cost can be 'cyclically adjusted' (INTERLINK), or productivity set equal to its local trend value (GEM), smoothed or taken as its current value (both cases to be found in MIMOSA) or even removed of the indicator, including a downward deterministic trend in the equation instead (QUEST).

Secondly the mark-up is assumed to vary: the competition conditions in the market might change, for instance in connection with the conditions of domestic supply or with the pressure of foreign prices. As to the former, most models accounted for -or tried to include- the capacity utilisation rate or any other excess demand index, INTERLINK being the only model in which the mark-up varies everywhere with respect to such indexes.

As to the role of foreign producers, the price-taker position of most countries as well as some input price effects lead to include import prices in the equations, and all models -but strangely enough QUEST- agree on that. QUEST accounts only for a transitory effect of import prices. The OECD model is also remarkable on this point, for it is the only one to allow for an impact -yet restricted to the short-run- of the terms of trade: the non-energy sector profit margin is assumed to increase transitorily with the terms of trade.

3. Dynamics and the long-run properties

Starting with the above grounds for a basic specification, the dynamic adjustment of the current price to its optimal level is generally expressed with an auto-regressive process in price levels, either with a Koyck-like partial adjustment model, or with an Error-Correction-Model including a feedback-term on the optimal price, denoted P^* , with respect to Unit Costs, Import Prices and Capacity Utilisation Rate:

$$\begin{aligned} d\ln P &= m.d\ln P - 1 + n.d\ln P^* - g.\ln(P/P^*) - 1 \text{ ECM} \\ d\ln P &= a.\ln(P^*/P - 1) \text{ partial adjustment} \end{aligned}$$

with the optimal price equation:

$$\begin{aligned} \ln P^* &= b_1.\ln(UC) + b_2.\ln(MP) + c.t + d.CUR + cst \\ \text{or } \ln P^* &= \ln(b_1'.UC + b_2'.MP) + c.t + d.CUR + cst \end{aligned}$$

The dynamic specifications above allow to analyse very easily the long-run properties of the equations, for instance price homogeneity, ie whether multiplying by a common factor all prices but one would finally have the same effect on this one. As long as the optimal price is a weighted average of unit costs and import prices, this homogeneity requires $b_1 + b_2$ be equal to one and nothing specific on b_1' and b_2' .

Note that apart from the output price in the UK for GEM, apparently no other team seems to have chosen an equation with prices expressed in first differences, ie in growth rates or inflation. Specifications in terms of inflation would imply no specific solution for the long-run level of prices:

one would get persistent effects of transitory shocks on the mark-up. As far as the expenditure deflators are concerned, some of the linking equations use inflation too (in QUEST and INTERLINK).

If one thinks of the long-run path in terms of a constant non-zero inflation rather than constant price levels, provided the initial levels of prices were identical, the equations at time t would reduce to:

$$\begin{aligned} d\ln P(1 - m + g.t) &= d\ln P^*(n + g.t) \text{ ECM} \\ d\ln P &= a.d\ln P^* \text{ partial adjustment} \end{aligned}$$

The ECM might be consistent with this steady path at the same inflation for all prices -ie the same price level at each time t - if $1 - m$ equals n , on the contrary the other adjustment never would.

A connected problem is the „law-of-one-price” property: other equations would be involved, namely the real wage and consumption price equations⁴. One must bear in mind that the time trends in the equations might keep the long-run solution away from this „law-of-one-price” path. So would a constant term added to the adjustment first-difference equation.

The various coefficients m , n , g and a , which lead the dynamics, would generally appear only in the speed of adjustment to the optimal price level. These parameters are always constant but remarkably for MIMOSA's Italian commercial margins indicator, of which the inflation accelerates the adjustment process. The steady path, at a constant inflation level, would nevertheless be unaffected.

4. Estimation procedures

Since the above specifications are easily restricted so that they would allow price homogeneity, most of the teams got close to that, either imposing it (INTERLINK, GEM, MIMOSA and QUEST) or as a result from econometrics (OEF), at least as far as long run homogeneity is concerned. Only did the INTERLINK team impose as well inflation homogeneity, ie $1 - m$ set equal to n in the ECM, this property being also included the other price equations so that the „law-of-one-price” would hold. Also note the identification of the constants in the equations as non-zero trend, though crucial in terms of long-run inflation, is not always possible: when estimated in first-difference, without any preliminary analysis of the level equation, one cannot tell whether this coefficient is an actual drift or added for balancing or scaling purposes.

An other attractive feature, strictly in terms of econometrics, of the specifications just mentioned should have been its convenient way of handling non-stationary variables, and prices obviously are. This would have been so especially when the error term would appear stationary -in other words when P and P^* are cointegrated.

⁴ See appendix for a brief sum-up of the full system and a discussion of the relevant restrictions.

Though the estimation of an ECM has been widely performed, maybe due to somewhat „old” estimations in most cases or else to small samples, strangely enough no team but OEF has reported stationarity analysis of the long-run residuals. Yet, even in this case the only test presented is the Cointegrating Regression Durbin-Watson (CRDW). One could have preferred, or at least appreciated, to know the Dickey-Fuller tests, basic and augmented (DF and ADF), the latter being here the more relevant due to the usual high degree of autocorrelation in the prices series.

Two other estimation procedures are worth mentioning apart from the OEF one, though they might suffer from spurious statistical inference, due to the non-stationarity of the data. On the one hand, the MIMOSA team estimated a general equation in levels, which was either an ECM, a partial adjustment model or an equation in first difference, depending on the linear restrictions on coefficients. The dynamics were specified according to the results of the competing specifications, most of the time rejecting the ECM. On the other hand, the INTERLINK team used the 'mixed' regression technique: i) actual costs were cyclically-adjusted to get long-run 'normal' cost measures with constant income shares for each factor, ii) priors on non-cost variables were determined through OLS on the

conditional prices given the 'normal' costs, iii) 'mixed' regressions were performed with all variables and priors, with price homogeneity imposed. Due to that procedure, all equations eventually include capacity utilisation effects, though the final magnitude of them is a lot inferior to the priors.

5. The 'big four' key price equations

The table 1 gives a comparative assessment of all core equations in the five models under review. The optimal price is given in terms of its long-run equation, derived from the either explicit -in the ECM- or implicit specifications. OECD, QUEST and MIMOSA -but for France with production price modelled the value-added deflators, whereas GEM and OEF -but for the UK with output price- estimated a production or wholesale price equation. Within each subset of models, one can in fact observe very similar results.

As a conclusion some quick comments can be made on these equations:

Price homogeneity: in every model roughly speaking this property is assumed to hold in the long run. Yet one may

Table 1

The long-run key price equations: Manufacturing
(MIMOSA, GEM, OEF), Non-Energy (OECD), Global (QUEST)

	UC ¹⁾	MP ²⁾	CU ³⁾	trend ⁴⁾	
Italy					
MIMOSA ⁵⁾	.77	.23	x	+	
OEF	.68	.33	.6	x	
GEM	.74	.26	x	+	
OECD	.73	.27	.39	x	
Germany					PMeng
MIMOSA	.92	.08	-.07	x	x
OEF	.58	.36	x	x	.06
GEM	.54	.46	.56	+	x
OECD	.86	.14	.19	x	x
QUEST	1.0	x	x	-	x
UK					PMman
MIMOSA ⁵⁾	.79	.21	-.12	x	x
OEF	.73	.10	-.3	x	.17
GEM ⁶⁾	.74	.26	x	x	x
OECD	.47	.53	.54	x	x
QUEST	1.0	x	.1	-	x
France					
MIMOSA ⁵⁾	.88	.12	x	x	
OEF ⁵⁾	.49	.51	.66	x	
GEM ⁷⁾	.88	.12	.5	x	
OECD	.87	.13	.42	x	
QUEST	1.0	x	.46	-	

Notes: 1) Labor costs for OEF, factor costs for OECD, 'Global' cost for MIMOSA, stochastic IMF 'current' productivity in GEM; elasticities. — 2) Manufactured imports for MIMOSA, all goods elsewhere; elasticities. — 3) Manufacturing Capacity utilisation rates, capacity margins for MIMOSA, survey data on excess capacity firms for OEF's UK, actual to potential non-energy output for OECD; semi-elasticities * 100. — 4) The time trend is difficult to interpret but in QUEST, where it obviously stands mainly as a proxy for productivity evolution. — 5) $\ln P^* = \ln (aUC + bPM)$. — 6) First-difference equation. — 7) Consumption deflator, wholesale price would give (.67, .33,0).

find deterministic trends in the equations, namely in Italy for three of the models and in Germany for GEM, which means the long-run levels of relative prices might diverge in some countries. One should also have considered wage and expenditure deflators equations or simulations restricted to the wage-price spiral in order to give a detailed answer to this question.

Capacity utilisation: OECD is the the only team for which that indicator is included in all equations. For each of the other teams only two of the European countries and not always the same ones- show evidence of such an effect. The variety of indicators also make comparisons in terms of elasticities less than straightforward... GEM and INTERLINK also account for such effects in their consumption price equations. Strangely enough, only did the model made in France ignore such an effect for France.

Price taking or setting: The comparison is somewhat difficult to achieve because not all the prices equations are based on the same kind of deflator. Comparing production and value-added deflators is not directly relevant, one would rather need the overall impact on demand prices, such as the consumption expenditure deflator.

Yet analysing the Unit Cost to Import Prices coefficients ratio would give a first idea of the hierarchy of the European countries in each model, as to their reaction to an external price shock. Remember such an effect is only transitory in QUEST, whereas one expects on the one hand OEF and GEM, on the other hand MIMOSA and INTERLINK to be pretty similar.

Italy: the ratio UC/MP ranges from 2 to 3 for all models. Germany: the indicator is close to one for OEF and GEM; it is much higher, with 6 and 10 respectively, for OECD and MIMOSA. UK: the ratio is equal to 3 or 4 for all teams but to one for the OECD. France: the indicator is close to one for OEF and reaches 7 for GEM, OECD and MIMOSA.

In terms of simulation properties, i) in most cases, room is given to some internal inflationary pressure from an excess demand situation, the magnitude of the responses being nevertheless puzzlingly varied; ii) the more „price-taking” country and consequently the more likely to respond violently to an external inflationary pressure would apparently be: the UK for OECD, Italy for MIMOSA and Germany for GEM and OEF.

As a matter of fact, an achieved comparison would require not only the analysis of the production-output price equation but also its connection with the consumption prices, its part in the wage-price spiral, and its feedback on the import prices as well.

The speed of adjustment to the long-run behaviour might also differ enough to cause very contrasted responses in simulation to the inflationary shocks, whether external or internal. So would the degree of smoothing in the productivity entering the unit cost index. For instance, no smoothing at all is made in the UK for MIMOSA and OECD and at the opposite actual current productivity is completely excluded of

the cost in QUEST, which indeed implies very contrasted results in simulation. The latter model would react to an expansionary simulation with a higher inflation whereas the former two would make the most of the virtuous short-run impacts of the productivity cycle.

Appendix: A short note on the long run price level.

The long-run equations for deflators and wages per head can be stylised by the following system, not omitting the deterministic trends and accounting for price homogeneity:

$$\begin{aligned} \ln P &= b1.\ln W - b1.\ln PROD + b2.\ln(OTHER) + (1-b1-b2).\ln MP + c1.t + d.CUR \\ \ln PC &= a.\ln P + (1-a).\ln MP + c2.t \text{ or the same in 1st difference} \\ \ln W &= \ln PC + \ln PROD - u.UR \text{ or } d\ln W = d\ln PC - u.UR + c3 \end{aligned}$$

all coefficients but the c's are positive;
 CUR is capacity utilisation rate,
 d first-difference operator,
 MP import prices,
 OTHER unit costs other than wages,
 P output price,
 PC consumption deflator,
 PROD productivity per head,
 UR unemployment rate
 and W wages per head.

The unemployment rate in the alternative wage equation can be determined so that the real wage would also grow in line with productivity. In the long-run a fixed growth rate for productivity is then consistent with only one level of unemployment rate, which amounts to assuming a constant ratio between labour force and actual employment. Under this assumption, and with a constant capacity utilisation and world prices growing at rate r, that is with exogenous import prices, the system can be reduced to:

$$\begin{aligned} \ln P &= b1.\ln PC + b2.\ln(OTHER) + (1-b1-b2).r.t + c1.t + d.CUR \\ d\ln PC &= a.d\ln P + (1-a).r + c2 \end{aligned}$$

Two problems arise at this stage for the „law-of-one-price” to hold: i) what about the drift c's? ii) how do the 'other' costs behave?

Firstly, if one forgets the impact of 'other' unit-costs (GEM, QUEST and OEF) and thus sets b2 to zero, zero-drifts is a sufficient condition for all prices to follow the same path. Yet non-zero drifts may compensate and yield the same result. Such drifts would possibly account for tax rate evolutions or structural changes.

Secondly, under such well-behaved drift coefficients, as long as the other unit costs can be expressed in terms of a price level multiplying a constant long-run ratio (such as the Investment to Output ratio for MIMOSA or the real Unit Cost of Capital in INTERLINK) the inflation path would be common to all prices. For instance the OECD did not use the actual cost of capital -which depends on the factor prices through the current capital-output ratio- but a simpler form „to dampen possible price effects”.