# True prices, latent prices and the Ghosh model: some inconsistencies

***Louis de MESNARD***

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**<u>AUTHOR</u>**. Louis de MESNARD

**<u>AFFILIATION</u>**. LATEC (UMR CNRS 5118), Faculty of Economics, University of Burgundy

**<u>ADDRESS</u>**.
LATEC
2 Bd Gabriel,
B.P. 26611,
F-21066 Dijon Cedex,
FRANCE
Tel: (33) 3 80 39 35 22
Fax: (33) 3 80 39 35 22
E-mail: *louis.de-mesnard@u-bourgogne.fr*

**<u>ABSTRACT</u>**. The Ghosh model, a supply-driven input-output model, uses money terms rather than physical terms for all flows or outputs, "latent prices" (or price indexes) rather than true prices, and "demand prices" rather than "supply prices" (or "production prices"). This paper explores the consequences of these substitutions by comparison with the traditional Leontief demand-driven model. In conclusion, the Ghosh model (particularly because of its latent demand prices), is not as credible as the other version, while itself offers very limited results.

## I. Introduction

The Ghosh model (1958) assumes that, in an input-output framework, each commodity is sold to each sector in fixed proportions. It is a view that has its critics and its supporters (Bon, 1986, 2000; Chen, 1986, 1991; Davar, 1989; de Mesnard, 1997; Deman, 1988, 1991; Dietzenbacher, 1989, 1997; Helsmstadter and Richtering, 1982; Gruver, 1989; Miller, 1989; Oosterhaven, 1988, 1989, 1996; Rose and Allison, 1989, Sonis and Hewings, 1992). The model has a number of other special features: 1) all flows or outputs are in money terms and not in physical terms, 2) as a corollary, "latent" prices (i.e. price indexes) are used instead of true prices, and 3) demand prices (i.e. prices that affect a whole column of the exchange table) replace supply prices (i.e. "production prices" in the Classical sense, affecting a whole row of the exchange table, that is prices of commodities sold by sector; for a review, see Seton, 1993). Money terms and latent demand prices are not the only way to develop the model: physical quantities, true prices and supply prices could also have been introduced. In this paper, a near-complete typology of the possible models will be presented, reasoning both in physical terms and in money terms, both with true and latent prices, and both with demand and supply prices, through comparison with the traditional demand-driven model. It will be shown that the "Ghoshian version" of the supply-driven model with its demand prices is not as credible as the supply-price version, which in turn offers very limited results.

# II. The input-output models with true prices

## A. The hypothesis of the simple linear model of production and exchange

In this section I follow Gale (1989), leaving aside the more complicated cases such as the "von Neumann model". Consider *n* sectors, producing *n* commodities, and a set of final consumers. Each sector produces one and only one commodity and each commodity is produced by one and only one sector. The physical quantity bought by sector *j* from sector *i* when *j* produces commodity *j* is denoted $\bar{z}_{ij}$. By hypothesis $\bar{z}_{ij} \geq 0$. The model is closed: for each commodity *i*, the total sold is equal to the total produced and is denoted $\bar{x}_i$, with $\bar{x}_i = \sum_j \bar{z}_{ij} + \bar{f}_i$, where $\bar{f}_i \geq 0$ denotes the final demand. Note that if the rows of matrix $\bar{\mathbf{X}}$ are accepted as homogeneous, columns cannot be summed. Commodities *i* have a price $p_i$: these prices are true prices in the usual economic sense of the word. Initially, the value of each commodity *i* is equal to $\bar{x}_i p_i$ and each sector *j* has in hand $x_j$ of money. The model is monetarily closed: agents have the same quantity of money before and after an exchange, i.e. the model is at equilibrium sector by sector, that is $\bar{x}_i p_i = x_i$ for all *i*. So, after an exchange, the value of each product *i* is disposed of completely:

(1) $$\sum_j z_{ij} + f_i = x_i \Leftrightarrow \sum_j \bar{z}_{ij} + \bar{f}_i = \bar{x}_i \text{ for all } i$$

by simplifying prices in both sides of the equation, where $z_{ij} = \bar{z}_{ij} p_i$ is the value of the flow from *i* to *j* and $f_i = \bar{f}_i p_i$ is the final demand in value; and each sector *j* spends all of the money that it has in hand:

(1) $$\sum_i z_{ij} + v_j = x_j \Leftrightarrow \sum_i \bar{z}_{ij}\, p_i + \bar{v}_j\, w = \bar{x}_j\, p_j \text{ for all } j$$

where $v_j = \bar{v}_j\, w$ is the value added measured in money terms, while $\bar{v}_j$ is the amount of labor employed by sector *j*, and *w* is the wage rate (profits are taken as the owner's remuneration). To shift to a linear model of exchange, it is sufficient to posit $\bar{f}_i = 0$ and $\bar{v}_j = 0$. Then, two main hypotheses about behavior can be made: either demand drives the model or supply does.

## B. The demand-driven model

In the demand-driven model, it is assumed that each sector buys each commodity in fixed proportions, but there are two possibilities: coefficients may be defined in physical terms or in value terms.

If coefficients are defined in physical terms, it is assumed that the ratios $\bar{a}_{ij} = \frac{\bar{z}_{ij}}{\bar{x}_j}$ are stable for all *i* and *j*. Note that nothing prevents the coefficients from being greater than 1, their magnitude depends on the chosen scale but the determinant is scale-independent, as is the result, after the appropriate conversion of scale. In matrix terms, this can be written: $\bar{\mathbf{A}} = \bar{\mathbf{Z}}\,\langle \bar{\mathbf{x}} \rangle^{-1}$.The economy must be at equilibrium by row and by column. By rows (I call this the *primal*), the accounting identity (1) becomes $\sum_j \bar{a}_{ij}\, x_j + \bar{f}_i = \bar{x}_i$, that is:

(3) $$\bar{\mathbf{A}}\,\bar{\mathbf{x}} + \bar{\mathbf{f}} = \bar{\mathbf{x}} \Leftrightarrow \left(\mathbf{I} - \bar{\mathbf{A}}\right)\bar{\mathbf{x}} = \bar{\mathbf{f}}$$

This Cramer system has a non trivial solution only if the determinant $\left|\mathbf{I} - \bar{\mathbf{A}}\right|$ is not equal to zero; this solution is $\bar{\mathbf{x}} = \left(\mathbf{I} - \bar{\mathbf{A}}\right)^{-1}\bar{\mathbf{f}}$. By columns (I call this the *dual*), the accounting identity (2) becomes $\sum_i \bar{a}_{ij}\, \bar{x}_j\, p_i + \bar{v}_j\, w = \bar{x}_j\, p_j$ or $\sum_i \bar{a}_{ij}\, p_i + \bar{l}_j\, w = p_j$, where $\bar{l}_j = \frac{\bar{v}_j}{\bar{x}_j}$ are the input coefficients of labor in quantity and *w* is the wage rate. This can be noted in matrix terms:

(4) $$\mathbf{p}'\,\bar{\mathbf{A}} + w\,\bar{\mathbf{l}}\,' = \mathbf{p}'$$

Coefficients can also be defined as a ratio of values in money terms: the ratio $a_{ij} = \frac{z_{ij}}{x_j} = \frac{\bar{z}_{ij}\,p_i}{\bar{x}_j\,p_j} = \bar{a}_{ij}\,\frac{p_i}{p_j}$ is assumed to be stable for all $i$ and $j$. This is done in most national accounting systems for the sake of convenience. In particular, value coefficients allow aggregation of the very large number of elementary commodities (e.g. the numerous types and grades of steel) into the small number of commodities usually chosen (e.g. "Steel"). However, these coefficients defined in money terms are only a stopgap. They should be called "technico-economic coefficients" rather than "technical coefficients" because their stability implies stable prices (in fact, the stability of the ratio $\frac{p_i}{p_j}$ as soon as $\bar{a}_{ij}$ is assumed to be fixed). Technico-economic coefficients should not be considered as the normal case. The normal case remains that of coefficients defined in physical terms with commodities and flows expressed in physical units, as is assumed in the other areas of economics.

By rows, (1) becomes: $\sum_j a_{ij}\,x_j + f_i = x_i$ for all $i$, that is:

(5) $$\mathbf{A}\,\mathbf{x} + \mathbf{f} = \mathbf{x} \Leftrightarrow (\mathbf{I} - \mathbf{A})\,\mathbf{x} = \mathbf{f}$$

This will have a solution $\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\,\mathbf{f}$ if $|\mathbf{I} - \mathbf{A}| \neq 0$.

By columns, (2) becomes $\sum_i a_{ij} + l_j = 1$ where $l_j = \frac{v_j}{x_j}$, that is:

(6) $$\mathbf{s}'\,\mathbf{A} + \mathbf{l}' = \mathbf{s}' \Leftrightarrow \mathbf{s}'\,(\mathbf{I} - \mathbf{A}) = \mathbf{l}'$$

where $\mathbf{s}' = \begin{pmatrix} 1 & \dots & 1 \end{pmatrix}$. This is not a Cramer system of equations to be solved in $\mathbf{s}$, a fixed vector: so, if $|\mathbf{I} - \mathbf{A}| = 0$ then $\mathbf{s}' \neq 1$, which is impossible, so (6) requires $|\mathbf{I} - \mathbf{A}| \neq 0$. Hence the demand-driven model in value (5) always has a non-trivial solution. And as $|\mathbf{I} - \mathbf{A}| = \left|\mathbf{I} - \hat{\mathbf{p}}\,\bar{\mathbf{A}}\,\hat{\mathbf{p}}^{-1}\right| = \hat{\mathbf{p}}\,\left|\mathbf{I} - \bar{\mathbf{A}}\right|\,\hat{\mathbf{p}}^{-1}$, if $|\mathbf{I} - \mathbf{A}| = 0$ then $\left|\mathbf{I} - \bar{\mathbf{A}}\right| = 0$ unless prices are null. Then the demand-driven model in quantity (3) will likewise always have a non-trivial solution unless prices are null. Moreover, if $\mathbf{f} > 0$ and as $\mathbf{f} = \mathbf{x} - \mathbf{A}\,\mathbf{x}$, then $\mathbf{x} > \mathbf{A}\,\mathbf{x}$: matrix $\mathbf{A}$ is always productive; the demonstration of the condition of productivity $\mathbf{x} > \mathbf{A}\,\mathbf{x}$ can be found in (Gale, 1989, p. 296-...).

## C. *The supply-driven model*

Two variants of the model can be explored: the supply-driven model with production prices and the supply-driven model with demand prices.

### 1. Supply prices

Supply prices are also demand prices: they are used above for the demand-driven model. Homogeneity by columns is not assumed. It is assumed that each commodity is sold in fixed proportions to each sector. Again there are two possibilities.

In physical terms, $\bar{b}_{ij} = \frac{\bar{z}_{ij}}{\bar{x}_i}$ is assumed to be stable for all *i*, *j*; in matrix form, this can be written $\bar{\mathbf{B}} = \langle \bar{\mathbf{x}} \rangle^{-1}\,\bar{\mathbf{Z}}$. By rows, (1) becomes $\sum_j \bar{b}_{ij} + \bar{d}_i = 1$ for all *i* where $\bar{d}_i = \frac{\bar{f}_i}{\bar{x}_i}$, that is:

(7) $$\bar{\mathbf{B}}\,\mathbf{s} + \bar{\mathbf{d}} = \mathbf{s} \Leftrightarrow \left(\mathbf{I} - \bar{\mathbf{B}}\right)\mathbf{s} = \bar{\mathbf{d}}$$

Again, this imposes $\left|\mathbf{I} - \bar{\mathbf{B}}\right| \neq 0$ to be always true. Note that this equation never provides prices as it might be expected to do at first glance. By columns, (2) is transformed into $\sum_i \bar{b}_{ij}\,x_i + v_j = x_j \Leftrightarrow \sum_i \bar{b}_{ij}\,\bar{x}_i\,p_i + \bar{v}_j\,w = \bar{x}_j\,p_j$ for all *i*, that is:

(8) $$\mathbf{x}'\,\bar{\mathbf{B}} + \mathbf{v}' = \mathbf{x}' \Leftrightarrow \mathbf{x}'\left(\mathbf{I} - \bar{\mathbf{B}}\right) = \mathbf{v}'$$

Note that this expression is in money terms, not in quantities as might be expected at first sight. It always has a solution $\mathbf{x}' = \mathbf{v}' \left(\mathbf{I} - \bar{\mathbf{B}}\right)^{-1}$ since $\left|\mathbf{I} - \bar{\mathbf{B}}\right| \neq 0$. As can be seen, prices (of commodities) are undetermined: neither (7) nor (8) provide prices.

When computed in money terms, the stable coefficients are defined as follows: $b_{ij} = \frac{z_{ij}}{x_i} = \frac{\bar{z}_{ij}\, p_i}{\bar{x}_i\, p_i} = \frac{\bar{z}_{ij}}{\bar{x}_i} = \bar{b}_{ij}$ for all $i$, $j$; as they are equal to the coefficients in quantities, the model is exactly the same as above, either by rows or by columns.

Dichotomy is not guaranteed with either type of coefficient: in the primal, nothing is obtained, while in the dual, only values in money terms are found, so there is no way of telling whether it is prices or physical quantities that have varied.

Note that as $\mathbf{A} = \hat{\mathbf{x}}\, \mathbf{B}\, \hat{\mathbf{x}}^{-1}$, then $\mathbf{I} - \mathbf{A} = \mathbf{I} - \hat{\mathbf{x}}\, \mathbf{B}\, \hat{\mathbf{x}}^{-1} = \hat{\mathbf{x}}\, (\hat{\mathbf{x}}^{-1}\hat{\mathbf{x}} - \mathbf{B})\, \hat{\mathbf{x}}^{-1} = \hat{\mathbf{x}}\, (\mathbf{I} - \mathbf{B})\, \hat{\mathbf{x}}^{-1}$ and so $|\mathbf{I} - \mathbf{A}| = |\mathbf{I} - \mathbf{B}| \neq 0$: the model always has a solution, whether in physical quantities or in money terms.

## 2. Demand prices

Although the following formula appears to lack credibility, it is introduced at this point as it will be useful for what follows. The supply-driven model can be written by considering "demand prices", that is prices affecting a column of the exchange table, as in:

(9) $$\sum_j \bar{z}_{ij}\, p_j + \bar{f}_i\, p^f = \bar{x}_i\, p_i$$

but the product of a quantity $\bar{z}_{ij}$ of commodity $i$ sent to $j$ multiplied by the price $p_j$ is simply meaningless in economics. In column $j$, the agent $j$ is assumed to buy all commodities at the same price, whatever the nature of this commodity. For example, what could be the meaning of the product of 1) a quantity $\bar{z}_{ij}$ of steel (*i*) sold to the automobile industry (*j*) by the steel industry, multiplied by 2) a price $p_j$ of automobiles, even if this price is a "demand price"? It contradicts the hypotheses of the linear models of exchange and production. The same holds for the final demands $\bar{f}_i$ for commodities *i* to which the same price $p^f$ is assigned.

With coefficients of money terms, the "economic allocation coefficients" are again $b_{ij} = \frac{z_{ij}}{x_i}$ but what must be chosen for $z_{ij}$? Is it $z_{ij} = \bar{z}_{ij}\, p_i$ or $z_{ij} = \bar{z}_{ij}\, p_j$? The answer is unclear: it seems logical enough to multiply $\bar{z}_{ij}$ by $p_i$ but this is in contradiction with the philosophy of the Ghosh model, while to multiply it by $p_j$ invites the same criticisms as for demand prices above.

## III. Latent prices

The above reasoning explains what happens with true prices, particularly for the supply-driven model. This leaves the question of what happens with latent prices. Many authors (e.g., Davar, 1989; Oosterhaven, 1996; Dietzenbacher, 1997) have touched upon the plausibility of latent prices, or price indexes. Latent prices, denoted $\pi$, are not incorrect *per se*: they are introduced as the ratio of the prices of the current year to those of the base-year; the models are formally unchanged, except that latent prices replace true prices.

### *A. The demand-driven model*

The demand-driven model is not radically changed when latent prices are substituted for true prices, except that latent prices are applied to values in money terms, not to physical quantities.

For the primal, formula (1) is unchanged, that is $\sum_j z_{ij}\,\pi_i + f_i\,\pi_i \;= x_i\,\pi_i \Leftrightarrow \sum_j z_{ij} + f_i = x_i$, which implies that $\sum_j a_{ij}\,x_j + f_i = x_i$, that is $\mathbf{A}\,\mathbf{x} + \mathbf{f} = \mathbf{x}$: the outputs, **x**, in money terms are formed from final demands, **f**, in money terms.

In the dual, equation (2) transforms into:

(10) $$\sum_i z_{ij}\,\pi_i + v_j\,\pi^w = x_j\,\pi_j$$

which implies that $\sum_i a_{ij}\,x_j\,\pi_i + v_j\,\pi^w = x_j\,\pi_j \Leftrightarrow \sum_i a_{ij}\,\pi_i + \frac{v_j}{x_j}\,\pi^w = \pi_j$, where $l_j = \frac{v_j}{x_j}$ is the coefficient of value added measured as a ratio of money terms, that is $\boldsymbol{\pi}'\,\mathbf{A} + \pi^w\,\mathbf{L}' = \boldsymbol{\pi}'$: the latent prices, $\boldsymbol{\pi}$, are formed from **L**, the vector of value-added coefficients.

As in the base year, $\pi_i = 1$ for all *i*, which does not affect (1), while (2) becomes $\sum_i z_{ij} + v_j = x_j$, which is exactly the same as (2). Homogeneity by rows and columns is required for this model: there is only one commodity, in money terms, that is distributed from sectors and factors to sectors and final demand.

## *B. The supply-driven model*

With the supply-driven model things are more complicated. When latent prices are applied to values in money terms, two categories can again be considered, namely supply prices and demand prices.

## 1. Latent supply prices

For the primal, formula (1) transforms into

(11) $$\sum_j z_{ij}\,\pi_i + f_i\,\pi_i = x_i\,\pi_i$$

so $\pi_i$ can be simplified on both sides of this equation. *Mutatis mutandis* the same reasoning as above applies: latent prices are undetermined. The rest is as in the demand driven model: outputs in money terms, **x**, are formed from final demands in money terms, **f**.

For the dual, formula (2) becomes:

(12) $$\sum_i z_{ij}\,\pi_i + v_j\,\pi_w = x_j\,\pi_j$$

which implies that $\sum_i b_{ij}\,x_i\,\pi_i + v_j\,\pi_w = x_j\,\pi_j \;\Rightarrow \sum_i b_{ij}\,\tilde{x}_i + \tilde{v}_j = \tilde{x}_j$ or $\tilde{\mathbf{x}}'\,\mathbf{B} + \tilde{\mathbf{v}}' = \tilde{\mathbf{x}}'$, where $\tilde{x}_i = x_i\,\pi_i$ and $\tilde{v}_j = v_j\,\pi_j$ could be called "super values", that is values formed by the product of a value (i.e. a quantity in money terms) by a latent price. This dual allows only the super values $\tilde{\mathbf{x}}$ to be determined from the super value of value added $\tilde{\mathbf{v}}$, but never values or latent prices.

Again dichotomy is not guaranteed either in the primal or in the dual. From (11), outputs in money terms are found, so there is no way of saying whether it is the quantities in physical terms or the prices that have changed. In (12) or (13), things are worse still: it cannot be determined whether it is the latent prices or the values in money terms that have varied, but it is certain that a variation in a latent price obviously implies a variation in a true price, and probably a variation in the corresponding value in money terms...

## 2. Latent demand prices

With demand prices, by rows (1) becomes:

$$\sum_j z_{ij}\,\pi_j + f_i\,\pi^f = x_i\,\pi_i \tag{13}$$

that is $\sum_j b_{ij}\,x_i\,\pi_j + f_i\,\pi^f = x_i\,\pi_i \Leftrightarrow \sum_j b_{ij}\,\pi_j + d_i\,\pi^f = \pi_i$, where $d_i = \frac{f_i}{x_i}$ is the coefficient of final demand measured as a ratio of money terms, that is $\mathbf{B}\,\boldsymbol{\pi} + \mathbf{d}\,\pi^f = \boldsymbol{\pi}$: latent prices $\boldsymbol{\pi}$ are found from the latent price of final demand $\pi^f$.

By columns, (2) changes into:

$$\sum_i z_{ij}\,\pi_j + \pi^w\,v_j = x_j\,\pi_j \tag{14}$$

which implies that $\pi_j \sum_i b_{ij}\,x_i + \pi^w\,v_j = x_j\,\pi_j \Leftrightarrow \sum_i b_{ij}\,x_i + w_j = x_j$, where $w_j = \frac{\pi^w}{\pi_j}\,v_j$ may be termed "compensated value added", that is

$$\mathbf{x}'\,\mathbf{B} + \mathbf{w}' = \mathbf{x}' \tag{15}$$

an output in money terms is found from the compensated value added. If all latent prices are set to one, in the base year, then (14) changes into $\sum_i z_{ij} + v_j = x_j$ and the result becomes $\sum_i b_{ij}\,x_i + v_j = x_j$ (Oosterhaven, 1996, p. 753), a correct result but valid only for the base year, while (14) and (15) are more complicated but valid for all years.

Discussion

Formulas (13) and (14) correspond to what is known as the Ghosh model: as pointed out by Oosterhaven (1996), it is assumed that input is now homogenous by columns. However, homogeneity is required by rows also: for the base year, all latent prices are equal to 1, and (13) becomes $\sum_j z_{ij} + f_i = x_i$, which is nothing other than (1). So, homogeneity is guaranteed in rows and columns alike, i.e. there is only one input commodity and one output commodity, composed of money, and distributed from value added and sectors to sectors and final demand, as in the demand-driven model. This is why homogeneity can be assumed for columns, even if the flows $\bar{z}_{ij}$ in physical terms are not homogeneous. The flows $z_{ij}$ in money terms are homogenous, but this homogeneity is fictitious; it is the homogeneity of money, not of the real world of terms $\bar{z}_{ij}$.

Equation (13) or (14) could imply two alternative consequences.

1) True demand prices are combined with latent demand prices, multiplying $z_{ij} = \bar{z}_{ij} p_j$ by $\pi_j = \frac{p_j^{(t)}}{p_j^{(0)}}$ (considering the most simple type of price index; Laspeyres or Paasche are more sophisticated, taking into account not only the evolution of true prices but also of physical quantities). That is agent *j* increases (or decreases) its true demand prices for a same column by the same percentage (which might be an acceptable hypothesis but true demand prices have no meaning as demonstrated above).

2) Alternatively, true supply prices are combined with latent demand prices: $z_{ij} = \bar{z}_{ij} p_i$ is multiplied by $\pi_j = \frac{p_j^{(t)}}{p_j^{(0)}}$. This hypothesis is rather difficult to justify because how could an agent *j* exert a uniform action over the prices controlled by all producers *i*? This leads then to the concept of personalized prices and even to bilateral prices, formed by a bilateral monopoly, by mutual agreement, which can be written $p_{ij}$. In this last case, it is obvious that these $n^2$ prices cannot be computed. Finally, demand latent prices lack consistency, although they seem to convert the Ghosh model into the dual of the Leontief model.

Moreover, for the Ghosh model as for the Leontief model, the fact that latent prices are not equal to 1 violates the hypothesis of stability of technico-economic coefficients.

Remark. The above reasoning is unchanged when multiple categories of final uses and multiple factors are considered.

## IV. Conclusion

This paper has examined the consistency of one of the two main input-output models, the supply-driven model developed by Ghosh, with emphasis on the question of the treatment of quantities and prices. In the Ghosh model, all flows or outputs are generally expressed in money terms rather than in physical terms, "latent" prices (price indexes) are used instead of true prices and demand prices replace supply prices (production prices). By comparing this model with the traditional Leontief demand-driven model, this paper has explored the consequences of replacing quantities in money terms by physical terms, latent prices by true prices, and demand prices by supply prices.

It has been demonstrated that a supply-driven model with true prices is consistent only with supply prices, but these true prices cannot be determined by the model. True demand prices are not economically well founded.

The demand-driven model is compatible with latent prices. However, for the supply-driven model with latent supply prices, it becomes possible to determine only "super values" (that is the product of a value in money terms by a latent price), but never latent prices themselves. Latent demand prices in the supply-driven model seem to be acceptable at first glance, but 1) latent demand prices rely on complete homogeneity by rows and columns which can be considered only in money terms, and 2) demand latent prices remain difficult to interpret because they entail the assumption that true demand prices exist, which has been ruled out.

Finally, the supply driven model in its "Ghoshian version" (latent demand prices) is less credible than the other versions (latent supply prices, but also true prices), which themselves offer very limited results. Should we abandon the Ghosh model? Probably not, for at least two reasons. First, technical coefficients are not much more stable than allocation coefficients over time (Bon 1986, 2000), (Mesnard, 1997), so the Ghosh hypothesis does not seem any less reliable than the Leontief hypothesis. Second, the supply-driven model is acceptable in its supply-price version, even if values can only be computed in money terms.

## V. Bibliographical references

BON, Ranko. 1986. "Comparative stability analysis of demand-side and supply-side input-output models," *International Journal of Forecasting* 2: 231-235.

________ 2000. *Economic Structure and Maturity. Collected Papers in Input-Output Modelling and Applications,* Ashgate, Adelshot.

CHEN, Chia-Yon and Adam ROSE. 1986. "The Joint Stability of Input-Output Production and Allocation Coefficients," *Modeling and Simulation* 17: 251-255.

______ 1991. "The absolute and relative Joint Stability of Input-Output Production and Allocation Coefficients," in A.W.A. Peterson (Ed.) *Advances in Input-Output Analysis*. Oxford University Press, New-York, pp. 25-36.

DEMAN, S. 1988. "Stability of Supply Coefficients and Consistency of Supply-Driven and Demand-Driven Input-Output Models," *Environment and Planning A* 20, 6: 811-816.

______ 1991. "Stability of Supply Coefficients and Consistency of Supply-Driven and Demand-Driven Input-Output Models: a reply," *Environment and Planning A* 23, 12: 1811-17.

DAVAR, Ezra. 1989. "Input-output and general equilibrium", *Economic Systems Research*, 1, 3: 331-343.

de MESNARD, Louis 1997. "A biproportional filter to compare technical and allocation coefficient variations", *Journal of Regional Science*, 37, 4: 541-564.

DIETZENBACHER, Erik. 1989. "On the relationship between the supply-driven and the demand-driven input-output model", *Environment and Planning A* 21, 11: 1533-39.

______ 1997. "In vindication of the Ghosh model: a reinterpretation as a price model", *Journal of Regional Science* 37, 4: 629-651.

GALE, David. 1989. *The Theory of Linear Economic Models*., Chicago Press, Chicago (originally published in 1960).

GHOSH, Ambica. 1958. "Input-output approach to an allocative system", *Economica*, 25, 1: 58-64.

GRUVER, Gene W. 1989. "A comment on the plausibility of supply-driven input-output models", *Journal of Regional Science*, 29, 3: 441-50.

HELMSTADTER, Ernst and Jürgen RICHTERING. 1982. "Input coefficients versus output coefficients type sof models and empirical findicngs", in *Proceedings of the Third Hungarian Conference on Input-Output Techniques*, Budapest, Statistical Publishing House, pp. 213-24.

LEONTIEF, Wassily. 1936. "Quantitative input-output relations in the economic system of the United States," *Review of Economics and Statistics* 18, 3: 105-125.

______ 1986, *Input-Output Economics,* Oxford University Press, New-York, second edition.

MILLER, Ronald E., 1989. "Stability of supply coefficients and consistency of supply-driven and demand-driven input-output models: a comment," *Environment and Planning A* 21, 8: 1113-1120.

OOSTERHAVEN, Jan 1988. "On the plausibility of the supply-driven input-output model," *Journal of Regional Science* 28, 2: 203-217.

______ 1989. "The supply-driven input-output model: a new interpretation but still implausible," *Journal of Regional Science* 29, 3: 459-465.

______ 1996. "Leontief versus Ghoshian price and quantity models", *Southern Economic Journal* 62, 3: 750-759.

ROSE, Adam and Tim ALLISON. 1989. "On the plausibility of the supply-driven input-output model: empirical evidence on joint stability," *Journal of Regional Science* 29, 3: 451-458.

SETON, Francis. 1993. "Price models based on input-output analysis: East and West", *Economic Systems Research* 5, 2: 101-11.

SONIS, Michael and Geoffrey J.D. HEWINGS. 1992. "Coefficient Change in Input-Output Models: Theory and Applications", *Economic Systems Research* 4, 2: 143-57.