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ON THE MEASUREMENT OF IMPORT SUBSTITUTION

By

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ON THE MEASUREMENT OF IMPORT SUBSTITUTION*

Hollis Chenery, in his "Patterns of Industrial Growth," introduced the measure of import substitution which has since become most widely used.[1] For Chenery, import substitution occurs with a decline in the ratio of imports to total supply. The magnitude of import substitution between two periods o and t is then given by:

$$(1) \quad IS = (m_i^o/z_i^o - m_i^t/z_i^t)/\, z_i^t$$

m_i = imports and

z_i = total supply of the products of sector i.

Most authors have divided this number by the increase in domestic production to obtain the percentage of growth in the sector "accounted for","due to" or "attributable to" import substitution. Despite the "causation" language,[2] Chenery's is clearly an ex post descriptive measure, but one which can be of considerable utility in analyzing the structural changes accompanying growth.

Because of its narrow definition of imports, however, the traditional approach has missed much of what can be meaningfully considered as import substitution. In this paper we examine the nature of this bias. We attempt to correct it by expanding our concept of imports to

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*This paper grew out of our participation in the Brazil Development Assistance Program of the University of California, Berkeley. We wish to thank Joel Bergsman and Donald Huddle for their comments and encouragement. A study by Professor Huddle on import substitution and growth in Brazil first drew our attention to the measurement problem.

include the intermediate demands "generated by" import substitution. We then present calculations for Brazil 1949/64 to give some idea of the magnitude of the bias for a semi-industrialized LDC. These results, together with a brief examination of import substitution in other countries, suggest that for long periods of industrialization and/or for international cross sections, imports substitution measures which do not incorporate intermediate demands can be very misleading even as descriptive tools.

I. The Concept of Imports and Total Supply

The basic identity for the measurement of import substitution is:

$$(2) \quad x_i + m_i = f_i + \sum_j a_{ij} x_j \quad i = 1, \ldots, n$$

m_i = imports

x_i = gross production

f_i = final demand, both domestic and foreign

a_{ij} = observed input-output coefficient so that

$\sum_j a_{ij} x_j$ = total intermediate use of sector i's production.

That is, total gross supply equals total use or gross demand in each sector.

Now, imports usually have been defined as m_i and total supply as $x_i + m_i$ (Chenery, Steuer and Voivados, Lewis and Soligo, Ahmad, Huddle, Diaz-Alejandro).[3] Thus imports supplement domestic production in satisfying gross demand.

Alfred Maizels in his Industrial Growth and World Trade finds this definition inadequate--it does not value imports and domestic production on a "comparable basis".[4] Whereas imports are available *in toto* for use outside the sector, a portion of domestic production (a_{ii}) must be reserved to produce itself. Hence Maizels eliminates intrasectoral sales from gross production in calculating total supply and demand.[5]

Neither of these definitions recognizes that an import ultimately substitutes for the output of many domestic sectors. If an import is to be replaced without an induced rise in imported inputs or reductions in the supplies available for final demand in other sectors, production must be increased not only in the industry finally processing the good, but also in its supplier industries and in their supplier industries and so forth. This, of course, is the root of Hirschman's "backward linkages." The linkages are potentially operative exactly because an import augments domestic resources in many sectors. This does not mean that somehow there is a multiple expansion of value added through backward linkages alone. Rather, it is gross production which expands by some multiple, but only because it involves the double-counting of inter-establishment transactions.

In any case, the Chenery-Maizels (C-M) definitions do not include the potential linkages in measured imports, nor do the linkages appear as import substitution when they are in fact realized. By way of example, suppose a country imports all its refined petroleum products in the inital year. Then oil is discovered and domestic refineries are built which use domestic crude exclusively. Assume that final demand is constant. C-M will show import substitution in refining equal to the original imports, but none in crude oil. But the elimination of refined imports without importing crude was made possible only by this domestic production of crude. It, too, should therefore be counted as import-substituting production.

Now, backward linkages can be incorporated with a sufficiently detailed and accurate domestic input-output table.[6] Let A be such a

table, and assume that the a_{ij} are constant over the relevant range. Then, in matrix notation,

$$[I-A]x + m = f$$

$$x + [I-A]^{-1}m = [I-A]^{-1}f$$

(3) $m^* = [I-A]^{-1}m$ = the vector of redefined imports.

(4) $z^* = x + m^*$ = the new vector of total supply.

(5) $IS_i^* = (m_i^{o*}/z_i^{o*} - m_i^{t*}/z_i^{t*})\, z_i^{t*}$. m^* includes the backward linkages implicit in the product imports, and can be viewed as the domestic production necessary to substitute completely for imports, holding all final demands constant. This does not mean that complete substitution must be feasible within any arbitrarily short period of time. Rather we assume only that when and if import substitution of any product does become feasible, the technology employed will be accurately described by the a_{ij}.

II. Differences Between the Two Measures

$IS_i^* >_< IS_i$ (the traditional measure)+, depending upon whether the <u>indirect</u> imports of sector i's products grow less or more rapidly than the sector's total <u>direct</u> supply. To show this, note that

$(m_i^o/z_i^o - m_i^t/z_i^t) = (x_i^t/z_i^t - x_i^o/z_i^o)$. Thus,

$$IS_i^* - IS_i = (x_i^t/z_i^{t*} - x_i^o/z_i^{o*})\, z^{t*} - (x_i^t/z_i^t - x_i^o/z_i^o)z_i^t$$

(6) $$= (z_i^t/z_i^o - z_i^{t*}/z_i^{o*})x_i^o \quad .$$

+ Henceforth, variables without asterisks refer to the traditional Chenery definitions.

The bracketed term can be rewritten as:

$$(7) \quad (x_i^t + m_i^t)/(x_i^o + m_i^o) -$$

$$[(x_i^t + m_i^t) + (\sum_j r_{ij} m_j^t - m_i^t)]/[(x_i^o + m_i^o) + (\sum_j r_{ij} m_j^o - m_i^o)], \text{ where}$$

r_{ij} is the ij^{th} element of the Leontieff inverse.

Thus $IS_i^* - IS_i >_< 0$ depending upon whether $(x_i^t + m_i^t)/(x_i^o + m_i^o) >_<$

$(\sum_j r_{ij} m_j^t - m_i^t)/(\sum_j r_{ij} m_j^o - m_i^o)$, i.e., upon whether the direct supply grows more or less rapidly than the indirect supply embodied in imports.

Abstractly, then, the Chenery definitions may over or underestimate import substitution in comparison with IS_i^*. Concretely, however, the bias is likely to be downward for periods of import substitution observed in recent decades in most semi-industrialized countries (Brazil is a good example).

The process of import substitution in LDC's seems to pass through rather distinct stages[7]: (1) light consumer goods based on local raw materials--clothing-textiles, food processing, beverages, etc.; (2) consummer durables; (3) some intermediates and capital goods. In stage (2) IS_i may be negative in some capital goods and intermediate sectors, but this is not likely to continue for any extended period. Obviously these stages are not mutually exclusive compartments. Rather they reflect the sequence of dominant sectors in the substitution process.

Import substitution can be measured between any two periods or years of this process. Of particular interest, however, is its magnitude as a country moves from light industry to a more diversified manufacturing sector, i.e., from somewhere in stage (1) or early in stage (2) to somewhere in stage (3). Not only is this transition of great importance for the ultimate success of industrialization, but also all empirical studies of which we are aware have in fact measured import substitution between stages (1)-(2) and (3).[8] What differences would we expect in the results obtained from the two approaches?

For sectors producing exclusively for final demand, $IS_i^* = IS_i$, since indirect imports are always zero. If the sector produces but little for intermediate use, the relative differences will be small, since indirect supply is a minor portion of the total (see equation (6)). Clothing, transportation equipment, food processing, etc. fit in here.

At the opposite extreme, consider a pure intermediate industry, one for which $\sum_j a_{ij}x_j = x_i + m_i$. Total direct supply is a unique function of the production of the user sectors, while indirect supply is a linear function of imports. If import substitution in the traditional sense is occurring in the major users of such an intermediate product, then $IS_i^* > IS_i$, since $(\sum_j a_{ij}x_j^t / \sum_j a_{ij}x_j^o) > [(\sum_j r_{ij}m_j^t - m_i^t)/(\sum_j r_{ij}m_j^o - m_i^o)]$.

Some intermediates--metals is a prime example--are tied primarily to consumer durables and capital goods. In the stages we are considering, consumer durables imports grow much more slowly than their domestic production, often at a negative rate. If IS_i is not highly negative in capital goods and the intermediate itself--and none of the studies cited

above show this negative substitution for extended periods -- the traditional measure will understate import substitution, perhaps substantially so.

Other intermediates, such as textiles, supply primarily industries which took over the domestic market early in the industrialization process. Import substitution in this type of intermediate will not differ greatly for the two measures, since indirect imports will be a very small proportion of the total supply.

Finally, intermediates such as power and internal transportation, which are not traded internationally, are worthy of special comment. For them IS_i must always be zero. If their output growth rate exceeds that of their indirect imports, however, $IS_i^* > 0$. This usually occurs in the stages we are examining.

A particular country may not fit this pattern well, frustrating our attempt at broad generalizations. Then only an examination of the basic underlying data can determine the direction of the bias. We return to this in section IV below.

III. Import Substitution on A Value Added Basis

In a development context, it is more useful to measure import substitution on a value added rather than a gross production basis. This is readily incorporated into our definitions. Let v_i = (value added/gross production), and assume this to be fixed.[9] Multiplying (3) by v_i yields,

$$(8) \quad v_i x_i + v_i \sum_j r_{ij} m_j = v_i \sum_j r_{ij} f_j$$

(8) measures total supply and use on a value added, rather than gross

production basis. Calculations of import substitution can then be made through the usual formula (1). This transformation leaves unchanged the individual sectoral percentages of growth "due to" import substitution, but uses value added rather than gross production weights to aggregate into such broader groups as manufacturing.[10] We have used value added in our Brazilian calculations.

The value added transformation shows more directly the shortcomings of the traditional concept of imports. Lewis and Soligo[11] applied the same transformation to IS estimated using the Chenery definitions. This is equivalent to defining total sectoral supply as $v_i x_i + v_i m_i$. The remaining $(1-v_i)m_i$ of imports is "lost" from both sides of our identity, an arbitrary and misleading procedure. The excluded imports are exactly the (potential) intermediate inputs necessary for import substitution. The reader can verify that our definitions in the aggregate reduce to G.N.P.=(C+I+G+X)-M, whereas Lewis-Soligo become G.N.P. $-\sum_i(1-v_i)m_i$ = $(C+I+G+X) - M - \sum_i(1-v_i)\, m_i$.

IV. Brazilian Import Substitution, 1949/64

1949/64 encompasses substantial portions of stage (2) and (3) for Brazil. In the post World War II period appreciable import substitution occurred in manufacturing. Not only was the import share in consumer durables and even capital goods drastically reduced, but by the early 1960's the major proportion of the resulting intermediate demand was supplied by domestic factories.

An explanation of data sources and procedures is given in the appendix. Table 1 presents calculations of import substitution for this period using the two sets of concepts. All series are in the

Table 1

Brazilian Import Substitution in Value Added Terms
According to Different Measures
1949/64

1959 Cruzeiros

	Our Measure			Standard Value Added Measure		
	vIS*/vΔX	x/z* 49	x/z* 64	vIS/vΔX	x/z 49	x/z 64
Manufacturing	.440			.342		
Non Met. Min.	.262	.788	.953	.208	.838	.972
Metals	.511	.463	.744	.123	.793	.872
Machinery	.722	.350	.749	.711	.359	.755
Elec. Eq.	.859	.156	.891	.835	.180	.907
Transp. Eq.	.841	.183	.929	.813	.211	.941
Wood	.122	.891	.956	.014	.986	.994
Furn.	.030	.975	.995	0	1.000	1.000
Paper	.332	.680	.872	.143	.864	.959
Rubber	.131	.887	.982	.036	.972	.998
Hides	.270	.906	.971	.217	.929	.981
Chemicals	.778	.219	.789	.686	.310	.856
Drugs	.260	.783	.935	.250	.793	.941
Perfume	.007	.993	.997	.002	.997	.999
Plastics	.496	.509	.986	0	1.000	1.000
Textiles	.123	.922	.986	.070	.961	.999
Clothing	.003	.998	.999	0	1.000	1.000
Food	.043	.943	.966	.034	.952	.971
Drinks	.191	.894	.984	.173	.911	.993
Tobacco	---	1.000	1.000	---	1.000	1.000
Print. & Pub.	.094	.891	.953	.024	.963	.979
Misc.	.312	.715	.881	.302	.724	.886
Agriculture	.024	.907	.917	.013	.949	.944
Energy	.181	.815	.922	0	1.000	1.000
Commerce	.036	.964	.983	0	1.000	1.000
Services	.056	.945	.965	0	1.000	1.000
Mining	.141	.330	.368	-.734	.712	.461
Constr.	.014	.985	.993	---	1.000	1.000
Transport.	.031	.964	.984	---	1.000	1.000
Whole Economy	.211			.138		

Source of data: See Appendix.

prices and exchange rates of 1959, the year for which the van Rijckeghem 32x32 input-output table was computed. We assume for the moment that this table accurately reflects the technology (in 1959 prices) employed for import substitutes in our terminal year, 1964.

Our definitions show about a third again as much import substitution as Chenery's in manufacturing and 53% more for the economy as a whole. As expected, most of the differences in manufacturing, 87%, are accounted for by seven intermediate goods industries,[12] while the two approaches give rather similar results for industries producing mainly for final demand. Note also that our measure shows positive import substitution in such sectors as energy and transportation which are not imported directly at all.

Metals show particularly well the differences in the two methods. Already in 1949, domestic production satisfied almost 80% of the direct use of metals. But most of the supply of many heavy metal using sectors such as transportation equipment, machinery and electric equipment was still imported in 1949 (79%, 64%, and 82% respectively). When import substitution occurred in these products, most of the metals were supplied by domestic industry. Our measure identifies this as import substitution in metals, the traditional measure, as an increase in domestic demand. The former is clearly more indicative of the actual process of growth.

The largest relative differences occur in mining, a primary intermediate, where $IS^*/\Delta X = .14$ and $IS/\Delta X = -.73$. This arises from the behavior of crude oil (included in mining) and refined petroleum products. In 1949, no crude oil was imported directly while practically all refined products were supplied from abroad.[13] By 1964, however, more than 90% of

the latter was produced domestically, while over 70% of the crude was imported.[14] This resulted in large negative direct IS in mining, which was more than offset, however, by the positive indirect substitution from producing at home almost 30% of the crude which had 1949 conditions continued would have been imported in already processed form.

Summarizing, fully a quarter of import substitution in Brazilian manufacturing and about a third overall is missed by the usual approach.[15] The differences would have been even greater had we used 1939 instead of 1949 as our initial year, since basic steel and many other intermediates developed rapidly in the interval.

V. Evidence from Other Countries

We have not made similar comparisons for other countries. However, we expect the bias to be significant in many other cases. Its direction and general magnitude for any intermediate product, can be approximately determined by comparing two growth rates, those of direct supply and imports of the principal user sectors. If the first is substantially greater than the second, then the bias in the traditional measure will be considerable (see equation (7) above). The data presented by Ahmad for India, Diaz-Alejandro for Argentina and by Chenery in his "Patterns" all point to a significant downward bias in intermediates for the periods they cover. IS_i in all final and intermediate sectors is positive and appreciable.[16] Thus, it is likely that IS_i^* was significantly greater than the standard measures in all intermediate sectors with indirectly imported supply.

Among published studies, the only possible exception to this pattern is Lewis and Soligo's Pakistan. Even so, substitution in intermediates and capital goods as a whole and in most of their sub-categories is significant 1954/55 to 1963/64, the longest period covered by their estimates.[17]

VI. Limitations and Observations

Granted the desirability of such an approach as we have set forth, there are still several limitations to using observed input-output tables for actual measurement of import substitution.

(1) The two-digit level of aggregation is too great, and imports substituted for are just not of the same composition as total domestic production in a given industry. For example, petroleum refining appears with caustic soda in the Brazilian chemical industry.

(2) The basic data on interindustry transactions may be of doubtful accuracy.

(3) Some imports cannot be produced at home due to lack of natural resources, technology, etc. All the same, these imports will be "decomposed" exactly as the average for production which does occur in the sector. Commercial jets are in this category for Brazil. Ideally, these products should be treated separately since they are not (economically) substitutable. We were unable to do this in the Brazilian calculations.

(4) The a_{ij} may not be fixed over time. Non-constancy may arise from (a) changing output composition within 2-digit SIC industries, (b) shifts in relative prices and (c) from marginal a_{ij}'s different from the average.

The fourth problem is not serious <u>if</u> the table used accurately reflects end-period technology. Then import substitution will still measure differences in domestic output for that year "due to" a decline in the import share, holding technology constant. The 1959 Brazilian table no doubt differs from the one we would have observed in 1964. But similar results are obtained for 1949/59, when import substitution is 39% of manufacturing growth under our definitions and 30% with the traditional approach.

All of the other difficulties make errors in the a_{ij} likely in any concrete application. The basic issue, however, is whether a more accurate picture of import substitution can be obtained by letting all $a_{ij}=0$, as in the traditional approach, or by accepting erroneous, but observed $\hat{a}_{ij}$. It is barely conceivable that the $\hat{a}_{ij}$ leads to results farther from the correct a_{ij} than the traditional approach. The errors will, of course, be concentrated in intermediate goods industries in both approaches. In the input-output approach the bulk of the errors are likely to arise from aggregation problems. Without a more detailed table, they are difficult to evaluate.

A final word is in order on the interpretation of import substitution as a "cause" of economic growth. These measures identify industries where substantial import substitution has occurred. They do not tell us how much lower domestic production would have been had import shares remained constant. All feedbacks on relative prices, efficiency, aggregate

demand, and capacity are ignored. To determine the total impact of import substitution, a complete model of the economy incorporating these feedbacks would be required.

VII. Conclusion

In this paper we have introduced backward linkages directly into a Chenery-type measurement of import substitution, and we have shown how the traditional definitions, which ignore the linkages, miss import substitution in intermediate goods industries. If few intermediates are actually produced in a country, the differences in results will not be great. But for a country like Brazil, with well-developed intermediate industries, our measure will give a much more meaningful picture of import substitution if an accurate and fairly detailed input-output table is available.

APPENDIX

The input-output table was constructed by Willy van Rijckeghem using 1959 census data.[18] We inverted it. Imports in 1959 dollars were grouped using Brazil's IBGE industrial (similar to the SIC two-digit) classification, as are the sectors of the input-output table. Relative prices in 1959, and hence the a_{ij}, should reflect 1959 exchange rates and tariffs for the different sectors. Hence each year's imports were converted into cruzeiros using 1959 effective exchange rates, including tariffs. The basic commodity imports and exchange rate data for 1959 and 1964 were kindly supplied by IBGE's Laboratório Estatístico. For 1949 we relied primarily on the good quantitative estimates in Economic Commission for Latin America, "The Growth and Decline of Import Substitution in Brazil", Economic Bulletin for Latin America, IX, No. 1, (March 1964), with some corrections for differences in coverage.

The value added series starts with 1959 value added as computed from the census by van Rijckeghem.[19] This series is projected back to 1949 and forward to 1964 through indices of real output supplied by the Brazilian Planning Ministry's Instituto de Pesquisa Econômica-Social Aplicado (IPEA). The 1964 indices are unofficial estimates made by IPEA itself, while the remaining two years were computed by the Fundação Getúlio Vargas.

Footnotes

1. Chenery, Hollis B., "Patterns of Industrial Growth," American Economic Review, L, No. 4 (September, 1960), pp. 624-654; Chenery, Hollis B., S. Shishido, and T. Watanabe, "The Pattern of Japanese Growth," Econometrica, January, 1962, pp. 98-139; Lewis, Stephen R., Jr. and Ronald Soligo, "Growth and Structural Changes in Pakistan's Manufacturing Industry, 1954 to 1964," Pakistan Development Review, V, No. 1 (Spring, 1965), pp. 94-139; Steuer, M.D. and C. Voivados, "Import Substitution and Chenery's Patterns of Industrial Growth: A Further Study," Economia Internazionale, XVIII, No.1 (February, 1965), pp. 47-77; Ahmad, J., "Import Substitution and Structural Change in Indian Manufacturing Industry," Journal of Development Studies, IV, No. 3 (April, 1968), pp. 350-379; Huddle, Donald L., "Postwar Brazilian Industrialization: Growth Patterns, Inflation, and Sources of Stagnation," in Baklanoff, Eric N. (ed.), The Shaping of Modern Brazil (Baton Rouge: Louisiana State University Press, 1969), pp. 86-108; Diaz-Alejandro, Carlos F., Essays on the Economic History of the Argentine Republic (forthcoming), Chapter 3.
2. Steuer and Voivados, op. cit., pp. 48-49, avoid this language and clearly recognize that division by the growth of domestic production is merely a convenient way of "normalizing" import substitution.
3. See footnote 1.
4. Maizels, Alfred, Industrial Growth and World Trade (Cambridge: N.I.E.S.R., 1963), p. .
5. Ibid., p. .

6. This would include input-output coefficients in constant prices for all import substitutables, some quantity of which will be domestically produced by the terminal period. Ideally, products which will not be produced domestically in any proportion should be treated as a separate category. Actual data are usually too aggregative to do this, however.

7. Cf. inter alia Hirschman, A.O., "The Political Economy of Import-Substituting Industrialization in Latin America," Quarterly Journal of Economics, 82, 1 (February, 1968); Diaz-Alejandro, Carlos F., op. cit., Chapter 3; Maria da Conceição, "The Growth and Decline of Import Substitution in Brazil," Economic Bulletin for Latin America, IX, No. 1 (March , 1964), pp. 1-59.

8. See footnote 1 above.

9. If we were interested in partitioning growth exhaustively into various categories as do many authors, we would have to take into account the effect of changes in the value added ratio upon total value added. In measuring import substitution alone, however, we can assume v_i to be fixed at the level observed in the input-output year.

10. Specifically,

$$v_i IS_i / v_i \Delta x_i = IS_i / \Delta x_i; \; \Sigma IS_i / \Sigma \Delta x_i = \Sigma (IS_i / \Delta x_i)(\Delta x_i / \Sigma \Delta x_i) \text{ and}$$

$$\Sigma v_i IS_i / \Sigma v_i \Delta x_i = \Sigma (v_i IS_i / v_i \Delta x_i)(v_i \Delta x_i / \Sigma v_i \Delta x_i)$$

11. Lewis, Stephen R. and Ronald Soligo, op. cit., pp. 108-109.

12. Metals, lumber and wood, paper, rubber, chemicals, plastics and textiles.

13. Baer, Werner, Industrialization and Economic Development in Brazil (Homewood, Illinois: Richard D. Irwin, 1965), p. 283 and Ministério de Planejamento e Coordenação Econômica, Escritório de Pesquisa Economica Aplicada, Petróleo: Diagnóstico Preliminar (Rio de Janeiro, 1966), pp. 45 and 55.

14. Ibid., p. 55.

15. We analyze these results and their relation to government policy and foreign investment in our forthcoming paper, "Import Substitution as an Industrialization Strategy in Brazil."

16. Ahmad, J., op. cit., p. 360; Diaz Alejandro, Carlos F., op. cit., Chapter 3; Chenery, H. op. cit., pp. 642-43. Huddle's data concern Brazil, but are too aggregated for present purposes. See Huddle, Donald, op. cit., p. 96. Chenery, Shishido and Watanabe's data on Japan, 1914/54 (op. cit., p. 116) are not in a form permitting a comparable judgment of the biases of applying the original Chenery measure to Japan. Chenery, et al, define direct import substitution as $(\lambda m_j^o - m_j t)$ where $\lambda = G.N.P.^t/G.N.P.^o$. In general this will be much smaller than the normal proportionality-in-total-industry-supply criterion: most sectors of industry grow more rapidly than G.N.P. Even so, only petroleum and coal, machinery, food and mining show negative substitution under this definition, suggesting that here too the bias would be downward. The downward bias is probably present in Maizels estimates of import substitution also, since imports in all but a few countries have been growing much more slowly than national

production. His data do not separate industrial products into final and intermediate, however. See Maizels, op. cit., pp. 150-161.

17. Lewis, Stephen R. and Ronald Soligo, op. cit.

18. Ministério do Planejamento e Coordenação Geral, Instituto de Pesquisa Econômico-Social Aplicada, Relações Interindustriais no Brasil (Rio de Janeiro: Cadernos IPEA No. 2, Dec., 1967.

19. Ibid., p. 23.