ACCOUNTING FOR DEMAND-EFFECTS IN INPUT-OUTPUT PRICE-MODELS

TAMÁS RÉVÉSZ
Ministry of Economic Affairs, Hungary

Input-output price-models traditionally concentrate on the cost-component of price formation rules. This includes a mechanism determining which factors' costs and/or returns will be built into the price of the products. Prices which do not fit to this standard treatment are given either exogenously or determined residually. Demand or pull-effects are treated explicitly only by general equilibrium models or similar models determining prices and quantities simultaneously. However, even the transparent, simple, linear input-output models can represent most of the demand effects in a way which is not less realistic than the results of complex 'black box' models which usually contain untested and dubiously uniform price elasticities. Therefore, so-called reference prices are introduced which in the first place represent the prices of the competitors, i.e., the price of the import or the price of the substitutes. In addition, reference prices can be the exchange rate the wage level or the price of any commodity which can be used as an argument or excuse for the price increases of government set or monopolised products. More generally, by weighting the individual possible reference prices one can derive baskets of reference prices. In the final step of generalization one can weight together the cost-effects and the reference prices in the following way:

$$\mathbf{p} = (\mathbf{p} \cdot \mathbf{C} + \mathbf{z}) \cdot \langle \mathbf{w} \rangle + \mathbf{p} \cdot \mathbf{Q} \cdot (\mathbf{I} - \langle \mathbf{w} \rangle) ,$$

where $\mathbf{p}$ is the vector of all prices, $\mathbf{z}$ is the vector of expected nominal unit profits, $\mathbf{C}$ is the matrix of the input coefficients augmented by the rate of returns, $\mathbf{Q}$ is the matrix of the weights of the reference prices, $\mathbf{I}$ is the identity matrix and $\mathbf{w}$ is the vector of the weight of the cost-formula in the price formation of the given product. The paper discusses several special cases of this general formula which usually can be achieved by setting many of the parameter values to zero or by exempting some of the prices from this price formation rule completely. Some prices can be set exogenously and in the case of the closed homogenous price model at least one price must be exogenous and one rate of return must be endogenized. After the theoretical part, the paper presents the results of a plausible scenario for Hungary. In this scenario, in accordance with the government policy, the exchange rate is devalued by 5% and a 30% oil and gas price increase is assumed at the world market relative to their average price in 1999. For the individual sectors different price formation rules i.e. different parameter values of the above general formula are assumed. As a result the model predicts a 8% consumer price increase for 2000 which is 1% higher than the original official progno-

sis (which counts on lower oil prices) but is in accordance with the general expectation of the economic research institutes and the public opinion. The author's view is that such transparent models can be used widely and effectively in the process of labor disputes and macroeconomic policy analyses and can be easily modified to include even more sophisticated and relevant price formation mechanisms.

1 Theoretical background

Economic theory has developed many (sometimes conflicting) theories of profits, wages and prices. Demand side considerations refer to price and income elasticities which in turn sometimes are derived from utility maximization. However, on the market there are rather different users. The government, the foreign buyers, the different industries and different social groups have rather different consumer behavior. Therefore, models mostly describe the demand of these agents separately which makes the model large and less transparent. However, in the case of a single commodity not all these agents are significant buyers. So the demand of the individual commodities can be characterized in a much simpler way. It suggests the elaboration of various partial equilibrium models. However, one should not forget to take into account the price-*interdependencies*. I-O price models are the widely used tools to take into account the repercussion of changes in the unit costs of the various products.

Input-output price-models traditionally concentrate on the *cost-component* of price formation rules. This includes a mechanism determining which factors' costs and/or returns will be built into the price of the products. Prices which do not fit to this standard treatment are given either exogenously or determined residually.

To take into account the *demand* side effects too, I introduced so-called *reference prices*, which in the first place represent the prices of the competitors, i.e. the world market prices of the same commodity (more directly represented by the import or export prices) or the price of the substitutes. In addition, reference prices can be the exchange rate the wage level or the price of any commodity which can be used as an argument or excuse for the price increases of government set or monopolised products. More generally, by weighting the individual possible reference prices one can derive baskets of reference prices. In the final step of generalization one can *weight* together the cost-effects and the reference prices.

Note, that the suggested weighted-price concept has different assumptions about the demand. In the case of the exogenous prices, change in the demand is not considered at all. In the case of the monopolistic prices one can assume that they maximize profits subject to social tolerance. Finally, in the case of the commodities facing strong competition the computed weighted price estimates the price level which *partially* would not change the share of the suppliers of the total supply, which in turn should equal to total demand of the given commodity. Obviously, the simultaneous solution of the price system and the possible (presumably not too significant) feedback of the changing consumption patterns on the relevant price indices requires more theoretical discussion and clarification of the definitions, but in practice it probably can be handled by the distinction of further cases, without fundamentally changing the mathematical characteristic of the solution method, which we are going to review in the next section.

2 The formal presentation of the general price model

The result of the above generalizations can be formalised in the following way:

$$\mathbf{p} = (\mathbf{p} \cdot \mathbf{C} + \mathbf{z}) \cdot \langle \mathbf{w} \rangle + \mathbf{p} \cdot \mathbf{Q} \cdot (\mathbf{I} - \langle \mathbf{w} \rangle) \ , \tag{1}$$

where

$\mathbf{p}$ is the vector of all prices (products and factors alike),

$\mathbf{C} = \mathbf{U} + \langle \mathbf{r} \rangle \cdot \mathbf{D} + \langle \mathbf{s} \rangle$ is the sum of the input coefficients ($\mathbf{U}$, which is the technology matrix supplemented with the rows of the unit factor inputs and with the columns of the consumption, investment and export patterns) and the basis of the price proportional returns,

$\mathbf{z}$ is the vector of expected nominal unit profits,

$\mathbf{Q}$ is the matrix of the weights of the reference prices,

$\mathbf{I}$ is the identity matrix, and

$\mathbf{w}$ is the vector of the weight of the cost-formula in the price formation of the given product ($\langle \mathbf{w} \rangle$ is its diagonal matrix equivalent).

The formula of $\mathbf{C}$ requires some more explanation. Above the costs of the inputs a part of the surplus is expected to be generated as given percentages of the costs. Costs, as can be seen, are the products of prices and quantities (volumes). Therefore, in the first round we can compute the expected returns at constant prices and multiply them by the prices only afterwards (mathematically: $\mathbf{r} \cdot \langle \mathbf{p} \rangle \cdot \mathbf{D} = \mathbf{p} \cdot \langle \mathbf{r} \rangle \cdot \mathbf{D}$). Similarly, prices may include a certain kind of cost-independent but still output-price proportional term ('mark up' or *ad valorem* indirect tax) which in effect is a given percent of the current output *value*. These percentages are included in the vector denoted by $\mathbf{s}$.

Note that $\mathbf{D}$ can differ from $\mathbf{U}$ at least for two reasons. First, while the corresponding rows of the $\mathbf{U}$ input coefficient matrix contain the quantity of the *consumed* capital and labor, in $\mathbf{D}$ we may replace these rows by the total *stock* of the physical and human capital required for producing one unit output. These latter categories can be (and in the case of the capital usually are) the basis of the return expectations. More generally, we can modify the basis of the return calculations according to our ideas about their relevance in the price formation of the given product. Setting them to zeros will exempt them completely from the return generation requirement, even if for the given category a positive standard rate of return (corresponding element of $\mathbf{r}$) applies. In general $\mathbf{D}$ renders possible the differentiation of the return expectations accross users.

Moreover, the whole cost-based formula can be dropped by setting the corresponding element of $\mathbf{w}$ to zero.

Turning our attention to the second part of (1), let us discuss the meaning and role of the $\mathbf{Q}$ matrix. For example, a value of 0.5 at the intersection of row 1 and column 2 means that half of the first price (multiplied subsequently by the corresponding element of $\langle \mathbf{1} - \mathbf{w} \rangle$) will be built into the price of the 2nd good. Generally, in regard of price homogeneity, the sum of each column of $\mathbf{Q}$ must be 1. Otherwise an e.g. 10% inrease of each reference prices would result in a different increase in the dependent price which is rather difficult to justify.

The role of the reference prices are particularly important in open market economies where prices have to accommodate to world market prices and the exhange rate. If the import prices do not guarantee sufficient profitability for the domestic producers they should improve their efficiency or by closing down the less efficient factories they should contract.

Pull-effects of higher household incomes can be taken into account by using the general wage index as a reference price. Wage income is the owerwhelming component of household incomes so this trick captures most of the income effects. Note that this kind of use of the wage index is different from the wage-cost consideration which belongs to the supply analysis.

The possible cases of the reference prices are so numerous that we do not attempt to disscuss them all. Instead, in section 3 we present an application which was elaborated for the currently rather important and much debated issue of the effect of the big jump of the world market oil prices.

2.1 The solution of the general price model

By rearranging (1) we obtain the following:

$$\mathbf{p} \cdot \left\{ (\mathbf{I} - \mathbf{C}) \cdot \langle \mathbf{w} \rangle + (\mathbf{I} - \mathbf{Q}) \cdot (\mathbf{I} - \langle \mathbf{w} \rangle) \right\} = \mathbf{z} \cdot \langle \mathbf{w} \rangle \ . \tag{2}$$

Note, that if $\mathbf{z}$ is different from zero, then the *inhomogenous* price model can be solved by multiplying the equation by the (normally existing) inverse of the matrix in the { } brackets. Otherwise, we get the so called *closed* price model, in which the price level can not be determined from (2), therefore one has to select some exogenous prices (at least a numeraire), and by endogenizing (rescaling) some of the elements of $\mathbf{r}$ make sure that the system has a non-trivial solution.

Returning to the inhomogenous case, after permutating (reordering) the elements of $\mathbf{p}$ and similarly the corresponding rows of the compounded matrix in the { } brackets appropriately, we can derive the following relationship:

$$[\mathbf{p}_n, \mathbf{p}_x] \cdot \mathbf{M} = \mathbf{b} \ , \tag{3}$$

where $\mathbf{p}_n$, $\mathbf{p}_x$ are the vectors of the endogenous and exogenous components of $\mathbf{p}$ respectively, $\mathbf{b} = \mathbf{z} \cdot \langle \mathbf{w} \rangle$ and $\mathbf{M}$ is the permutated matrix. By partitioning $\mathbf{M}$ to an $\mathbf{M}_n$ and $\mathbf{M}_x$ upper and lower part respectively, we get

$$\mathbf{p}_n \cdot \mathbf{M}_n + \mathbf{p}_x \cdot \mathbf{M}_x = \mathbf{b} \ , \tag{4}$$

formula. This has a unique solution if we drop so many columns (price equations) that the remaining $\mathbf{M}_{nn}$ matrix becomes a square matrix and invertible. Then the solution will be the following:

$$\mathbf{p}_n = (\mathbf{b}_n - \mathbf{p}_x \cdot \mathbf{M}_{xn}) \cdot \mathbf{M}_{nn}^{-1} \ . \tag{5}$$

where $\mathbf{M}_{xn}$ and $\mathbf{b}_n$ denote the similarly truncated $\mathbf{M}_x$ matrix and $\mathbf{b}$ vector respectively, and the -1 exponent represents the matrix inversion.

3 Estimating the effect of the oil price increase

3.1 Formation of the scenario

For the analysis I choose the latest I-O table for Hungary i.e., the 1996 table. In this table one can find 21 sectors. Unfortunately, energy sectors are not separated out of the mining, chemical industry and utilities. However, since imports of mining products consists almost exlusively natural gas and crude oil I just assumed that the import price (in dollars) of the mining industry products increase by 30%. Note that in 1999 the average import price was \$18/barrel while from the beginning of this year it has increased from cca. \$25/barrel to \$30/barrel. So even by taking into account that natural gas prices lag behind the oil price fluctuations, the 30% increase seems to be a rather modest (optimistic) assumption (especially knowing that the forint is pegged to the euro and the dollar has appreciated considerably against the euro).

In the last 5 years the exhange rate served as an inflation anchor in Hungary. In every year, the forint has been appreciated in real terms (cca. around 2-3% a year). In any case, the crawling peg system with the pre-announced future nominal devaluation rate makes the exhange rate as a practically exogenous and predictable price of the Hungarian price system. For year 2000 the yearly average nominal devaluation will be around 5%. So in the price model the exchange rate index is set exogenously to 1.05. Next, the price index of the mining industry products is set to $1.3 \cdot 1.05 = 1.36$.

For the rest of the 21 sectors and the labor and capital I assumed that there is no 'money illusion', i.e., they try to maintain the *real* value of their surplus. I did not want to assume any conceptual change in the existing price formation mechanisms.

Therefore, I simply assumed that the sectors will try to maintain their observed surplus/output value ratio. Here the 'surplus' is defined as the value added less the wage cost, which means that (due to lack of data) capital costs are not separated out.

However, these desired cost-based prices can be put into practice only in the case of government protected or monopolistic sectors where the demand is inelastic. Note that although the demand for certain agricultural products is elastic, the government provides large export subsidies and imposes import quotas and prohibitive tariffs to create artificial shortages in the domestic market. In addition, the inputed price of the non-market services absorbs all cost increase by definition. Into this category belong the services produced by budgetary institutions and provided free to the households and the inputed rent of the housing stock. Note that in the latter case I assumed that prices follow directly (and exclusively) the price of capital (which is in turn determined by the investment price index). After all these and similar considerations, I selected sectors No. 1, 2, 8, 11, 16, 17, 19, 20 and 21 as sectors which can pass all their cost increases to the users. On the other extreme, sectors No. 5 and 9 are assumed to be just takers of the world market prices. Since I did not consider any other world market price movements (which is again a little bit optimistic approach), their price index is simply equal to the exchange rate index. The rest of the sectors differ in the weight of the cost-plus formula in their price formation rule and in the name(s) of their reference prices as shown by *Table 1*.

		Weight of the			
	Sector name	cost formula	wage	capital	exch.rate
1.	Agriculture	1			
2.	Forestry	1			
3.	Mining	exogenous			1
4.	Food-industry	0.5	0.5		
5.	Light industry	0			1
6.	Chemical industry	1			
7.	Building materials	0.6	0.2		0.2
8.	Metallurgy	1			
9.	Engineering	0			1
10.	Other manufacturing	0.4	0.3		0.3
11.	Utilities	1			
12.	Construction	0.4	0.6		
13.	Trade	0.5	0.5		
14.	Hotels-restaurants-catering	0.7	0.3		
15.	Transportation	0.6	0.4		
16.	Telecommunication	1			
17.	Financial services	1			
18.	Business and personal serv.	0		1	
19.	Public services	1			
20.	Education	1			
21.	Health and welfare services	1			
	Wages	1			
	Capital	1			
	Foreign Exchange	exogenous			

Table 1. The assumed prices formation rules

	Sector name	Price increase %
1.	Agriculture	8.1
2.	Forestry	8.3
3.	Mining	36.0
4.	Food-industry	8.0
5.	Light industry	5.0
6.	Chemical industry	12.8
7.	Building materials	8.6
8.	Metallurgy	9.1
9.	Engineering	5.0
10.	Other manufacturing	6.9
11.	Utilities	15.7
12.	Construction	8.1
13.	Trade	7.9
14.	Hotels-restaurants-catering	7.9
15.	Transportation	8.1
16.	Telecommunication	7.7
17.	Financial services	7.3
18.	Business and personal services	7.1
19.	Public services	8.0
20.	Education	8.0
21.	Health and welfare services	8.1
	Wages (=Consumer Price Index)	8.0
	Capital (=Investment Price Ind.)	7.1
	Foreign Exchange	5.0

Table 2. The resulting price indices

3.2 The results

The main results can be seen in *Table 2*. Apart from mining, the highest price index is that of the sector of 'utilities'. This is due to the fact, that utilities contain the heat and electricity production, which use considerable amount of natural gas. As specified above, all the price increases are assumed to be passed over to the consumers. In the second place we find the chemical industry which contain the refinery too. The refinery sector uses crude oil while the heavy chemical industry (which produces fertilizers, polivinilchlorids, olefins etc.) uses much of the refinery products and natural gas. Note that for the heavy chemical industry the price index would be much higher, but the not energy intensive light chemical industry (pharmaceutical products, cosmetics, etc.) partly counterbalances this effect.

From the above weight one may compute how the above changes affected the average profitability of the individual sectors. Since wages were assumed to be fully indexed to inflation, the observed 8% wage increase represents the consumer price index, too (by assuming that the effective consumption tax rates do not change which, however, may be questioned in the case of the gasoline tax). More precisely, we could just say that the wage index is equal to the average producer price index weighted by the household consumption structure. Investment (i.e., capital) price index shows a little lower average price index. As known, the investment price index is practically the weighted average of the price of the engineering industry and the construction industry.

The simulation results show that the government's 6-7% prognosis for this year's consumer price index seems to be difficult to reach. Of course, efficiency improvement may help in reducing the costs, but then workers may demand higher real wages, too (not just mere indexation). Our doubt is in accordance with the general expectation of the economic research institutes and the public opinion. As a further check, I run similar scenarios with the only operating Hungarian applied general equilibrium (CGE) model (Révész-Zalai, 1999) which was calibrated for 1998.

Depending on the macroeconomic closure of the model and assuming downward rigidity or stickiness of certain prices I could compute a 2-3% increase in the price level as a result of the 30% increase of the world market oil and gas prices. Note that these scenarios do not take into account the internal inflationary pressures which was represented by the 5% nominal devaluation in the I-O model. Hence, by adding the internal component (i.e., the 5%) of inflation, we may say that the CGE model predicts also a 7-8% price increase in 2000.

The author's view is that such transparent models can be used widely and effectively in the process of labor disputes and macroeconomic policy analyses and can be easily modified to include even more sophisticated and relevant price formation mechanisms.

References

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