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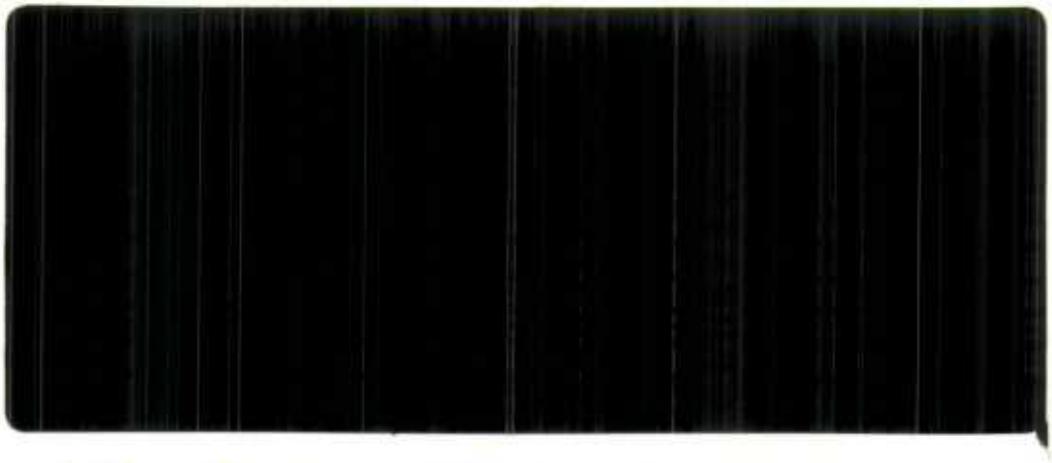

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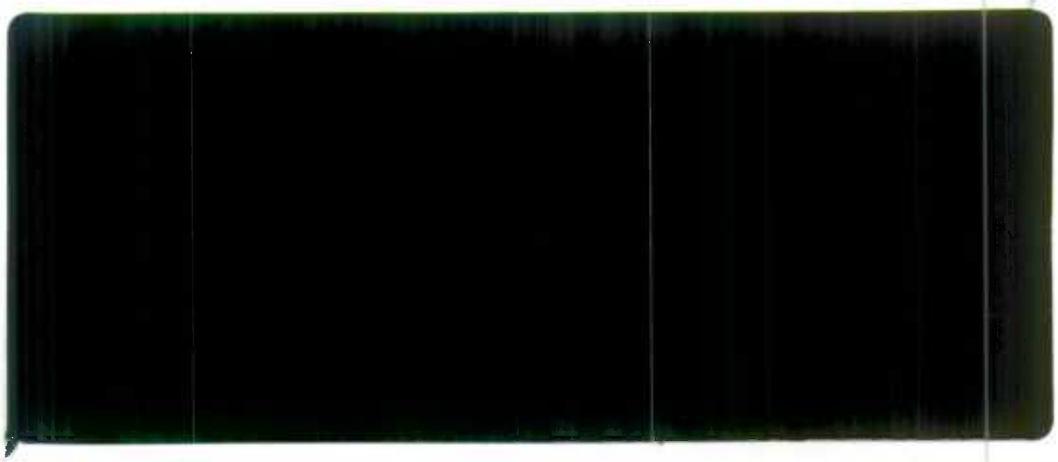

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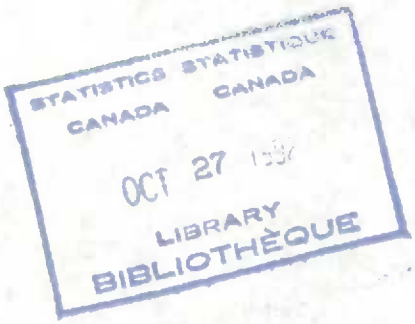
SPECIFICATION OF PARAMETERS FOR THE NATIONAL INPUT-OUTPUT MODEL

By

Pierre Mercier, René Durand and Aldo Diaz

18(E)

December 1991



INTRODUCTION

When the empirical analysis of results was carried out for the development of a model to represent commodity indirect taxes, gaps were found in the specification of leakage parameters in the open input-output national model[1]. This note deals with these empirical problems, and describes a different specification of leakage parameters. This new specification should be considered as a modification of that used in the conventional national model[2]. It also takes into account constraints deriving from the use of the model to simulate the impact of any expenditure effects.

The open input-output model aims to determine the propagation of any demand for commodities in the economy and, in particular, through the various activities of its productive structure. We are mainly interested in the activity of the business sector, even though part of the demand may translate into production by households and the government sector. This production by the non-business sectors appears in the value-added components of final demand. If we add the value-added of business, we obtain the total value-added of the economy deriving from a given shock of expenditures upon final demand. In the open model, the total value-added generated will nevertheless be lower than the given expenditure shock on demand. The difference between the two values is made up by what we call leakages. These consist of taxes and commodity expenditures. Tax leakages consist of indirect taxes collected by various levels of government. Commodity leakages represent components in the supply of goods and services other than the current production of the business sector. They include imports, withdrawals from inventories, the sale of goods and services by governments, and various other revenues included with expenditures by households and those who invest in machinery and equipment. These other leakages will be described in more detail later.

In the input-output tables, flows of commodity leakages are, by convention, entered in the final demand table as negative demands. For purposes of modelling, it is more useful to consider them as (positive) supply components. It highlights that these supply components also meet intermediate demand.

The former specification of leakages in the model has various weaknesses that should be corrected. The first is that it omits certain commodity leakages that appear in the final demand. These are commodity leakages that remain after taking into account imports, the sale of services by governments, and withdrawals from inventories. We must take into account all the production included with the household and investor expenditures, such as sales of used automobile and aircraft parts, rentals of student housing by educational institutions, consulting services offered by the universities, the income of non-profit organizations, etc. A second weakness derives from the fact that, in the case of some goods, imports are higher in value than domestic use and re-exports together. The third weakness is that we do not take into account situations where re-exports have higher values than imports. Finally, a fourth weakness in the treatment of leakages in the conventional model derives from the fact that the sum of the leakage parameters - to which we will return later - may be greater than unity. When we apply an arbitrary expenditures impact on goods where this happens, we obtain a negative production, which does not make sense.

The analysis of leakages omitted in the conventional specification has led to a new specification that makes it possible to obtain a better correspondence between the supply and demand components. In the

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[1] *See Durand R. and A. Diaz, "Input-Output Modelling of Commodity Indirect Taxes for Macroeconomic Analysis," mimeograph, Statistics Canada, Input-Output Division, January 1989.*

[2] *See Chapter 6, in* ***The Input-Output Structure of the Canadian Economy, 1961-1981****. Statistics Canada, Catalogue No. 15-510; December, 1987.*

following sections, we will review the conventional specification of leakage parameters, and will introduce the new definitions necessary for the description of the new specification of leakage parameters. Finally, in the last section, we will reformulate the new specification for use specifically in the analysis of the impact of expenditure shocks. In this case, leakage parameters have an additive form, which makes it possible to arrive at a more intuitive interpretation when we want to modify them.

THE CONVENTIONAL SPECIFICATION

The commodity balance equation in the open national model is as follows:

$$q + m + a + v = Bg + e^{*} + x_D + x_R \qquad (1)$$

where

- q is a vector of the production of goods and services
- m is a vector of the imports of goods and services
- a is a vector of the revenues of governments from the production of goods and services
- v is a vector of the values of withdrawals from inventories
- Bg is a vector of the intermediate demand for goods and services associated with the level of production g and the technological coefficients B
- e^{*} is the final domestic demand vector including additions to inventories, net of some negative values, such as the incomes of non-profit organizations, production from the sale of used automobile and aircraft parts, etc.
- x_D is a vector of the values of domestic exports
- x_R is a vector of the values of re-exports.

The left and right terms of equation (1) represent the supply and demand respectively. Supply variables are endogenous, while demand variables are exogenous. Imports, the production of governments, and withdrawals from inventories are specified by linear relationships, where the coefficients (or leakage parameters) apply only to specific demand components. Production q can be obtained residually from the balance equation (1).

The imports of goods and services are specified as follows:

$$m = \hat{\mu}\,(Bg + e^{*} + x_R) \qquad (2)$$

The production of governments can be obtained by:

$$\boldsymbol{a} = \hat{\alpha}\ (\boldsymbol{Bg} + \boldsymbol{e}^{*} + \boldsymbol{x}_{D}) \tag{3}$$

Finally, withdrawals from inventories can be obtained by:

$$\boldsymbol{v} = \hat{\beta}\ (\boldsymbol{Bg} + \boldsymbol{e}^{*} + \boldsymbol{x}_{D}) \tag{4}$$

The vectors of parameters μ, α, and β are determined by equations (2), (3), and (4), using historical values for $\boldsymbol{m}$, $\boldsymbol{a}$, and $\boldsymbol{v}$. The values of these parameters are revised each time that new input-output tables are available. Thus, equations (2) to (4) lead to leakage values observed when observed demand values are applied. Import parameters μ may be considered as the average propensity to import shared by all economic agents, producers, consumers, and exporters of imported products, with the exception of exporters of domestic products. By definition, the latter export only domestically manufactured products.

Thus, demand can be broken down into three segments:

i) exports of domestic products,

ii) re-exports, and

iii) domestic demand, including additions to inventories.

Only the last two segments are supplied by imports. This distinction has various implications that have not been entirely considered, as we will see below. In the case of government production and withdrawals from inventories, we assume that they meet demand from all sources, except re-exports, as equations (3) and (4) show.

In order to obtain the effect of an expenditure shock on commodities on gross production by industry, we need an additional hypothesis to allocate the production of commodities $\boldsymbol{q}$ to the production by industry $\boldsymbol{g}$. We formulate the hypothesis that the industries' shares of the market are fixed and represented by their historical value. The matrix representing the production of goods and services by industry for a given year is used to calculate the shares market $\boldsymbol{D}$. Formally, this hypothesis is expressed as follows:

$$\boldsymbol{g} = \boldsymbol{Dq} \tag{5}$$

By multiplying equation (1) by $\boldsymbol{D}$ and substituting equations (2) to (5), we can express the reduced form of gross production by industry as a function of exogenous variables:

$$\begin{aligned}\boldsymbol{g} = [\boldsymbol{I} - \boldsymbol{D}\,(\boldsymbol{I} - \hat{\alpha} - \hat{\beta} - \hat{\mu})\,\boldsymbol{B}]^{-1}\,\boldsymbol{D}[&(\boldsymbol{I} - \hat{\alpha} - \hat{\beta} - \hat{\mu})\,\boldsymbol{e}^{*} \\ &+ (\boldsymbol{I} - \hat{\alpha} - \hat{\beta})\,\boldsymbol{x}_{D} + (\boldsymbol{I} - \hat{\mu})\,\boldsymbol{x}_{R}]\end{aligned} \tag{6}$$

NEW DEFINITIONS

As we saw above, some production other than explicit leakages are included with household and investor expenditures. In the 1981 to 1987 tables, we can find up to nine:

COMMODITY	FINAL DEMAND CATEGORY
263 Scrap & waste materials NES	78 M&E Used cars, equipment & scrap
323 Mach. ind. specified & special purp.	78 M&E Used cars, equipment & scrap
330 Aircraft, all types	78 M&E Used cars, equipment & scrap
334 Passenger automobiles & chassis	78 M&E Used cars, equipment & scrap
559 Other rent	33 PE Education & cultural services
566 Services to business management	33 PE Education & cultural services
570 Meals	32 PE Recreational services
571 Serv. marg. on alcoholic beverages	32 PE Recreational services
576 Other serv. to businesses & persons	33 PE Education & cultural services

When the values of these table cells are negative, they represent supply components and thus leakages. A case by case analysis of these leakages suggests that they should be classified into two groups. The first group (commodities 334, 559, 570, and 571) represented by vector $\boldsymbol{s}_c$, includes leakages that meet only personal consumption demand (the first 40 categories of final demand)[3]. The second group (commodities 263, 323, 330, 566, and 576), represented by vector $\boldsymbol{s}_o$, includes leakages that meet both intermediate and final demand, except re-exports.

Thus, we can define the vector of the final gross domestic demand of all observed leakages, as follows:

$$\boldsymbol{e} = \boldsymbol{e}^* + \boldsymbol{s}_c + \boldsymbol{s}_o \qquad (7)$$

We are proposing other definitions that will be of help later to mitigate some anomalies in the modelling of import and export. Even though, in their construction, the import-output tables respect the equation of the overall balance of goods and services (1), the model does not truly represent all commodity sub-markets related to exports and imports. For some commodities, imports are higher than the sum of their domestic use and re-exports. Since the overall balance is respected, it follows that part of the domestic exports can only come from imports, which by definition should not be the case. This type of anomaly is found in the case of the following commodities[4]:

32 Gold and alloys in primary form, and
594 Unallocated imports and exports.

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[3] *Vector s_c is included in the goods and services item and contains zero values for all goods for which the leakage does not apply. The same is true for s_o. For purposes of the model, all leakage vectors are expressed as positive values.*

[4] *In the case of gold and primary alloys, the anomaly appeared in 1981 and 1986. This commodity represents a particular problem because it is partly used as currency. Unallocated imports and exports represent a residual class of goods and services for the statistician. We cannot properly refer to them as a market ruled by the laws of supply and demand. The observed equilibrium under this heading, is only meaningful from an accounting point of view.*

Finally, in other cases, re-exports display values that are higher than imports. This is the case with the following commodities[5]:

53 Horse meat, fresh, chilled, or frozen,
81 Infant and junior foods, canned, and
583 Transportation margins.

In the new leakage specification, these anomalies are corrected by redistributing total exports into domestic exports and re-exports. Excess imports over domestic consumption and observed re-exports are allocated to re-exports. Similarly, excess re-exports over imports are allocated to domestic exports:

$$x_R^* = \begin{cases} m + s_c - (Bg + e) & \text{if } m + s_c \geq Bg + e + x_R \\ m & \text{if } x_R > m \\ x_R & \text{if no} \end{cases} \quad (8)$$

and

$$x_D^* = x_D - (x_R^* - x_R) \quad (9)$$

NEW SPECIFICATION OF PARAMETERS

Once all the commodity leakages have been isolated from demand by the definition of the new vectors s_c, s_o, and e, and the lack of coherence between imports and exports has been taken into account for the construction of export vectors x_D^* and x_R^*, we can formulate a specification of parameters such that the observed value of the leakage is not above the value of the segment of the demand that it serves to supply.

In order to do this, it is useful to separate imports for domestic use from those that supply re-exports. Thus, we define:

$$m_R = x_R^* \quad (10)$$

and

$$m_D = m - m_R \quad (11)$$

---

[5] *The statistician allows that re-exports are not completely supplied by imports during a given period, when synchronization problems do not make it possible to evaluate with enough precision the value of the net withdrawals from the physical value of inventories at the end of the period. In these cases, the value of the net withdrawals from the physical value of inventories may cover re-exports not covered by imports. This is true for horse meat and infant foods. As far as transportation margins are concerned, the problem arises when we transform the data on consumer prices into producer prices. Since some transportation margins enter into the consumer prices of some re-exports of goods, when they are isolated, these margins appear as re-exports. However, it is not the transportation margins that are re-exports, but rather the goods to which these margins apply.*

As we saw above, the leakage vector s_c can only serve to supply personal domestic consumption. Thus, it is useful to define e_c as the vector of personal consumption and

$$\bar{e} = e - e_c \tag{12}$$

where $\bar{e}$ is the complement of e_c, i.e. the vector of domestic demand other than personal consumption[6].

Taking into account the newly-defined components of supply and demand, the commodity balance equation takes the following form:

$$q + m_D + m_R + a + v + s_c + s_o = Bg + e_c + \bar{e} + x_R^* + x_D^* \tag{13}$$

Since the leakage vector m_R serves only to supply the x_R^* component of the demand that it can entirely meet, we may drop m_R and x_R^* from equation (13).

The other vectors of the leakage parameters can be obtained by the following relationships (behavioural hypotheses):

$$s_c = \hat{\nu}\, e_c \tag{14}$$

$$m_D = \hat{\mu}\, (Bg + e - s_c) \tag{15}$$

$$a = \hat{\alpha}\, (Bg + e + x_D^* - s_c - m_D) \tag{16}$$

$$v = \hat{\beta}\, (Bg + e + x_D^* - s_c - m_D) \tag{17}$$

$$s_o = \hat{\gamma}\, (Bg + e + x_D^* - s_c - m_D) \tag{18}$$

---

[6] *This vector includes fixed capital formation, the value of additions to the physical value of inventories, and current gross government expenditures.*

The hypotheses dealing with the segments of the market met by the leakages expressed by (14) to (18) implicitly incorporate a ranking order among the leakages with respect to the segments of the demand that they supply. This ranking order arises from the relationship between the demand segments and the leakages that supply them:

$$\{e_c\} \subset \{Bg,e\} \subset \{Bg,\ e,\ x_D^*\} \tag{19}$$

By substituting (14) to (18) in (13), we obtain the reduced form of gross production by industry in accordance with the new specification:

$$\begin{aligned} g = [I - D\,(I - \hat{\alpha} - \hat{\beta} - \hat{\gamma})\,(I - \hat{\mu})B]^{-1}\ D[(I - \hat{\alpha} - \hat{\beta} - \hat{\gamma})\,(I - \hat{\mu}) \\ (I - \hat{v})\ e_c + (I - \hat{\alpha} - \hat{\beta} - \hat{\gamma})\,(I - \hat{\mu})\bar{e} + (I - \hat{\alpha} - \hat{\beta} - \hat{\gamma})\ x_D^*] \end{aligned} \tag{20}$$

where the demand for re-exports is absent, because it does not generate any production activity.

FORMULATION FOR IMPACT SIMULATION

In formula (20) of production by industry, the leakage parameters are not completely additive. While calculating the impact effect of expenditure shocks using the model, we may want to modify the leakage parameters at the level of final demand, or at the first iteration of intermediate demand. It would then be easier to use and interpret additive leakage parameters.

More specifically, we want to find a correspondence between reduced form (20) and the following reduced form:

$$\begin{aligned} g = [I - D\,(I - \hat{\mu}_I - \hat{\alpha}_I - \hat{\beta}_I - \hat{\gamma}_I)B]^{-1}\ D[(I - \hat{v} - \hat{\mu}_c - \hat{\alpha}_c - \hat{\beta}_c - \hat{\gamma}_c)\ e_c \\ + (I - \hat{\mu}_e - \hat{\alpha}_e - \hat{\beta}_e - \hat{\gamma}_e)\,\bar{e} + (I - \hat{\alpha}_x - \hat{\beta}_x - \hat{\gamma}_x)\ x_D^*] \end{aligned} \tag{21}$$

where the leakage parameters are completely additive.

In order to obtain a correspondence between the multiplicative and additive parameters, we may construct the following linear system, which consists of partial matrices where we separate the four components of the demand and related leakages:

$$\begin{pmatrix} s_c \\ m_D \\ a \\ v \\ s_o \end{pmatrix} = \begin{pmatrix} \hat{\nu} & 0 & 0 & 0 \\ \hat{\mu}(I-\hat{\nu}) & \hat{\mu} & \hat{\mu} & 0 \\ \hat{\alpha}(I-\hat{\mu})(I-\hat{\nu}) & \hat{\alpha}(I-\hat{\mu}) & \hat{\alpha}(I-\hat{\mu}) & \hat{\alpha} \\ \hat{\beta}(I-\hat{\mu})(I-\hat{\nu}) & \hat{\beta}(I-\hat{\mu}) & \hat{\beta}(I-\hat{\mu}) & \hat{\beta} \\ \hat{\gamma}(I-\hat{\mu})(I-\hat{\nu}) & \hat{\gamma}(I-\hat{\mu}) & \hat{\gamma}(I-\hat{\mu}) & \hat{\gamma} \end{pmatrix} \begin{pmatrix} e_c \\ \bar{e} \\ Bg \\ x_D^* \end{pmatrix} \quad (22)$$

and we may define the additive leakage parameters:

$$\begin{pmatrix} s_c \\ m_D \\ a \\ v \\ s_o \end{pmatrix} = \begin{pmatrix} \hat{\nu} & 0 & 0 & 0 \\ \hat{\mu}_c & \hat{\mu}_{\bar{e}} & \hat{\mu}_I & 0 \\ \hat{\alpha}_c & \hat{\alpha}_{\bar{e}} & \hat{\alpha}_I & \hat{\alpha}_x \\ \hat{\beta}_c & \hat{\beta}_{\bar{e}} & \hat{\beta}_I & \hat{\beta}_x \\ \hat{\gamma}_c & \hat{\gamma}_{\bar{e}} & \hat{\gamma}_I & \hat{\gamma}_x \end{pmatrix} \begin{pmatrix} e_c \\ \bar{e} \\ Bg \\ x_D^* \end{pmatrix} \quad (23)$$

By construction, the additive parameters of the matrix of system **(23)** are such that the value of the sum of each column is less or equal to unity. This condition is essential to simulate the impact of the effect of arbitrary expenditures; otherwise, we will obtain negative production, which does not make sense. It is important to point out that, contrary to the conventional specification, the leakage parameters in the new specification may vary depending upon the economic agents involved.

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