DEPARTMENT OF ECONOMICS

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UNIVERSITY OF ANTWERP
Faculty of Applied Economics

FACULTY OF APPLIED ECONOMICS

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Ko Min Lin   Joseph Plasmans   Song-ken Hsu

Faculty of Applied Economics
University Antwerp
Department of Industrial Economics
Tamkang University

Import substitution is meant to reduce the import of (some) certain products by means of promoting domestic production, which as a result may entail structural changes in the economy.[1]Also, as one of the development policies, import substitution is often recommended to transfer the economy of a less developed country in order to catch up with that of developed countries. Although there is so much lambasting relevant to this strategy, until now, there is no commonly accepted conclusion yet.[2] Moreover, it is difficult to evaluate the power of import substitution, partly because it involves complicated issues, *i.e.* protection, learning, *etc.* (see Bruton, 1989 and 1998), and its evaluations vary easily with the different formulas used (Bruton, 1989, p. 1620, fn. 6). Hence, an appropriate measure of import substitution is vital to illustrate the effects of this economic policy.

To the best of our knowledge, a widespread use of import substitution measures is proposed by Chenery (1960) who attributed industrial growth partly to the effect of import substitution.[3] However, the problem is how to go from a measure for each industry to an

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[1] For example, the general concept of import substitution is illustrated by Dennis R. Appleyard *et al*. (1995, Ch. 15, p. 274), "*Developing countries often propound the argument in the context of an import substitution program, whereby reliance on the world market for a good is to be replaced by home production, whether or not export potential is envisioned.*"

[2] As Bruton (1989) highlighted, there are limitations in many criticisms relevant to the import substitution policies. For example, the issue of distortion *per se* cannot explain clearly the observed difference in economic growth among developing countries; in other words, the literature on this issue does not provide an exact evidence with respect to the growth of a distortion-free economy. The consequence of other shortcomings (such as the costs imposed on the economy, the terms of trade problem, and so on), which are associated with import substitution policies, cannot be judged assertively unless a satisfactory theory of development is acquired surely (see Bruton (1989) for a more excellent discussion).

[3] Basic measures of import substitution can be found in earlier papers, such as *Economic Survey of Latin America 1956*, (1957), United Nations: Department of Economic and Social Affairs. However, Chenery (1960) proposed a pattern, namely "*structure change decomposition*", to illustrate that the effect of import substitution is recognized as playing a considerable role in the analysis of industrial growth. Moreover, a substantial consequence in a number of papers displays that economic growth is associated with the rise of industry (or industrialization). According to the pattern proposed by Chenery (1960), the effect of import substitution, therefore, becomes a vital feature of the procedure in industrialization during the past decades.

aggregation of those industries. To assess the aggregate import substitution, most studies pursue Chereny's approach by means of simple aggregation of those measures at each given level, and they are usually designed for analyzing an individual industry; thus, the aggregation is structured by simply summing up those measures of each industry. Those studies were discussed in papers such as Lewis and Soligo (1965), Morley and Smith (1970 and 1971), *etc.*, but the opposite result was produced by Desai (1969). Some of the interesting solutions to consistent aggregation have been presented by Fane (1973) and Guillaumont (1979). In our view, their consistent measures of import substitution seem to be questionable or incomplete, which will be discussed later in this paper. Therefore, it still opens a debate with respect to an appropriate method to measure consistent aggregation across industries.

Our purpose in this paper is to provide a coherent approach for the measurement of import substitution, not only for consistent aggregation (*viz.* by displaying how low levels construct the high level) but also for consistent definitions at all levels. The measure will also illustrate the role of the changes of relative industry sizes within the effect of import substitution policy. In Section I, we introduce aggregation in conventional approaches and other subsequent papers and we further illustrate conflicts that have been found in prior studies. In Section II, our approach for a consistent aggregate measure with individual industries is constructed and the difference between the traditional and our aggregate measures of import substitution is also demonstrated. In Section III, we apply our new approach to analyze a case study for Belgium and Taiwan. Section IV describes limitations and conclusions are summarized in Section V.

I. The traditional approach in measuring aggregate import substitution

According to the work proposed by Chenery (1960), import substitution in relative value for a given industry, is_i, is suggested to be measured by the difference in import coefficient, μ_i, between two periods. This import coefficient is defined as the ratio of imports to total supply at a single product level. If the import coefficient declines over time, import substitution occurs in that given product level.[4] The magnitude of import substitution in absolute value for a

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[4] The difference in import coefficients between two periods can be computed in two alternative ways. On the one hand, Chenery (1960) subtracts the current period import coefficient from the initial period's one, *i.e.* $M_i^{(0)}/Z_i^{(0)} - M_i^{(1)}/Z_i^{(1)}$, and, on the other hand, Desai (1969) suggested to use the conventional difference operator between variables, that is, $M_i^{(1)}/Z_i^{(1)} - M_i^{(0)}/Z_i^{(0)}$, where M_i is the total import for industry i, Z_i is the total supply for industry i and 0 (1) is the initial (current) period. Import substitution occurs if the Chenery-type measure of import substitution is positive, whereas Desai's measure is negative.

In addition, it is worth to point out that Chenery (1960) defines the import coefficient as that fraction of total supply that comes from the import since the size of the market is considered as one of the major determinants of imports. In addition to the definition of the import coefficient proposed by Chenery (1960), there are many others provided by subsequent papers, such as the fraction of imports in domestic production (Bacon, 1979), or the proportion of imports in intermediate demand or in final demand produced domestically (*e.g.* Balassa, 1979; Kuo, 1982; Kubo *et al.*, 1985).

given industry, IS_i, is then evaluated by:

(1) $$IS_i = (is_i)Z_i^{(1)},$$

where IS_i is the import substitution in absolute value for industry i;

is_i is the import substitution in relative value for industry i
$$(= M_i^{(0)}/Z_i^{(0)} - M_i^{(1)}/Z_i^{(1)} = \mu_i^{(0)} - \mu_i^{(1)} = -(\mu_i^{(1)} - \mu_i^{(0)}) = -\Delta\mu_i);$$

μ_i is the import coefficient for industry i and

Δ is the conventional difference operator for a variable between two periods.

In order to assess import substitution at an aggregate level (*e.g.* a group of industries or the whole economy), Chenery directly summed up (single) industry import substitutions in absolute value as eq. (2) displays,

(2) $$IS = \sum_i IS_i = \sum_i(-\Delta\mu_i)\, Z_i^{(1)} = \sum_i is_i Z_i^{(1)}.$$

The characteristic in Chenery's aggregate measure is that import substitution at an aggregate level is always constructed by the sum of measures at a single industry level. Most of the subsequent authors adopted the same method for the aggregate measure as Chenery suggested, even though their measures are with refined identities for more precise estimation (*e.g.* Lewis and Soligo, 1965; Morley and Smith, 1970 and 1971; Bacon, 1979; Balassa, 1979)

The inconsistency issue has, however, arisen from a different aggregating technique proposed by Desai (1969). She suggested that import substitution at an aggregate level can be assessed by first aggregating imports and total supply across all single industries, and then, applying Chenery's definition of import substitution for an individual industry to an aggregate measure, rather than by summing up all industries' import substitutions. Her approach is illustrated as:

(3) $$IS = isZ^{(1)} = (-\Delta\mu)Z^{(1)},$$

where IS is the aggregate import substitution in absolute value;

is is the aggregate import substitution in relative value $(= -(\mu^{(1)} - \mu^{(0)}) = -\Delta\mu)$;

μ is the import coefficient at the aggregate level $(\mu = M/Z)$;

Z is the total supply at the aggregate level $(Z = \sum_i Z_i)$;

M is the total imports at the aggregate level $(M = \sum_i M_i)$.

In Desai's case study (1969) of the manufacturing industry in India, there is a conflict between the results of aggregate import substitution measured by eq. (3) and eq. (2), respectively.[5]

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[5] The aggregate import substitution for the manufacturing industry is then expressed as $IS = isZ^{(1)}$, where $is = -\left[\left(\sum_i M_i^{(1)}/\sum_i Z_i^{(1)}\right) - \left(\sum_i M_i^{(0)}/\sum_i Z_i^{(0)}\right)\right]$ and $Z^{(1)} = \sum_i Z_i^{(1)}$ with i indicating a group of industries (*e.g.*

When the measure depends on Chenery's approach, the aggregate import substitution of the manufacturing industries points out a positive result whereas it has a negative value in Desai's method. However, her approach reminds us that the definitions of import substitution at different levels in Chenery's approach are inconsistent since Chenery's aggregate import substitution is not constructed by those terms at the aggregate level (*i.e.* $IS = \sum_i is_i Z_i^{(1)} \neq isZ^{(1)}$). This is called the inconsistency problem.

In an attempt to prevent this inconsistency, there are various solutions either by offering a different aggregating technique or by considering coefficients other than the import coefficient at the single product level. One of them is offered by Fane (1973), who attributed the cause of the inconsistency to the aggregation technique and showed how to estimate the extra contribution of import substitution at each level.

Since an industry's total supply is defined as $Z_i \equiv M_i + X_i$, where X_i is industry i's gross output/domestic production, the import coefficient for industry i can be rewritten in terms of gross output as $\mu_i = M_i/Z_i = (Z_i - X_i)/Z_i = 1 - U_i$, where $U_i = X_i/Z_i$ is the ratio of domestic gross output to total supply in industry i. This transformation of the import coefficient in terms of the (gross) output coefficient entails that import substitution takes place at that given industry level if and only if the output coefficient increases over time, since according to Chenery's (1960) definition of import substitution applied by Fane (1973),[6] industry i's import substitution in relative value is $is_i = -\Delta\mu_i = -\Delta(1 - U_i) = \Delta U_i$ and industry i's import substitution in absolute value is $IS_i = is_i Z_i^{(1)} = Z_i^{(1)} \Delta U_i$.

Fane (1973) pointed out that there are two parts in the total import substitution of each industry. One is import substitution within industry i (*i.e.* IS_i) and the other is the extra contribution of growth in industry i to import substitution in all industries, denoted by IS_i^*. Hence, his total import substitution of industry i in absolute value is of the form:

(4) $$IS_i^T = IS_i + IS_i^*.$$

Fane (1973) did not show the exact formula of IS_i^* and the only clear concept is the definition of IS_i $(= Z_i^{(1)} \Delta U_i)$. In order to obtain a consistent aggregate import substitution measure, Fane directly transformed the difference between two periods into an infinitesimal change for each term in eq. (4), and his aggregate import substitution can be derived using the

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the consumption, intermediate and investment industries) but not the whole economy. Desai compared this measure of the manufacturing industry calculated by aggregate data with Chenery's (traditional) approach computed by disaggregate data, $IS^c = \sum_i is_i Z_i^{(1)}$, and she found that the results between them are different, where $is_i Z_i^{(1)}$ is the import substitution in absolute value of industry i.

[6] As Fane (1973, p. 255) mentioned in his paper, "*This section accepts Chenery's criterion for import substitution that positive import substitution corresponds to an increase in the ratio of domestic gross output to total supply* ".

total differential operator, d; hence, under the assumption that the output coefficients show only very small changes and even also very small changes in the total supply. This is completely unbelievable![7] Fane (1973) declared that his aggregate of individual import substitutions in absolute value is just the import substitution of the whole economy; however, as just mentioned, it is only for infinitesimal changes in time but not for period-to-period changes.

According to Guillaumont (1979, p. 326) "the most consistent way to obtain a definition of the import coefficient of a sector is to start from the final demand for each product (homogenous industry/sector) and then weight the import coefficients by the relative shares of the final demand. The actual import coefficient of a given product i, purchased at the final demand stage, is the relative import content of this demand."

Guillaumont (1979) believes that the inconsistency is produced by including the imported intermediate inputs within the import coefficient of each industry i but not in the aggregate one. If this misuse in the measure of every industry i is eliminated, the aggregate import substitution will be consistent with the sum of disaggregate ones. The import coefficient for industry i, thus, needs to be refined by introducing a proxy for the imported intermediate uses in domestic production. His import-output ratio is then derived from the import coefficient as follows:

(5) $$\mu_i = M_i/Z_i = M_i/(X_i + M_i), \text{ or}$$

$$\mu_i(X_i + M_i) = M_i, \text{ i.e.}$$
$$\mu_i X_i = M_i(1 - \mu_i), \text{ or}$$
$$M_i/X_i = \frac{\mu_i}{1-\mu_i} \ .$$

Using matrix notation, Guillaumont (1979) constructed his measure of import substitution while exploiting the Leontief input-output model to take the effect of all intermediate uses into account, or for

(6) $$\begin{pmatrix} X_1 \\ \vdots \\ X_n \end{pmatrix} \equiv Q, \ \begin{pmatrix} M_1 \\ \vdots \\ M_n \end{pmatrix} \equiv R, \ \begin{pmatrix} Z_1 \\ \vdots \\ Z_n \end{pmatrix} \equiv S, \ \begin{pmatrix} W_1 \\ \vdots \\ W_n \end{pmatrix} \equiv N, \ \begin{pmatrix} D_1 \\ \vdots \\ D_n \end{pmatrix} \equiv F$$

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[7] Fane's (1973) differential import substitution within industry i in absolute value is $dIS_i = Z_i dU_i$ and the differential "extra contribution" is $dIS_i^* = (U_i - U)dZ_i$. Thus, his total differential import substitution is: $\sum_i dIS_i^T = \sum_i Z_i dU_i + \sum_i (U_i - U)dZ_i = \sum_i (Z_i dU_i + U_i dZ_i) - U \sum_i dZ_i$. Since $X_i = Z_i U_i$, $dX_i = Z_i dU_i + U_i dZ_i$. Similarly, $X = ZU$ and $dX = ZdU + UdZ$. $\sum_i dIS_i^T = \sum_i dX_i - U \sum_i dZ_i = dX - UdZ = ZdU = dIS$, where $U = \sum_i X_i / \sum_i Z_i$ (see Fane, 1973, p. 256 for more details).

$$S \equiv Q + R = N + F = AQ + F \quad \text{or} \quad (I - A)Q + R = F,$$

where Q, R, S, N and F are the column vectors with as elements: domestic gross output (X_i), import (M_i), total supply (Z_i), intermediate uses (W_i) and final demand (D_i), respectively; A is the Leontief input-output coefficient matrix and i denotes the industry, $i=1,\cdots, n$. Thus, we have from the aggregate (total) import and (total) output:

(7) $$R = \phi Q,$$

where ϕ is the diagonal matrix with elements computed from eq. (5): φ_i $(= \mu_i/(1 - \mu_i))$. Then, he derived the vector of imports (R) by replacing eq. (7) in eq. (6):

(8) $$(I - A)Q + \phi Q = F, \text{ or}$$
$$Q = \phi(I - A + \phi)^{-1}F, \text{ thus}$$
$$R = \phi(I - A + \phi)^{-1}F = \Omega F,$$

where Ω $(= \phi(I - A + \phi)^{-1})$ is the import content coefficient matrix of final demand with $(I - A + \phi)^{-1}$, a matrix with elements d_{ij}. Denoting the elements of the inverse matrix $(I - A + \phi)^{-1}$ as d_{ij}, any transposed column of Ω, ω_i', can be written as $\omega_i' = \sum_j d_{ij}\varphi_j$.

According to Guillaumont (1979), the actual import substitution for a given industry is $-\Delta\omega_i'$, which indicates the import substitution in relative value at each industry level, $is_i^{G},$[8] and other measures are:

(9) $$is_i^G = -\Delta\omega_i'$$
$$is^G = - \sum_i \Delta\omega_i'\alpha_i = \sum_i \alpha_i is_i^G$$
$$IS^G = is^G Z' = Z' \sum_i \alpha_i is_i^G = \sum_i IS_i^G,$$

where is_i^G (is^G) is the import substitution in relative value at the industry i (aggregate) level;

IS_i^G (IS^G) is the import substitution in absolute value at the industry i (aggregate) level;

Z' $(= \sum_i Z_i' = \sum_i(X_i' + M_i)$, with X_i', the net output value added) is the total net aggregate supply which excludes intermediate uses;

$\alpha_i(= D_i/Z')$ is the weighted ratio of final demand of industry i to the total final demand / net aggregate supply (with $\sum_i (D_i/Z') = 1$; and $\sum_i D_i = Z'$).

According to Guillaumont's definition of α_i, the total net supply (Z') is equal to the sum of final demand ($\sum_i D_i$), that is, there are no total intermediate uses. However, this phenomenon is

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[8] Guillaumont's $U, \hat{\mu}, \mu_i,$ and m_i'' are replaced in this paper by our F, ϕ, φ_i and ω_i', respectively.

unreasonable and inconsistent with what has been displayed in IO-tables. Moreover, his import substitution is very different from those conventionally used: the conventional import coefficient used for computing import substitution had been replaced by his "import content coefficient of final demand".

These measures are considered to be consistent in absolute value under certain conditions. However, the definitions of import substitution in relative value are not consistent (*i.e.* $is_i^G = -\Delta\omega_i'$ but $is^G \neq -\Delta\Omega$). The major rationale of the consistency may be resulted from artificially attributing is^G to the weighted sum of import substitutions in relative value. If we replace all terms in eq. (10) by those terms with Chenery's definition, a consistent result also could be acquired. Moreover, the term φ_i (*i.e.* M_i/X_i) implies that all import is deemed to be intermediate in domestic production. His refining work, therefore, appears not to be appropriate while including the imported final consumption in the economy.

So far, Fane (1973) and Guillaumont (1979) have tried to solve the inconsistency by means of refining a conventional industry measure or dividing the natural difference between aggregate and disaggregate measures, but both of them appear to be inappropriate or questionable. Most importantly, the same feature of those approaches is that the aggregate measure is always structured by the sum of industry measures as Chenery (1960) did. To trace the sources of the changes at different aggregation levels and the structure of import substitution, an alternative method can be carried out by decomposing the relation between the aggregate and industry measures. Thus, the mystery of the inconsistency and the structure of how industry measures construct the aggregate measure may be uncovered.

II. A consistent aggregate measure of import substitution

A. *A new consistent measure of aggregate import substitution*

To solve this problem of inconsistency, our measure was carried out by decomposing the effect of aggregate import substitution to outline the connection between aggregate and disaggregate measures.

We first accept the concept of import substitution in accordance with Chenery (1960) for both aggregate and single industry levels. Import substitution at a given level takes place while the import coefficient declines over time. This given level might be a single industry, a group of industries or the whole economy, that is, the definitions (meanings) of both import coefficient and import substitution are similar for any aggregation level, or

(10)
$$\mu_i = M_i/Z_i$$
$$\mu = \sum_i M_i / \sum_i Z_i = M/Z$$

$$is_i = -\Delta\mu_i = -(\mu_i^{(1)} - \mu_i^{(0)})$$
$$is = -\Delta\mu = -(\mu^{(1)} - \mu^{(0)}),$$

where μ_i (μ) is the import coefficient for industry i (the aggregate import coefficient);

M_i (M) is the import for industry i (the aggregate import);

Z_i (Z) is the total supply for industry i (the aggregate total supply);

is_i (is) is the import substitution for industry i in relative value (the aggregate import substitution in relative value);

Δ is the difference in the relevant variable between two periods (defined as its value at the current period minus its value at the initial period).

For the reason of simplicity (but without loss of generality), we suppose that there are only two levels in the whole economy: the individual industries and the whole economy that aggregates the individual industries.[9] The decomposition of the aggregate import coefficient can be displayed as:

$$(11) \qquad \mu = \frac{M}{Z} = \sum_i \left(\frac{M_i}{Z_i}\right)\left(\frac{Z_i}{Z}\right) = \sum_i \left(\frac{M_i}{Z_i}\right)\rho_i = \sum_i \mu_i\rho_i,$$

where ρ_i is the share of industry i's total supply to the aggregate total supply or, in short, the relative size of industry i ($\equiv Z_i/Z$). In other words, the aggregate import coefficient is the sum of weighted industry import coefficients, the weights being the relative industry sizes. Accordingly, the aggregate import substitution in relative value, is, can be written according to Chenery (1960) as:

$$(12) \qquad is = -\left(\sum_i \mu_i^{(1)}\rho_i^{(1)} - \sum_i \mu_i^{(0)}\rho_i^{(0)}\right)$$
$$= -\left(\sum_i \mu_i^{(1)}\rho_i^{(1)} - \sum_i \mu_i^{(0)}\rho_i^{(1)} + \sum_i \mu_i^{(0)}\rho_i^{(1)} - \sum_i \mu_i^{(0)}\rho_i^{(0)}\right)$$
$$= \sum_i is_i\rho_i^{(1)} - \sum_i \mu_i^{(0)}\Delta\rho_i,$$

where $\Delta\rho_i$ is the change in the relative size for industry i ($\Delta\rho_i \equiv \rho_i^{(1)} - \rho_i^{(0)}$);[10]

$\sum_i is_i\rho_i^{(1)}$ is the sum of weighted industry import substitutions in relative value;

$\sum_i \mu_i^{(0)}\Delta\rho_i$ is the effect of the changes of the relative industry sizes on the aggregate import substitution in relative value.

These two components at the right-hand side of eq. (12) clearly outline how effects of

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import substitutions at a lower level determine the import substitution at the aggregate level. Apparently, the aggregate import substitution should also reflect the influence coming from the weighted relative size changes in industries rather than only the sum of weighted industry import substitutions. In other words, the inconsistency between $\sum_i is_i Z_i^{(1)}$ and isZ_1, observed by Desai (1969), is generated by the effects of the weighted changes in the relative industry sizes.

$\Delta\rho_i < 0$ or $\Delta\rho_i > 0$ means a decline or an increase in the relative size of industry i between two periods, respectively. If $\sum_i \mu_i^{(0)}\Delta\rho_i > 0$ $(\sum_i \mu_i^{(0)}\Delta\rho_i < 0)$, the influence of the increases (declines) in the relative industry sizes may enlarge (decrease) the demand for imports to weaken (reinforce) the magnitude of the import substitution effect at the aggregate level.

That is to say, the effect of structural change(s) might be negative enough to overweigh the negative value in the sum of weighted industry import substitutions. Therefore, the results of the aggregate measure would display a different story as other authors have highlighted (Desai, 1969; Fane, 1973). Consequently, the aggregate import substitution in absolute value is from equations (3) and (12):

(13) $$IS = isZ^{(1)} = Z^{(1)}\left(\sum_i is_i\rho_i^{(1)} - \sum_i \mu_i^{(0)}\Delta\rho_i\right),$$

where $Z^{(1)}$ is the aggregate total supply in the current period. The comparison between Chenery's and our approach might be clearer by using this measure.

B. *Differences between our approach and other ones*

Contrary to the other import substitution measures discussed earlier, we started from the aggregate import substitution measure instead of the disaggregate ones. For example, the difference between our and Chenery's measures of import substitution in absolute value can be derived from equations (13) and (2).[11]

(14) $$IS - IS^c = -(\sum_i \mu_i^{(1)}\rho_i^{(1)} - \sum_i \mu_i^{(0)}\rho_i^{(0)})Z^{(1)} - \sum_i \left(\mu_i^{(0)} - \mu_i^{(1)}\right)Z_i^{(1)}$$

$$= \sum_i \left(\mu_i^{(0)}\rho_i^{(0)} - \mu_i^{(1)}\rho_i^{(1)}\right)Z^{(1)} - \sum_i \left(\mu_i^{(0)} - \mu_i^{(1)}\right)Z_i^{(1)}$$

$$= \sum_i \left[\left(\mu_i^{(0)}\frac{Z^{(1)}Z_i^{(0)}}{Z^{(0)}} - \mu_i^{(1)}\frac{Z^{(1)}Z_i^{(1)}}{Z^{(1)}}\right) - \left(\mu_i^{(0)}Z_i^{(1)} - \mu_i^{(1)}Z_i^{(1)}\right)\right]$$

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[11] *IS* and *IS^c* represent our and Chenery's (traditional) aggregate import substitutions in absolute value, respectively.

$$= Z^{(1)} \sum_i \frac{\mu_i^{(0)} Z_i^{(0)}}{Z^{(0)}} - \sum_i \mu_i^{(0)} Z_i^{(1)} = Z^{(1)} \sum_i \mu_i^{(0)} \left(\frac{Z_i^{(0)}}{Z^{(0)}} - \frac{Z_i^{(1)}}{Z^{(1)}} \right)$$

$$= -Z^{(1)} \sum_i \left(\mu_i^{(0)} \Delta\rho_i \right), \text{ or}$$

(15)
$$IS^c = IS + Z^{(1)} \sum_i \left(\mu_i^{(0)} \Delta\rho_i \right).$$

The difference between IS and IS^c is the sum of the weighted initial import coefficients, where the weights are the changes of the relative industry sizes multiplied by the current aggregate total supply.[12]

Equations (14) and (15) illustrate why the sum of the industry import substitutions is not consistent with the measure calculated by aggregate data.

Our approach is also distinct from Guillaumont's (1979) method. His measure is consistent because of two major rationales: eliminating all intermediate uses from total supply/demand[13] at both the individual industry and the aggregate levels and is^G is the weighted sum of industry import substitutions in relative value. Note that:

(9′)
$$IS^G = is^G \sum_i D_i = Z' \left(\sum_i is_i^G \frac{D_i}{Z'} \right).$$

In spite of those distinct definitions in Guillaumont's equations, his aggregating technique is similar to our first term in eq. (13) for the aggregate import substitution. In other words, Guillaumont's version is merely equal to the sum of weighted industry import substitutions.

In the next section, the different results between the traditional and our approaches in the aggregate import substitution will be illustrated by a case study.

III. A case study

In our case study, we choose Taiwan and Belgium as examples to illustrate the differences between the traditional (Chenery's) and our approaches. We choose these countries as case studies where import-oriented and non-import-oriented policies have been applied,

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[12] In other words, Chenery's aggregate measure in absolute value is equal to the sum of our aggregate measure of import substitution in absolute value and the sum of the weighted industry import coefficients, the weighs being the current aggregate total supply multiplied by the changes in relative industry sizes. Since from eq. (2) also $IS^c = \sum_i is_i Z_i^{(1)} = Z^{(1)} \sum_i is_i \frac{Z_i^{(1)}}{Z^{(1)}} = Z^{(1)} \sum_i is_i \rho_i^{(1)}$ is valid. Chenery's measure of import substitution in absolute value is also equal to the weighted sum of industry import substitutions, where the weights are equal to the relative industry sizes multiplied by the aggregate total supply.

[13] Guillaumont (1979) assumes equilibrium between supply and demand, *i.e.* $\sum_i D_i = Z'$.

respectively. For instance, in Taiwan, the import substitution policy in the 1970s focused on petrochemical industry, heavy machinery industry and electronic products, *etc.* mostly in the secondary industry so that some papers alerted that those policies in 1970s is helpful for Taiwan to the promotion of economic structure / prevention of oil crises (see *e.g.* Chu, 1994, *etc.*).[14] The effect can be further examined by both approaches in this paper.

We collected the data from input-output tables (in short, IOTs) of Belgium and Taiwan to analyze the effects of import substitution. Belgian IOTs are compiled as 59 X 59 (with 59 industries) tables in 5-year sub-periods including 1980, 1985, 1990, 1995, 2000 and 2005. However, the classifications in the compilation of Belgian IOTs are different from 1995 onwards. Before 1995, those tables were classified by NACE/CLIO.[15] From 1995 on, CPA[16] (Classification of Products by Activity) has become one of the statistical classifications of products and services obligatory for all EU Member States and also used for compiling Belgian IOTs. Because of these two different systems in Belgian IOTs, the content of each industry *i* in 1990 would not match that in 1995 completely (*e.g.* CPA 24 Chemicals, chemical products and man-made fibers = CLIO 17.1 chemical products + CLIO 17.3 artificial and synthetic fibers) so that the Chenery-type import substitutions for industries *i* in the 1990/1995 sub-period cannot be measured. Fortunately, the IOTs of Taiwan are established by 29 industries, with a consistent classification, in 3-5 year sub-periods from 1964 to 2004.[17]

For both countries, these industries are aggregated to three major industries (that we define as industry *j*=1, 2, 3 in the economy) for a more systematic analysis: (1) the primary industry; (2) the secondary industry (manufacturing); and (3) the tertiary industry (services). These three major industries consist of those industries *i* that belong to a certain category of industry *j* and the whole economy consist of these three major industries. The explanation of the data sources and the classification of major industries are given in the Appendix A. Hence, we have 3 levels in the economy: (1) 59 (and 29) industries in the IOTs, namely industries *i*=1, 2, …, *n* construct the first level; (2) the second level consists of the three major industries *j*=1, 2, 3, which are groups of classification for 59 (and 29) industries *i*; (3) the whole economy is the

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[14] In 1970s, Taiwan adopted both import substitution and export-oriented policies and the import substitution policy during this period is often named "the second import substitution era". During the first oil crisis (1973), the import substitution policy focused on the industries related to intermediate goods (*e.g.* petrochemical industry, iron and steel industry, *etc.*). In 1979 (*i.e.* the second oil crisis), Taiwan started to focus on those industries with technology intensive and lower-pollution features (*e.g.* electronic products, *etc.*).

[15] As the general industrial classification of economic activities in the European Union of that time, it was a branch of NACE 1970 and has been replaced by NACE Rev. 1 in 1990.

[16] CPA is classified by the standard of NACE (the classification of industries in the EU).

[17] The classification of Taiwanese IOTs is based on the categories of industries for Business census, the Standard Industrial Classification System (SICS) and the General Economic Surveys adopted by the Directorate-General of Budget, Accounting and Statistics (DGBAS) of Taiwan. We obtained IOTs in digital form from DGBAS for the years 1964 till 2004.

third level which consists of our three major industries. All measures related to the conventional (*i.e.* Chenery's, 1960) and our approaches for both countries with these three levels are displayed in Tables 1 and 2.[18]

Apparently, Chenery's import substitution of industry j (*i.e.* IS_j^c) is the same as our sum of weighted industry import substitutions of industries i within industry j while comparing columns (1) and (10). The effects of the changes in relative industry sizes at first and second levels, indeed, are not included in both IS_j^c and IS^c $(= \sum_j IS_j^c)$. On the contrary, in column (2), our import substitution measure for the whole economy reflects the influences coming from the changes in relative industry sizes of both first and second levels which can also be used for investigating the transitions in the economy of a country.[19]

Since the different principles between IS^c and IS as mentioned in previous paragraph (see more details in section II and Appendix B), the differences in the aggregate import substitutions of both countries are presented by two ways: one is that the signs of IS^c and IS are inverses; the other is the large differences between them.

1. The causes to induce the inverse signs for both countries

(a) In Belgium case, our positive measures in both 1985/1990 and 2000/05 sub-periods are mostly produced by the declines in the relative industry sizes (*i.e.* the size changes in primary industry and manufacturing, respectively) which induced the decreases in the demand of the scale in aggregate import. The changes in relative industry sizes become the determinant probably because the Belgian economy is mainly devoted to the processing of imported raw materials into semi-finished and finished products. Therefore, the declines (increases) in the relative industry size will induce an effect similar to the import substitution with the decrease (increase) in the ratio of import to total supply over time (*e.g.* the measures in columns (4) and (5) for the secondary industry in Table 1).

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[18] Tables 1 and 2 represent all calculations measured by both approaches for the major industries and the whole economy in different sub-periods. The outcomes of column (1) are measured in accordance with Chenery's (1960) method (*i.e.* eq. (B5) in Appendix B) through summing up each import substitution for industry i. The results in columns (2) to (11) are calculated by our approach in accordance with equations (B3) to (B4′). Also, our aggregate import substitution is obviously consistent with the sum of those measures of industries j and i as equations (B3) to (B4′) display (*e.g.* columns (3) - (5)).

[19] The structure of import substitution for different groups of industries could be clearly observed in our approach. Columns (3) to (8) show how the measure in industries i influenced that in industries j / whole economy and the changes of the relative industry sizes in each group of industries as well. These measurements conveyed the determinant factors (or industries) that actually affected aggregate import substitution. Indeed, these aggregate import substitutions appropriately illustrate the influences on the demand for imports while the relative importance of industries changes. It could also be expressed by the proof in eq. (B5) in Appendix B.

Table 1 Import substitution in Belgium

	Chenery IS_j^c and IS^c [eq. (B5)]	IS [eq. (B3')]	is $(=-\Delta\mu)$ [eq. (B1)]	$(= \sum_j is_j \rho_j^{(1)} - \sum_j \mu_j^{(0)} \Delta\rho_j)$ [eq. (B3)]		is_j $(=-\Delta\mu_j)$ [eq. (B1)]	$(= \sum_i is_{ij}\rho_{ij}^{(1)} - \sum_i \mu_{ij}^{(0)}\Delta\rho_{ij})$ [eq. (B4)]		IS_j $\left(= is_j \cdot Z_j^{(1)}\right)$ [eq (B4')]	[eq (B4')]	
				$is_j\rho_j^{(1)}$	$\mu_j^{(0)}\Delta\rho_j$		$\sum_i is_{ij}\rho_{ij}^{(1)}$	$\sum_i \mu_{ij}^{(0)}\Delta\rho_{ij}$		$Z_j^{(1)}\sum_i is_{ij}\rho_{ij}^{(1)}$	$Z_j^{(1)}\sum_i \mu_{ij}^{(0)}\Delta\rho_{ij}$
1980/85	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Primary industry	**-2470.23**			-0.0032	-0.0044	-0.0212	-0.03408	-0.01284	-1539.61	**-2470.23**	-930.61
Secondary industry	**-4107.39**			-0.0110	0.0114	-0.0242	-0.0186	0.0056	-5354.65	**-4107.39**	1247.26
Tertiary industry	**-1842.13**			-0.0043	-0.0008	-0.0109	-0.0096	0.0013	-2084.26	**-1842.13**	242.14
Subtotal	-8419.74		**-0.0246**	**-0.0185**	**0.0061**						
Whole economy	-8419.74	-11941.56	**-0.0246**								
1985/1990											
Primary industry	**766.78**			0.0066	-0.0176	0.0570	0.0125	-0.0445	3491.57	**766.78**	-2724.79
Secondary industry	**-4568.08**			-0.0131	0.0015	-0.0286	-0.0188	0.0098	-6954.49	**-4568.08**	2386.41
Tertiary industry	**10.20**			-0.0016	0.0016	-0.0037	0.000045	0.0037	-831.53	**10.20**	841.73
Subtotal	-3791.10		**0.0064**	**-0.0081**	**-0.0145**						
Whole economy	-3791.10	3383.02	**0.0064**								
1995/2000[2]											
Primary industry	**-343.98**			-0.0036	0.0005	-0.0901	-0.0098	0.0803	-3170.14	**-343.98**	2826.16
Secondary industry	**-11462.16**			-0.0171	0.0035	-0.0390	-0.02995	0.0091	-14927.43	**-11462.16**	3456.27
Tertiary industry	**-4228.02**			-0.0084	-0.0006	-0.0160	-0.0093	0.0067	-7294.13	**-4228.02**	3066.11
Subtotal	-16034.17		**-0.0325**	**-0.0291**	**0.0034**						
Whole economy	-16034.17	-28348.99	**-0.0325**								
2000/05											
Primary industry	**-983.34**			-0.0024	-0.0014	-0.0616	-0.0282	0.0334	-2146.78	**-983.34**	1163.44
Secondary industry	**-3471.15**			-0.0008	-0.0169	-0.0020	-0.0095	-0.0076	-713.88	**-3471.15**	-2757.27
Tertiary industry	**-3626.52**			-0.0071	0.0031	-0.0126	-0.0071	0.0055	-6433.41	**-3626.52**	2806.896
Subtotal	-8081.01		**0.0051**	**-0.0102**	**-0.0153**						
Whole economy	-8081.01	4598.23	**0.0051**								

Source of data: see Appendix A.

Note: 1. The year 1985/1990, for instance, represents that 1985 is the initial year and 1990 is the current year.

2. The figures from 1995 onwards are calculated in millions of Euro, whereas the figures before 1995 are evaluated in millions of BEF. We have transformed the value of the total supply for all different groups/industries before 1995 into Euro as a uniform valuation for the calculations using the fixed exchange rate, 1€ = 40.3399 BEF.

Table 2 Import substitution in Taiwan

	Chenery IS_j^c and IS^c [eq. (B5)]	IS [eq. (B3')]	is $(=-\Delta\mu)$ [eq. (B1)]	$(= \sum_j is_j\rho_j^{(1)} - \sum_j \mu_j^{(0)}\Delta\rho_j)$ [eq. (B3)]		is_j $(=-\Delta\mu_j)$ [eq. (B1)]	$(= \sum_i is_{ij}\rho_{ij}^{(1)} - \sum_i \mu_{ij}^{(0)}\Delta\rho_{ij})$ [eq. (B4)]		IS_j $(= is_j \cdot Z_j^{(1)})$ [eq (B4')]	[eq (B4')]	
				$is_j\rho_j^{(1)}$	$\mu_j^{(0)}\Delta\rho_j$		$\sum_i is_{ij}\rho_{ij}^{(1)}$	$\sum_i \mu_{ij}^{(0)}\Delta\rho_{ij}$		$Z_j^{(1)}\sum_i is_{ij}\rho_{ij}^{(1)}$	$Z_j^{(1)}\sum_i \mu_{ij}^{(0)}\Delta\rho_{ij}$
1964/66	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Primary industry	-257.11			-0.0009	-0.0024	-0.0047	-0.0008	0.0039	-1542.10	-257.11	1284.99
Secondary industry	-10737.81			-0.0153	-0.0018	-0.0347	-0.0146	0.0202	-25587.94	-10737.81	14850.13
Tertiary industry	7887.35			-0.0004	0.0006	-0.0011	0.0129	0.0141	-682.65	7887.35	8570.00
Subtotal	-3107.57			**-0.0166**	**-0.0036**						
Whole economy	-3107.57	-21759.61	**-0.0130**								
1966/71											
Primary industry	-33204.47			-0.0116	-0.0084	-0.0889	-0.0850	0.0040	-34757.70	-33204.47	1553.22
Secondary industry	59863.95			-0.0010	0.0146	-0.0019	0.0375	0.0394	-3072.24	59863.95	62936.19
Tertiary industry	-12670.85			-0.0043	-0.0005	-0.0126	-0.0125	0.0001	-12789.55	-12670.85	118.70
Subtotal	13988.63			**-0.0169**	**0.0057**						
Whole economy	13988.63	-67862.47	**-0.0226**								
1971/76											
Primary industry	-98432.41			-0.0174	-0.0016	-0.1419	-0.1161	0.0258	-120303.40	-98432.41	21871.00
Secondary industry	47326.03			0.0003	0.0149	0.0005	0.0110	0.0105	2172.34	47326.03	45153.70
Tertiary industry	-22940.70			-0.0029	-0.0028	-0.0117	-0.0132	-0.0015	-20299.08	-22940.70	-2641.62
Subtotal	-74047.07			**-0.0201**	**0.0106**						
Whole economy	-74047.07	-211328.53	**-0.0306**								
1976/81											
Primary industry	-82014.77			-0.0154	-0.0073	-0.1499	-0.0703	0.0796	-174850.41	-82014.77	92835.64
Secondary industry	188541.88			0.0070	-0.0003	0.0112	0.0266	0.0154	79317.80	188541.88	109224.08
Tertiary industry	-45910.63			-0.0039	0.0010	-0.0142	-0.0147	-0.0004	-44607.20	-45910.63	-1303.43
Subtotal	60616.48			**-0.0123**	**-0.0067**						
Whole economy	60616.48	-64034.16	**-0.0056**								
1981/86											
Primary industry	45592.94			0.0083	-0.0193	0.1293	0.0461	-0.0832	127830.92	45592.94	-82237.98
Secondary industry	12382.65			0.0018	0.0044	0.0027	0.0012	-0.0015	27171.30	12382.65	-14788.66
Tertiary industry	41559.86			0.0018	0.0005	0.0063	0.0095	0.0033	27320.21	41559.86	14239.66
Subtotal	99535.45			**0.0119**	**-0.0144**	-0.0145					
Whole economy	99535.45	404809.59	**0.0263**								

1986/91											
Primary industry	6167.48			0.0003	-0.0065	0.0061	0.0064	0.0003	5844.91	6167.48	322.57
Secondary industry	-498707.33			-0.0310	-0.0082	-0.0520	-0.0409	0.0110	-633031.02	-498707.33	134323.69
Tertiary industry	-50575.44			-0.0032	0.0038	-0.0091	-0.0069	0.0022	-66398.25	-50575.44	15822.81
Subtotal	-543115.28			**-0.0339**	**-0.0109**						
Whole economy	-543115.28	-470899.06	-0.0230								
1991/96											
Primary industry	-16656.31			-0.0008	-0.0020	-0.0184	-0.0146	0.0038	-20995.82	-16656.31	4339.51
Secondary industry	-243110.67			-0.0170	-0.0057	-0.0300	-0.0157	0.0143	-464763.69	-243110.67	221653.03
Tertiary industry	29206.18			0.0012	0.0021	0.0030	0.0027	-0.0002	31565.87	29206.18	-2359.70
Subtotal	-230560.81			**-0.0166**	**-0.0056**						
Whole economy	-230560.81	-300399.56	-0.0110								
1996/2001											
Primary industry	-35757.50			-0.0042	-0.0022	-0.1170	-0.0301	0.0868	-138785.13	-35757.50	103027.63
Secondary industry	-114232.77			-0.0091	-0.0030	-0.0164	-0.0063	0.0101	-299146.04	-114232.77	184913.27
Tertiary industry	52170.12			0.0004	0.0011	0.0009	0.0039	0.0030	11817.00	52170.12	40353.13
Subtotal	-97820.15			**-0.0129**	**-0.0042**						
Whole economy	-97820.15	-288899.11	-0.0088								
2001/04											
Primary industry	-59676.94			-0.0050	0.0023	-0.1243	-0.0334	0.0909	-222241.97	-59676.94	162565.03
Secondary industry	33595.72			-0.0083	0.0119	-0.0137	0.0013	0.0150	-365361.49	33595.72	398957.21
Tertiary industry	-63267.35			-0.0013	-0.0030	-0.0036	-0.0040	-0.0004	-56394.75	-63267.35	-6872.60
Subtotal	-89348.57			**-0.0146**	**0.0111**						
Whole economy	-89348.57	-1135598.77	-0.0257								

Source of data: see Appendix A.

Note: 1. The year 1964/1966, for instance, represents that 1964 is the initial year and 1966 is the current year.

2. All calculations in Table 2 are made in millions of NT$ at constant prices.

(b) In Taiwan, the measures of both approaches in 1966/71 and 1976/81 display an inverse result. In 1966/71, the import substitution only occurs in those i industries which construct manufacturing but not spread to manufacturing itself and the whole economy (because the influence coming from the increases in the relative industry sizes in i industries of manufacturing overweigh the import substitution effect). The phenomenon in 1976/81 is that the import substitution only occurs in manufacturing while the import substitution policy emphasized on heavy industry, *etc.* as part of secondary industry; however, there is no aggregate import substitution effect because the increases in relative industry size of those i industries, which construct primary and manufacturing industries, weaken the effect of import substitution for whole economy.

2. The causes of the large differences between both approaches in both study cases

The large differences between IS^c and IS can be observed for the sub-period 1995/2000 in Belgium and for the sub-periods 1971/76, 1981/86 and 2001/2004 in Taiwan.

(a) In Belgium case, the large difference is mainly generated by the increases in the relative industry size of all industries i at the first level.

(b) The large differences for different sub-periods in Taiwan can illustrate and reflect the distinct development economic policies. In 1971/76, they are mainly produced by the increases in the relative industry size of manufacturing industry and those industries i which construct it, where displays the fact that Taiwanese government engaged in investing and expanding the manufacturing industry. During 1981/1986, the large differences are caused by the decline of the relative size in primary industry. In addition, the import substitution effect in this sub-period is mainly generated by the secondary and services industries, approximately with the beginning of "strategic development policies" to put the emphases on high value-added, high density technology industries, and the industries with less pollution by giving subsidies and technical assistance, *etc.* Finally, the differences in 2001/04 are influenced by some rationales: (1) the economic growth rate in 2001 is negative (the very first time since 1947) and with a recovery since 2003 which mainly occurs in manufacturing; (2) the rapid increase in the demand of imports in primary industry to induced the increase in its relative industry size.

3. The changes in the relative importance of industries for both countries

Since the sustained enlargement of a long-term balance of trade surplus induced an appreciation in Taiwanese national currency,[20] an offshore migration in some traditional industries of Taiwan, especially the light industries, occurred in the 1986/1991 sub-period. Therefore, a decline in the importance of the manufacturing to the overall economy took place, whereas services started to expand after 1990 except the 2001/2004 period.[21] In Belgium case,

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[20] In addition, one of the main reasons for this phenomenon is because President Ronald Reagan of the United States wanted to solve the double deficits of the USA while he was running for his presidency reelection. In order to solve its balance of payments deficit, the USA forced countries like Taiwan and Japan, who had huge trade surpluses with the USA, to reduce trade barriers such as tariffs and other import restrictions. Another American policy instrument was to force some countries like Taiwan to appreciate their currencies. As a consequence, Taiwan has appreciated its New Taiwan Dollar from 40 NT Dollars per US Dollar in 1985 to 28-27 per US Dollar in 1987. Many trade restrictions have been relaxed, including on some goods which are not very healthy such as wine and cigars from the USA. In addition to this trade liberalization, the economic environment in Taiwan also witnessed extreme changes (e.g. wages, environmental consciousness and the upsurge of price land) so that firms in Taiwan (most of them belonging to the manufacturing industry) had to invest outward or directly move to the countries which are with lower production costs, especially with lower labor costs.

[21] As we explain in footnote 18, after the mid-1980s, 90% of those firms that move to other countries belong to the manufacturing industry. However, 70% of foreign investments are services.

during the 2000/05 sub-period, the transition in the structure of its economy relied more on services than before while the other two major industries display obvious decreases, especially after 2004, when 10 East European countries (including Baltic countries) joined the European Union.

General speaking, our approach precisely illustrates the difference between the true or resembling effect of import substitution as we show in the two different developing-types of countries. This effect can be examined through investigating the role of the changes in relative industry size to speculate the causes of the decline/increase in the ratio of import demand to total supply. As we illustrate above, all measures for Taiwan show that the effects of import substitution mainly occur in the secondary industry but not spread to the whole economy in most sub-periods, especially during the 1970s, where our result are different from some papers that affirmed the contribution of import substitution to Taiwanese economic growth. Furthermore, we can also precisely show the effect similar to the import substitution in Belgian economy and the rationales of it.

IV. The limitation

As is well known, the measure of import substitution is extracted from Chenery's (1960) "pattern" for decomposing the sources of a single industry growth. Two sources affect the industrial growth in his pattern. One is the non-proportional growth in total supply (*i.e.* $(1 - \mu_i^{(0)})\Delta Z_i$) and the other is the import substitution (*i.e.* $is_i Z_i^{(1)}$).[22] While involving several groups in the whole economy, Chenery used the simple sum of each term to obtain the aggregate measures. If our decomposition of aggregate import substitution is directly applied to Chenery's pattern, the definition of non-proportional growth in total supply between the individual industry and the aggregate level will not be consistent.[23] On the other hand, if we directly apply aggregate data on this pattern inconsistency may exist between the results of non-proportional growth in total supply measured by aggregate and disaggregate data. To attempt establishing consistent definitions of each term in the decomposition of industrial growth at disaggregate and aggregate levels, a further decomposition of non-proportional growth in total supply may be necessary. However, our measure provides an alternative method for those countries that need to assess the effects of development policy with regard to import substitution.

V. Conclusion

In this paper, we have proposed an alternative approach to solve the inconsistency in the aggregate measure of import substitution. This method extends the original definition of import substitution successfully and seems to be appropriate in estimating aggregate import substitution across different groups of industries. In addition, the sources of changes in the aggregate import substitution can be traced level by level as well as the determining factors in

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[22] From $X_i/Z_i = (1 - \mu_i)$, $X_i = (1 - \mu_i)Z_i$, or $\Delta X_i = (1 - \mu_i^{(0)})\Delta Z_i - Z_i\Delta\mu_i = (1 - \mu_i^{(0)})\Delta Z_i + is_i Z_i^{(1)}$, where ΔX_i refers to the non-proportional growth in domestic production for a given industry i with $\Delta X_i \equiv X_i^{(1)} - X_i^{(0)}$. The aggregate measure can be expressed as: $\sum_i \Delta X_i = \sum_i [(1 - \mu_i^{(0)})\Delta Z_i] + \sum_i is_i Z_i^{(1)}$ where $\sum_i is_i Z_i^{(1)} = IS^c$.

[23] That is, $\sum_i \Delta X_i = \sum_i [(1 - \mu_i^{(0)})\Delta Z_i] + IS^c = \sum_i [(1 - \mu_i^{(0)})\Delta Z_i] + \{IS - Z^{(1)}(\sum_i \mu_i^{(0)}\Delta\rho_i)\}$, *i.e.* see eq. (14) for more details, and $\sum_i [(1 - \mu_i^{(0)})\Delta Z_i] \neq (1 - \mu^{(0)})\Delta Z)$.

the variation of import substitution at different levels. We have also highlighted that our measure can reflect how deep the influence of the changes in industry sizes is on it, although the relation between them was not necessarily inverse or positive. Especially, the index of the changes in industry sizes can be used for illustrating the growth and decline of an industry over time. One possible application of our technique would be applied for a long-term period economic analysis as we displayed in the case studies that the aggregate import substitution effect in Belgium (non-import-oriented case) reflects the decreases in imports only / mainly caused by the declines in industries but not by the replacement of domestic products. On the contrary, the import substitution effect in Taiwan (import-oriented case) mainly occurs in manufacturing industry in accordance with the annunciation of the economic policies (see footnote 16), but this effect does not make the contribution to the whole economy, except the 1984/1986 sub-period.

As a result, our method may be useful to establish a much more thorough picture for analyzing the sources and structure of changes in import substitution at different aggregation levels while examining the effect of this economic policy. (*Repeat shortly some conclusions from the Belgian and Taiwanese case studies*)

Appendix A

The IOTs of Belgium have been charted according to the European System of Accounts (ESA95 rules) since 1995.[24] So far the database calculated in Euro could be obtained only from 1995 to 2005 for five-year periods. Afterwards, the FPB further supplemented the IOTs for 1980, 1985 and 1990 in May 1999 based on Belgian Franc (BEF). We use the fixing exchange rate (*i.e.* 1€ = 40.3399 BEF, see note 2 of Table 1) to make the calculations in a uniform valuation. All IOTs of Belgium are evaluated at basic prices,[25] since the repetitions of evaluation for outcome should be averted. Moreover, those tables are in nominal value where the outcomes measured by our approach are 'liberated' from the factor of inflation and are hence deflated. Therefore, we made use of the Belgian GDP deflator *(explain shortly)* to obtain the IOTs at constant prices.

The IOTs of Taiwan are generally compiled by the categories of industries for Business census and the General Economic Surveys (see footnote 14).[26] All of them are valued in millions of New Taiwan Dollar. Similar to the Belgian case, these tables are in nominal value but at producer's prices and the imported tables present the CIF (i.e. Cost Insurance and Freight) value of imports. In order to eliminate the influences coming from the inflation, the GDP deflator of Taiwan is adopted to obtain the IOTs at constant prices.

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[24] In the past, the IOTs of Belgium were drawn up by Statistics Belgium (INS/NIS). In 1994 the National Accounts Institute was created as a coordinating structure for some important macroeconomic statistics; this responsibility was transferred to the Federal Planning Bureau (FPB) under the authority of the Prime Minister and Minister of Economic Affairs. http://epp.eurostat.ec.europa.eu/portal/page/portal/quality/documents/BEDE SCRIPTION.pdf.

[25] The basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced. The definition of the basic price is that output minus any tax payable and plus the subsidy receivable on that unit as a consequence of its production or sale. It excludes any transport charges invoiced separately by the producer. http:// stats.oecd.org/glossary/detail.asp?ID=189

[26] The numbers of the industries in Taiwanese IOTs are diverse. Although the classifications of those tables are according to the Business census which is implemented by DGBAS, they are compiled (?) in each 2-3 years to match up the statistics of National Accounts. We obtain the IOTs of Taiwan directly from DGBAS with a uniform classification in 29 industries.

In order to have a uniform classification of calculations for both countries, we categorized and reconciled the different classifications for the whole economy to be:

Table A.

	Belgium	Taiwan
Primary Industry	Agriculture, forestry, fishery, hunting and mining (CLIO 01.0-03.3, 07.1, 07.5, 09.8, 13.7-15.1, 15.7-15.9; CPA 01-14).	Agricultural and livestock, forestry products, fishery products, minerals
Secondary (Manufacturing) Industry	Food products and beverages (CLIO 31.0-37.0; CPA 15); wearing apparel and furs (CLIO 41.1, 41.3; CPA 18); tobacco products (CLIO 39.0; CPA 16); Textiles (CLIO 41.3; CPA 17); leather products (CLIO 43.0; CPA 19); wood and products (CLIO 39.0; CPA 20); paper products and pulp (CLIO 47.1; CPA 21); printed matter and recorded media (CLIO 47.3; CPA 22); coke, refined petroleum products and unclear fuels (CLIO 05.0, 07.3; CPA 23); chemicals, chemical products and man-made fibers (CLIO 17.1, 17.3; CPA 24); rubber and plastic products (CLIO 49.1; CPA 25); other non-metallic mineral products, basic metals, fabricated metal products (CLIO 13.5, 13.6; CPA 26-28); machinery and equipment, office machinery and computers, electrical machinery and apparatus, radio, television and communication equipment and apparatus, medical, precision and optical instruments, watches and clocks (CLIO 21.0, 23.0, 25.0; CPA 29-33); motor vehicles, trailers and semi-trailers (CLIO 27.0; CPA 34); other transport equipment (CLIO 29.0; CPA 35); furniture, other manufactured goods (CLIO 45.0, 51.0; CPA 36).	Processed foods Beverages and tobacco and alcohol Textile Wearing Apparel and Clothing Wood and wood products Paper and paper products Chemical raw materials Plastics and articles of man-made fiber Other chemicals Refined petroleum products Non-metallic Mineral Products Iron and steel Other metals and metal products Machinery Household appliances Electronic products Motor and other electrical Conveyance Miscellaneous manufactured articles
Tertiary Industry	Services (CLIO 09.5-09.7, 53.0-85.0; CPA 37-95)	Construction Engineering Electricity Gas and water Transport and Communications warehousing Commodity trading Other services

Appendix B

In most exercises, more than two levels of aggregation over industries are needed as we display in our case study. Suppose that there are three sub-groups of the whole economy indicated by suffix j: the primary, the manufacturing and the services industries. These industries j consist of those industries i (*e.g.* Agriculture and Forestry (industries i) belong to the primary industry (industry j)). Similarly, we accept the concept of import substitution in accordance with Chenery (1960) for all three levels:

(B1)
$$\mu_{ij} = M_{ij}/Z_{ij}$$
$$\mu_j = \sum_i M_{ij} \Big/ \sum_i Z_{ij} = M_j/Z_j$$

$$\mu = \sum_j \sum_i M_{ij} \Big/ \sum_j \sum_i Z_{ij} = \sum_j M_j \Big/ \sum_j Z_j = M/Z$$

$$is_{ij} = -\Delta\mu_{ij} = -(\mu_{ij}^{(1)} - \mu_{ij}^{(0)})$$

$$is_j = -\Delta\mu_j = -(\mu_j^{(1)} - \mu_j^{(0)})$$

$$is = -\Delta\mu = -(\mu^{(1)} - \mu^{(0)}),$$

where subscript ij denotes industry i which belongs to industry (group) j. By the same procedure, the decompositions of the import coefficients at the aggregate and industry j levels, μ and μ_j, respectively, can be derived as:.

(B2)
$$\mu = \frac{M}{Z} = \sum_j \left(\frac{M_j}{Z_j}\right)\left(\frac{Z_j}{Z}\right) = \sum_j \left(\frac{M_j}{Z_j}\right)\rho_j = \sum_j \mu_j\rho_j$$

$$\mu_j = \frac{M_j}{Z_j} = \sum_i \left(\frac{M_{ij}}{Z_{ij}}\right)\left(\frac{Z_{ij}}{Z_j}\right) = \sum_i \left(\frac{M_{ij}}{Z_{ij}}\right)\rho_{ij} = \sum_i \mu_{ij}\rho_{ij} \,,$$

where $\rho_j \ (\equiv Z_j/Z)$ is the share of industry j's total supply to the aggregate total supply and $\rho_{ij} \ (\equiv Z_{ij}/Z_j)$ refers to the share of industry i's total supply to industry j's total supply. Similarly to the decomposition at two levels, the aggregate import coefficient is the sum of weighted import coefficients of those industries which construct that aggregate level. The aggregate import substitution for the whole economy in relative value is:

(B3)
$$is = -\left(\sum_j \mu_j^{(1)}\rho_j^{(1)} - \sum_j \mu_j^{(0)}\rho_j^{(0)}\right)$$

$$= -\left(\Sigma_j \mu_j^{(1)}\rho_j^{(1)} - \Sigma_j \mu_j^{(0)}\rho_j^{(1)} + \mu_j^{(0)}\rho_j^{(1)} - \Sigma_j \mu_j^{(0)}\rho_j^{(0)}\right)$$

$$= \Sigma_j is_j\rho_j^{(1)} - \Sigma_j \mu_j^{(0)}\Delta\rho_j \,,$$

where $\Delta\rho_j$ is the change in the relative size for industry j $(\Delta\rho_j \equiv \rho_j^{(1)} - \rho_j^{(0)})$;

$\Sigma_j is_j\rho_j^{(1)}$ is the sum of industries' j weighted import substitutions in relative value;

$\Sigma_j \mu_j^{(0)}\Delta\rho_j$ is the sum of the effect of the changes in industry j's relative industry sizes on the aggregate import substitution.

The aggregate import substitution in absolute value for whole economy satisfies:

(B3′)
$$IS = Z^{(1)}is = Z^{(1)}\left(\Sigma_j is_j\rho_j^{(1)} - \Sigma_j \mu_j^{(0)}\Delta\rho_j\right).$$

The import substitution for industry j in relative value is:

(B4)
$$is_j = -\left(\sum_i \mu_{ij}^{(1)}\rho_{ij}^{(1)} - \sum_i \mu_{ij}^{(0)}\rho_{ij}^{(0)}\right)$$

$$= -\left(\Sigma_i \mu_{ij}^{(1)}\rho_{ij}^{(1)} - \Sigma_i \mu_{ij}^{(0)}\rho_{ij}^{(1)} + \mu_{ij}^{(0)}\rho_{ij}^{(1)} - \Sigma_i \mu_{ij}^{(0)}\rho_{ij}^{(0)}\right)$$

$$= \Sigma_i is_{ij}\rho_{ij}^{(1)} - \Sigma_i \mu_{ij}^{(0)}\Delta\rho_{ij},$$

where $\Delta\rho_{ij}$ is the change in the relative size for industry j to which industry i belongs $(\Delta\rho_{ij} \equiv \rho_{ij}^{(1)} - \rho_{ij}^{(0)})$;

$\Sigma_i is_{ij}\rho_{ij}^{(1)}$ is the sum of weighted import substitutions in relative value for industry j;

$\Sigma_i \mu_{ij}^{(0)}\Delta\rho_{ij}$ is the sum of the effect of the changes in industry i's relative industry sizes

on industry j's aggregate import substitution.

The aggregate import substitution in absolute value for industry j satisfies:

(B4′) $$IS_j = is_j Z_j^{(1)} = Z_j^{(1)}\left(\sum_i is_{ij}\rho_{ij}^{(1)} - \sum_i \mu_{ij}^{(0)}\Delta\rho_{ij}\right).$$

From equations (B3′) and (B4′), the influences which affect the aggregate import substitution in absolute value for the whole economy can be easily traced as well as the differences between Chereny's (1960) and our approach while involving three levels of aggregation in the economy through replacing IS_j in eq. (B3′) with the terms in eq. (B4′).

(B5)
$$\begin{aligned}
IS &= Z^{(1)}is = Z^{(1)}\left(\sum_j is_j \rho_j^{(1)} - \sum_j \mu_j^{(0)}\Delta\rho_j\right)\\
&= Z^{(1)}\left\{\sum_j\left[\left(\sum_i is_{ij}\rho_{ij}^{(1)} - \sum_i \mu_{ij}^{(0)}\Delta\rho_{ij}\right)\rho_j^{(1)} - \left(\sum_j \mu_j^{(0)}\Delta\rho_j\right)\right]\right\}\\
&= \left[\sum_j\left(\sum_i is_{ij}\rho_{ij}^{(1)} - \sum_i \mu_{ij}^{(0)}\Delta\rho_{ij}\right)Z_j^{(1)}\right] - Z^{(1)}\left(\sum_j \mu_j^{(0)}\Delta\rho_j\right)\\
&= \sum_j\sum_i is_{ij}Z_{ij}^{(1)} - \sum_j\left[Z_j^{(1)}\left(\sum_i \mu_{ij}^{(0)}\Delta\rho_{ij}\right)\right] - Z^{(1)}\left(\sum_j \mu_j^{(0)}\Delta\rho_j\right)\\
&= IS^c - \sum_j\left[Z_j^{(1)}\left(\sum_i \mu_{ij}^{(0)}\Delta\rho_{ij}\right)\right] - Z_1\left(\sum_j \mu_j^{(0)}\Delta\rho_j\right),
\end{aligned}$$

where $IS^c = \sum_j IS_j^c = \sum_j\sum_i is_{ij}Z_{ij}^{(1)}$ with $IS_j^c = \sum_i is_{ij}Z_{ij}^{(1)}$.

The second and third terms in the last formula are the effects of the sums of weighted changes in the relative sizes for industries i and j, respectively.

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