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THE POTENTIAL IMPACT OF INTERNATIONAL TRADE AND INVESTMENT SANCTIONS ON THE SOUTH AFRICAN ECONOMY

by

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ABSTRACT

The purpose of this paper is to clarify the theory of international economic sanctions and to provide estimates of the short-run economic impact on South Africa of externally imposed reductions in the imports and capital flows into that country. Several theories of how sanctions "work" are examined, and they are shown to be not all equally plausible and not all consistent with each other. A macroeconomic picture of South Africa's "dependence" is drawn, and the economy's point of vulnerability in the short run is seen to be in its capacity to import, not in exports or capital flows. Finally, a static linear programming model of the South African economy is constructed. This model estimates that small sanctions would have small impact -- i.e. if imports were reduced by less than one-fourth, GDP would be cut by only about one-half as large a percentage as imports. Larger import reductions cause ever greater damage. And if imports were cut in half, not only would GDP be seriously reduced but massive unemployment and relocation of white labor would occur.

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THE POTENTIAL IMPACT OF INTERNATIONAL TRADE AND INVESTMENT SANCTIONS ON THE SOUTH AFRICAN ECONOMY

Richard C. Porter[1]

I. Introduction

For some time, and with increasing frequency, sanctions have been suggested as a means whereby the world community might force changes in South Africa's racial policies. But the resulting debate has been hampered by a lack of clarity about how sanctions are supposed to function and by a nearly total absence of refined empirical estimates of the potential impact of sanctions. The goal of this paper is to alleviate those deficiencies.

The word "sanctions" covers a wide variety of international actions.[2] Here, we shall consider only one set of such actions, where South Africa's international trade of goods and factors of production is impeded by agreement among its trading partners. Thus, the initial impact of international sanctions - or boycott, or embargo, the words are here considered synonyms - is upon South Africa's exports, imports, and net inflow of foreign capital; the ultimate incidence is, as well, on the volume, structure, and growth of South African output, income, and employment.

The theory of how sanctions "work" is developed in Section II. Not surprisingly, the received literature displays a variety of theories, not

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[1]Department of Economics, University of Michigan. For their careful work on the data and the computer, I am indebted to A. Beyaert, K. Maskus, and J. Tempalski. For helpful comments in an earlier draft, I thank R. Barlow, T. Bell, E. Berg, W. Cotter, A. Deardorff, D. Myers, and M. Nziramasanga. I am also grateful to the Ford Foundation for its financial support.

[2]For a sampling, see Ferguson and Cotter, 1978.

all equally plausible and not all consistent with each other. A broad picture of South African "dependence" is drawn in Section III, and a macroeconomic assessment made of what kinds of sanctions do and do not have a potential to damage South African welfare. The source of the potential damage is seen to be the deprivation of imports. A sectoral model is then constructed and simulated in Sections IV and V in order to generate quantitative estimates of the potential short-run impact of import reductions. The conclusions of these simulations, stated more fully in Section VI, are essentially that small import reductions would have small impact but that significant import reductions would cause nearly proportionate reductions in South Africa's output plus extensive white labor relocation and unemployment.[1]

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[1]There are four appendices. In Appendix A, the model of Sections IV and V is fully displayed. In Appendix B, the derivation of the data and of the parameters of the model is described. In Appendix C, the sectoral production functions of the model are developed in detail. And in Appendix D, previous work on sanctions using input-output models is examined closely.

II. The Theory of Economic Sanctions

Although economists have written extensively about universal economic sanctions, the precise mechanism whereby sanctions are supposed to prove effective is not always clear, and several quite different mechanisms can be discerned in the received literature. The goal of sanctions is clear and simple: to impose a reduction in economic welfare on the target country and thereby reduce its willingness to persist in antagonizing the world community. But even for this simple statement, two complexities should be noted. First, the "thereby" is critical, although there is neither logical reason nor historical evidence that political or psychological collapse inevitably follows economic hardship, no matter how great that hardship.[1] Nonetheless, I intend to ignore this essentially non-economic issue and focus on the link between the international imposition of economic sanctions and the ensuing loss of economic welfare. The second problem lies in the words, "target country." This simple concept is adequate only if we deal with a homogenous population, with each member identically affected by sanctions, which reaches policy decisions by consensus. In any application of sanctions to South Africa, it must be remembered that the target is white South Africans' welfare; indeed, the true objective presumably would be to reduce the sum of white South Africans welfares, individually weighted by their importance in the political process.

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[1] Much recent evidence comes from North Vietnam: "...the argument that the bombing would affect the will of Hanoi's leadership is generally based on three suppositions. First, the bombing would so reduce North Vietnam's capability to successfully prosecute the war that Hanoi would either sue for peace or substantially reduce the level of warfare. Second, the leadership would decide that the level of destruction visited upon the North Vietnamese economy was greater than the gain from supporting the revolution in the South. Or third, that the morale of the North Vietnamese population would so deteriorate that the leadership would be forced to seek relief from the bombing through negotiations or reduced support for the forces in the South.

"Examination of the results of the bombing indicates that none of these suppositions have been borne out in practice." (Biles, 1972, p. 15).

One seeks in vain for evidence from Rhodesia, where real GDP grew at nearly 7% per annum during 1965-74. Only in an opportunity-cost sense could it be said that there was hardship. In any case, it was not sanctions that humbled the white government of Rhodesia. See Porter, 1978a.

I begin with a "basic theory" of sanctions. For ease of exposition, this theory is aggregative, static, and neo-classical.[1] After this "basic theory" is developed, five alternative theories of how sanctions are supposed to work will be briefly examined. To understand the "basic theory," it is sufficient to consider a hypothetical target country that produces and consumes two commodities and initially trades freely at exogenously determined prices.[2] Figure 1 displays the standard trade model, with the (concave) production possibility curve, the (convex) community indifference curve, and the optimizing trade possibility line, tangent to both curves. For maximum welfare (W_0), the country produces x_0 and y_0, exports good x and imports good y, and consumes x_1 and y_1. In Figure 2, a dashed community indifference curve (W_1) is added which shows the highest welfare the country can attain if it is denied access to international trade; it produces and consumes x_2 and y_2; its welfare, W_1 instead of W_0, is clearly reduced.

Examination of Figure 2 indicates that the magnitude of this relative loss of real income will be greater i) the less flat (i.e., more concave) is the production possibility curve, ii) the less flat (i.e., more convex) is the community indifference curve, or iii) the greater is the initial trade. In other words, sanctions which preclude trade will be more effective i) the more inflexible is the target country's production structure, ii) the more inflexible are its consumption preferences, or iii) the greater is its initial dependence on imports and exports.[3] In

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[1] However, the empirical work in Sections IV and V is based on a model that is disaggregated (i.e. the economy contains eight sectors), and fixed-coefficient (i.e. much of the substitutability of neo-classical functions will be discarded in order to make the empirical work feasible). The empirical work there continues to be static, which means that it will be concerned only with the short-run implications of sanctions.

[2] For analytical simplicity, the possibility that factors of production also move is ignored. But we must remember that, for South Africa, labor and capital movements have always been important.

[3] This last condition is the only one that is usually explicitly mentioned in the sanctions literature - see for example Maizels, 1964, pp. 120-121.

FIGURE · 1

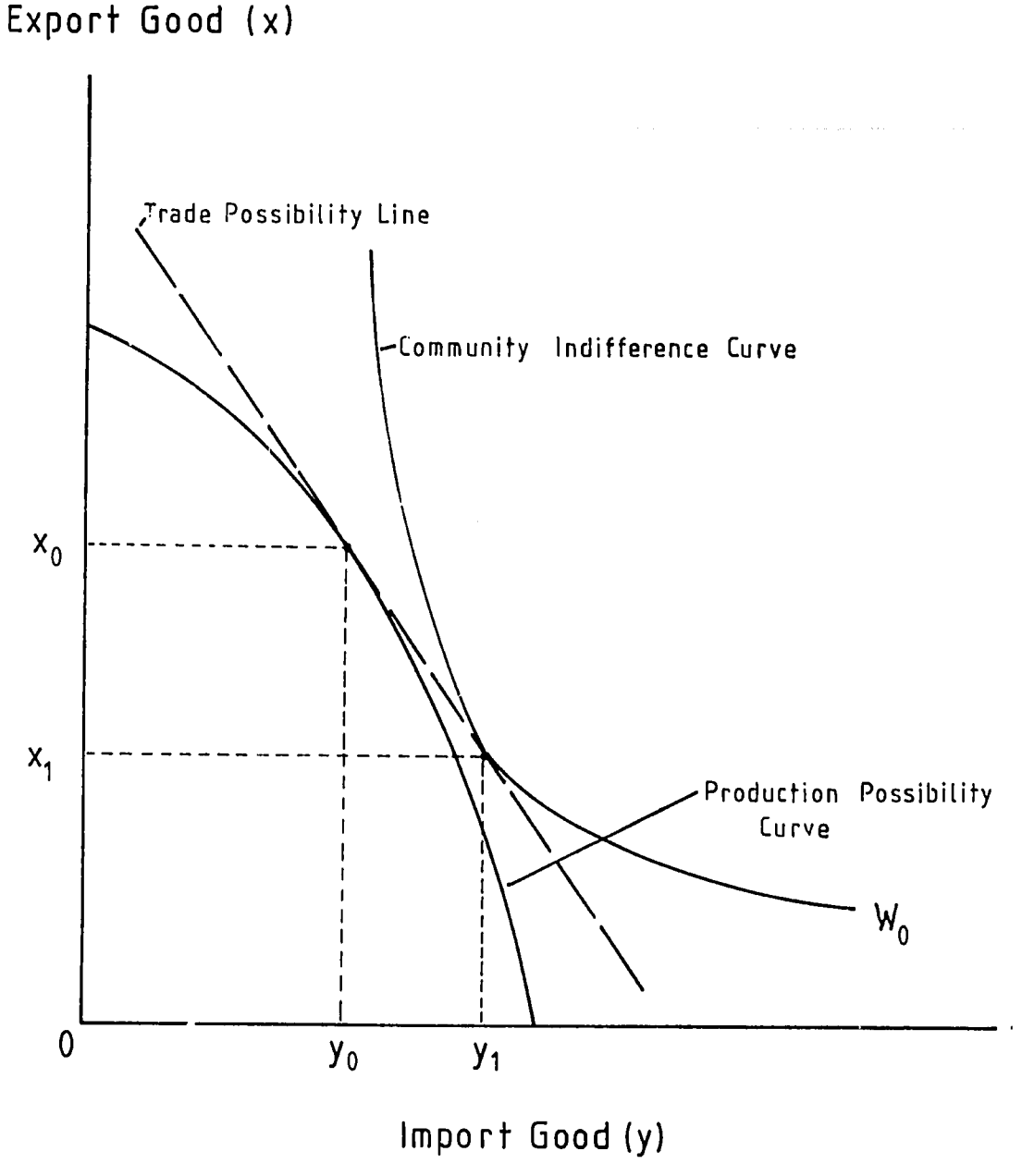
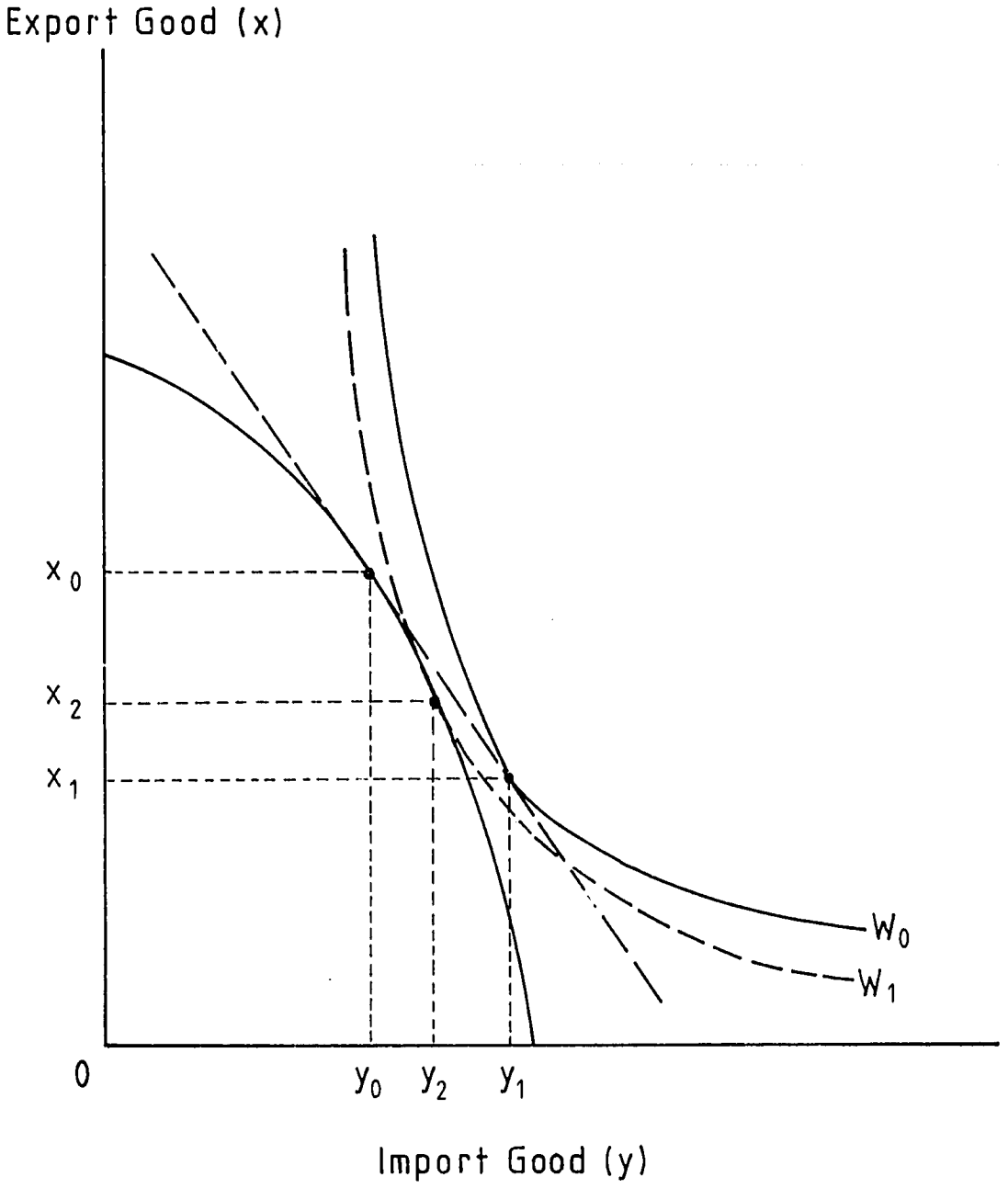

Export Good (x)
Trade Possibility Line
Community Indifference Curve
x_0
x_1
Production Possibility Curve
W_0
0
y_0
y_1
Import Good (y)

FIGURE 2



light of these three conditions, it is easy to see why great things might be expected by the world community of sanctions against South Africa. Imports equal roughly one-fourth of South Africa's Gross Domestic Product (GDP); its exports are heavily dependent on a few minerals; and it might still be viewed as lacking the economic maturity that lends flexibility to a productive structure.

So far this basic theory has treated the degree of flexibility and dependence of the target country as essentially exogenous data. For the sanctioning countries, of course, this is correct; but an expectant target country can do much to increase its flexibility and reduce its dependence on imports.[1] One can readily envisage incorporation of duopoly-like threats and reactions into the model, but no formal extension is necessary to see its principal lesson: that the longer the world debates the imposition of sanctions, the smaller may be their effect when finally imposed.[2]

The basic theory above is also developed on the assumption that sanctions are universal - that is, they completely prevent all imports into the country. If only some countries impose sanctions, the impact depends critically on the extent to which the target country can acquire the same imports from other sources.[3] Again, a formal model - incorporating limits to the target country's exports and imports - is not needed to see the principal result: partial sanctions achieve, at best, partial results.

While the foregoing analysis and conclusions seem straightforward, there are alternative theories about the connection between sanctions and welfare:

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[1] For the theory, see Arad and Hillman, 1978. Their potential target seeks to balance "the deadweight-loss of not producing according to comparative advantage" against "the benefit [because of learning by doing] of lower future domestic production costs in an embargoed equilibrium" (p. 2).

[2] In South Africa's case, preparation for sanctions has meant not so much a reduction in dependence or an increase in flexibility as a build-up of stockpiles of critical imports, particularly oil. Careful estimates of the size of South Africa's oil inventory suggest one and a half to two years (see Raiford, 1978, p. 57, and Bailey and Rivers, 1978, p. 58).

[3] The potential for sanctions imposed by all countries but only on certain kinds of imports is discussed shortly.

1. Sanctions which apply only to certain exports and/or imports may be effective if there are inflexibilities in particular areas of consumption or (more plausibly) production in the target economy. In the South African context, partial sanctions might be effective if they can i) somehow "clog" the South African economy with inexportable minerals[1] or ii) damage South African production through the scarcity of critical raw materials (particularly petroleum). The clogging possibility can be seen in Figure 2; if the policy-makers of the target country cannot (or dare not) force a reduction in export-good production (from x_0 to x_2) the final welfare position is reduced even below W_1 (as production and consumption of the import good is reduced below y_2 to y_0). Although this happened to some extent in Rhodesia (with tobacco), it seems less likely to arise in South Africa (with gold and diamonds) and will be ignored hereafter. The possibility of bottlenecks due to scarcity of particular imports is more relevant and could be examined through a sufficiently disaggregated model. Unfortunately, our simulations deal with eight sectors, which is hardly disaggregated enough.

2. Sanctions may cause a reduced growth rate. Even if the static real income losses are not large, they represent losses at the critical margin and increasingly will show up as inefficiency in the use of labor and capital, reduced saving (and investment) rates, hence a lower rate of growth of output. By focusing on growth, hence the long run, this alternative suggests the need for patience and persistence in the use of sanctions.[2] This theory conflicts with the basic theory more directly than it at first seems. Static analysis assumes that the elasticity of substitution in both production and consumption increases, the larger the period considered. Thus, for the basic theory, sanctions must work quickly, for they are increasingly averted by long-run adjustment. The empirical

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[1]The envisioned "clogging" is of course not physical but fiscal.

[2]It also assumes that foregone growth, even without an actual decline in living standards, will weaken the target country's resolve.

work in Sections IV and V is based on a simple model that does not consider saving, capacity growth or time, hence cannot examine this alternative to the basic theory, but it is discussed in the next section.

3. According to a more Keynesian view of sanctions, one should focus on the lost exports which represent a decline in aggregate demand and, after the operation of the multiplier, result in recession and unemployment (presumably of whites as well as blacks). This is a very different approach to sanctions. It is entirely demand-focused, whereas the basic theory is entirely supply-focused. Accordingly, the policy implications also differ. In neither view is it necessary to impose sanctions on both sides of the export-import trade. In the basic theory, the critical sanctions are against imports;[1] in the Keynesian model, the critical sanctions are against exports.[2] The difficulty with this Keynesian, aggregate-demand model is that it must be assumed that the target country is unable either to recognize the source of its reduced real income or to undertake the expansionary macroeconomic policies necessary to offset the losses in export demand. Both of these assumptions are dubious in general, and in the South African context especially unwarranted -- with increasing internal and external pressures requiring defense expenditures. Any aggregate-demand impact of economic sanctions is hereafter ignored.

4. According to a dualistic view of the South African economy, there is an "unlimited" supply of black labor available to the modern white-directed industrial and agricultural sectors at a low, constant, and irreducible opportunity cost. Under this assumption, none of the damage imposed by sanctions can be shifted to blacks; and hence even a quite small impact on aggregate variables may be critical to the wages, profits, employment, consumption and welfare of the relatively small white ruling community.[3]

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[1] In terms of Figure 2, if the country continues to export but is unable to import, its consumption bundle will be somewhere within the production possibility curve, and its welfare level therefore even lower than W_1.

[2] Although sanctions against imports will also have some effect to the extent that they lower the marginal propensity to import, and thus raise the multiplier. For examples of this demand-focused approach, see Appendix D.

[3] See Porter, 1978, for a more complete development of the picture of the South African economy which underlies this view of sanctions.

In fact, employed black laborers in the cities of South Africa earn wages well above the standard of living of rural blacks. Their unemployment as a result of sanctions would mean that blacks as well as (or instead of) whites suffered.

5. Finally, there is a view of sanctions that sees their effects as perverse (from the position of the countries imposing the sanctions). This theory begins with the belief that economic development requires a poor country to free itself of dependence on the export of primary products; hence the appropriate development policies include government encouragement of agricultural self-sufficiency and increased protection of industrial production. Thus, economic sanctions may force the target country to adopt the very policies needed for its development. Of course, for best results (from the target country's viewpoint) the sanctions must be partial, effective enough to induce industrialization but not so complete as to make it impossible. Very few writers take this extreme position on the working of economic sanctions,[1] and in any case the argument is much less appropriate for South Africa than it might have been for Rhodesia since the South African economy has already undergone such extensive industrialization and import-substitution. This view is ignored in the empirical effort of Sections IV and V.

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[1]But see, for example, Hoogvelt and Child, 1973.

III. The Dependence of South Africa

"Dependence" has been variously defined and much debated in the literature on economic development. Here, I want to use the word in the senses suggested by the preceding theoretical discussion, namely, the extent to which South Africa is vulnerable as a target for international economic sanctions.

This vulnerability is usually thought to be primarily in the target country's exports, partly because the very word "boycott" has come to mean a concerted refusal to buy rather than to sell, and partly because whatever success was achieved by the sanctions applied against Rhodesia[1] occurred largely through the refusal of the world markets to accept Rhodesian tobacco. The impact of such a reduction in exports follows from the concurrent loss of earnings of foreign exchange and hence the ability to purchase essential or highly desired imported goods.[2]

In South Africa's case, it may be difficult to muster a sufficient world consensus in practice against the purchase of exports as a means of denying South Africa foreign exchange. First of all, nearly half of South Africa's exports are the most eminently acceptable commodity of all: gold.[3] And one half of the remaining exports are readily marketable mineral outputs, raw or slightly processed, which are sufficiently homogeneous to enter world markets with few distinguishable South African markings.[4] It will not be easy for the world to reduce significantly South Africa's foreign

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[1]For a discussion and explanation of the notable lack of success of the Rhodesian sanctions, during 1965-1975, see Porter, 1978a. Total Rhodesian exports were reduced, in 1968, to an annual rate 39% below their 1965 annual rate. (They rose again thereafter.)

[2]Recall that I am ignoring the two possibilities i) that the export loss causes recession through a loss of aggregate demand and ii) that the economy is unable to reduce export production despite its inability to export the resulting output.

[3]Gold exports were R 2,565.3 million in 1974 out of an export total of R 5,571.3 million (excluding re-exports). (The South African rand (R) was worth US $1.40 before 1975 and US $1.15 after.)

[4]These are (in 1974); crude materials excluding fuels (SITC 2), R 594.2 million; non-metallic mineral manufactures (SITC 66), $ 374.3 million; iron and steel (SITC 67), R 217.2 million; and non-ferrous metals (SITC 68), R 290.9 million. The total is R 1,476.6 million, 49% of total non-gold exports.

exchange availability. An alternative would be world sanctions aimed directly at restricting South African imports. But this also may be difficult to achieve in practice as long as South Africa has the foreign exhcange to pay for imports.

Whether imports are cut off directly or indirectly through a reduction in South Africa's ability to export and hence its ability to pay for imports, the critical question remains: what damage would the resulting import reductions impose on the South African economy? If one measures dependence on imports as the ratio of imports to output (GDP), South Africa is an average country in this respect, with imports amounting to about one fifth of GDP.[1] Of course, that fraction by itself divulges little because it says nothing of how easily South Africa can dispense with (previously) imported goods entirely or can introduce their production domestically. For this, one must turn to the composition of imports. South African trade data are elaborately reported by both SITC and ISIC (i.e., by source sector),[2] but they are most interestingly viewed by use, as in Table 1.

The industrialization of South Africa over the last half century has not been atypical. As white incomes rose, consumer goods became manufactured domestically, and the intermediate inputs needed also became increasingly produced domestically. Accordingly, the importance of consumer goods and intermediate inputs declined in total imports. Simultaneously, low tariffs on capital equipment, maintained to encourage investment and reduce manufacturing costs, insured that domestic capital goods production lagged, and capital equipment became an ever larger portion of total imports.[3] Indeed, as import-substitution industrialization proceeded into its later, more technologically advanced and capital intensive stages, not only did the dependence on imports of capital equipment intensify, but the ability to produce intermediate inputs domestically failed to keep up. Thus, the decline of

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[1]The countries reported in Kindleberger and Herrick, 1977, range from nearly zero to 76%, with 33 below South Africa and 39 above (p. 284). The median there of imports/GDP is 21%. It should be noted that the Rhodesian ratio was over 30% in 1965.

[2]See also Table B-2 (of Appendix B) for an import classification by sector of source and use.

[3]Zarenda, 1977, calculates that the (weighted average) effective protection of capital equipment was <u>negative</u> in 1956-1957.

TABLE 1

SOUTH AFRICAN IMPORTS, BY USE, 1974[a]

Category of Import	1957	1964	1974
	(R millions)		
Intermediate Inputs[b]	560.2 (51.0%)[e]	645.5 (42.2%)[e]	2,045.9 (41.7%)[e]
Consumer Goods[c]	231.4 (21.1%)	322.7 (21.1%)	775.5 (15.8%)
Capital Goods[d]	306.4 (27.9%)	556.2 (36.4%)	2,047.4 (41.7%)
Total[f]	1,098.3	1,529.9	4,905.1

[a]Source: Dept. of Statistics, South African Statistics, various years, table entitled "Imports by Use and Stage of Processing."

[b]Includes "Raw (or crude) materials" and "Processed or manufactured materials" other than "Capital equipment"

[c]I.e. "Articles ready for retail sale or consumers' use."

[d]I.e. "Capital equipment."

[e]Figures in parentheses are percentages of total exports.

[f]Columns do not sum to total because two minor hard-to-classify categories are omitted.

intermediate inputs in total imports decelerated.

Though brief and over-simplified,[1] this account of South African industrialization indicates its point of vulnerability to sanctions. Reduced capacity to import would not have much direct impact on consumer welfare. Less than 10% of total consumption is imported,[2] and much of this is "luxury" consumption, easily expendable in a time of crisis. The brunt of sanctions would be felt in the other two categories of imports, intermediate inputs and capital goods.

For intermediate inputs, analysis at the highly aggregate level at which this section deals yields no insight into the potential effect of sanctions. For that, one must examine the composition of these inputs and estimate the extent to which they can be replaced by domestic production and at what resource cost. A systematic effort to do this is the chief thrust of the next two sections, but only at an eight-sector level of disaggregation.

For capital goods, analysis at the macro level yields a great deal of insight. Imports of capital equipment currently comprise more than one third of total South African gross domestic fixed investment,[3] and the South African construction sector provides 70% of the remainder.[4] Although South Africa has for some time recognized (and worried about) its almost

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[1] A fuller description is found in Houghton, 1976, Chapters 6 and 8.

[2] See Table B-7.

[3] In 1974, 33.9% (R 2,047.4 million of R 6,026 million). This percentage has remained quite stable over the past two decades: in 1964, 34.7% (R 556.2 million of R 1,605 million); and in 1957, 32.7% (R 306.4 million of R 936 million). (Source for gross domestic fixed investment data: I.M.F., May 1978.) Put differently, imported capital goods made up 79.0% of the total equipment content of fixed investment in 1974 (R 2,047.4 million out of R 2,593 million; source of latter figure: South African Reserve Bank, March 1978, p. S-81); these figures may not be exactly comparable, but they are suggestive.

[4] See Table B-9.

total dependence on capital goods imports, it is still accurate to say that South Africa imports almost all of its capital equipment -- with domestic industry essentially providing only the plant in which it is housed. Thus, if sanctions were to cut off South Africa from capital equipment, South Africa's growth would effectively cease. Indeed, as time went on and depreciation became relevant, the output potential of South Africa would be reduced unless it could rapidly develop from a very undeveloped base its own capital goods industries. No elaborate model is needed to conclude that sanctions against South Africa could be effective in the sense that South Africa's growth as a modern, industrial economy could be dramatically interrupted.[1] Because this conclusion is so obvious, the model developed and applied in the next two sections is only concerned with the short-run impact of sanctions.

Besides trade, there is a second way in which South Africa is dependent on the world economy: for its net inflow of factors of production. Consider, first, capital. South Africa was a net debtor in the world community in 1976, as Table 2 shows, to the tune of nearly fifteen billion rands, a figure that is roughly half its GDP. Needless to say, few discussions of sanctions against South Africa fail to consider the "disengagement" or "withdrawal" of foreign capital.

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[1] All studies I have seen agree on this. For examples:

> Within a few weeks - if I am right in thinking that the South African authorities would react by rationing and putting the country on a war footing - there would be a marked but not fatal impact on the business community, on agriculture; and on the way of life of everybody. Quickly shortages of all luxury goods and more gradually of certain engineering products would emerge. Unemployment in the Reef, in the Cape Peninsula, and more particularly in Port Elizabeth area would grow. But I think it would probably be about two years before the country was faced with breakdown. (Marvin, 1964, p. 240.)

> ...sanctions, although they might foster economic growth in the short and medium-term, are unlikely to have the same result in the long-run as well. In fact, it is likely that with the continuation of the boycotts, the future economic growth of South Africa will be slower than it would be if free international trade were upheld. Presumably, the degree of labour productivity would drop as a consequence of boycotts, ... (Spandau, 1978, p. 271.)

Note that the two authors do disagree on the short-run impact of sanctions.

TABLE 2

FOREIGN ASSETS AND LIABILITIES OF SOUTH AFRICA, 1976[a,b]

Category	Assets	Liabilities	Net Liabilities
Private Sector			
Short-term	989	2,660	1,671
Long-term			
Direct	1,787	6,342	4,555
Non-Direct	368	6,684	6,316
Government[c]			
Short-term	1,221	2,235	1,014
Long-term	645	2,008	1,363
Total	5,010	19,929	14,919

[a]At end of year.

[b]Source: South African Reserve Bank, March 1978, pp. S-64 through S-67.

[c]Banks are included under "Government."

[d]Short-term assets includes "Gold reserves" and "SDR's."

The process whereby sanctions on international investment damage the target economy is more subtle than the theory about trade sanctions, and misconceptions abound. To begin with, the very words "disengagement" and "withdrawal" invite misinterpretation. There is no possibility that South Africa would permit the actual withdrawal of the capital equipment which is the physical counterpart of the foreign net asset position in South Africa.[1] Should foreigners attempt to unload the shares, loans, mortgages, etc. that represent claims on South African output, they would threaten disorder in the financial and foreign exchange markets of South Africa, but they would not reduce the economy's real capital stock one iota.[2] The most that "disengagement" can mean, therefore, is the cessation of new (and replacement) investment. It might also mean, in the case of multinational corporations,[3] that the parent would withhold personnel, intermediate inputs, and technological information from its South African subsidiary. With respect to personnel, withdrawal would be marginal, as South Africans now provide almost all the manpower, even at the highest levels, in their industrial establishment. With respect to inputs, the workings of the sanctions follow the path already discussed for imports in general; the amount of damage hinges on the difficulty in South Africa of replacing the foregone imports from other (domestic or foreign) sources, or doing without.

In the end, therefore, withdrawal of international investment is basically a growth-related threat. Except as a form of import sanction, it cannot impose much short-run impact. Through its investment and technological components, however, such disengagement has a large potential impact on South Africa's rate of growth.

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[1] Of course, not all such assets need have a physical counterpart -- one can borrow to consume as well as to invest.

[2] A point carefully made by Harvey, 1975. Of course, the financial disruption might make it difficult for South Africa to operate this capital at capacity. (See Myers et.al., 1978.)

[3] Note that nearly one third of South Africa's international liabilities are comprised of direct, long-term, private sector indebtedness.

A second misconception about investment sanctions stems from a fascination with the ratio in South Africa of foreign investment to total investment: "During the years 1970 to 1977, average annual foreign capital inflows amounted to $580 million or 9.4 percent of gross investments " (Spandau, 1978, p. 197). The implication is that a one dollar reduction in foreign investment will lead to a one dollar reduction in total investment.[1] The implicit macro model is both naive theoretically and refuted empirically. In 1977, for example, the net capital inflow into South Africa fell to minus R 1,096 million from plus R 1,110 million in 1976, a drop of R 2,206 million. Gross domestic investment fell from R 8,608 million to R 8,303 million, only 3.5%.[2] Even lagged relationships are unlikely. In the early 1960s, foreign capital flowed out of South Africa for seven years[3] and real GDP in South Africa continued to grow at five to six percent per annum throughout the period.

The real impact of any reduction in foreign (net) investment in South Africa must derive, in the short run, from its impact on the balance of payments. Inflow of capital permits South Africa to import more, for given exports, and hence achieve a higher level of welfare (if the additional imports are consumer goods), output (if they are raw materials), or growth (if they are capital goods). A reduction in this capital inflow would force South Africa to reduce its imports -- even without trade sanctions being imposed and as a result the economy would suffer the same kind of short-run economic damage as with direct import sanctions.

Capital sanctions would, of course, invite retaliation. South Africa probably would, as Rhodesia did, react to a ban on capital inflows by banning capital outflows and, more critically, the remission of interest, dividends, etc. on foreign assets in South Africa. It is instructive to examine the joint impact on South Africa's balance of payments of world

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[1] Or perhaps even a multiplied reduction of US $10.64 (equals $1/.094) in total investment!

[2] Source: South African Reserve Bank, March 1978, p. S-81.

[3] The net outflow was R 485 million over 1959-1965 (Harvey, 1975, p. 21).

investment sanctions and such a South African retaliation. In Table 3, the South African balance of payments for 1972-76 is shown.[1] In parentheses are shown what the figures would have been in each year if i) world investment sanctions had cut off all long-term capital movements into and out of South Africa, ii) South Africa had prevented all investment income, non-trade-related service payments, and transfers from moving into or out of South Africa, and iii) trade had (somehow) not been affected by either of these events.[2] It can be seen in Table 3 that the net effect of these changes would have worsened South Africa's "basic balance" in only three of the last five years. Indeed, if South Africa had altered its imports each year so as to have maintained the same basic balance with investment sanctions as it would have had without, its total imports for the five-year period would have had to contract by less than 3 percent. If short-term financing had also become unavailable, and South Africa had had to alter its imports each year so as to have maintained a zero basic balance under investment sanctions, its total imports for the five-year period would have had to contract by less than four percent.

In sum, investment sanctions show much less potential than trade sanctions for causing a reduction in South African imports. Total capital sanctions might reduce imports by only a few percent. In the model of the next two sections, we will make different assumptions about what happens to South African foreign capital flows (i.e., to the balance of trade) under sanctions; as might be anticipated from the above discussion, the results in the short-run, which is all the model considers, are not very sensitive to this choice of assumption.

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[1] 1977 is not yet available.

[2] Travel is also assumed unaffected. The reason for excluding trade effects is not (obviously) to write a realistic scenario but rather to isolate the potential balance-of-payments impact of investment sanctions alone. In reality, of course, many of the capital flows are simply the financial counterpart of a trade flow.

TABLE 3

SOUTH AFRICA'S BALANCE OF PAYMENTS, 1972-1976, WITH AND WITHOUT INVESTMENT SANCTIONS[a,b]

(in R millions)

Category	1972	1973	1974	1975	1976
Exports (including gold)	3,377	4,287	5,729	6,193	7,235
Imports	-2,840	-3,550	-5,768	-6,742	-7,443
Balance of Trade	+537	+737	- 39	- 549	- 208
Services Receipts[c]	762(348)	962(414)	1,114(537)	1,400(662)	1,505(684)
Services Payments[c]	-1,436(-530)	-1,765(-632)	-2,157(-894)	-2,802(-1,045)	-3,023(-1,028)
Transfers (net)[d]	47(0)	14(0)	84(0)	138(0)	96(0)
Balance on Current Account	- 90(+355)	- 52(+519)	-398(-396)	-1,813(-932)	-1,630(-552)
Long-Term Capital Movement (net)	628(0)	214(0)	761(0)	1,746(0)	989(0)
Basic Balance	+538(+355)	+162(+519)	-237(-396)	- 67(-932)	- 641(-552)

[a]Data source: South African Reserve Bank, March 1978, pp. S-57, S-60.

[b]Figures not in parentheses are the actual (i.e., without sanctions) data; those in parentheses are the hypothetical (i.e., with sanctions) data.

[c]"Services" includes "investment income," "non-merchandise insurance" and "earnings and expenditures by foreign workers, communications, advertising, rentals, royalties, etc."

[d]"Transfers" includes "migrants' funds, legacies, grants, etc."

A second factor of production also migrates, in a net sense, into South Africa: labor. The "modern" part of the South African economy receives (net) both white and black labor through migration. International sanctions could attempt to reduce either or both of these flows. The magnitudes are not trivial. South Africa's white population currently has a natural rate of increase (i.e. birth rate minus death rate) of 1.2 percent. Net immigration of whites has, over the past decade, been around 30,000 per annum, which has raised the growth rate of the white population by about one percentage point. White immigration supports the white polity and economy in a number of well-known ways. The availability of black labor from neighboring countries helps to insure an unlimited supply of low-opportunity-cost labor.[1] However, since sanctions along these lines are rarely discussed, I shall ignore them in the work of the next two sections.

In summary, there are two basic kinds of sanctions, trade sanctions and capital sanctions, and two general kinds of impact, in the short run and on growth. South Africa's extreme dependence on imported capital goods makes it very probable that its growth would be critically affected by a reduction in its ability to import. And investment sanctions which reduced its access to new technology would also hurt its growth potential. The impact of sanctions in the short run, however, is much less clear. Sanctions which cut off capital inflows into South Africa would almost surely be met by retaliatory bans on outflows, and the overall short-run effect on imports and output would probably be small. Sanctions which directly reduced imports would certainly directly affect South Africa's output, but by how much is an empirical issue which hinges essentially on the flexibility and adaptability of the South African industrial structure. The model developed and exercised in the next two sections is intended to provide some insight into this flexibility, hence some idea about how much South African output would be reduced by imposed reduction in its imports.

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[1]See Porter, 1978.

IV. A Model to Estimate the Impact of Sanctions

In this section, a model is developed to estimate the short-run effects on the South African economy of various trade and investment sanctions that could be imposed. The model is static, in the sense that the initial capital stock is taken as given throughout, in total and by sector, so that the estimated effects of sanctions can be thought of as those occurring in the short run -- a period long enough that initial stockpiles become irrelevant but short enough that compensatory growth and shifts (and depreciation) of capital are not yet critical. The model is consistent, in the sense that the total supplies from all sources of each output and input must be adequate to provide the total demands for all uses. And the model relies on input-output relationships -- for the output of each of the eight sectors considered, there are needs for inputs of seven kinds of labor, intermediate-good imports, intermediate goods from each of the eight domestic sectors, and plant capacity.

Two ingredients of the model which critically underlie the estimates of the impact of sanctions (calculated in the next section) require discussion before turning to the details of the model. First, it is assumed that the South Africans react optimally to sanctions; that is, they maximize a social objective function,[1] subject to the constraints imposed upon them by sanctions. This means that the model specifically ignores those theories of sanctions that work through reduced aggregate demand or target-country policy failure or inertia. In this sense, therefore, the resulting estimates are of the minimum impact of sanctions. South African policy ineptness, confusion, or inadequacy could immeasurably compound this impact.

And second, it is assumed that there is some substitutability in South African production functions. If there were none, then except as unnecessary final-demand imports could be curtailed, any reduction in imports would mean reductions in intermediate good imports; this, in turn, would cause a proportionate reduction in the output of the sector for which they were destined and unemployment of a proportionate amount of labor and capital there. Such an assumption would be extreme, as examination both

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[1] Its components will be discussed later.

of South Africa's specific imports at the detailed microeconomic level and of the evidence from Rhodesia in the late 1960s shows.[1] But the other extreme, to assume that South African labor and capital could readily produce a replacement for any import, is equally untenable. We shall assume that, even in the short run before new capital can be installed, South African labor can replace imports to some extent but at a high cost.

That is a broad outline of the ingredients of the model. The rest of this section explains the model in greater detail, but still entirely in words. (The equations of the full model are described in Appendix A; the data base and the parameter estimates are shown in Appendix B; and the precise nature of the substitutability between labor and imports is developed in Appendix C.)

The discussion below is first of the constraints on South Africa's economic activity, and then of the objective function of South African policy-makers. There are three kinds of constraints: i) technological constraints; ii) external constraints imposed through international sanctions on imports into South Africa; and iii) constraints which South Africans choose to impose upon themselves. This third group of constraints perhaps needs a few words of general explanation, as it appears inconsistent to try to maximize an objective function and simultaneously to restrict one's actions in that effort. Some of these constraints are historically, culturally, or behaviorally sufficiently entrenched as to be either unrecognizeable to South African policy-makers as potential policy tools or not susceptible to change even under conditions of crisis. Others of these constraints are really part of the objective function, but the extremely non-linear way in which they enter makes it more convenient to consider them as policy constraints.

The technological constraints involve the relationship between the various inputs and each sector's output. For the most part, it is assumed that there is no substitutability between inputs, hence that there is a certain amount of each input required per unit of each sector's output.

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[1] Rhodesia's real GDP fell only in 1966, by 4.4%, while its imports fell by 29.4%. Real GDP began to rise again in 1967, even though imports did not regain their 1965 level until 1971. See Table 1 of Porter (1978a).

Thus, for each of the seven occupations and eight sectors, there are labor-output coefficients (56); there are also interindustry intermediate-good input-output coefficients (64, though many are zero); there are intermediate-good import-output coefficients (8); and there are capital-output coefficients (since capital is unchanging and sector-specific in the short run, these coefficients enter simply through a maximum output level for each sector). The one kind of substitution between inputs which can occur in the model is that labor can replace intermediate-good imports. In terms of Figure 3, if output under sanctions were to require labor and imports in the same ratios as before sanctions, the unit-output isoquant would be the solid right-angled line, $\alpha\beta\gamma$. In the model, we shall assume instead that such imports can be economized if sufficient new labor is employed; hence a range, $\beta\delta$, in which substitution can occur. The unit isoquant employed in the model is therefore the partly solid and partly dashed line, $\alpha\beta\delta\varepsilon$.[1]

Labor in the model is disaggregated into occupations (seven), races (two[2]) as well as sectors (eight). It would be clearly unrealistic to assume that, even in the short run, there is a fixed labor-output coefficient for each kind of labor and for each race. But introducing substitutability -- with less than an infinite elasticity of substitution -- is difficult in a linear programming model. The very system of South African discrimination suggests the solution. Within any broad occupational category such as we are using -- e.g., production or sales worker -- blacks there will be trained to do only the lower-rung jobs and hence would be able to substitute for the better educated, better trained, higher-rung whites to only a limited extent, namely around the ladder-rungs at which the races are divided. Thus, within any occupation, whites and non-whites are assumed perfectly substitutable as long as the ratio between the two races remains within a

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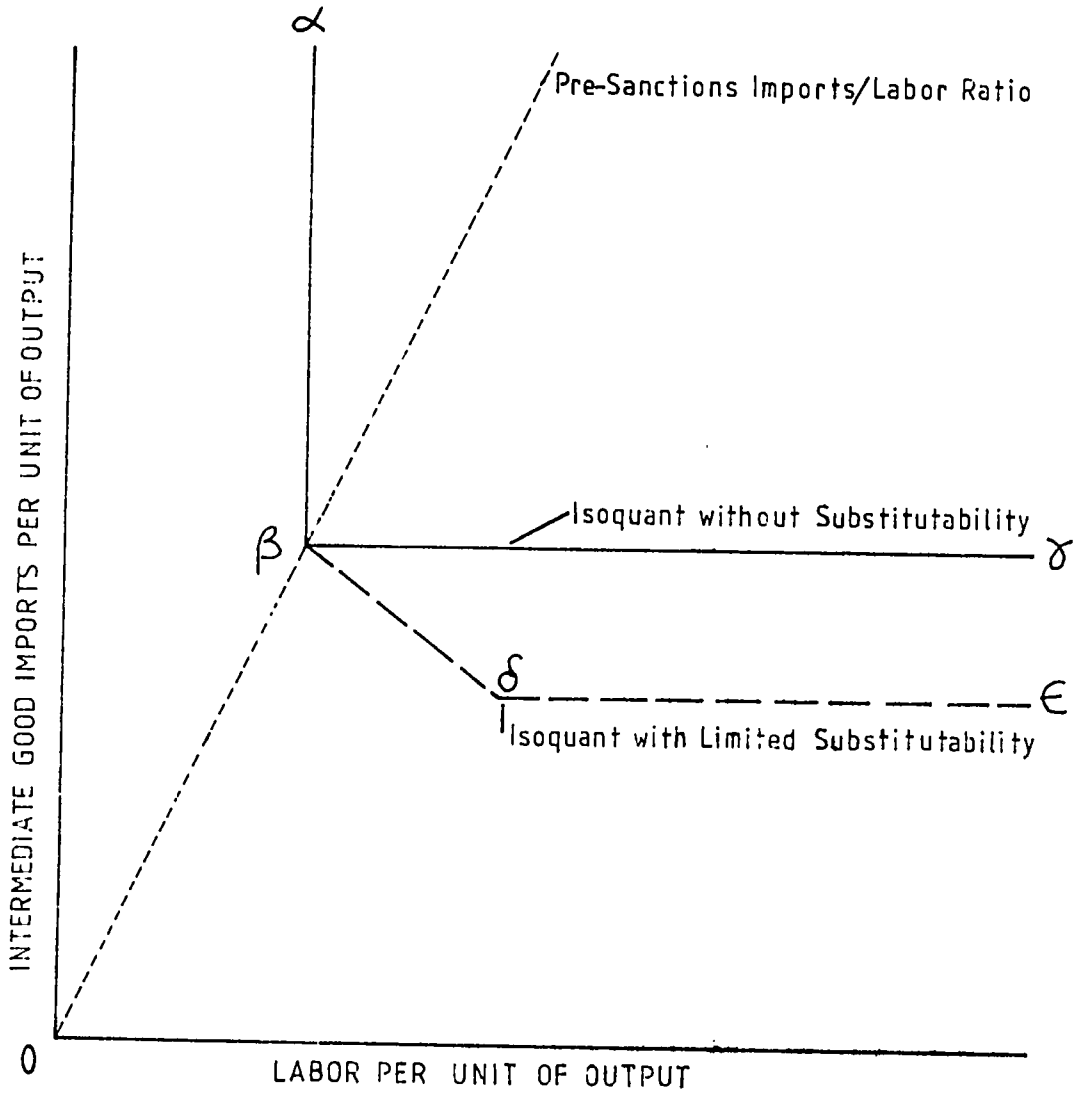
[1]This means, of course, that the implicit production possibility curve of Figures 1 and 2 is not a smoothly curved function.

[2]White and non-white. At the level of aggregation of sectors and occupations, it seemed overly ambitious to attempt to treat "coloureds" and "Asians" separately.

FIGURE 3


α
Pre-Sanctions Imports/Labor Ratio
INTERMEDIATE GOOD IMPORTS PER UNIT OF OUTPUT
Isoquant without Substitutability
β
γ
δ
ε
Isoquant with Limited Substitutability
0
LABOR PER UNIT OF OUTPUT

certain percentage of the pre-sanctions ratio; beyond that percentage, no further substitution is possible.[1] Because the occupational groups are so broad, it seems reasonable to assume that there is no substitutability between labor of different occupations. Finally, a constraint was also included concerning the total number of workers in the more skilled occupations; this is intended to reflect the fact that, in the short run, the amount of labor upgrading and training that can be completed is quite limited.

The possible constraints imposed on South Africa through international sanctions have been extensively discussed in the previous two sections. Here it need only be recalled that their common denominator is the withholding of crucial imports. The model treats this not as a direct curtailment of imports but rather as a reduction in exports and/or foreign capital flows, which in turn means a reduction in foreign exchange earnings by South Africa, hence its ability to pay for imports. In the next section, the extent to which exports and the balance of trade are affected by sanctions will be varied among simulations, but the effect is always to reduce imports, hence the ability of the South African economy to produce output. The sanctions this model considers are always reductions in imports, but South Africa is always left free to determine the composition of these imports. Direct restrictions on the composition of imports would further hurt South African GDP.

Although is it difficult to forecast how policy-makers will react to a crisis of a nature and extent not previously observed, there are clearly constraints on what South African policy can do. We assume relatively few constraints; if there are more, and they are binding, then the GDP estimates of this model are biased upward (that is, the harm done by sanctions would in fact be greater than here estimated). The policy constraints in the model:

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[1]Of course, in the long run, even in South Africa, workers of the same occupation but different races are potentially substitutable to any extent. But we here are concerned with the short run within a system of continuing, institutionalized racism.

1. The long run must not be sacrificed, thus the total and sectoral composition of investment is to be maintained (if possible).

2. The need for government activity is not reduced because of the crisis, thus total government consumption is to be maintained (if possible) and its sectoral composition varied only within narrow limits.

3. The sectoral composition of private consumption can only be varied, in the short run, within narrow limits.[1]

4. Full employment of the white labor force is to be achieved (if possible).

5. White laborers are not to be "uprooted" (if possible), so the total number of white workers in each occupation-and-sector is subject to change only within narrow limits.[2]

The objective of South African policy-makers, once faced with sanctions, is assumed to be simply the maximization of total output, or GDP. Other objectives were considered -- such as the maximization of total white (wage plus nonwage) income or consumption -- but, given the model and its constraints, this seemingly important change did not much affect the results of the simulations.

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[1]This means, of course, that the implicit community indifference curve of Figures 1 and 2 is not a smoothly curved function.

[2]The parenthetical "if possible" (in each of the constraints except #3) indicates that the constraint will be relaxed if no solution is feasible when the constraint is included. (The precise way in which they are relaxed is described in Appendix A.) That these constraints have been relaxed is signaled in the next section by reference to a "less exacting set of policy constraints."

V. Estimates of the Impact of Sanctions

This section, which estimates the impact of sanctions (according to the model described in the previous section), is divided into four parts. First, a baseline picture is established of a South African economy that is prepared for, but not yet actually subject to, sanctions. Second, the economy is simulated, through the model, as if it were subject to sanctions which reduced its exports and capital inflows by various across-the-board percentages. Third, the sensitivity of the results to changes in parameter values and assumptions is explored. And finally, a "greatest impact" of sanctions is estimated by moving simultaneously all parameter values and assumptions to their most damaging but still plausible extremes.

A baseline picture of the South African economy without sanctions must be drawn in order to estimate the impact of sanctions. Although the actual official South African statistics of some recent year would seem to provide an adequate base, there are two problems. First, the data needs of the model are sufficiently great that the year 1967 had to be chosen as the base.[1] Moreover, since data from different official sources had to be molded into one internally consistent set, the base-year "1967" that emerged is not exactly the same, in most of its statistical components, as any official South African "1967." The adjustments are more fully explained in Appendix B.

The second difficulty with using actual data as a basis for comparison is that South Africa has never urgently anticipated the imposition of sanctions. Thus, the proper comparison, for estimates of the impact of sanctions, is between South Africa under sanctions and a South Africa prepared for, but not actually suffering from, sanctions. The very preparation process, which would presumably achieve a fuller utilization of existing supplies of capital and labor, might itself raise South Africa's GDP. Accordingly, the base year itself requires simulation. This picture of South Africa before sanctions but prepared for sanctions is created by running the model with exports and the balance-of-trade deficit only constrained to be no greater than their actual 1967 levels.

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[1] Real GDP rose by about one half between 1967 and 1977.

The "actual" data of 1967, adjusted as described in Appendix B, and the hypothetical model-generated 1967 data of a South Africa prepared for sanctions are compared in Table 4.[1] The model indicates that two notable changes occur in this process of becoming prepared. First, exports and imports are reduced about six percent. This seems curious in that sanctions have not yet been imposed, but what it actually reflects is a large reduction in luxury consumption imports and a simultaneous reduction in the need to export to pay for them -- and hence a release of export-labor for production in domestic activities. And second, GDP is expanded by three percent, chiefly by the use of more non-white labor.[2] The figures in the "prepared" column of Table 4 are the base-year data to which all subsequent simulations are compared.

There are an infinite variety of trade sanctions that could be applied to South Africa -- different combinations of sanctioning countries, different combinations of prohibited exports (to South Africa), and different degrees of success in applying those sanctions. The model is too aggregated to explore this variety fully. Here, we will look primarily at across-the-board sanctions; meaning that the maximum value of each sector's exports[3] and the net capital flow (i.e., the trade balance) is reduced, through sanctions, by some percentage. The simulations consider these cuts in 10-percent jumps, from 10% through 60%. Such across-the-board, but less than 100%, sanctions can be interpreted as a less than complete world involvement in the sanctions and/or a less than complete success at implementing universal sanctions. The simulations cease at 60% across-the-board reductions simply because I felt that by then, the basic structure of the South African economy would surely have become so changed that the model would no longer describe it.

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[1]The fact that the two differ indicates either the extent to which the model is inaccurate or that the economic objectives of South Africa, when not sanctioned, involve other variables than GDP. I am assuming it is largely the latter. Indeed, the larger GDP with "preparedness" may well require policy actions that are dysfunctional for the economy under normal circumstances (a point suggested in correspondence by Desaix Myers).

[2]Recall, white labor is assumed to be already at maximum employment.

[3]Actually, only six of the eight sectors export; see Table B-1 of Appendix B.

TABLE 4

THE ACTUAL AND PREPARED SOUTH AFRICAN ECONOMY, 1967

(R millions)

Statistic		South African "Data," 1967 Actual	"Prepared"[a]	Percentage Difference[b]
Value Added in				
Agriculture	(1)	941	1,009	+7.2%
Mining	(2)	953	963	+1.0
Manufact'g	(3)	1,507	1,632	+8.3
Construction	(4)	413	414	+0.2
Electricity	(5)	228	247	+8.3
Trade	(6)	632	653	+3.3
Transport	(7)	1,228	1,150	-6.4
Services	(8)	2,253	2,332	+3.5
Total (GDP)		8,156	8,400	+3.0
Exports	(E)	2,547	2,396	-5.9
Imports	(M)	2,440	2,289	-6.2
Deficit	(D)	-107	-107	--[c]
Wage Income				
of Whites		2,740	2,747	+0.3
of Non-Whites		1,193	1,272	+6.6
Non-Wage Income		4,223	4,382	+3.8
Employment[d]				
White		1,190	1,190	--[c]
Non-White		5,179	5,510	+6.4

[a]See text for description of this term.

[b]Prepared minus Actual, divided by Actual.

[c]Constrained to zero; any difference is due to rounding error.

[d]Thousands of workers.

The simulated results of these across-the-board percentage cuts are shown in Figure 4. The data for the zero "cut" represent the "prepared" but not yet sanctioned economy described earlier. 10% and 20% reductions have relatively small impacts on GDP and its components.[1] The implied elasticity of GDP with respect to sanctions is less than one-half -- that is, for small reductions, an x% across-the-board cut in exports and the trade balance causes a less than 1/2 x% cut in GDP.

The impact increases significantly once 30% cuts are considered. GDP drops to R 6,575 million, 21.7% below the prepared but not yet sanctioned level of R 8,400 million. The cause of this increased impact is not hard to find. Initially, imports of finished consumption goods comprise 17.8% of total imports. When sanctions are applied, luxury consumption imports are foregone (by South Africa) first. These provide a cushion of expendable imports that prevent "light" sanctions from having much impact on real output. But, by the time 30% cuts are reached, consumption-good imports have fallen to only 8.5% of total imports, and the remaining consumption goods are not so readily given up. At somewhere between 20% and 30% effectiveness, sanctions begin to "bite."

At 40% across-the-board sanctions, there is <u>no feasible solution</u> to the model. By then, sanctions have become sufficiently constricting to the South African economy that all the technological, behavioral and policy constraints of the model cannot be simultaneously satisfied. The South African reaction must be to relax some of the policy constraints. Specifically, I assume that in this circumstance: i) investment can no longer be held at its pre-sanctions level but is only required to be at its pre-sanctions ratio to consumption; ii) ditto for government expenditures; and iii) the "uprooting" of white laborers (i.e., their transfer to other occupations and/or sectors) will be permitted to whatever extent necessary.[2]

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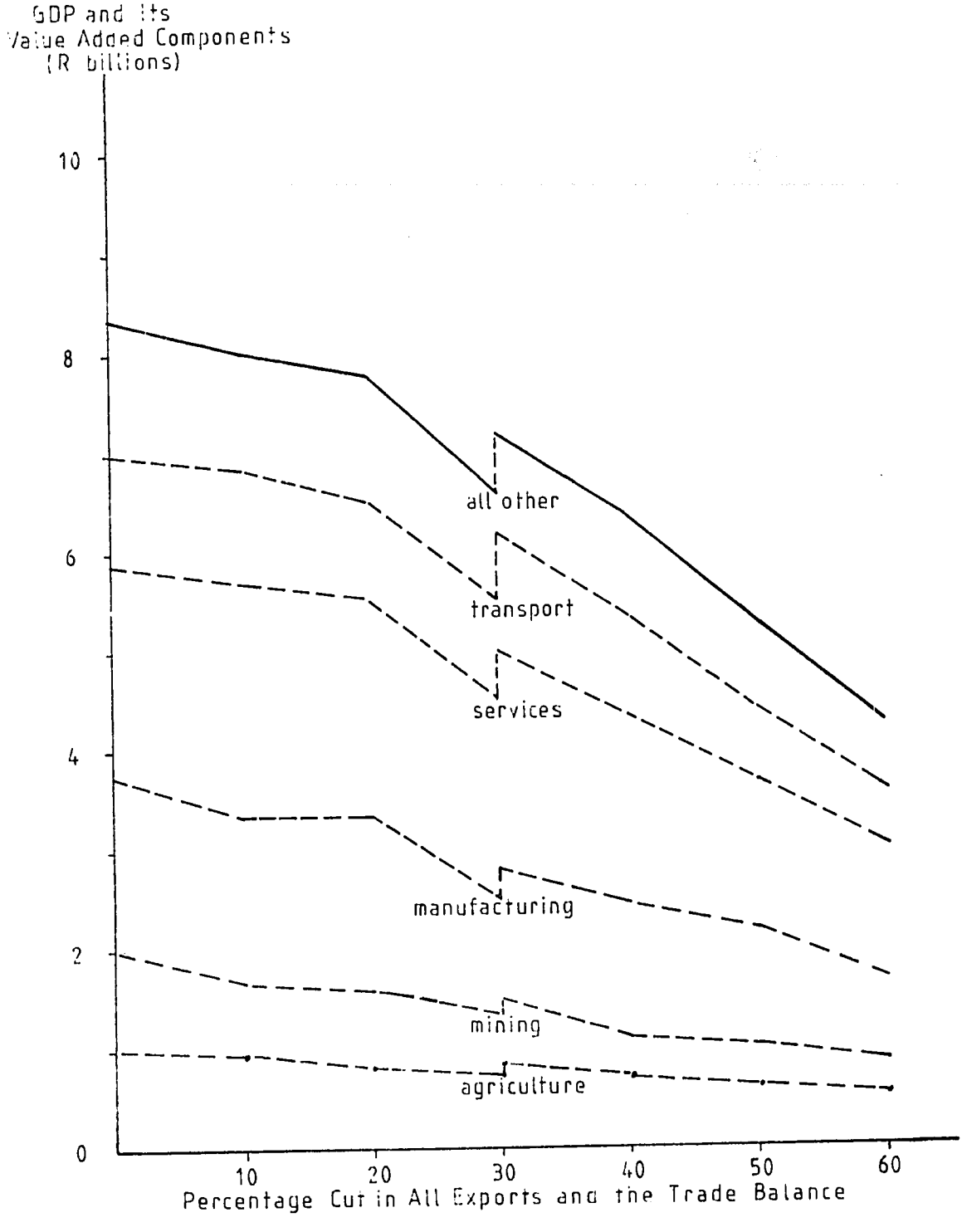
[1] GDP declines from R 8,400 million to R 8,036 million and R 7,811 million, respectively.

[2] Subject still, of course, to a technological constraint on the rate at which new labor can be trained in the skilled occupations. The white full-employment constraint is also relaxed, but white employment is then included in the objective function. (For detailed description of these changes, see Appendix A.)

FIGURE 4 Impact of Across-the-Board Trade Reductions



This less exacting set of policy constraints permits the South Africans to find a feasible solution under sanctions-imposed export cuts of 40% or more.

With the less exacting set of policy constraints, a 30% across-the-board cut in all exports and the trade balance reduces GDP to R 7,002 million. (This is shown, in Figure 4, as the higher of the set of points above 30%.) The implied elasticity of GDP with respect to sanctions remains less than one half. But the achievement of this feasible solution is not without cost. Investment drops to R 2,082 million, only 86.0% of its pre-sanctions level. Similarly, government expenditures are reduced to R 820 million, also (perforce) 86.0% of their pre-sanctions level. There is, moreover, some "uprooting" of white labor, particularly in two sectors (and in one of which, mining, white labor has historically proven the most troublesome in South Africa). In the process of achieving the feasible solution at 30% export cuts, there are 18 thousand white workers laid off in mining, a reduction of 31.0%, and 19 thousand white workers withdrawn from the trade sector, a reduction of 15.8%. Particularly in mining, this may represent a politically intolerable shift in the structure of white employment.

Once the adjustment is made to the less exacting set of policy constraints, further across-the-board reductions in exports and the trade balance as a result of sanctions cause quantitatively even more severe, but qualitatively similar, output reductions. As 40%, 50%, and 60% sanctions are simulated, South Africa's GDP drops to 74.5%, 62.3% and 50.3%, respectively, of its pre-sanctions (but "prepared") level. Clearly, sanctions at these levels can cause significant damage to South African GDP. The damage is not only in the loss of output. With 60% sanctions, 10.3% of the white labor force becomes unemployed (and non-white employment has fallen from 5,510 thousand in the pre-sanctions situation to 4,530 thousand, i.e., by 17.8%). And the uprooting of whites in certain sectors has become an immense problem; for example, 37.4% of the white construction workers and 30.6% of the white manufacturing workers must be laid off (or reallocated to other sectors).

There are two other basic variations of sanctions that were examined. First, we have so far estimated the impact of sanctions which had "across-the-board" effects on exports -- that is, which reduced the exports of all sectors by the same percentage; but South Africa's mining sector exports appear much less vulnerable to sanctions than are its other exports. Let us consider the extreme case where sanctions are completely effective against the exports of all sectors other than mining but are completely ineffective against the exports of the mining sector. This means a 100% reduction in the non-mining 55% of South Africa's total exports,[1] and the results of this simulation of unbalanced sanctions can be meaningfully compared to across-the-board sanctions which achieve 50% or 60% reductions in each sector's exports.[2] In fact, the aggregate statistics of the mining-exports-only simulation compare quite closely to the 50% across-the-board sanctions, as Table 5 shows. GDP and consumption are only slightly lower. And white full employment continues to be achieved in the mining-exports-only situation, as it had in the 50% but not in the 60% across-the-board case. The difference between the two lies, as one might guess, in the mining sector. In the mining-exports-only simulation, value added and employment in mining are 80.4% and 225.0% higher, respectively, than in the 50% across-the-board simulation. In the 50% across-the-board case, nearly half the white (and non-white) mining workers must be laid off; while in the mining-exports-only case, the white (and non-white) mining work force must be almost doubled -- somehow -- from its pre-sanctions level.

The second variation examines the impact, ceteris paribus, of sanctions that affect the net capital flow differently from the trade flow. In the across-the-board simulations, each sector's exports and the balance of trade were all varied by the same percentage. Now, we consider a situation in which each sector's exports decline by some percentage but the balance of trade does not change. Since the balance of trade was positive in the

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[1] It is also assumed in this run that trade is balanced, i.e., that sanctions effectively stop all capital flows that might permit trade imbalance.

[2] All runs are made with the less exacting set of policy constraints.

TABLE 5

COMPARISON OF ACROSS-THE-BOARD AND MINING-EXPORTS-ONLY SANCTIONS

(R millions and thousands of workers)

Statistic	Prepared But Not Yet Sanctioned	Across-the-Board Cuts of 50%	Across-the-Board Cuts of 60%	Mining Exports Only
Value Added in				
Mining (2)	963	491	398	886
Total (GDP)	8,400	5,234	4,224	5,130
Consumption (C)	4,918	3,072	2,479	3,042
Employment in				
Mining (2)[a]	594	336	491	1,092
Total White	1,190	1,190	1,068	1,190
Total Non-White	5,510	5,461	4,530	5,388

[a]Production workers only (i.e., $L_{162} + L_{262}$).

base year, this is equivalent to assuming that net capital movements into South Africa were reduced by a larger percentage than were exports, thus that imports must also be reduced by a larger percentage. In the simulation actually undertaken, exports were reduced, across-the-board, by 30% and the balance of trade kept at its initial level. This meant that imports had to be reduced by (at least) 31.31%. In order to see the difference between the effect of import cuts caused by trade sanctions and those caused by capital flow sanctions, we will compare these results with an across-the-board export and trade surplus reduction of exactly 31.31%. Imports are reduced identically in the two cases, but the export total is reduced 30% in one case and 31.31% in the other.[1] The difference, as one would hypothesize from the discussion in Section III, is slight. GDP differs by only 0.3% in the two cases.

Before conducting sensitivity tests, we should notice exactly where in the South African economy the critical pressure of sanctions is felt -- or more precisely, in the terms of the linear-programming model and its optimization, which of the constraints are most binding[2] at the optimal solution. Rather than report on all the simulations, I will examine two in detail, the 30% and the 60% across-the-board export and trade balance reductions, both under the less exacting set of policy constraints.

At 30% sanctions, many of the foreign trade, import-substitution and labor constraints are already seriously binding. If sanctions could be evaded to the extent that R 1,000 of additional exports could be made, hence R 1,000 of additional imports be acquired, the South Africans could raise their GDP by from R 3,419 to R 3,978, depending upon which sector did the exporting. If R 1,000 of additional capital inflow could be induced, South Africa could add R 3,135 to its GDP. Thus, on the margin (of 30% effective sanctions), each R 1,000 cut in South Africa's exports or capital inflow imposes a loss of output of R 3,000-4,000. Given the costliness of the export losses, the South African economy

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[1] The composition of exports by sector is the same in both cases.

[2] By "most" binding, I mean binding in costly fashion, this being indicated by the shadow price of the constraint.

turns to intensive efforts at import substitution. But there are limits to this process in the short run, and these limits are reached in two sectors, manufacturing and electricity. Furthermore, the ability to reduce final-goods imports, as a percentage of total deliveries, is exhausted for both private and public consumption. The limits of import substitution are not reached in the other sectors because of a scarcity of skilled white labor: an additional white laborer would permit sufficient new hiring of non-whites, labor reallocation and extra import substitution to be worth R 550 in added GDP.[1] Thus, at 30% effective sanctions, any sanctions-induced net white emigration would add somewhat to the economic damage.

At 60% sanctions, several more constraints have become binding. A marginal gain of R 1,000 of exports would mean GDP gain of from R 4,871 to R 5,656, depending on the sector from which the export is made; and a marginal R 1,000 of capital inflow would be worth R 4,503 in GDP. At 60% sanctions, the limits to import substitution have been reached in almost every sector.[2] Scarcity of white labor no longer provides any constraint; to the contrary, white unemployment has become serious.[3]

Sensitivity tests were performed on the model by moving, individually and in combinations up and down by 40% of their basic values, many of the parameters of the model, especially those whose values were based more on intuition than evidence. In none of these tests was the solution value of GDP moved by as much as one percent, except when the parameters representing the maximum limits to import substitution by sector[4] were altered. Let us look at the solution when these limits are all contracted by 40%.[5] With

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[1] While this figure seems low (see Table B-4), it must be remembered that this marginal white is employed in costly import substitution.

[2] The limit is not quite reached in construction.

[3] The unemployment could only be avoided by downgrading whites to low-rung jobs normally done by non-whites.

[4] I.e. the values of the eight h_j's (see Appendices A and B).

[5] I.e. each h_j is reduced by 40% of its basic value (see Appendices A and B).

sanctions that effect across-the-board 40% cuts in exports and the trade balance and with the basic parameter values, South African GDP would be cut from $ 8,400 millions (i.e. the pre-sanctions but prepared level) to R 6,260 millions -- that is, by 25.5%. If the simulation is re-run reducing the parameters limiting the scope for import substitution by 40%, the GDP drops still further, to $ 5,730 millions, that is, by another 6.3 percentage points.

In a way, the sensitivity tests tell us what we could well have guessed; namely, that one's estimate of the short-run impact of sanctions on South Africa depends importantly on the estimate of the limits to short-run South African import substitution. But there is a more interesting interpretation of these results. The estimates of the impact of sanctions are not so sensitive as we might have expected to the estimates of the limits to import substitution. In each of the sectors, a careful, plausible guess was made as to these limits. Now these limits are arbitrarily cut by 40% of that guess. And the resulting estimates of the impact of 40% effective sanctions changed by only a few percentage points - i.e. from a 25.5% cut in GDP (from the pre-sanctions level) to a 31.8% cut.[1] In short, the sensitivity tests greatly raise our confidence that the estimates produced by the model are in the right "ball park" and are not highly sensitive to the largely intuited ingredients.

One final sensitivity test was performed, whereby all the arbitrary parameters were simultaneously moved to values 40% from their basic values in the direction which increased the damage to South African output owing to sanctions. Specifically, this "greatest impact" simulation assumed the following:[2]

1. The South African objective function places heavy weight on white employment, to the point where R 2,000 of output (GDP) will be given up in order to employ one more white worker.

2. Sanctions cut all exports and the trade balance to zero, except for mining exports, which continue undiminished.[3]

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[1] In other words, the estimates of impact moved by 25% (31.8 minus 25.5, divided by 25.5) in response to a 40% change in the critical set of parameters.

[2] See Appendix B for the exact description.

[3] Thus, maximum total exports are reduced by 54.8% and imports must be reduced by at least 52.8%.

3. Import substitution is made still more costly,[1] and its limit reduced by 40%, in all sectors.

4. The initial excess capacity in each sector is reduced by 40%.

5. The maximum number of new members that can be trained for the skilled occupations in the short run is lowered by 40%.

6. The extent to which blacks and whites are substitutable for each other, in any given occupation-and-sector, is narrowed by 40%.

7. The degree of flexibility in the sectoral composition of public and private consumption is reduced by 40%.[2]

This "greatest impact" simulation should be compared to the "mining exports only" simulation (see Table 5) since both incorporate the same export assumption. Worsening all the arbitrary parameters at once lowers the estimated GDP from R 5,130 million to R 4,591 million, an additional 6.4% (of the prepared but not yet sanctioned level of R 8,400). Thus, the output estimates are not too sensitive to this extensive parameter variation.[3] Employment estimates, however, tell a different story. Whereas white full employment had been achieved in the mining-exports-only simulation, this greatest-impact simulation displays an 11.8% white unemployment rate (and a reduction also in non-white employment of 14.7%). Thus, the employment estimates generated by the model are fairly sensitive to parameter variation.

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[1] Intermediate inputs as well as labor are required to replace imports (see the "D" simulation of Appendix D, and especially equation (D-12)).

[2] Also, the less exacting set of policy constraints is introduced since, without them, no solution is feasible.

[3] The reduction in the limits to import substitution alone reduced GDP by 6.3%, so all the other changes make practically no difference.

VI. Conclusions and Caveats

Estimates of the impact of sanctions on South Africa depend critically on the kinds of sanctions one envisages, the extent to which they are imposed and enforced, and whether one thinks of the short run or the long run.

Although the analysis in this paper of the long run is brief, it seems clear that sanctions could seriously damage South Africa's growth rates. Cut off from access to new foreign technology and imported capital goods,[1] South Africa could not continue to grow at anything like its historical rates,[2] and perhaps not at all.

The short-run impact of sanctions depends critically on the extent to which imports into South Africa are reduced. Capital, or investment, sanctions would probably not much affect such imports -- especially after the expected South African retaliation cut off capital outflow -- and hence in themselves would not much affect South African production.

Direct restriction of South Africa's ability to import could have a serious impact, in the short run as well as the long run, on South Africa. How much impact would depend on the effectiveness of the embargo. If South Africa's imports were reduced by less than one-fourth, little economic damage would be inflicted - each one percentage-point cut in imports would cause about a one-half percentage-point cut in GDP. Once imports were reduced by more than one-fourth, the damage would become more significant. The elasticity of GDP reductions with respect to import reductions rises to about one and one-fourth, as import reductions reach one-half. Should imports be cut by more than one-half, massive unemployment and relocation of white labor (as well as of non-white labor) would have begun to occur.

There are four caveats needed before concluding. First, models like the one developed and exercised here are inevitably stylized abstractions of the economy they try to represent. Anyone who has worked with sectoral optimization models (especially for LDCs) knows that they can occasionally

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[1] The goods themselves, not just the capital flow that shows up in the balance of payments.

[2] 5.5 percent over the past quarter century, 4 percent in the 1970s (growth rates per annum of real GDP).

-- and not so occasionally as one would like -- generate nonsense, despite the fact that each ingredient seems a plausible if simplified representation of reality. The proper defense of the model developed here is hardly unbounded faith in complex mathematical modeling but rather a lack of confidence in the alternative, the hidden models that underlie gut reactions and broad judgments.

The second caveat follows the first. Even if the model is a sensible simplified replication of the South African economic structure, that structure might alter dramatically under the pressure of sanctions. The model, with its innately unchanging view of structure, might then forecast quite badly. While such structural change cannot be easily encompassed within a model, it must be remembered that it is also difficult to foresee without a model. This shortcoming is probably not too serious as long as our concern is with the short run. But conclusions about South African growth under sanctions require a strong implicit assumption about South Africa's ability to alter the structure of (i.e., create) its capital goods industries. To the extent that history provides evidence, it is that modern economies fare better than we might expect when struck by calamity.[1] But this recent evidence includes no observations of economies so dualistic and so internally divided at the time of crisis as is South Africa today.

The third caveat, clear to the careful reader of Sections IV and V, is that the model does not remove our uncertainty about the impact of sanctions. Rather, it serves only to locate its source and circumscribe it. In the end, the estimates of the parameters of South Africa's potential for import replacement are largely guesses. The results are not terribly sensitive to variations in these guesses, but they nevertheless are dependent upon them.

Finally, one should recognize that the direction of error of the results is not clear. The model assumes that South Africa maximizes GDP under sanctions, and it would therefore appear that its actual GDP under sanctions would be surely lower than the model estimates. But the model specifies many structural rigidities -- for example, in the composition of consumption and the mobility of white labor -- that may in fact turn out to be quite flexible in a beleaguered South Africa. Accordingly, it is impossible to be sure whether the estimates (presented in Section V) are high or low.

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[1]See, for example, the brief surveys and analyses in Hirshleifer, 1963.

APPENDIX A

THE MODEL

The model of the text is a static linear programming model in which South Africa is assumed to maximize an objective function in the face of various linear constraints. Some, the result of sanctions, are externally imposed constraints on exports, imports and capital flows. The rest of the constraints represent restrictions on South African choices imposed by custom, behavior and technology. In all, three objective functions are considered, 253 variables, and 411 constraints (of which 165 are equalities and 246 are inequalities).[1]

The organization of this appendix is as follows. First, the variables and their symbols are listed and defined. Second, the accounting identities of the model are given. Third, the constraints are discussed. And fourth, the objective function is explained.

Variables. In general, the variables of the model are written as capital letters (parameters and subscripts being written in lower case). There are eight production sectors, referred to with the subscript i or j. There are seven occupations, referred to with the subscript o. Two races of laborers are considered, referred to with the subscript r. All value variables are in rands at 1967 prices.

The variables:

X_j = gross value of output of sector j.

X_{ij} = intermediate input flow of output from sector i to sector j.

C_i = final consumption goods produced by sector i.

I_i = final (fixed and inventory) investment goods produced by sector i.

G_i = final government consumption purchases from sector i.

E_i = exports of sector i.

M_j = imports of intermediate inputs for use in sector j.

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[1] Some of these constraints are altered or eliminated when a less exacting set of policy constraints is considered.

M_C, M_I, M_G = imports of final goods for consumption (C), investment (I), and government (G), respectively.

V_j = value added in sector j.

C = aggregate consumption.

I = aggregate investment.

G = aggregate government current-account expenditure.

E = aggregate exports.

M = aggregate imports.

D = balance-of-trade deficit.

Y = GDP.

W_r = wage earnings of laborers of race r.

N_j = non-wage earnings in sector j.

N = aggregate non-wage earnings.

L_{roj} = laborers of race r and occupation o employed in sector j.

The total potential number of variables is 253, although many of these (especially the inter-industry flows, X_{ij}) will be zero for all simulations. All of the variables, with the sole exception of D, are throughout constrained to be non-negative.

Identities. The total output of a sector[1] (X_i) must be exactly used up, either in intermediate uses (X_{ij}) or in final demands (C_i, I_i, G_i, and E_i):

$$X_i = \sum_j X_{ij} + C_i + I_i + G_i + E_i. \qquad \text{(A-1)}$$

The total value of a sector's output (X_j) consists of intermediate inputs from domestic sectors (X_{ij}) and abroad (M_j) and of value added (V_j):

$$X_j = \sum_i X_{ij} + M_j + V_j. \qquad \text{(A-2)}$$

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[1]The sectors are:

1. Agriculture
2. Mining
3. Manufacturing
4. Construction
5. Electricity
6. Trade
7. Transport
8. Services

See Appendix B for sources and data details.

The aggregates of consumption (C), investment (I), government expenditure (G), and exports (E) consist of the final goods delivered to them from each domestic sector plus those imported directly:

$$C = \sum_i C_i + M_C \quad ; \tag{A-3}$$

$$I = \sum_i I_i + M_I \quad ; \tag{A-4}$$

$$G = \sum_i G_i + M_G \quad ; \text{ and} \tag{A-5}$$

$$E = \sum_i E_i \quad . \tag{A-6}$$

Re-exports are ignored in the model so that no M_E is considered.

Aggregate imports (M) are the sum of intermediate good imports into each sector (M_j) and imports of final products for consumption, investment and government expenditure:

$$M = \sum_j M_j + M_C + M_I + M_G \tag{A-7}$$

The balance-of-trade deficit (D) is simply the excess of imports over exports:

$$D = M - E. \tag{A-8}$$

Aggregate value added, or GDP (Y), is the sum of final goods demands minus imports:

$$Y = C + I + G + E - M. \tag{A-9}$$

Value added in each sector consists of wage and non-wage payments to the factors employed in that sector:

$$V_j = \sum_r \sum_o w_{roj} L_{roj} + N_j \quad . \tag{A-10}$$

The wage payments in sector j are the product of the wage rate (w_{roj}) and the quantity employed (L_{roj}) of each of the r races and o occupations laborer, summed over r and o. The wage rates are parameters and are assumed not to change over the simulations despite any changes in the employment situation.

The total wage earnings of each of the races (W_r) is the sum of those earnings across sectors and occupations:

$$W_r = \sum_o \sum_j w_{roj} L_{roj} \quad . \tag{A-11}$$

Aggregate non-wage earnings are also the sum across sectors:

$$N = \sum_j N_j \quad . \qquad \text{(A-12)}$$

One could also write, as an identity, that GDP (Y) is the sum of income shares, i.e., $Y = \sum_r W_r + N$, but this is not an independent equation; it is derivable from the other identities.

Constraints. There are three kinds of constraints on the South African economy, as reflected in the model. The first are essentially technological, and these are discussed first. Then there are the constraints imposed from abroad -- i.e., by the international sanctions. And finally, there are constraints imposed by the South Africans themselves, through the pressures of culture, behavior and/or policy targets.

The essence of an input-output model is in its recognition of the need for inter-industry flows of intermediate goods. Here this dependence is assumed to be linear and proportional to the gross output of each sector:[1]

$$X_{ij} = a_{ij} X_j \quad . \qquad \text{(A-13)}$$

Production also requires imported intermediate inputs; and in the case of the final demands (private consumption, investment and government consumption), an imported component is demanded. But this model does not assume that the ratios of such imports (M_j) to gross output (X_j) are inflexible.[2] The flexibility is reflected by a range for each such ratio, bounded by an upper and a lower limit. The upper limit is the actual base-year (i.e., pre-sanctions) ratio, m_j; thus,

$$M_j \leq m_j X_j \ ,$$

$$M_C \leq m_C C \ ,$$

$$M_I \leq m_i I \ , \text{ and}$$

$$M_G \leq m_G G \ . \qquad \text{(A-14)}$$

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[1]Except in Appendix D and the final simulation of Section V. There (see equation D-12), it is recognized that reductions of intermediate imports, induced by sanctions, will require each sector to utilize not only more labor (see equation A-16) but also increase domestic flows of intermediate goods.

[2]Similarly, the ratios for final demands are permitted some flexibility.

And the lower limit is some fraction, $1 - h_j$, of that base-year ratio:

$$M_j \geq (1 - h_j)\, m_j\, X_j \,,$$

$$M_C \geq (1 - h_C)\, m_C\, C \,,$$

$$M_I \geq (1 - h_I)\, m_I\, I \,, \text{ and}$$

$$M_G \geq (1 - h_G)\, m_G\, G \,. \qquad \text{(A-15)}$$

As imports are reduced from their upper limits - i.e., the "normal" base-year levels -- toward their lower limits, ever more labor is required. This import-substitution labor is required in addition to the normal labor needs of production, which are captured here through a linear, proportional (at ℓ_{oj}) ratio of labor to output for each occupation and sector. Labor needs, by sector and occupation (i.e. $\sum_r L_{roj}$), are therefore:

$$\sum_r L_{roj} = \ell_{oj}\,(1 + v_j)\, X_j - \frac{v_j\, \ell_{oj}}{m_j}\, M_j \,. \qquad \text{(A-16)}$$

Equations (A-16) are fully derived and explained in Appendix C, so it suffices here to notice that the parameter, v_j, indicates the degree of technical difficulty in substituting labor for imported inputs. As v_j goes to infinity, this difficulty becomes insurmountable; at a v_j of zero, no difficulty is encountered.

The model considers the impact of sanctions over a period sufficiently brief that it is impossible for South Africa to augment or sectorally shift its extant capital stock -- this is called "the short run". Accordingly, capital need not be explicitly introduced as a variable in the model, but it must be recognized that capacity limits exist in each sector and that the potential for output increases is limited.[1] Here this limit is expressed as:

$$X_j \leq (1 + b_j)\, \bar{X}_j \,, \qquad \text{(A-17)}$$

where $\bar{X}_j$ is the base-year value of gross output in j, and b_j is a parameter indicating the degree of excess capacity that can be mobilized when the

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[1]The role of capital is spelled out in somewhat greater detail in the course of Appendix C.

[2]In general, a bar over a variable means its base-year value and is interpreted as the pre-sanctions, "normal" value.

economy is faced with sanctions.

In the more highly skilled occupations, there are limits to the rate at which new practitioners can be trained in the short run. This limit is written here for three occupations[1] (professional, administrative and clerical) as:

$$\sum_r \sum_j L_{roj} \leq (1 + q) \sum_r \sum_j \bar{L}_{roj} \quad , \qquad \text{(A-18)}$$

where the parameter q indicates the maximum percentage by which these three kinds of labor can exceed their base-year levels.

Up to now, we have been treating labor in color-blind fashion -- that is, assuming that white and non-white labor are productively interchangeable.[2] Presumably, in the long run, if different races were not hampered by public policy or social custom, labor of different colors would indeed be interchangeable within any correctly defined occupational group. In South Africa, on the other hand, the long history of educational and occupational discrimination against non-whites has meant that they have been relegated to "low-rung" jobs on the occupational ladder. This, together with the fact that this model distinguishes only seven quite broad occupational classifications, means that within any given occupation, blacks and whites are almost certainly <u>not</u> perfectly substitutable for each other. For simplicity in the model, limited substitutability is assumed to mean perfect substitutability within a narrow range and no substitutability beyond that range. The ratio of non-white to white workers (L_{2oj}/L_{1oj}) within any o and j must

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[1] The seven occupations are:

1. Professional
2. Administrative
3. Clerical
4. Sales
5. Farmer
6. Production
7. Service

See Appendix B for sources and data details.

[2] See constraints (A-16) and (A-18); in both, L_{roj} is aggregated, on a one-to-one basis across the races (r). The races are:

1. White
2. Non-White

remain within plus-or-minus s percent of the base-year ratio for that o and j:

$$L_{2oj} \geq (1 - s)\,(\bar{L}_{2oj}/\bar{L}_{1oj})\,L_{1oj} \quad \text{, and} \qquad \text{(A-19)}$$

$$L_{2oj} \leq (1 + s)\,(\bar{L}_{2oj}/\bar{L}_{1oj})\,L_{1oj} \qquad \text{(A-20)}$$

These (constraints (A-13) through (A-20)) are the technological constraints in the model.[1]

International sanctions may provide several kinds of constraints on the operation of the economy. We shall view the sanctions as potentially placing restrictions on all of South Africa's exports, capital inflow and imports, although we shall include formally in the model only two of these three kinds of restrictions. Sanctions could limit the total and/or the composition of South African exports; we shall assume they do both:

$$E_i \leq \tilde{E}_i, \qquad \text{(A-21)}$$

where $\tilde{E}_i$ is an exogenously determined maximum which the international community places (and enforces) on exports of sector i.[2] These sectoral maxima for exports imply, of course, a maximum for the total export revenues -- i.e., $E \leq \sum_i \tilde{E}_i$. Secondly, sanctions might reduce the inflow of international capital into South Africa; and we recognize the strong possibility that South Africa, in retaliation, might similarly restrict the outflow of international capital from South Africa. The net effect of such changes will be a limit on the balance-of-trade deficit (D) that South Africa can incur:

$$D \leq \tilde{D} \qquad \text{(A-22)}$$

Together with the balance-of-trade identity (A-8), constraints (A-21) and (A-22) imply a limit on total imports, namely, $M \leq \tilde{D} + \sum_i \tilde{E}_i$. Since it is

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[1] Obviously, constraints (A-19) and (A-20) are not technological constraints in the same sense as the others, that is, in the sense of being irremedially constraining in the long run despite sensible public policy. But in the short run, with which we are concerned, they operate in much the same way as "nature's" constraints.

[2] In general, the tilde over a variable represents an exogenously (from South Africa's viewpoint) determined maximum.

implied, it need not be incorporated explicitly into the model; but its exclusion does mean that we cannot consider the possibility that sanctions mean some sort of sectoral limits, or other compositional limits, on South Africa's imports. Within the overall constraint on M, the M_j are free to vary, subject only to non-negativity and constraints (A-14) and (A-15). Normally, in the simulations, we consider an equal percentage reduction of each E_i and of D, which means in the end of an identical percentage reduction of M. But, in places, we consider a given percentage reduction of each E_i with no change in D from its base-year value. Since the base-year D is negative, this means a larger percentage reduction in M than in E.

We turn now to the internal South African policy constraints. It should be noted that the difference between what are called "policy constraints" and the ingredients in the objective function which South Africa is assumed to seek to maximize is largely a matter of convenience. The policy constraints are, in a sense, the more important objectives, for the target level of such a constrained variable must be met by the optimal economic program. On the other hand, more than fulfilling this target is assumed to yield no further increment to social welfare. Thus, the constraints discussed below are so treated because of their "threshold" impact on welfare; variables with a continuous, monotonic effect on welfare are reserved for the objective function.

An economy in crisis always has a tough, basic decision to make about investment. A drastic reduction in investment is possible without much short-run impact on output; since more than one-third of South Africa's imports are capital goods, a fairly stiff sanctions-imposed import scarcity could be met simply by ceasing to invest. If the sanctions were believed by South African policy-makers to be a temporary phenomenon, then such a drastic cut in investment might even be a sensible South African reaction.[1] I assume that South Africans would fear sanctions to be a lasting phenomenon and that they would intently guard against any reduction in their current

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[1] Not necessarily, it must be pointed out. Such a step reduces growth rates for a few years and, ceteris paribus, permanently lowers South African output below the level that would have been achieved if, say, consumption had been cut rather than investment.

investment (I) and hence their near-term growth rates. Thus, the policy constraint,

$$I = \bar{\bar{I}} . \qquad \text{(A-23)}$$

Furthermore, the composition of investment would be protected from distortion under the impact of sanctions:

$$I_i = k_i I , \qquad \text{(A-24)}$$

where the parameters, k_i, are derived from the normal, base-year composition of investment.

Similarly, government consumption might seem to provide a temporarily harmless place into which to deflect the import shortages caused by sanctions. But the government usually accounts for only a small percentage of total imports, so little saving can be made there. And more important, in a time of crisis, the government will be needed to provide leadership, continuity and security. Accordingly, we assume that South Africa will insist that government expenditures (G) be maintained,

$$G = \bar{\bar{G}} , \qquad \text{(A-25)}$$

and the composition of such expenditures not be greatly altered:

$$G_i \geq (1 - u)\, g_i\, G , \text{ and} \qquad \text{(A-26)}$$

$$G_i \leq (1 + u)\, g_i\, G , \qquad \text{(A-27)}$$

where g_i is the base-year (i.e., normal) ratio of G_i to G, and u indicates the degree of flexibility that is permitted in the composition of government expenditures.

In effect, the above restrictions on investment and government consumption mean that the entire burden of sanctions -- however great they are -- will fall on private consumption (C). While the total cannot, therefore, be constrained, the composition of consumption can. We will assume, as we did with government expenditure (constraints (A-26) and (A-27)), that some flexibility is permitted around the base-year composition of consumption:

$$C_i \geq (1 - u)\, c_i\, C, \text{ and} \qquad \text{(A-28)}$$

$$C_i \leq (1 + u)\, c_i\, C , \qquad \text{(A-29)}$$

where c_i is the base-year (i.e., normal) ratio of C_i to C, and u again indicates the degree of flexibility that is permitted in the composition of consumption.[1]

A principal element of South African economic policy over the past half century has been that jobs will be opened to blacks only after white full employment has been assured. There is no reason to think that under sanctions white unemployment will be countenanced as long as it can be avoided. Thus, if there are feasible solutions to the model with the constraint,

$$\sum_o \sum_j L_{1oj} = \sum_o \sum_j \bar{L}_{1oj} , \qquad \text{(A-30)}$$

we shall continue to include it.

Finally, the white-run government would presumably seek to insulate white workers from any upheavals that sanctions might cause. In the model, this effort is incorporated through a restriction on the fraction of white laborers in each occupation (o) and in each sector (j) that can be "uprooted" -- that is, moved to another occupation and/or sector. Thus,

$$L_{1oj} \geq (1 - z) \bar{L}_{1oj} , \qquad \text{(A-31)}$$

for each o and each j, where z is a parameter indicating the maximum fraction of white workers that can be uprooted from any particular job category (i.e., o <u>and</u> j). We shall assume, partly for simplicity and partly because the South African government might seek equality of sacrifice among different classes of white workers, the same value of z for all o and j.

As is seen in the text's discussion of the simulations, not all these constraints can be met when sufficiently large trade and foreign investment reductions are caused by sanctions. In technical terms, for sufficiently low values of $\tilde{E}_i$ and/or $\tilde{D}$, there is <u>no</u> feasible region. When this occurs, we shall assume that some of the policy constraints are relaxed -- indeed, they must be relaxed. Specifically, four of the constraints will then be altered:

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[1] For simplicity, the same values of u are used in all 32 of the constraints, (A-26) through (A-29).

1. The degree of uprooting of whites will no longer be constrained at all -- that is, enforced white labor mobility will be imposed to whatever extent necessitated by the remaining constraints on (and objectives of) the economy. Thus, constraints (A-31) are removed.

2. White full employment is removed as a constraint,[1] and equality (A-30) is weakened to the point that it merely prevents the hiring of more whites than there are in the economy. Thus, (A-30) is replaced by:

$$\sum_o \sum_j L_{1oj} \leq \sum_o \sum_j \bar{L}_{1oj} \cdot \qquad \text{(A-30')}$$

3. It is recognized that government expenditures can no longer be maintained at their pre-sanctions levels. We shall then assume that the compositional restrictions, (A-26) and (A-29), are retained but that the aggregate government consumption is merely kept up to its original level relative to private consumption. Thus, equality (A-25) is replaced by:

$$G = (\bar{G}/\bar{C})\ C. \qquad \text{(A-25')}$$

4. Similarly, the effort to maintain aggregate investment is reluctantly relaxed, and it, too, is simply maintained at its original level relative to consumption. Thus, equality (A-23) is replaced by

$$I = (\bar{I}/\bar{C})\ C. \qquad \text{(A-23')}$$

These four changes in the policy constraint set are made whenever it is necessary to achieve a feasible solution to the economic problem. They are referred to, in the text, as the "less exacting set of policy constraints".

Objective Function. The basic objective function which we assume South Africa would attempt to maximize in the face of international trade and investment sanctions is simply the Gross Domestic Product (Y). Of course, given the identities and constraints above, the maximization of GDP is essentially the same thing as the maximization of aggregate consumption (C).[2] If the South African social welfare objective is a rising monotonic function of the aggregate of net outputs valued at current prices

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[1] White employment is then made part of the objective function (as will be discussed shortly).

[2] See (A-8), (A-9), (A-22), (A-23) and (A-25).

(i.e. of value added), then the maximization of Y (or C) is the maximization of welfare.

Alternatively, one might recognize that Y (or C) includes not only goods and services allocated to whites, but also those consumed by wage-earning non-whites, who, according to all evidence from South Africa, are weighted much less heavily in the white-determined social objective function. Accordingly, one other objective function is examined briefly, namely, the maximization of white incomes, or in symbols, the maximization of $(W_1 + N)$.[1]

Finally, for the full set of constraints in the model -- i.e. all of (A-1) through (A-31) -- there is sometimes no feasible region. Then the less exacting set of policy constraints (just described) is introduced into the model. In that process, it should be recalled, the constraint that white full employment be completely achieved is removed. A feasible region is thereby created, but we do not want to ignore the fact that white employment still matters a great deal to (white) policy makers. A simple way to incorporate this dual concern for output (Y) and white employment ($\sum_o \sum_j L_{1oj}$) is to include them both additively in the objective function,

$$Y + p \sum_o \sum_j L_{1oj} , \qquad \text{(A-32)}$$

where p is the rate at which GDP and white employment substitute for each other (in thousands of rands per worker) in the objective function. This objective function will be used whenever the less exacting set of policy constraints is made necessary.

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[1] It is reasonably assumed that almost all non-wage income (N) accrues to whites.

APPENDIX B

THE DATA

The data requirements of the model transcended the statistics produced by any single official or unofficial South African source. Thus, it has been necessary to take data from various sources and make extensive adjustments in order to create a set of data that is conceptually comparable and internally consistent. The principal sources are: 1) for output, final delivery, and inter-industry trade, Krogh, 1961, and Department of Planning, various years; 2) for international trade and payments, South African Reserve Bank, various years, Department of Customs and Excise, various years, and Department of Statistics, various years; and 3) for employment and wage payments, Department of Statistics, 1960 and 1970.

The need to collect data from different sources resulted in two major shortcomings in the data that were finally used. First, the data in this study (to be presented and discussed shortly) are with few exceptions not quite the same as any of the sources. Thus, what is called "normal" or the "base year" in this study is not discoverable in any official tables. Nor is it suggested that this data, in any of its particular elements, is as accurate as the official data. Rather, the data used in the simulations present an internally consistent and (it is hoped) a broadly correct picture of the South African economy.

The second shortcoming is that, with so many different sources, it has been difficult to put together (in Ann Arbor and in a short time) a complete data set for a recent year. As a result, the base year of the simulations of the text is 1967. The labor and wage data, needed by sector, race and occupation, are inevitably limited by the most recent census[1] except by extrapolation. And the choice of 1967, rather than 1970, was made because that was the latest year for which an input-output table was available.[2] Accordingly, the simulations of the text are all estimates of

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[1] For South Africa, 1970.

[2] Implicit in the development program for 1967 (Department of Planning, 1967). Actually, it was largely an updating of the 1956-57 table (Krogh, 1961). I have (too late) discovered a more recent (1971) table (Department of Statistics, 1977).

what would have happened had sanctions been imposed on (the modeled version of) the 1967 South African economy.[1] There have been efforts over the past decade to further insulate South Africa from international sanctions, and to the extent that they have been successful, the impact of sanctions would be relatively smaller than is estimated here. Otherwise, however, the choice of so distant a base year, while unfortunate, should not in itself much bias the resulting estimates.

The order of the remainder of this appendix is as follows. First, the 1967- base year data are shown and their derivation explained. And then the parameters of the model and the procedures of their estimation are reported.

1967 Data. The inter-sectoral and final demand flows were initally constructed from the Economic Development Program for the Republic of South Africa, 1967-72, produced by the Department of Planning. That document differs noticeably from, and presumably is an update of, the input-output accounts for 1956-57.[2] We contracted the number of sectors from 33 to 8, with the following mapping:

No.	Sector Title	Development Program Sectors	I.S.I.C. Sectors
1	Agriculture[a]	1	0
2	Mining	2-4	1
3	Manufacturing	5-27	2-3[b]
4	Construction	28	4
5	Electricity[c]	29	5
6	Trade	30-31	61
7	Transport[d]	32	7
8	Services	33	62, 63, 8

[a]Includes forestry and fishing.

[b]Sector 384 (motor trade) is in Sector 6 (trade).

[c]Includes gas and water.

[d]Includes communications.

[1]Among other things, this means that all values are in 1967 prices. Real GDP rose by 52% between 1967 and 1977, and the GDP price deflater rose by 135% over that same decade.

[2]By Krogh, 1961.

Some adjustments in the inter-industry flows were immediately necessary: "other sectors" of the Development Program were allocated (proportionately), and the unreported flows for sectors 6 through 8 constructed (by applying the relevant ratios in the 1956-57 table[1] to the gross outputs in 1967). Moreover, the unreported composition of final demand (between private and public consumption) of sectors 6 through 8 had to be estimated from other information.

The intermediate and final flows so obtained displayed some glaring inconsistencies with official South African national accounts data, with smaller value added totals in manufacturing (3), transport (7), and services (8), and a larger total in trade (6). A series of adjustments were therefore made whose intent was to reallocate some of the output attributed (by the Development Program) to "trade" to the sector whose output was "traded" and thus to make the data comparable with the allocation procedures of the national accounts. The entire process converted, in principle if only roughly in fact, the basis of the tables from "producers prices" to "factor costs".

Furthermore, examination suggested that the Development Program accounts did not cover all the sub-sectors of manufacturing (3), transport (7) and services (8). The final adjustment was, quite arbitrarily, to elevate the value added in these sectors to the levels of the national accounts and then to raise all the unknown components proportionately.

The resulting values, for the eight sectors, for 1967, for intermediate and final annual rates of flow, are given in Table B-1. The figures there are <u>all</u> for the source and use of domestic production only (i.e., imports have been removed from each entry). The implied GDP is R 8,156 million.[2]

Since the import data are nowhere explicitly reported by sectors of use, it was necessary to allocate the actual import totals among the producing sectors and the components of final demand. From inspection of

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[1] Krogh, 1961.

[2] Total imports were R 2,440 million. GDP equals the sum of C, I, G and E in Table B-1, less imports of intermediate goods only (i.e., R 1,051 million).

TABLE B-1

PRODUCTION, SOURCES AND USES BY SECTOR, 1967
(R millions)

Sector(j)	1	2	3	4	5	6	7	8	Consumption(C)	Investment(I)	Government(G)	Exports(E)	Gross Output(X)
Agriculture (1)	68	-	797	-	-	4	-	6	268	160	2	275	1,579
Mining (2)	16	19	123	19	36	-	20	1	5	10	4	1,151	1,405
Manufacturing(3)	345	170	2,260	586	5	122	122	152	2,248	250	106	623	6,989
Construction (4)	-	-	2	-	-	-	-	1	-	1,086	-	-	1,089
Electricity (5)	-	57	38	31	8	9	27	11	104	-	19	-	303
Trade (6)	60	54	501	-	2	12	7	5	252	25	17	37	970
Transport (7)	96	86	788	-	3	18	10	8	280	20	17	196	1,522
Services (8)	25	64	130	-	13	166	88	52	1,083	-	705	264	2,587
Value Added	941	953	1,507	414	229	632	1,228	2,253					
Totals:									4,240	1,551	870	2,547	16,445

NOTE: Throughout this appendix, totals may not add because of rounding.

Table Q-10 in the 1970 volume of South African Statistics, it was decided that roughly 21% of total 1967 imports went to final consumption. Of this figure, 84% was allocated to private and 16% to public consumption (the same percentage reported in Table 2-1 of the 1968-73 Economic Development Program). Imports for investment were taken as the "capital equipment" entry. It was assumed that no importing for the purpose of re-exporting occurred. Residual imports were allocated among the eight intermediate sectors on the basis of the data given in Volume 1 of the 1968 Foreign Trade Statistics. This source listed imports by six-digit SITC classification; knowing also the corresponding ISIC classification, one can get a fairly accurate idea of the use for which most imports were destined. Nonetheless, inevitably, a number of cases remained in which it was not clear to which sector or sectors the imports should be allocated. In these instances, imports were distributed on the basis of instinct and/or proportionality.

Two final adjustments were required. First, since many sources and methods were used to determine the allocation of imports among final demands and intermediate sectors, some minor inconsistencies surfaced. Especially, the allocation resulted in figures which were too large in the sense that the sum of sectoral imports plus final-demand imports exceeded the total of 1967 imports. Accordingly, downward adjustments were made, based on relative sectoral size. And second, the Foreign Trade Statistics data did not include the services imports (payments for non-factor services), harbor dues and mail fees which were listed in the Economic Development Program. It was decided to include these figures, the total of which was allocated among the sectors and the final demand components in proportion to their share of other imports. The estimates that resulted are given in Table B-2.

There are labor estimates by race and sector in the Economic Development Program, but for labor data by race, occupation and sector, it is necessary to go to the more comprehensive Population Census. This census has been done recently in South Africa decennially and is available for each of 1960 and 1970. From the national accounts, value added by sector is known for 1960 and 1970; and 1967 value added by sector has already

been estimated (Table B-1). The assumption was made that the 1967 ratio of labor to value added for each race, occupation and sector fell along a smooth geometric trend between the 1960 and 1970 values of that ratio. In symbols (see Appendix A for definitions of the variables):

$$L_{roj1967} = V_{j1967} \left(\frac{L_{roj1960}}{V_{j1960}}\right)^{0.3} \left(\frac{L_{roj1970}}{V_{j1970}}\right)^{0.7} \qquad \text{(B-1)}$$

The resulting labor estimates are presented in Table B-3.

Total wage income for whites by sector in 1960 and 1970 is provided by South African Statistics. Dividing these sectoral white wages by the number of white workers in the sector (Table B-3,Part A), yields the average white wage rate by sector in 1960 and 1970. (For some sectors in 1960, no such wage data were available; it was then assumed that the increase in wages there over 1960 to 1970 was equal to the average increase in wages in the other sectors.)

In the population censuses, total white income per occupation is found. However, this number will generally overstate total wages per occupation. To correct somewhat for this, we arbitrarily multiplied total income in the professional, administrative and farming occupations by 0.8 to allow for the fact that these occupations are most likely to display a significant percentage of non-wage income. By dividing the occupational wage total by the numbers of workers in that occupation, we then estimate the average annual wage rate per occupation for whites.

We next assumed that a white worker's annual wage rate was equal to 1/2 the sum of the average wage rate for the occupation plus the average wage rate of the sector to obtain estimates of the average annual wage rate per white worker in 1960 and 1970 for all 56 cells (i.e. 7 occupations, 8 sectors). These wage rates were put into 1967 prices by use of the consumer price index, and the 1967 wage rate was assumed to lie, for each occupation and sector, along the smooth geometric trend from the 1960 to 1970 values. In symbols,

$$w_{1oj1967} = \left(w_{1oj1960}\right)^{0.3} \left(w_{1oj1970}\right)^{0.7} \qquad \text{(B-2)}$$

These are given in Part A of Table B-4.

TABLE B-2

IMPORTS, BY SECTORAL SOURCE AND DESTINATION, 1967
(R millions)

Sector (j)	1	2	3	4	5	6	7	8	Consumption(C)	Investment(I)	Government(G)	Total
Agriculture (1)	9	-	38	-	-	3	-	-	33	-	6	89
Mining (2)	4	-	117	0	0	-	-	-	0	-	-	121
Manufacturing(3)	10	1	535	40	5	3	21	24	321	871	62	1,892
Construction (4)	-	-	-	-	-	-	-	-	-	-	-	-
Electricity (5)	-	-	-	-	-	-	-	-	-	-	-	-
Trade (6)	-	-	-	-	-	-	-	-	-	-	-	-
Transport (7)	0	-	10	-	0	0	0	1	5	-	1	18
Services (8)	5	-	145	-	3	2	5	72	74	-	14	320
TOTAL	27	1	845	40	8	8	26	97	434	871	83	2,440

NOTE - means zero; 0 means less than R 0.5 million (and similar notation is used throughout this appendix).

TABLE B-3

LABOR, BY RACE, OCCUPATION, AND SECTOR, 1967

(thousands of workers)

A. WHITES

Occupation (o) \ Sector (j)	1	2	3	4	5	6	7	8	Total
Professional (1)	1	5	19	7	2	4	10	142	191
Administrative (2)	1	1	16	9	0	9	7	17	61
Clerical (3)	1	7	44	7	2	31	88	160	340
Sales (4)	0	0	11	1	0	53	1	13	79
Farmer (5)	107	0	0	0	0	0	0	2	109
Production (6)	2	44	102	74	8	18	99	24	371
Services (7)	0	1	2	0	0	4	5	26	38
Total	112	58	194	99	13	120	209	385	1,190

B. NON-WHITES

Occupation (o) \ Sector (j)	1	2	3	4	5	6	7	8	Total
Professional (1)	0	1	1	0	0	1	0	102	105
Administrative (2)	0	0	0	1	0	1	0	3	5
Clerical (3)	1	8	21	4	1	11	4	26	76
Sales (4)	0	0	3	0	0	49	0	3	55
Farmer (5)	2,249	2	2	1	0	1	0	57	2,311
Production (6)	20	539	431	340	28	91	62	107	1,617
Services (7)	4	16	17	5	2	28	4	935	1,010
Total	2,274	566	475	350	31	182	70	1,231	5,179

TABLE B-4

WAGE RATES, BY RACE, OCCUPATION, AND SECTOR, 1967

(R thousands per worker)

Occupation (o) \ Sector (j)	1	2	3	4	5	6	7	8
				WHITES				
Professional (1)	1.40	3.07	2.55	2.00	2.36	2.22	2.61	2.48
Administrative (2)	2.36	3.40	3.47	2.37	3.30	3.18	3.56	3.46
Clerical (3)	1.07	2.74	2.23	1.68	2.92	1.88	2.27	2.17
Sales (4)	1.47	3.09	2.62	2.07	2.41	2.30	2.67	2.57
Farmer (5)	1.28	2.95	2.42	1.87	2.23	2.22	2.52	2.49
Production (6)	1.34	3.05	2.52	1.98	2.31	2.19	2.57	2.46
Services (7)	1.21	2.74	2.21	1.67	2.01	1.89	2.32	2.15

Occupation (o) \ Sector (j)	1	2	3	4	5	6	7	8
				NON-WHITES				
Professional (1)	0.09	0.19	0.64	0.38	0.28	0.32	0.45	0.34
Administrative (2)	0.15	0.24	0.88	0.56	0.38	0.44	0.63	0.49
Clerical (3)	0.07	0.17	0.56	0.31	0.23	0.26	0.40	0.31
Sales (4)	0.09	0.20	0.66	0.40	0.28	0.32	0.47	0.36
Farmer (5)	0.08	0.18	0.61	0.35	0.26	0.31	0.44	0.35
Production (6)	0.08	0.19	0.63	0.37	0.27	0.31	0.46	0.35
Services (7)	0.07	0.17	0.56	0.31	0.24	0.26	0.41	0.30

Non-white wages present an additional problem as the censuses contain no income data for blacks. The only useful data along these lines is the sectoral total wages of non-whites, published annually in South African Statistics. Accordingly, it is necessary to assume that the ratio of non-white to white wage rates, within any occupation and sector, is equal to the average non-white wage rate in that sector divided by the average white wage rate in that sector.[1] In symbols,

$$w_{2oj} = w_{1oj} \frac{\sum_o W_{2oj}}{\sum_o w_{1oj} L_{2oj}} \qquad \text{(B-4)}$$

Thus, as can be seen in Part B of Table B-4, much of the occupation-and-sector detail of non-white wages is specious. Furthermore, in order to avoid detailed research into the functioning of labor markets, we assume that these wage rates do not change during the simulations, no matter how much unemployment or labor re-allocation occurs. For these reasons, the wage implications of sanctions, as determined by the simulations, are reported sparingly and tentatively.

Finally, with the labor data of Table B-3 and the wage rate data of Table B-4, the value added of each sector (see Table B-1) can be divided into white wage income, non-white wage income and non-wage income. This is shown in Table B-5.

Parameters. In their simplest form, inter-industry flows are assumed proportional to the gross output of the receiving sector (equation A-13). Thus, appropriate divisions with the data of Table B-1 yield the input-output coefficients (a_{ij}) of the South African economy, shown in Table B-6.

The various import coefficients (m_j) are also readily produced by division, with Table B-2. Since there is no particular value with the model we are using to estimating m_{ij} (i.e. by foreign source sector i as well as by South African use sector j), the import values are added

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[1] The average white wage rate being calculated using non-white labor weights, i.e., as

$$\frac{\sum_o w_{1oj} L_{2oj}}{\sum_o L_{2oj}} \qquad \text{(B-3)}$$

TABLE B-5

DIVISION OF VALUE ADDED BY INCOME SHARES, 1967

(R millions)

Share / Sector (j)	White Wage Income (W_1)	Non-White Wage Income (W_2)	Non-Wage Income (N)	Value Added (V)
Agriculture (1)	144	182	615	941
Mining (2)	176	107	670	953
Manufacturing (3)	493	297	717	1,507
Construction (4)	197	129	87	413
Electricity (5)	31	8	189	228
Trade (6)	267	55	310	632
Transportation (7)	518	32	678	1,228
Services (8)	914	382	957	2,253
Total	2,740	1,193	4,223	8,156

TABLE B-6

INPUT-OUTPUT COEFFICIENTS (a_{ij})

Producing Sector (i) \ Using Sector (j)	1	2	3	4	5	6	7	8
Agriculture (1)	.043	-	.144	-	-	.004	-	.002
Mining (2)	.010	.013	.018	.017	.120	-	.013	.000
Manufacturing (3)	.219	.121	.323	.538	.017	.126	.080	.059
Construction (4)	-	-	.000	-	-	-	-	.000
Electricity (5)	-	.041	.005	.029	.027	.009	.016	.004
Trade (6)	.038	.038	.072	-	.005	.012	.004	.002
Transportation (7)	.061	.061	.113	-	.009	.019	.007	.003
Services (8)	.016	.046	.019	-	.043	.171	.056	.020

vertically before being divided by gross output of the receiving sector. The resulting import ratios (m_j), needed for inequalities (A-14) and (A-15), are shown in Table B-7.

The labor-output coefficients (ℓ_{oj}) of equations (A-16) are not calculated by race, so the total number of laborers in each occupation and sector (i.e. $\sum_r L_{roj}$) is divided by the gross output of the sector. These coefficients are presented in Table B-8.

The sectoral composition of the totals for consumption (C), investment (I) and government expenditure (G) is assumed, for constraints (A-24) and (A-26) through (A-29), to be simply the relevant proportion in 1967. These ratios are reported in Table B-9.

For none of the remaining parameters is there hard evidence, from the base-year accounts estimated above or elsewhere. The values inserted for the simulations of the text are arbitrary and based on little more than intuition. For this reason, it was necessary to use much of the scarce computer budget conducting sensitivity tests on these parameters. The basic values given to these essentially arbitrary parameters are as follows:

Parameter	Basic Value
v_j	2.00
b_j	0.10
q	0.10
s	0.10
u	0.10
z	0.10
p	1.00

In general, the sensitivity tests moved each parameter value by 40% of its basic value in the direction that hurt South Africa's ability to produce GDP.

The values of the various h parameters were constructed only after perusing carefully the kinds of imports brought into each sector. The value of h for each j (and for C, I, and G as well) represents a judgment

TABLE B-7

IMPORT COEFFICIENTS (m_j)

Sector (j)	Coefficient (m_j)
Agriculture (1)	.017
Mining (2)	.001
Manufacturing (3)	.121
Construction (4)	.037
Electricity (5)	.025
Trade (6)	.008
Transportation (7)	.017
Services (8)	.038
Consumption (C)	.093
Investment (I)	.360
Government Consumption (G)	.087

NOTE: The final three coefficients are the m_C, m_I, and m_G, respectively, of inequalities (A-14) and (A-15).

TABLE B-8

LABOR-OUTPUT COEFFICIENTS (ℓ_{oj})

(workers per R million)

Sector (j)	1	2	3	4	5	6	7	8
Occupation (o)								
Professional (1)	0.98	3.98	2.92	6.92	6.68	4.60	6.77	94.24
Administrative (2)	0.37	1.02	2.42	9.55	0.42	10.02	5.08	7.77
Clerical (3)	1.67	10.89	9.21	10.39	9.31	43.69	61.42	70.85
Sales (4)	0.20	0.18	1.95	1.00	0.40	105.74	0.68	6.17
Farmer (5)	1491.79	1.30	0.33	0.50	1.02	1.17	0.34	22.64
Production (6)	13.88	418.01	76.25	379.58	118.68	112.62	128.70	50.64
Services (7)	2.69	11.90	2.70	4.4[illegible]	7.64	32.92	7.13	371.26

TABLE B-9

SECTORAL COMPOSITION OF CONSUMPTION, INVESTMENT, AND GOVERNMENT

Sector (i)	Fraction of total in that sector of		
	Consumption (c_i)	Investment (k_i)	Government (g_i)
Agriculture (1)	.057	.066	.002
Mining (2)	.001	.004	.004
Manufacturing (3)	.481	.103	.111
Construction (4)	-	.448	-
Electricity (5)	.022	-	.020
Trade (6)	.054	.010	.018
Transportation (7)	.060	.008	.013
Services (8)	.232	-	.739

about how large a percentage of these imports can be replaced.[1] The basic values of these h parameters are:

Subscript of h	Basic Value
j = 1	0.450
2	0.500
3	0.250
4	0.275
5	0.475
6	0.425
7	0.325
8	0.325
C	0.500
T	–[2]
G	0.250

The (weighted by inputs) average value of all these h's is 0.213 -- that is about one of every five rands of imports is assumed to be replaceable by domestic production (at a cost). The time-span is critical for discussion of values for the h's -- in the very long run, almost all values of h are one. We are considering a fairly short period. But even smaller values of the h's are tried as sensitivity tests, namely, each h value reduced 40% below its value in the above table.

For the "greatest impact" simulation (the results of which are described in Section V of the text), the following changes were made from the basic model and parameter values:

1. Objective function (A-32) is used, with p = 2.
2. The "less exacting set of policy constraints" is applied (see Appendix A for the definition).
3. The production function of Appendix D is used (see equation (D-12)).
4. All exports except those of the mining sector are cut to zero (i.e. $E_1 = E_3 = E_4 = E_5 = E_6 = E_7 = E_8 = 0$). Mining exports ($E_2$) are assumed to be not affected by sanctions, but no trade imbalance can occur (i.e. D = 0).

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[1] If they are replaced, it of course means a higher labor cost -- see Appendix C.

[2] i.e., zero -- no replacement possible.

5. All import-substitution limits (i.e., the h_j's) are reduced by 40%, and the following other parameters are also stiffened:

Parameter	In Equation	Value: Basic	Value: "Greatest Impact"
v_j	A-16	2.00	2.80
b_j	A-17	0.10	0.06
q	A-18	0.10	0.06
s	A-19,20	0.10	0.06
u	A-26,27, 28,29	0.10	0.06

APPENDIX C

THE SHORT-RUN POTENTIAL FOR IMPORT SUBSTITUTION, AS INCORPORATED IN THE MODEL

According to neo-classical production theory, output in j (X_j) is some function (f) of the inputs into the sector. For our purposes four kinds of inputs are relevant: 1) labor of the oth occupation (L_{oj}, where o = 1, ..., 7); 2) intermediate inputs delivered from the ith South African sector (X_{ij}, where i = 1, ..., 8); 3) non-competing[1] intermediate-input imports from the rest of the world (M_j): and 4) the capital stock available ($\bar{K}_j$, where the bar indicates that it is fixed in the short run, with which we are concerned). In symbols,

$$X_j = f\,[L_{oj}, X_{ij}, M_j, \bar{K}_j] \;,$$

where o = 1, ..., 7 and
i,j = 1, ..., 8. (C-1)

For simplicity in what follows, we will suppress all subscripts and ignore the domestically-produced intermediate inputs (X_{ij}).

If the elasticity of substitution in (C-1) were zero, it could be rewritten as

$$X = \text{Min}\,[L/\ell,\ M/m,\ \bar{K}/k] \;, \qquad \text{(C-2)}$$

where ℓ, m, and k are the relevant input-per-unit-of-output ratios.

Equation (C-2) embodies essentially the assumption about production made in the model, except that one explicit element of substitutability is introduced -- namely, that additional labor (i.e. beyond the needed ℓX) can be used to replace imports should they fall below mX.[2] One way to

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[1] By non-competing is meant that the products are not produced in South Africa.

[2] There is also an implicit substitutability, namely that $\bar{K}$ is adequate to produce levels of X slightly above the base-year values (see equation (A-17) of Appendix A). Excess capacity, which appears whenever $X < \bar{X}$, is assumed not to be substitutable for either labor or imports.

introduce this substitutability and still retain the linearity of the equations of the model is the following:

$$L = [1 + v\,(1 - \frac{M/X}{m})]\ \ell X\ . \qquad \text{(C-3)}$$

With (C-3), the labor requirement is ℓX as long as the full import need is fulfilled (i.e. as long as $M = mX$); but L will exceed ℓX if the ratio, M/X, falls below m.

Clearly, there are limits to the extent to which labor can substitute for imports. This is reflected in the model by an inequality to insure that[1]

$$M \geq (1 - h)\ mX\ , \qquad \text{(C-4)}$$

where h is a parameter expressing the maximum import substitution through labor use.

Two isoquants, for X and for $\bar{X}/2$, are drawn in Figure C-1, which show the rate and range of substitutability of L for M. Only the negatively sloped parts of the isoquants are relevant since there are limits to the direction and extent of the substitutability (i.e. $(1 - h)\ m\ X \leq M \leq m\ X$). The slope of this negatively sloped segment is (in absolute value) $m/v\ell$. The vertical and horizontal parts of the isoquants are sketched in, but they are never relevant since both imports and labor are scarce in the model.

The meaning of the parameter, h, is clear. It indicates the extent to which import replacement (by labor) is feasible. The meaning of the parameter, v, is less obvious. It is a pure (positive) number which indicates the rate at which labor substitutes for imports. The higher is v, the more labor required per unit of imports replaced.

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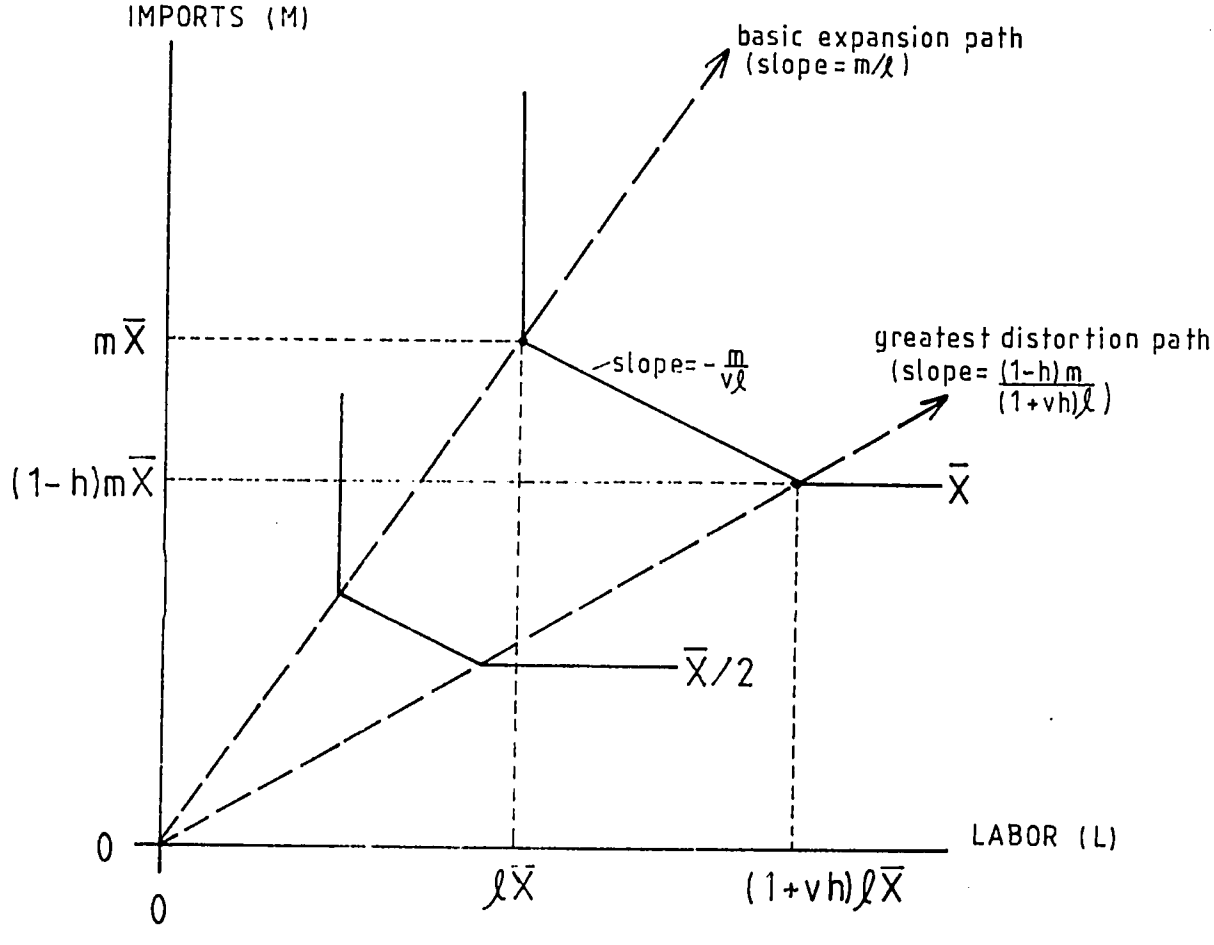
[1] There is also an inequality, $M \leq mX$ to indicate that imports cannot be used to replace labor.

FIGURE C-1

Import-Labor Isoquant Pattern



APPENDIX D

EARLIER INPUT-OUTPUT ANALYSES OF THE IMPACT OF SANCTIONS

There have been two previous studies of the potential impact of general economic sanctions that have used an input-output framework, one an eight-sector analysis of Rhodesia (Curtin and Murray, 1967) and the other a thirteen-sector analysis of South Africa (Spandau, 1978). Each employed a model considerably simpler than the present model. This appendix examines their methods.

For simplicity, the models are described for two sectors only, and intra-sector intermediate-good flows are ignored (i.e. $a_{ii} = 0$ for $i = 1, 2$) The basic explicit equations of the models are:

$$X_1 - a_{12} X_2 - F_1 = 0 \text{ , and} \qquad \text{(D-1)}$$

$$- a_{21} X_1 + X_2 - F_2 = 0 \text{ ,} \qquad \text{(D-2)}$$

where X_i = gross output of the ith sector, a_{ij} = inter-industry intermediate-good flow from sector i to sector j, and F_i = final goods (i.e. consumption, investment, government and exports) delivered by sector i. Implicit in the model are two other sets of equations:

$$M_j = m_j X_j \qquad (j = 1, 2) \text{ , and} \qquad \text{(D-3)}$$

$$V_j = v_j X_j \qquad (j = 1,2) \text{ ,} \qquad \text{(D-4)}$$

where M_j = intermediate-good imports into the jth sector, m_j = the average (and marginal) import propensity of sector j, V_j = value added in j, and v_j = the average (and marginal) ratio of value added to gross output in j. All the capital-letter variables (i.e. X, M, and V) are in value terms, so that

$$a_{21} + m_1 + v_1 = 1 \text{ , and} \qquad \text{(D-5)}$$

$$a_{12} + m_2 + v_2 = 1 \text{ .} \qquad \text{(D-6)}$$

Once the final demands (F_i) are known, equations (D-1) and (D-2) yield the solution values of the gross outputs (X_i); then, imports (M_j) and value added (V_j) can be found by use of equations (D-3) and (D-4). The solution process can be seen in Figure D-1, where equations (D-1) and (D-2) are graphed and the solution shown at

$$X_1 = \frac{F_1 + a_{12} F_2}{1 - a_{12} a_{21}}, \text{ and} \qquad \text{(D-7)}$$

$$X_2 = \frac{F_2 + a_{21} F_1}{1 - a_{12} a_{21}}, \qquad \text{(D-8)}$$

where $(1 - a_{12} a_{21})$ is positive (i.e. the Hawkins-Simon condition).

There are two methods by which the potential impact of sanctions are estimated. Both studies (i.e. Curtin and Murray, 1967 and Spandau, 1978) use the first; only the former uses the second method.

Method 1. Sanctions mean an agreement by the rest of the world to purchase fewer exports from the target country, hence a reduction in F_i. The gross output equations (D-1) and (D-2), are shown in Figure D-2, solid lines for before sanctions and dashed lines for after sanctions.[1] Clearly, the equilibrium values of each of X_1 and X_2 decline, and so also must imports (M_1 and M_2) and value added (V_1 and V_2) decline.

The magnitude of these changes is substantial. Curtin and Murray, 1967, assume that sanctions would reduce the total exports of Rhodesia by 59% (p. 45); total value added (i.e. GDP) would decline by 16% as a result. Spandau (1978) considers separately the impact of a 20% and 50% decline due to sanctions of exports and of investment; his resulting estimates of percentage GDP declines are shown in Table D-1. The results are additive; thus Spandau estimates that if sanctions reduced both exports and foreign investment by 50%, GDP would decline by roughly 14%. Coincidentally, the

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[1] A decline in F_1 lowers the intercept of equation (D-1), and a decline in F_2 raises the intercept of equation (D-2). In neither case is the slope affected.

FIGURE D-1

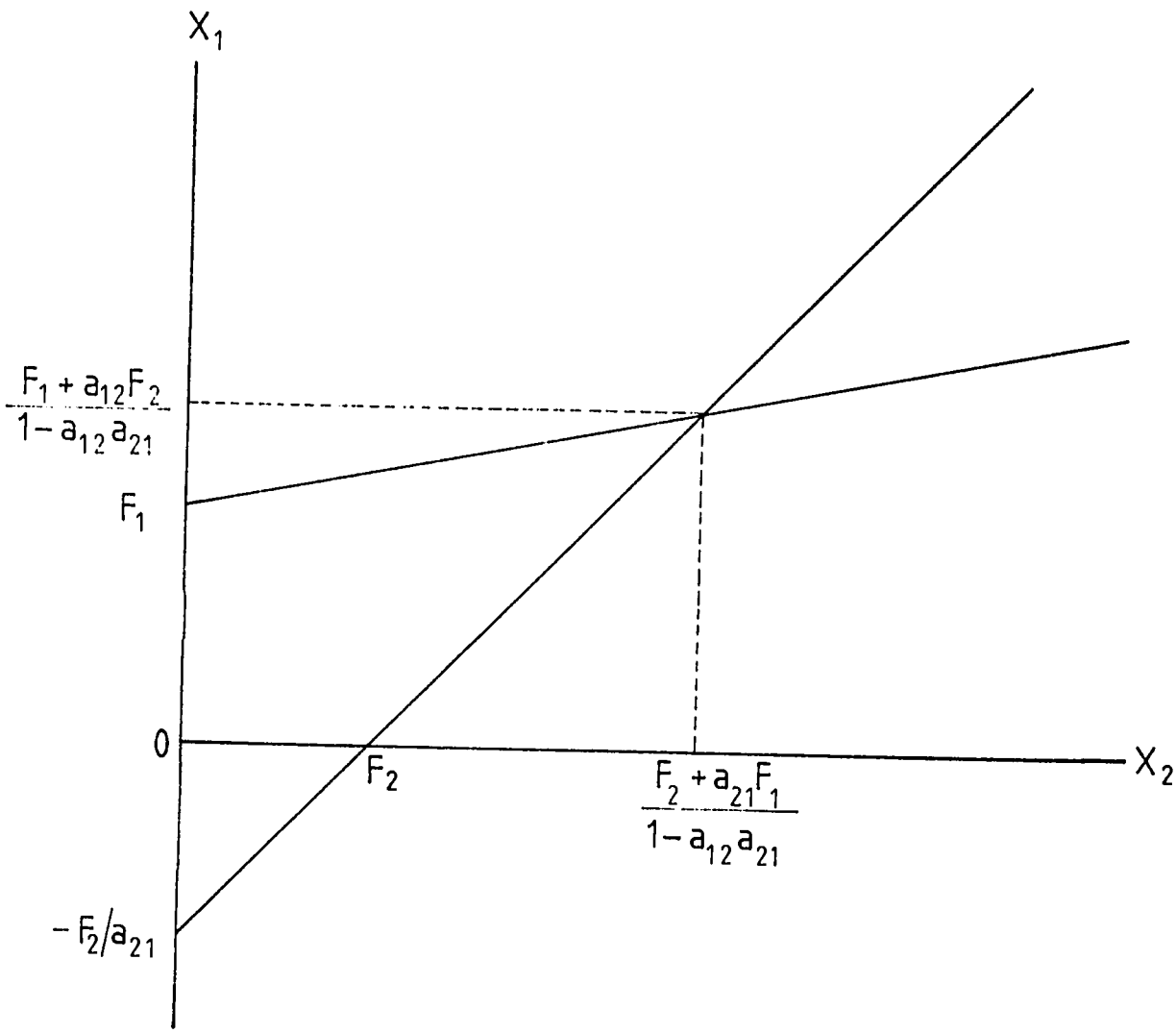
X_1
$\frac{F_1 + a_{12}F_2}{1 - a_{12}a_{21}}$
F_1
0
F_2
$\frac{F_2 + a_{21}F_1}{1 - a_{12}a_{21}}$
X_2
$-F_2/a_{21}$

FIGURE D-2

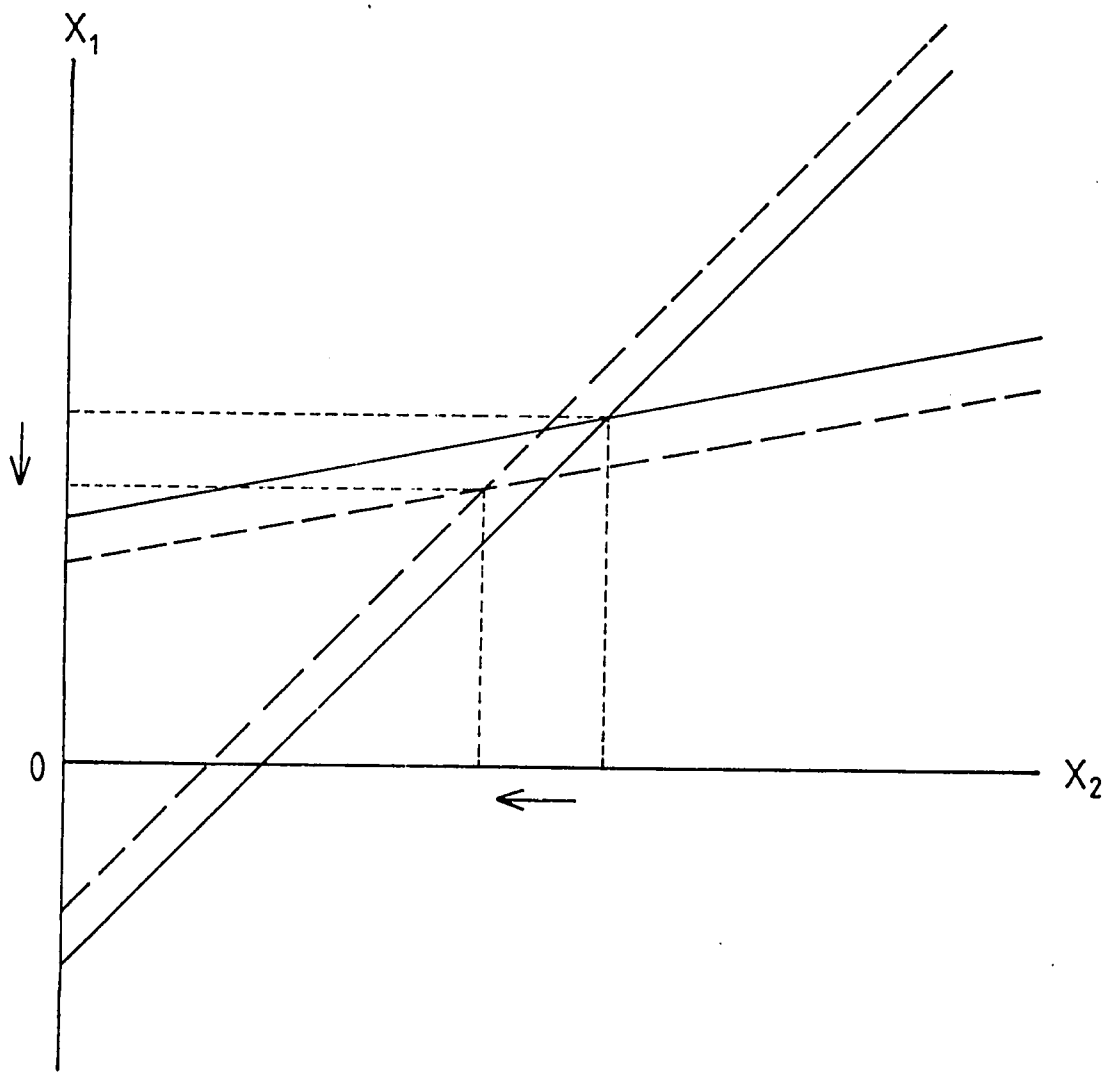

TABLE D-1

PERCENTAGE DECLINES OF GDP ESTIMATED BY SPANDAU[a]

Sanction-Induced Change		Resulting Percentage Decline in GDP[b]
Export Fall	- of 20%[c]	5.17%
	- of 50%[c]	12.92%
Investment Fall	- of 20%[d]	0.53%
	- of 50%[d]	1.33%

[a]Spandau, 1978, pp. 231 ff.

[b]Based on a 1976 GDP of R 29 billion.

[c]Uniform across sectors.

[d]Percentage of foreign investment in each sector.

results of the two studies are surprisingly similar: each percentage point decline in final demand reduces GDP by about one-fourth to one-third as many percentage points.

The straightforward simplicity of the method is attractive, but it contains two fundamental difficulties. First, it assumes that the target economy is unable or unwilling to offset the decline in exports (or foreign investment) by an expansion of consumption, domestic investment and/or government expenditures. In essence, sanctions are viewed as imposing a "Keynesian" recession through reduced aggregate demand upon the target country. It is unlikely, in fact, that South Africa would so quietly acquiesce in the face of sanctions. The Rhodesian data certainly indicate that no such passivity occurred there. Between 1965 and 1968, sanctions forced a reduction of $R 114.8 millions in the annual rate of exports (in 1965 prices);[1] meanwhile the sum of the annual rates of consumption, investment and government expenditures rose by $R 103.7 millions, almost exactly offsetting the export decline.[2]

The second difficulty is that there is no balance-of-payments constraint in the picture. The real cost of the loss of exports is the loss of foreign exchange with which to import. Seen through the simple two-sector model developed here, the total imports (M) needed by the economy are

$$M = M_1 + M_2 = \left[\frac{m_1 + m_2 a_{21}}{1 - a_{12} a_{21}}\right] F_1 + \left[\frac{m_2 + m_1 a_{12}}{1 - a_{12} a_{21}}\right] F_2 . \qquad \text{(D-9)}$$

Declines in exports (i.e. in F_1 and/or F_2) will reduce import needs, but not necessarily on a one-to-one basis. For example, a small change in exports in sector 1 (i.e. dF_1) will cause a change in imports (dM) of

$$dM = \frac{m_1 + m_2 a_{21}}{1 - a_{12} a_{21}} dF_1 , \qquad \text{(D-10)}$$

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[1] $R means Rhodesian dollars, worth U.S.$1.40 during 1965-1968.

[2] Source: I.B.R.D., 1977, pp. 198-199.

where d refers to the time differential. Similarly, for dF_2,

$$dM = \frac{m_2 + m_1 a_{12}}{1 - a_{12} a_{21}} dF_2 . \qquad \text{(D-11)}$$

Thus, we can only be sure that the balance of payments will not deteriorate if dM/dF_1 and dM/dF_2 are both greater than one, which implies a very narrow range of values for a_{12}, a_{21}, m_1 and m_2.[1] And, if the balance of payments does deteriorate, then an important impact of sanctions is being neglected by this model. This is not just a remote possibility, as the Curtin and Murray study shows. In their calculations by this method, Rhodesian exports are expected to decline by $R 107.1 million, while imports are expected to fall by only $R 15.4 million. But this method never raises the question of how Rhodesia is to finance, while under sanctions, this addition of $R 91.7 million to its balance-of-payments deficit.

Method 2. Sanctions mean a reduction in the availability of imports to the target country, and the logical response is import substitution. This method focuses on the process whereby imported intermediate inputs (i.e. the M_j of equations (D-3)) become produced domestically and hence are provided through an increase in the various a_{ij}'s. As applied by Curtin and Murray, the method assumes that v_j is unchanged in the process of import-substitution so that $m_j + \sum_i a_{ij}$ is a constant for each sector j. Thus any reduction in m_j is accompanied one-for-one by increases in the various a_{ij}'s.

Increases in a_{12} affect only equation (D-1) and increases in a_{21} only (D-2). Figure D-3 shows the effect of an increase in both a_{12} and a_{21}; the solid lines represent equations (D-1) and D-2) before the increase and the dashed lines after. Clearly, the increases in a_{12} and a_{21} cause an increase in both X_1 and X_2.[2]

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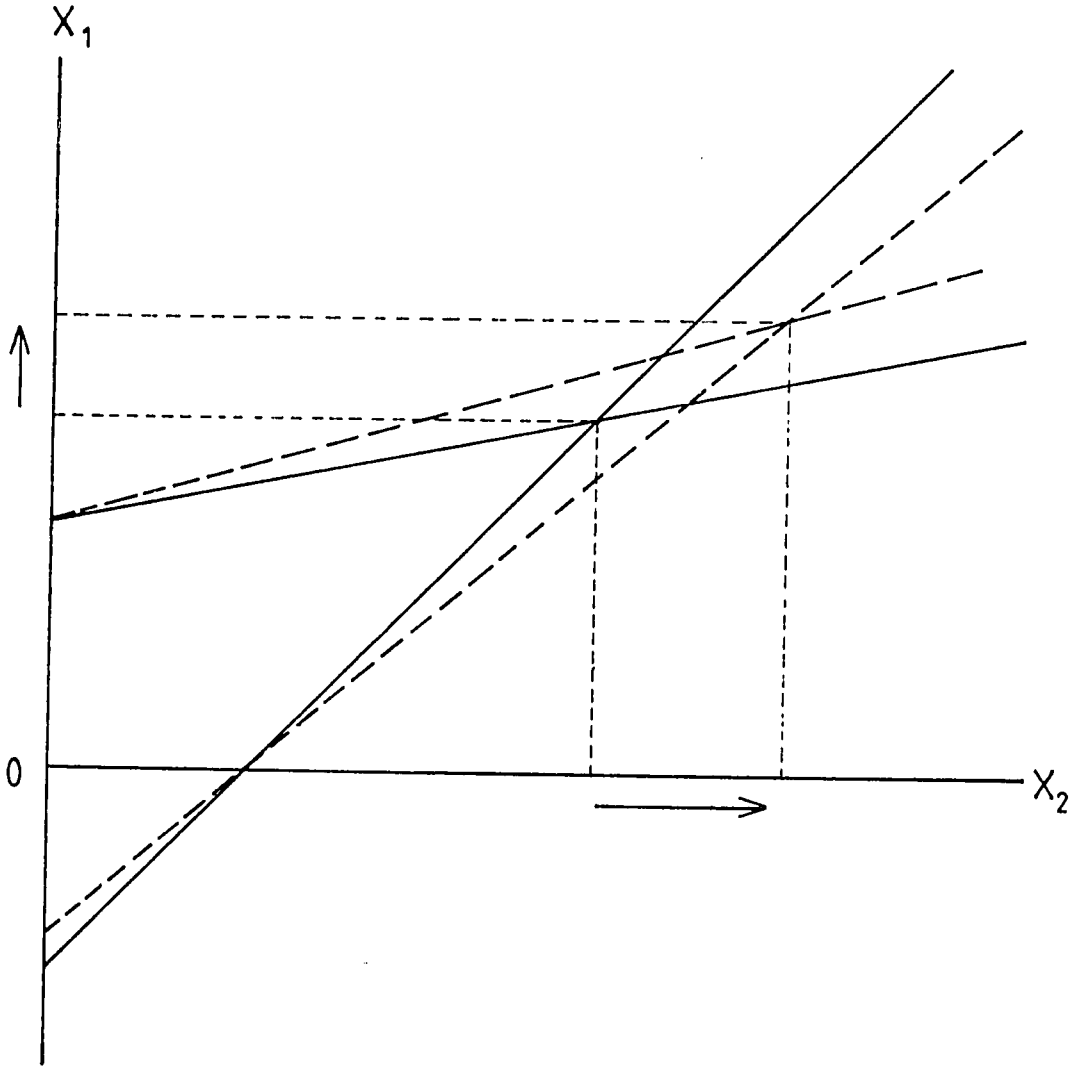
[1] Recall that $(1 - a_{12} a_{21})$ must be positive.

[2] An increase in either a_{12} or a_{21} will cause a rise in both X_1 and X_2. Of course, there is no assurance that all this "import substitution" will reduce total imports (M) since the larger values of X_1 and X_2 offset, to some extent at least, the lower values of the average propensities to import.

FIGURE D-3



The estimated magnitudes of these changes can be large. Curtin and Murray assume that, on average, the Rhodesian values of m_i can be reduced by almost one third of their pre-sanctions (1965) values. As a result, Rhodesian inter-industry deliveries rise from 19% to 21% of gross output and GDP rises by nearly 14%.[1] Total imports decline from $R 133.8 million to $R 93.7 million and the balance-of-payments deficit greatly improves -- though after sanctions there is still a deficit $R 51.6 million larger than before.

This approach is much more in tune with reality than Method 1 (even though it, too, suffers the defect of permitting a larger balance-of-payments deficit to appear). Import substitution did take place in Rhodesia during the immediate years after sanctions were imposed. The ratio of imports to GNP fell from 44% in 1965 to 28% in 1969,[2] almost exactly the percentage decline forecast by Curtin and Murray. Nevertheless, the method does beg the question of why this import substitution did not occur earlier and "naturally." There is no cost to it: each reduction in imports is exactly matched in value (i.e. cost) by an increase in domestic inter-industry deliveries. In the model developed here, such a cost is introduced into the labor requirements. If intermediate imports are cut, the labor-output ratios rise (see equation (A-16) of Appendix A).

Ideally, both methods would be used, that is, a reduction in intermediate imports would trigger both increased domestic inter-industry flows and higher labor requirements. But the cost, in complexity and computation time, is not low. To indicate the kind and extent of the differences this extension would make, however, one such run was made, for 1) a 40% reduction in all exports and the balance-of-trade deficit; 2) an objective function of $Y + \sum_o \sum_j L_{ioj}$; 3) $I = 0.4925\ C$; 4) $G = 0.1939\ C$; and 5) the 56 constraints, $L_{ioj} \geq 0.90\ L_{ioj}$, suppressed.[3] Only two differences exist between the simulations presented below. The "basic" simulation, just like those of the text, sets all the values of v_j in equation (A-16) equal to

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[1] All this is ceteris paribus, after exports have been cut by 59%. The numbers in this paragraph can be calculated from Tables 12 and 14 of Curtin and Murray, 1967.

[2] I.B.R.D., 1977, pp. 198-199.

[3] I.e., the less exacting set of policy constraints (as defined in Appendix A).

2.0 and uses the simple form of equation (A-16). The simulation reported here, called the "D" simulation for the appendix in which it appears, reduces the labor cost of import substitution (each v_j is cut to 1.0) and increases the domestic intermediate-input cost. To do the latter, equations (A-16) are replaced by:

$$X_{ij} = a_{ij} X_j + \frac{a_{ij}}{\sum_i a_{ij}} [m_j - \frac{M_j}{X_j}] X_j . \qquad \text{(D-12)}$$

The second term on the right-hand side of equations (D-12) insures that, as M_j falls below $m_j X_j$, the shortage is delivered domestically through $\sum_i X_{ij}$.

The differences between the two simulations are not large, as Table D-2 shows. The aggregate outputs (GDP) simulated are almost identical, and in only two sectors are the differences in value added as large as 5%. White full employment is achieved in both cases. The only notable difference is in non-white employment (and to a lesser extent in non-white wages). This single simulation, if it is systematic, suggests that the text model is greatly overstating the extent to which non-white employment would be stimulated in response to sanctions. This is easily understood: in the "D" simulation, non-white labor cannot replace imports as easily as is assumed in the text simulations. The "D" simulation seems to produce an intuitively more plausible non-white employment result; accordingly, the non-white employment and wages simulations reported in the text must be taken with especial caution.

TABLE D-2

DIFFERENCES BETWEEN THE TEXT RESULTS AND THE "D" SIMULATION

Variable (Symbol)[a]	Value Simulated by Text Model	Value Simulated by "D" Simulation	Percentage Difference[b]
GDP (Y)	6,260	6,273	0.2%
Value Added in			
Agric. (V_1)	705	729	3.4
Mining (V_2)	597	604	1.2
Manuf. (V_3)	1,279	1,293	1.1
Constr. (V_4)	314	310	1.3
Elect. (V_5)	181	184	1.7
Trade (V_6)	484	508	5.0
Transp. (V_7)	911	867	5.1
Serv. (V_8)	1,790	1,799	0.6
White wages (W_1)	2,699	2,732	1.2
Non-white wages (W_2)	1,318	1,248	5.6
Non-wage Income (N)	2,242	2,293	2.3
White employment ($\sum_o\sum_j L_{1oj}$)[c]	1,190	1,190	-
Non-white employment ($\sum_o\sum_j L_{2oj}$)	6,130	5,569	10.1

[a]Values in R millions, employment in thousands of workers.

[b]Percentage difference calculated with the smaller in the denominator.

[c]White full employment is achieved in both simulations.

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