South Africa without Apartheid: Estimates from General Equilibrium Simulations

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CENTER FOR RESEARCH ON ECONOMIC DEVELOPMENT
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Abstract

A general equilibrium model of the South African economy in the 1980s is constructed, focusing on the labor-market distortions created by legal and customary restrictions on nonwhite labor mobility. The model is static and calibrated to the data of 1980; its simplified representation of the economy incorporates five production sectors, two race categories, two skill levels, and five kinds of labor-market constraints. Three counter-factual simulations are conducted:

1. The labor-market constraints are relaxed marginally, one at a time. Such change has little impact on either the level of GDP or its distribution.

2. The constraints are derived that would be preferred by different white sub-groups -- were each sub-group to choose the various constraints so as to maximize its own income. No such group has an economic motive in keeping so many Blacks in the reserves. Beyond that, interests diverge. Urban capital would like to expand the entry of nonwhites into the cities and into skilled jobs. White farmers, white mining labor, and white urban unskilled labor would like to keep nonwhites out of the cities and out of skilled jobs. White urban skilled labor stands between these groups.

3. The outcome of perfectly free labor markets is examined, under the assumption that the education level of nonwhites permits them to move either slowly or rapidly into the newly accessible skilled jobs. GDP rises from five to ten percent, and dramatic income redistribution is achieved. Some nonwhites experience wage increases up to one half; skilled whites are not much affected, and even the direction of the impact on them is unclear; profits increase by as much as one fifth; and the incomes of white farmers and unskilled white laborers may fall by more than one half.

The measured changes owing to a transition to free labor markets, large as they are, represent no more than lower-bound estimates of the effects of apartheid since the simulations deal only with the racial restraints on labor markets and do not contemplate possible racial redistribution of the ownership of land, physical capital, or human capital.

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Murali Iyengar and Richard C. Porter[1]

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1. Graduate student and professor, respectively, in the Department of Economics, University of Michigan, Ann Arbor, Michigan 48109 (USA). We are indebted to Robin Barlow, David Gordon, Ronald Johnson, Elias Links, and members of the Development Seminar at the University of Michigan for discussion of, and comments on, earlier drafts of parts of this paper.

South Africa without Apartheid: Estimates from General Equilibrium Simulations

The actors play the rituals of their parts
-- Captains, killers, lovers, clowns --
At the end falling on those swords
That open windows to the audience
Those who consider their lives different
From the enacted play of passions.
But which are actors, truly, which the audience --
The players who only simulate
Or the spectators dangling from their fate?

Stephen Spender[2]

I. Introduction

"South Africa evokes a morbid fascination."[3] Indeed, this fascination evokes much scholarly, as well as angry and polemic, writing. But most of the research into apartheid is political, sociological, historical or philosophical in nature; and what little there is about the economic implications is seldom quantitative. We attempt here to begin to remedy this, providing some numbers about the extent of the misallocation of labor resources and the redistribution of factor incomes produced by South Africa's multifarious restrictions on nonwhite labor mobility.

A general-equilibrium picture of the South African economy is drawn (Section II) and is empirically calibrated so as to be consistent with the observed economy of 1980 (Section III). Three kinds of simulations are then undertaken. The effects of marginal, piecemeal removal of the various labor-market restrictions that apartheid imposes are shown to be very small (Section IV). The observed labor-market restrictions are then shown to be typically consistent with compromise among the various affected white groups, farmers,

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2. Spender, 1986, p. 102.

3. So begins a recent book (Adam and Moodley, 1986) with the same title as the first four words of this monograph.

unskilled laborers, skilled laborers, and capitalists (Section V). Finally, a completely free labor market (without any change in the ownership of land or physical or human capital) is shown to raise GDP by 5-10% and to redistribute this income significantly; nonwhite income rises by up to one third, while total white income changes little. However, the redistribution between different white groups is great: 1) the incomes of white unskilled workers and white farmers may fall by as much as one half; 2) the incomes of white skilled workers may fall by as much as one fifth; and 3) (white) profit income rises by 15-20% (Section VI).

Before continuing further, we must alert the reader to the limitations of the general equilibrium modeling developed here. There is no test as to whether ours is an accurate picture of the South African economy, and the observed data of 1980 are incorporated in such a way ("econometrics with a single observation") that the model is necessarily consistent with those 1980 data. Among the many simplifications, there are only five sectors, two skill levels for labor, and two races.[4] The way in which outputs and inputs are related in production is largely assumed, not estimated. The massive complexity of apartheid is captured in only five, very simplified, labor-market restrictions. The forms and magnitudes of these restrictions have been changing dramatically during the last ten years, and the model here freezes them stereotypically — with the result that the picture presented is not only rough but also probably not accurate for any particular recent year.

Moreover, the model is completely static in its formulation. Comparisons between South Africa with and South Africa without apartheid are all for 1980, a factual with a counter-factual, and give no clue about the process of change. Finally, the title, "South Africa without Apartheid", is itself misleading since this paper is concerned with only certain aspects of apartheid, namely the labor-market distortions. Not only are the political and philosophical aspects of apartheid ignored throughout, but so also are the effects of the extreme and imposed racial land ownership patterns, of the

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4. White and nonwhite. The latter group comprises "blacks" (or "Africans" or, more pejoratively, "natives" or Bantu), "coloreds", and "Asians". The myriad legal distinctions between these peoples will not be pursued here; the disadvantage to the model of grouping them together is that coloreds and Asians are less disfavored than blacks in actual public policy.

distorted volumes and sectoral allocations of capital, and of the inefficient and inequitable provision of education and other training. The estimates that emerge from this model of the inefficiency and the income redistribution of apartheid are clearly lower-bound estimates.[5] Alternatively, these estimates might be called measures of the "short-run" change, in that only the effects of reducing racial discrimination in labor markets are analyzed, while the concomitant, but inevitably more time-consuming, changes in the volume and distribution of physical and human capital are ignored.

Despite these shortcomings, we think the numbers should be taken seriously, if only because they are the only ones around that have been derived explicitly. They generally support the growing consensus among economists about the effects of apartheid. Small, piecemeal, or gradual changes ("the evolutionary hypothesis") will have little effect on either the level or racial distribution of South African income. There are sizeable efficiency losses in the present network of restrictions on the mobility of nonwhite labor. The big losers among the whites of a significant dismantling of the labor-market aspects of apartheid would be the unskilled laborers and farmers.

II. The General Equilibrium Model of the South African Economy

The economic history of South Africa is fascinating and instructive.[6] And the history, development, semantics, and workings of apartheid are complex and unique.[7] The following brief narrative foregoes much of the chronology and complexity in order to focus on the essential workings of apartheid as a cause of labor misallocation and as a tool of racial and functional income redistribution.

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5. Again, this assumes that our model is a useful way of viewing the South African economy. Not all economists would agree that apartheid is "inefficient". See, for example, the neo-Marxist writers, Davies, 1977 and Johnstone, 1976.

6. The standard sources are Wilson and Thompson, 1971; Houghton, 1976; and Nattrass, 1985.

7. The standard sources are Hutt, 1964; Horwitz, 1967; and Lipton, 1985; and for the rapidly changing policies of the mid-1980s, Greenberg, 1987.

A little over a century ago, when diamonds and gold were first being discovered, South Africa was mostly a land of subsistence agriculture for black and white alike. But one prominent feature of the later apartheid system had already become established in the rural areas: blacks either worked separately in agricultural activities or served as unskilled laborers on white-operated farms. What began as a de facto racial separation of land control was increasingly written into law in the twentieth century. Beginning with the Natives Land Act of 1913, the legal right of use and ownership of land by blacks has been increasingly restricted to certain geographical areas.[8]

Today the result of this restriction is that whites, comprising 16% of South Africa's population, control 85% of the nation's agricultural land (Nattrass, 1981, pp. 5, 7). The productivity of the white agricultural land (the platteland) has grown steadily over the past century, aided by increased use of capital, improved technology, the continued availability of cheap black labor and -- not least in importance -- government subsidy of price and infrastructure. Meanwhile in the black agricultural regions (variously known over the last century and a half as scheduled areas, native reserves, Bantustans, homelands, and Black States), to which nonwhite farmers have increasingly been relegated to prevent the verswarting of the platteland, productivity per acre has stagnated and productivity per person steadily declined as the population of the reserves has rapidly grown (ibid., p. 113). This push factor, together with the complete absence of a color bar in agricultural employment, has meant that all agricultural work is now done by blacks, the bywoners of old (i.e. white landless tenants) having long since become, first, urban "poor whites" and, more recently, the skilled part of South Africa's urban labor force.

With the discovery of diamonds and gold in the 1860s, mining became the wellspring of sudden, rapid, and continued South African growth. Initial chaos in the sector was soon ordered through luck, force, the distribution of skills, and racism. Small claims gave way to large mining corporations, owned

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8. These laws have always been, in principle, as much to protect black land from white incursion as the reverse, but in fact the purpose has been to keep down the wages of blacks working on "European" farms by preventing them from renting, buying, or sharecropping in "white" agricultural areas.

by foreign capital and -- increasingly — South African whites. The need for skilled labor for deep-level mining opened up wage differentials favoring skilled white workers who were scarce, and these were gradually transformed into white-black differentials maintained by non-economic forces. The legal reservation of high-paid jobs for white laborers, whether they were particularly skilled or not, began with the Mines and Works Act of 1911 and was completed after the Rand Rebellion by white unionized labor in 1922 with even tighter "color bars". The net result of all these restrictions and reservations has been that for the past half century about 90% of the mining employment -- the lower paid 90% -- has been filled by blacks (Wilson, 1972). "... from 1924 onwards ... the written and unwritten rules of White-Black job demarcation ... [have been] simply not an agenda item" (Horwitz, 1967, p. 217). Meanwhile, over this period, real white wage rates rose at better than 1% per annum, and real black wage rates rose not at all until the mid-1970s, though fairly rapidly since then.[9]

Mining growth did not immediately induce manufacturing growth in South Africa. By 1925, barely 10% of the GDP was generated there, and that largely in mining-related industries. The introduction of significant tariff protection for manufacturing and the influx of low-wage workers, both black and white, into the towns in the 1920s and 1930s provided the belated stimulus; and the trade interruptions of the Depression and World War II continued it. Today, manufacturing accounts for 25% of South Africa's GDP (Nattrass, 1981, Chap. 8).

Throughout this growth, nonwhite workers were restricted to the least skilled jobs, first by custom, the "civilized labor policy", the "rate for the job", and "job reservation", and later by bars to nonwhite apprenticeships and inferior nonwhite educational opportunities.[10] With weak or prohibited unions for nonwhite workers, the powerful and state-supported white unions were able

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9. Nattrass, 1981, pp. 139-140. In the 1980s, even the long-standing job reservation system in the mines has begun to weaken (Lipton, 1985, pp. 207-208).

10. The "civilized labor policy" threatened withdrawal of tariff protection from firms replacing white with nonwhite labor; the "rate for the job", along with minimum wage standards, prevented nonwhites from displacing whites by undercutting wages; "job reservation" specified jobs that could not legally be filled by nonwhites.

to bargain for the best jobs at the best pay for their members, and South African factories evolved into "multi-racial teams of non-competing workers" with whites doing only the top-rung jobs.[11]

In the last quarter century, the rate of growth of manufacturing has outrun the ability of white labor to supply its increasing need for skilled labor. Responding pragmatically, white unions and management have agreed to move nonwhites up the job-ladder. Those whites who vacated the lowest white rung were promoted into better jobs, and the nonwhites who replaced them often arrived to find the job "diluted" or "fragmented."[12] Today, if one separates the labor in manufacturing into unskilled and skilled, one finds almost all of the unskilled jobs in the hands of nonwhites and a vast majority of the skilled jobs still in the hands of whites.

The development of the "other" sectors — trade, transport, construction, government, etc. — has paralleled that of manufacturing with respect to the racial composition of labor, with one significant exception. The government has traditionally found ways to protect the living standards of the least skilled whites by insisting that employers — often government itself — pay a "civilized wage" to whites doing practically identical work as low-paid nonwhites. But despite this special protection for the least-skilled whites, the overall picture in these other sectors is the same as in manufacturing. Whites do most of the skilled work, and nonwhites do almost all the unskilled work; nonwhites have been permitted to move up the job-ladder into skilled jobs only as white labor scarcity necessitates.[13]

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11. The quote is from Frankel, 1947.

12. By the words, "diluted" and "fragmented", is meant that the former white job was broken down into two or more nonwhite jobs each of which required less skill, or could be perceived by whites as requiring less skill. This dilution could be nevertheless cost-effective since the wage rates of the new nonwhites were usually so much lower than the rate formerly earned by the white employee. See Porter, 1984, and Knight and McGrath, 1987.

13. Here, another dramatic change is in process: nonwhite job advances have recently begun to move at a pace faster than white labor scarcity dictates, with the precedential appearance in South Africa of unemployment among unskilled whites.

In addition to the regulations about the kinds of jobs and the numbers in which nonwhite labor could be utilized in the so-called white economy, apartheid restricted the number of blacks who could migrate out of the reserves into "European" agriculture, mining, and urban employment. Beginning with the Stallard Commission in 1922 -- which formulated the principle that a black "should only be allowed to enter the urban areas ... to minister to the needs of the white man, and should depart therefrom when he ceases so to minister" -- adult blacks had to carry a "pass", a proof of their permission to work in a particular white area.[14] These "influx controls" have always been imperfectly enforced and, especially recently, much circumvented, but they have served to limit the movement of blacks from the agricultural sector of the Black reserves (i.e. African reserves) to the "white" sectors (i.e. "European" farming, mining, manufacturing, and other urban activities).

With declining living standards in the African reserves and ever increasing opportunities for employment, skilled as well as unskilled, in manufacturing and other urban sectors, black workers began to flow toward the South African cities at a rate faster than the "pass laws" could contain. And the urban jobs to which they flowed required a more stable labor force than the principle of temporary African migrancy into white areas could provide. In the 1950s, with the Natives (Urban Areas) Consolidation Acts, certain nonwhites were given residency rights in the cities -- called "section 10" rights. Those who could acquire such rights could work regularly in the well-paid urban sectors of the economy; without such rights they could not, at least without risks.

Beyond the inequitable distribution of land ownership and restrictions on the mobility of nonwhite labor, the system of apartheid relied heavily on the unequal provision of education to maintain the racial income disparities. Not only was access to apprenticeships denied nonwhites but little general education was offered them and even that of little quality. The practice of restricting expenditure on black education to the amount collected in direct black taxation was dropped in 1972 (by the Education Account Abolition Act), but progress has been slow. While the average white adult in South Africa has completed 10 years of schooling, urban nonwhites receive much less and rural

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14. The Stallard Commission quote is from Rogers, 1976, p. 10.

nonwhites almost none at all; and expenditure per student is about one seventh as much for blacks as for whites (Cooper, 1984, p.420).

During the past ten years, with increased international attention and internal unrest, the formal legal apartheid restrictions began to be softened (Greenberg, 1987, passim). Following the Riekert Commission report (1979), government enforcement of apartheid was steadily reduced and now has been almost entirely abandoned. Throughout the last decade, nonwhite progress has been enhanced continually by the need for more skilled workers than the growth of the white labor supply can satisfy, and nonwhite wage rates have risen more rapidly, both for skilled and unskilled workers. But behind the official neutrality and the semantics of "separate development" in independent Black Homelands, the essential characteristic of the apartheid system -- constraint on the mobility of nonwhite labor -- has continued, supported by custom, history, racism, unions, housing, education, and the general milieu of government policy. Apartheid is in flux (in the late 1980s), and the static picture of it that we are about to draw is not only simplified but also probably not accurate for any particular year of the early 1980s.

A viable theoretical picture of the South African economy must distinguish five sectors of economic activity. These are (with the identifying subscripts that will be later used in parentheses):

1. Black reserve agriculture (b for Black). Here, unskilled nonwhite workers toil with poor land, little capital, few intermediate inputs, and primitive technology.

2. European agriculture (e for European). What is "European" here is the ownership and management, entirely white South African. The labor, beyond that of the white owner/operator, is done by unskilled nonwhites. Size is large, capital is significant, state support is extensive, and technology is modern.

3. Mining (g for gold and other mining).[15] Predominantly comprised of modern, large, corporate gold and diamond mining operations, this sector utilizes a thin vein of white

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15. The letter g is used here to save the letter m for manufacturing.

employees and a large lode of mostly unskilled, mostly migrant nonwhites.[16] In the model developed here, we ignore the facts that transient labor is employed and that many of the mining workers are still recruited from outside South Africa's borders. Some of the costs of apartheid that will be estimated here are therefore both spread over larger numbers of workers and borne by non-South-African nonwhites.

4. Manufacturing (m for manufacturing). Firms in this sector utilize unskilled labor, almost all done by nonwhites, as well as skilled labor. The skilled work is increasingly done by nonwhite labor as the scarcity of skilled whites necessitates.[17] The job-ladder that we consider here consists of just these two rungs, skilled labor and unskilled labor.

5. The "other" sectors (o for other). A catchall of the remaining (i.e. non-manufacturing) urban sectors, firms here also use almost entirely nonwhite unskilled labor and employ a small percentage of nonwhites in the skilled-labor category. This sector includes not only private profit-seeking firms but also government per se and many public corporations (in transport, communications, etc.), but we will ignore the fact that these latter entities have objectives other than profit in their hiring activities.

The general equilibrium model incorporating these five sectors will deal only with the production and supply side. Demand can be ignored provided we can think of South Africa as a small open economy with no untraded goods. It is arguably not small with respect to its mining sector; we ignore this. It is open, but both import and export taxation separate its internal prices from world prices; we ignore nontariff protection and never consider the impact of

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16. The migrancy of mining labor is an historical phenomenom that is fading only slowly today, long after its original function has eroded. See Wilson, 1972, Johnstone 1976, and Lipton, 1985.

17. In manufacturing, and in the "other" sector discussed next, nonwhite means not only blacks of African origin but also workers of mixed racial and Indian/Pakistani origin. The reader is reminded that these distinctions are not pursued here.

changes in South Africa's system of border taxation. There are many untraded goods (and, more so, services), primarily in the "other" sector; the fact that their prices are domestically determined is ignored.

First we write production functions for each of the five sectors. They are all constant-elasticity-of-substitution (CES) production functions that display diminishing returns to (skilled and unskilled) labor to reflect the fixity of other factors.[18] The value of output (i.e. value added in South African prices) is represented by Q, and the quantity of labor by L. Subscripts are added, whenever needed, to indicate the sector (b, e, g, m, or o), the skill level of labor (s for skilled or u for unskilled), and the race of the labor (n for nonwhite or w for white). The production function parameters are, for each sector, A, C, and E.[19] The five production functions:

(1) $$Q_b = A_b[(L_{nb})^{-E_b} + C_b]^{-1/E_b};$$

(2) $$Q_e = A_e[(L_{ne} + L_{we})^{-E_e} + C_e]^{-1/E_e};$$

(3) $$Q_g = A_g[(L_{ng} + L_{wg})^{-E_g} + C_g]^{-1/E_g};$$

(4) $$Q_m = A_m[B_m(L_{num} + L_{wum})^{-E_m} + (L_{nsm} + L_{wsm})^{-E_m} + C_m]^{-1/E_m};$$ and

(5) $$Q_o = A_o[B_o(L_{nuo} + L_{wuo})^{-E_o} + (L_{nso} + L_{wso})^{-E_o} + C_o]^{-1/E_o}].$$

The sum of the five values of Q is of course GDP. The sum of the thirteen labor variables is the total South African employed labor force.

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18. Principally capital and, in the two agricultural sectors, land and, in the mining sector, resource stocks.

19. In a CES function, the elasticity of substitution is equal to (1/(1+E)). Note, in what follows, that there is but one elasticity of substitution, applying equally to the substitutability between the two different kinds of labor and between labor and the unspecified other (i.e. land, capital, and/or resource) factors. Note also that, for the two sectors using both skilled and unskilled labor, a distribution parameter, B, is needed. The production functions, and their empirical content, are further discussed in Appendix B.

Changes in unemployment are not considered here.[20] Wage rates are assumed to adjust to assure the given employment level of each relevant labor group.[21] Thus the labor-supply equations for each of the two racial groups being considered are

$$(6) \qquad L_{nb} + L_{ne} + L_{ng} + L_{num} + L_{nsm} + L_{nuo} + L_{nso} = \bar{L}_n \text{ and}$$

$$(7) \qquad L_{we} + L_{wg} + L_{wum} + L_{wsm} + L_{wuo} + L_{wso} = \bar{L}_w,$$

where $\bar{L}_n$ and $\bar{L}_w$ are the total supplies available of nonwhite and white labor, respectively.

The values of the Cs in the production functions will be taken as given throughout the exercises conducted here. Since the parameter, C, contains the influence of the non-labor inputs, this means that the past allocations of capital to the different sectors, however distorted by the labor allocation restrictions imposed by various apartheid constraints, will not be reallocated during the simulations of other situations. Hence, apartheid's misallocations of capital will not be counted in the estimates of the costs or redistributions attributable to apartheid.[22]

In order to model the restrictions placed on labor allocations by apartheid, it is useful to define five new ratio variables, the Zs in equations (8) - (12):

$$(8) \qquad L_{nb} = Z_b(\bar{L}_n);$$

$$(9) \qquad L_{ng} = Z_g(L_{ng} + L_{wg});$$

$$(10) \qquad L_{nsm} = Z_m(L_{nsm} + L_{wsm});$$

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20. Neither are changes in the fraction of that employment drawn from neighboring countries nor changes in the degree of underemployment in the "reserves".

21. Or, for whites in some of the scenarios we will consider, various policy rules may intrude in order to insure full employment.

22. Land endowments are also implicit in the Cs of the two agricultural sectors, Black (b) and European (e), and these too are not reallocated in the simulations.

(11) $L_{nso} = Z_o(L_{nso} + L_{wso})$; and

(12) $L_{num} + L_{nuo} + L_{nsm} + L_{nso} = Z_x(\bar{L}_n)$.

Z_b is the fraction of the entire nonwhite labor force that is kept in the Black reserves. Z_g is the fraction of the total (recall, g for gold) mining labor force that is composed of nonwhite workers. Z_m and Z_o are the ratios of the nonwhite skilled labor to the total skilled labor utilized in manufacturing and "other" sectors, respectively. And Z_x is the fraction of the nonwhite labor force that works in the largely urban manufacturing and "other" sectors.

Apartheid places restrictions on each of these Zs. Z_b is fixed by means of "influx control", which prevents blacks from moving freely from the reserves to the different "white" sectors of the economy.[23] Z_g is fixed by the long-standing, quasi-legal agreements between mining corporations and the white mining unions. The values of Z_m and Z_o used to be fixed at times by explicit "job reservation" but are now more implicitly arranged through traditions and negotiations between the individual firms (and groups of firms) and their white employees. Z_x is determined by the fraction of the nonwhite labor force that has gained access to the manufacturing and "other" largely urban sectors.[24] In a free market, each of these Z variables would be free to vary from zero to one as the wage rates faced by employers should dictate. Indeed, corner solutions at zero or one would eventuate unless the wage rate of identical workers of different races were identical. Under apartheid, however, the Z variables are not free to vary so widely in response to market forces. The formal and fixed way in which we treat the imposition of the Z constraints is more appropriate to a model of apartheid in the early 1980s than to today. The following inequalities indicate in a general way the constraints that apartheid places on the five Zs:

(13) $0 < \underline{Z}_b < Z_b < \bar{Z}_b < 1$;

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23. This used to be determined by "pass laws", now removed, and is currently more subtly effected by job availability.

24. Once restricted to "section 10" rights-holders, this is now more loosely determined by the availability of housing in these areas.

(14) $0 < \underline{Z}_g < Z_g < \bar{Z}_g < 1$;

(15) $0 < \underline{Z}_m < Z_m < \bar{Z}_m < 1$;

(16) $0 < \underline{Z}_o < Z_o < \bar{Z}_o < 1$; and

(17) $0 < \underline{Z}_x < Z_x < \bar{Z}_x < 1$.

In each of the above strings of inequalities, the $\underline{Z}$ represents the lower limit that the Z can assume and the $\bar{Z}$ represents the upper limit.[25] Specifically, apartheid imposes a left-hand constraint on Z_b, in inequalities (13), and right-hand constraints on the other four Zs, in inequalities (14) - (17). The use of only five labor-mobility constraints is of course a great oversimplification of the web of nonwhite labor controls woven through the South African economic fabric. Certainly, for example, the implication that nonwhites who manage to leave the homelands are completely free to choose between jobs in European agriculture and jobs in mining is quite unrealistic. Another implication, that Africans with "section 10" rights are completely mobile structurally and geographically between the various employers of the manufacturing and "other" sectors, is also far from realized in fact.[26] Unfortunately, it is not at all clear whether the model's stylized simplifications of the restraints on nonwhite labor mobility lead to overestimates or underestimates of the force of apartheid.

Some whites are unable or unwilling to work in skilled jobs — the L_{wum} and L_{wuo} in equations (4) and (5). The system protects their wages from dropping to the level of the unskilled nonwhites who do similar jobs and protects them from unemployment in their competition with much lower paid nonwhites by white union insistence, formal wage differentials, and job reservations. Here, we will capture this in the following simple manner:[27]

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25. All the Z ratios are constrained by definition to be between zero and one.

26. These simplifications underlie, and indeed necessitate, the introduction of wage differentials (the D parameters) later on.

27. The simplicity of treatment is justified on the grounds that relatively few workers are involved -- barely a tenth of the white labor force works in what are called unskilled positions. This treatment ignores the major visible change in South Africa in the late 1980s: the removal of all

(18) $L_{wum} = \bar{L}_{wum}$;

(19) $L_{wuo} = \bar{L}_{wuo}$; and

(20) $Y_w^u = F\, Y_n^{urb}$.

Equations (18) and (19) insure that these unskilled whites become employed, through some kind of front-of-the-queue arrangements, regardless of how uncompetitive their wages are relative to equally productive nonwhites. $\bar{L}_{wum}$ and $\bar{L}_{wuo}$ are the total numbers of unskilled whites that present themselves for jobs in these two sectors, and they are in fact always the first employed in such jobs. Equation (20) fixes the wage rate of such unskilled whites (Y_w^u) at a multiple of the wage rate of unskilled urban nonwhite labor (Y_n^{urb}). The parameter F would be one in a free market (or less than one if no nonwhite unskilled workers were employed). But F is set by government regulations well above one under apartheid protection of the standard of living of unskilled whites.[28]

White farmers, who own and operate the farms of the European agricultural sector, generally also work there. Hence their inclusion in the labor input of equation (2). They themselves insure that they are not unemployed, and their sizeable incomes relative to the nonwhites that also work there is owing to their receipt of land rent and capital earnings. Here, we capture all this by simply writing

(21) $L_{we} = \bar{L}_{we}$.

Uneducated labor is not the same thing as educated labor. We will consider this in a very simple manner, namely, by assuming that the rate of return to schooling is 6%, at all levels of schooling.[29] Roughly, this means

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formal job reservation and appearance of unemployment among unskilled whites.

28. This use of F is the mirror image of the assumption of no white unskilled unemployment. This assumption too has become obsolete, and dramatically so, in the late 1980s.

29. The few attempts to measure this rate of return to education in South Africa have uncovered figures nearly double 6%, for the primary and secondary education of whites, but almost inevitably a large part of this

that the wage rate of a laborer, and the marginal product of that laborer, is 6% higher than it would have been, as a result of each year of schooling.[30]

Because we are interested in the distribution of income between races, and not between people of the same race, because of data limitations, and because the 6% assumption makes the variance of educational attainment irrelevant for the average wage, we can define units of "effective labor" that are adjusted for the average schooling of each race. Normalizing so that one nonwhite laborer is defined as one "effective laborer", we must now take account of both numbers of white laborers and numbers of "effective" white laborers, where the latter are higher than the former by a factor of (1.06) raised to a power; the power is the difference between the average years of schooling of whites and the average years of schooling of nonwhites.[31]

Given the total nonwhite employment $\bar{L}_n$ and given the fraction that is retained in the reserves Z_b, the Black agricultural production function (equation (1)) determines the value of output, the value of the average product of labor, and the value of the marginal product of labor there. Because the land in the reserves is owned by the blacks who farm it, the average product of labor there measures the standard of living; but it is the marginal product that is relevant to the decision whether or not a family should send (if permitted) a marginal family member to the "white" sectors for work. Let us call this marginal product of labor in the Black reserves the "wage", Y_n^{bla}; partial derivation of equation (1) yields

$$(22) \qquad Y_n^{bla} = A_b[1 + C_b(L_{nb})^{E_b}]^{-(1+E_b)/E_b}.$$

The bla superscript refers to Black (reserve) agriculture. This "wage", Y_n^{bla}, would of course be equal to the wage received by unskilled nonwhites in all

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measured return is due to the innately greater capacities of those who complete more schooling. See Trotter, 1977, p.357.

30. The cost of a year's schooling is principally the foregone wage rate that could have been earned by a worker with a year less schooling. The return to the schooling is a flow of additional income that is 6% higher each year for the remainder of the worker's active life. Ignoring depreciation of human capital, the finiteness of life, and the other resource costs of education, the assumed 6% return implies a wage and marginal product that is 6% higher.

31. This ignores the difference in the educational quality of those years.

the other, so-called "white" sectors if they were free to choose the sector in which they worked. With binding apartheid constraints on emigration from the African reserves, Y_n^{bla} provides no more than a lower bound for the nonwhite wage rates in the "white" parts of the economy.

This wage of unskilled nonwhite workers in the modern sectors must be, by competitive pressures, equal across sectors between which such workers are mobile and equal to the value of the marginal product of unskilled labor in sectors where no imposed marginal labor-use restrictions apply. Writing Y_n^{rur} for the basic wage of workers who escape the Black reserves but fail to acquire "section 10" rights -- and hence are only eligible for jobs in European agriculture and the mines -- and partially differentiating equation (2) with respect to L_{nb}:

$$(23) \qquad Y_n^{rur} = A_e[1 + C_e(L_{ne} + L_{we})^{E_e}]^{(1+E_e)/E_e}.$$

The rur superscript refers to the rural sectors, European agriculture and mining. While there also are white workers in this production function, they are the white owner/operators and, obviously, hire themselves first.

Similarly, wage-equals-marginal-product equations can be written for the unskilled nonwhite labor in the two urban sectors, manufacturing and "other". The wage in these sectors is written Y_n^{urb}, with the urb superscript for urban:

$$(24) \qquad D_{num}Y_n^{urb}=A_mB_m[B_m+C_m(L_{num}+L_{wum})^{E_m}+\{(L_{num}+L_{wum})/(L_{nsm}+L_{wsm})\}^{E_m}]^{(1+E_m)/E_m};$$

and

$$(25) \qquad Y_n^{urb}=A_oB_o[B_o+C_o(L_{nuo}+L_{wuo})^{E_o}+\{(L_{nuo}+L_{wuo})/(L_{nso}+L_{wso})\}^{E_o}]^{(1+E_o)/E_o}.$$

Note the D parameter in equation (24).[32] In the empirical work, we shall find that the wage rates of supposedly identical workers (i.e. identical in all of skill, race, and job mobility) are not quite equalized among the different sectors. The possible sources of such differentials are myriad, and we will not try to track them down. Instead, we will accept these gaps as educational or non-pecuniary-benefit differentials whose relative size is

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32. Other D parameters will appear in equations to come.

unaffected by the changes in apartheid rules that we shall simulate.[33] The values of D are normalized (to one) for European agriculture in the two "white rural" sectors and for "other" in the two "white urban" sectors. The various D parameters thus indicate the ratio of wage rates elsewhere to wage rates in the sector that is normalized.[34]

A few words are necessary about the workings of the labor markets implicit in equations (24) and (25). Both whites and nonwhites work in these sectors (manufacturing and other) as unskilled labor, but the white wage rate for unskilled labor does not enter the equation calling for the equality of wage rate and marginal productivity. In our model's (rapidly becoming obsolescent) picture of a rigid racial protection of unskilled whites in South Africa, an adequate number of unskilled jobs are reserved for the unskilled whites, and nonwhites are not hired until these are filled. This protects the potentially most endangered white group from wage and employment competition with the vast numbers of unskilled and low-wage nonwhites. Thus, <u>on the margin</u>, once the unskilled whites have been infra-marginally hired, employment decisions are based on a comparison of the nonwhite wage and the marginal product of such labor.[35]

Things are more complex in the mining sector (g) because employers are required to hire $(1-Z_g)$ white workers -- at skilled white workers' wage rates -- for each Z_g nonwhite workers they hire. Thus, the value of the marginal product of labor in this sector will be equal to a weighted average of the nonwhite rural wage rate Y_n^{rur} and the white wage rate of skilled workers, Y_w^s. This weighted average equation:

$$(26) \qquad Z_g D_{ng} Y_n^{rur} + (1-Z_g) D_{wg} Y_w^s = A_g[1 + C_g(L_{ng}+L_{wg})^{Eg}]^{-(1+Eg)/Eg}.$$

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33. Some of the differentials for nonwhites are almost certainly caused by apartheid barriers that escape the simplified model presented here. In the simulations, this assumption forces us to ignore such aspects of apartheid's distortions.

34. Precise definitions and calculations of all the D parameters are given in Appendix C.

35. The same phenomenon occurred in the European agricultural sector, i.e. equation (23), although there the priority is much more direct -- the white farm owners naturally employ themselves first before considering how many nonwhite employees to engage.

Competition between white and nonwhite workers is prevented in a different manner among skilled workers. The more skilled of the skilled jobs are reserved for whites, and the less skilled of the skilled jobs are opened to nonwhites. If we assume that these two parts of the skill ladder must be expanded or contracted together (i.e. the two are perfect complements), then the marginal decision on hiring skilled labor involves both wage rates, that of whites and that of nonwhites. Skilled workers in manufacturing and "other" sectors are therefore seen as being hired on a weighted basis -- $(1-Z_m)$ skilled whites at higher pay for every Z_m skilled nonwhites at lower pay in manufacturing (and, with Z_o replacing Z_m, ditto for the "other" sector). The conditions for equality of wage and marginal product of skilled labor in manufacturing and "other":

$$(27) \quad Z_m D_{nsm} Y_n^{urb} + (1-Z_m) D_{wsm} Y_w^s = A_m[1+B_m\{(L_{nsm}+L_{wsm})/(L_{num}+L_{wum})\}^{E_m} + C_m(L_{nsm}+L_{wsm})^{E_m}]^{-(1+E_m)/E_m};$$

and

$$(28) \quad Z_o D_{nso} Y_n^{urb} + (1-Z_o) Y_w^s = A_o[1+B_o\{(L_{nso}+L_{wso})/(L_{nuo}+L_{wuo})\}^{E_o} C_o(L_{nso}+L_{wso})^{E_o}]^{-(1+E_o)/E_o}.$$

Nonwhite wage rates for skilled workers in the manufacturing (m) and "other" (o) sectors are typically higher than those received by unskilled workers -- quite independently of any educational differentials -- because such workers have acquired marketable skills and must work with special care and punctuality. We will not explore the sources of these differentials but rather treat them as inalterable parameters, D_{nsm} and D_{nso}. The differential between white skilled and white unskilled workers, on the other hand, is <u>not</u> assumed fixed; rather it is determined by the economic workings of the model. Implicit, therefore, in the formulation of equations (27) and (28) is the assumption that nonwhite skilled workers are drawn from the same labor pool as all other nonwhite workers but that white skilled workers comprise a distinct group that does not compete with white unskilled workers.

This completes the formal model. When the inequalities of (13) - (17) are all binding, converting them into equations setting the levels of the Z variables, there are 28 equations in 28 unknown variables. To recapitulate, these variables are: five output values (Q_b, Q_e, Q_g, Q_m, and Q_o), five wage rates (Y_n^{bla}, Y_n^{rur}, Y_n^{urb}, Y_w^u and Y_w^s), seven nonwhite labor quantities (L_{nb},

L_{ne}, L_{ng}, L_{num}, L_{nsm}, L_{nuo}, and L_{nso}), six white labor quantities (L_{we}, L_{wg}, L_{wum}, L_{wsm}, L_{wuo}, and L_{wso}), and five Z ratios (Z_b, Z_g, Z_m, Z_o, and Z_x). When the inequalities (12) - (15) are not narrowed to the point that they determine the Z values, the solution process is more complex.[36]

The restrictions, distortions, and redistributions of South Africa's apartheid reside in the values of the Zs and in the constraints on them (inequalities (13) - (17)). Our measures of the impact of apartheid will emerge from varying these constraints.[37] But first, the basis of the later comparisons must be made explicit — the South African economy of 1980.

III. The South African Economy in 1980

In this brief section, we develop a picture of the South African economy in 1980. Obviously, it is not intended to be a very detailed picture, being static and limited to the variables (and combinations of variables) utilized in the model of Section II. Rather, our intention here is to provide a benchmark sketch of reality to which we can compare the outcomes of the various counterfactual simulations that make up the remainder of this paper.[38]

This basic structure of the economy is shown in Table III-1.[39] GDP is the number at the bottom of the "row-total" column of the table, R58.089 billion. Along the bottom line of the table, this GDP total is divided up: on the left of the GDP figure into the output (i.e. the value added) of the five sectors with which we work; and on the right of the GDP figure into the factor

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36. This problem will arise in Section V. The basic apartheid model of this section can be examined with the help of "Eureka"; the program is shown in Appendix F (file name: APARTHEI).

37. The parameter, F (see equation (20), is also an artificial constraint favoring the income of unskilled white laborers, and its effect will also be examined, but not until Section VI. This lesser concern is justified by the fact that F has no allocative impact on the model (i.e. F does not enter equations (24) and (25), where the employment of unskilled labor is determined).

38. The benchmark year is chosen for statistical convenience, not because the model of Section II is thought to be especially appropriate to that year.

39. For the sources and derivations of the data, see Appendix A.

Table III-1

South African Economic Structure, 1980[1,2]

	Sector						Race	
	Agriculture					Row		
	Black[3]	Euro.	Mining	Manuf.	"Other"	Totals[6]	Nonwhite	White
Wage Income[4]								
Skilled	--	--	--	4.133	12.571	16.704	1.770	14.934
Unskilled	--	2.123	2.642	2.802	7.459	15.026	12.533	2.493
Nonwage Income								
IFOO[5]	0.414	1.280	--	--	--	1.694	0.414	1.280
Profit	--	--	10.790	6.204	7.671	24.666	--	24.666
Column Totals	0.414	3.403	13.432	13.139	27.701	58.089 (=GDP)	14.717	43.372

Notes:
1. All figures in billions of 1980 Rands.
2. -- indicates zero. (But see notes 3 - 5.)
3. All income in Black agriculture is listed under IFOO. Some unknown fraction properly belongs under labor income.
4. Where there is only one kind of labor, its income is included under "unskilled".
5. IFOO = incomes of farm owner/operators. This includes returns to the owner's capital and labor as well as land.
6. Totals of the sector columns or of the race columns (the totals of each are identical).

incomes of whites and nonwhites. In the "row-totals" column of the table, the GDP is divided up into the factor shares received by labor and nonlabor inputs. Farm incomes (IFOO)[40] are reported separately from both wage incomes and profit.[41]

The internal entries in the matrix of Table III-1 give the breakdowns of income by both the factor recipient and either the sector of income generation or the race of the recipient. The dividing line between skilled and unskilled labor is inevitably arbitrary.[42] Two other arbitrary procedures in the table need clarification. One, all Black farm income has been included there as IFOO; although some of it is surely attributable, and even directly paid, to labor, we do not know how much.[43] And two, for the two agricultural sectors and for mining, where only one kind of labor is included in the production function that we consider, the labor income is entered in the table under "unskilled" labor. This is for convenience only. Labor allocations are shown in Table III-2, as percentages of the totals for each of the two race categories.

We are interested in discovering, through the counterfactual simulations, both the efficiency costs and the racial and functional income redistribution that apartheid imposes. The efficiency costs will be measured simply by reference to GDP. Because of our small-open-economy assumption and our ignoring of border taxes, GDP performs well as a scalar measure of the economic efficiency.

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40. IFOO = incomes of farm owner/operators.

41. This is a visually useful division, but it is certainly not precise. Much that is in the IFOO row (especially in the European agricultural sector) is undoubtedly profit in the sense of a rate of return to capital; and much that is in the profit row (especially in the mining sector) is undoubtedly a return to resource ownership rather than reproducible capital.

42. See Appendix A for discussion of this division.

43. See the discussion of Y_n^{bla} in Appendix C. The implicit wage earnings of the white owner/operators in the European farm sector are also included in their IFOO.

Table III-2

Allocation of Labor in South Africa, 1980

(As Percentage of Total Labor by Race[1])

	Agriculture Black	Agriculture Euro.	Mining	Manuf.	"Other"	Totals
Nonwhite Labor	13%	19%	11%	15%	42%	100%
Unskilled				14%	39%	
Skilled				1%	3%	
White Labor	—[2]	1%	5%	20%	74%	100%
Unskilled				3%	12%	
Skilled				17%	61%	

Notes:
1. Percentages may not add due to rounding.
2. — means zero; 0% means less than 0.5%.

No simple scalar is ever entirely adequate as a measure of the equity of the income distribution. This is especially true here. Thus, we shall use several. First, there is the question of the distribution between wage and nonwage incomes. To some extent this is an indication of racial distribution, since very little nonwage income is earned by nonwhites.[44] But principally we shall refer to wage income as a percentage of GDP as an indication of the extent of change in the class structure of rewards -- between proletariat and capitalist. In these calculations, the "proletariat" includes both nonwhite and white workers (and also, rather inappropriately, the incomes of farm owner/operators). The "capitalist" includes not only those who earn the returns on capital but also those who receive rents on the natural resources of the mining sector. In 1980, total wage income (including IF00) as a percentage of GDP was 57.54%.

For summary statistics of racial distribution, two will be used. One, the percentage of total wage income earned by whites.[45] This percentage in 1980 was 55.97%. And two, the percentage of total income (i.e. GDP) earned by whites (in wages, rents and profits). This percentage in 1980 was 74.66%.[46]

Finally, various Lorenz curves will be drawn and Gini coefficients calculated as another way of looking at inequality. Since we do not use population figures but rather labor force data only, and since we have no information on the distribution of profit income across the labor force (and across non-laborers), we cannot calculate the usual Lorenz curve for purposes of international comparison. But we will be able to use our Lorenz curves for comparing the base 1980 distribution with different counterfactual simulations. For the reader's information (only, at this point), the 1980 benchmark Lorenz curves are shown in Figure III-1, for labor income (including IF00) only and for all income (on the assumption that all profit is earned by

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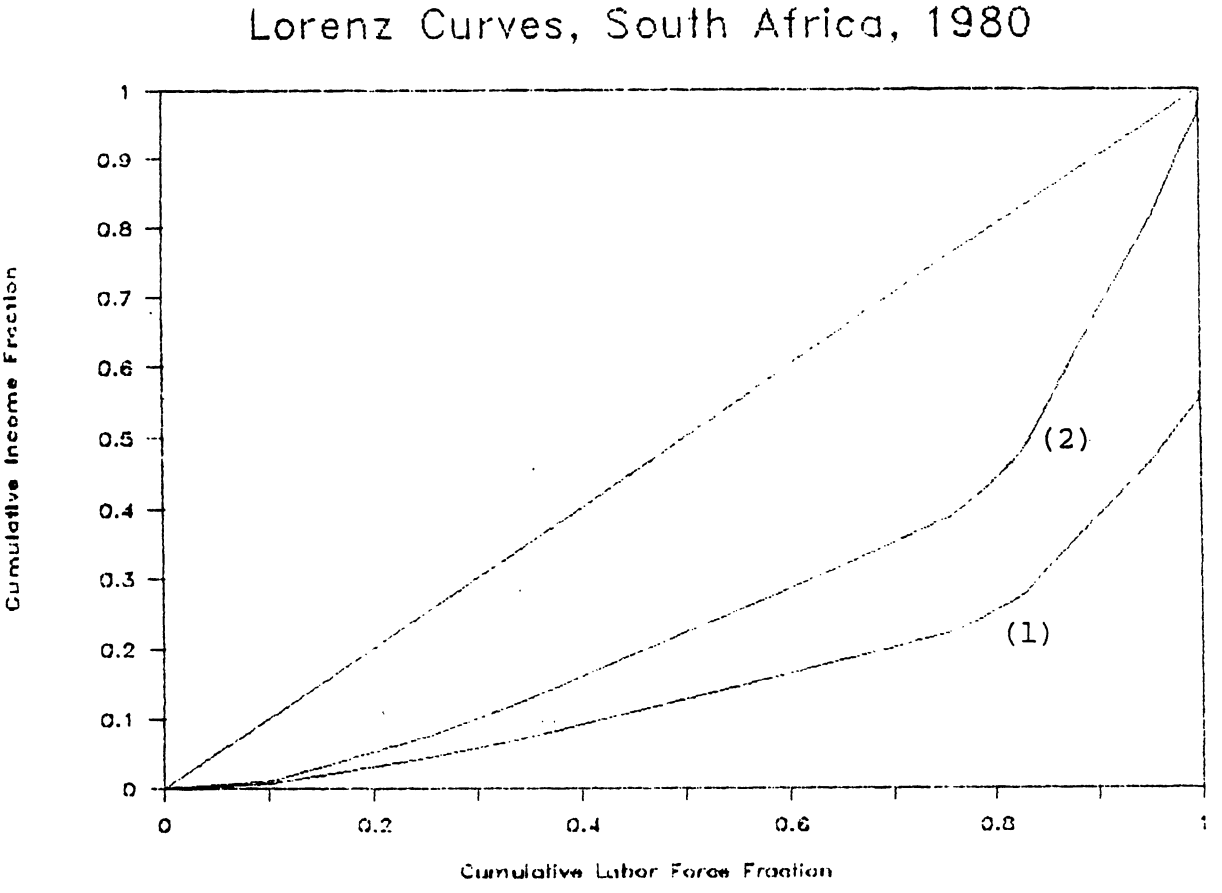
44. In the model, only that attributable to land and capital in the Black agriculture -- not a large amount. In reality, nonwhites earn some urban nonwage income, ignored here.

45. IF00 is counted throughout as wage income.

46. The three percentages reported in this and the preceding paragraph are, of course, not independent of each other:

$$0.7466 = 1 - (0.5754)(1 - 0.5597).$$

Figure III-1



Notes:
1. Profit income included (and attributed to final infinestesimal portion of the labor force).
2. Labor income only (including incomes of farm owner/operators (IFOO)).

the richest, infinitesimally small portion of the population). The Gini coefficients for these two Lorenz curves are .45 and .68, respectively.

IV. Simulations: Dismantling Racial Constraints One at a Time

Apartheid is an interrelated network of constraints, political and personal as well as economic, and it is, as they say, "academic" to think of relaxing these constraints one at a time. But we have already, in the name of theory, counted the number of labor-market restrictions as five, and we now proceed to look at each of these restrictions separately, in an effort to see quantitatively how much each affects the key economic magnitudes of the South African economy.

First, we examine the restrictions marginally. How would the economy have been altered (in 1980) by changing each, in turn, of the Z restrictions "a little"? Then a larger range of change for each of the Zs is examined, but again with only one of the Z restrictions being changed at a time.

The marginal impacts are reported in Table IV-1 in the form of elasticities -- that is, the percentage change in various variables that is occasioned by a one percent change in the relevant Z coefficient, with the other Z coefficients held constant (at their actual 1980 values). The Z coefficients are changed in the direction that increases GDP, which means that the elasticities are for a one-percentage-point decrease in Z_b and for a one-percentage-point increase in each of the four others (Z_g, Z_m, Z_o, and Z_x). These elasticities differ somewhat -- usually not much -- according to which of the 64 possible combinations of the production function coefficients are employed. Not all combinations were tried, for it quickly becomes apparent that the range of outcomes is small. Nevertheless, the true range of elasticities over all 64 combinations may in some cases be wider than those reported in Table IV-1.

The remarkable thing about Table IV-1 is how small the elasticities are. A one-percentage-point change in one of the Zs rarely changes GDP by as much as one tenth of one percentage point. And almost the same thing is true of total white income, total wage income, and white wage income. Though the

Table IV-1

Elasticities of Economic Variables with Respect to Labor-Market Restrictions

Economic Variable	Labor Market Restriction Changed[1]				
	Z_b[2]	Z_g	Z_m	Z_o	Z_v
GDP	0.0[3]	0.1	0.0	0.0	0.0/0.1
Q_b	-0.5/-0.1	0.0	0.0	0.0	0.0
Q_e	0.4	-1.8/-0.7	0.0	0.0	-1.7/-1.6
Q_g	0.0	0.2/0.8	0.0	0.0	-0.2
Q_m	0.0	0.0/0.1	0.0/0.1	0.0	0.2
Q_o	0.0	0.1/0.2	0.0	0.0/0.1	0.3
Y_n^{bla}	0.5/2.1	0.0	0.0	0.0	0.0
Y_n^{rur}	-0.4/-0.1	0.5/0.8	0.0	0.0	0.5/1.9
Y_n^{urb}	0.0	0.0	0.0/0.1	0.1/0.2	-1.4/-0.4
Y_w^u	0.0	0.0	0.0/0.1	0.1/0.2	-1.4/-0.4
Y_w^s	0.0	-0.4/0.0	-0.1/0.0	-0.2/0.0	0.2/0.6
Total White Income	0.0	-0.1	0.0	0.0	0.0/0.2
Total Wage Income[4]	0.0	-0.1	0.0	0.0	0.0/0.1
White Wage Income[4]	0.0/0.1	-0.5/-0.1	-0.1/0.0	-0.1/0.0	0.1/0.2

Notes:
1. Only one Z is changed; the others are held constant at their 1980 values. The slash indicates the range of elasticities that emerge from different combinations of production function parameters.
2. Z_b is reduced; all other Zs are increased.
3. 0.0 means between -0.5 and +0.5. Only one number is given if all combinations of parameters yield the same elasticity (to one decimal place).
4. Wage incomes include incomes of farm owner/operators (IFOO).

magnitudes are small, the directions are interesting and deserve a closer look:

Z_b. A decrease in Z_b — i.e. permitting more black laborers to leave the Black reserves — lowers output there, but never in percentage terms by more than the percentage decline in labor. Since none of the other Zs are changing, these new migrants go to European agriculture where output expands marginally.

Z_g. When blacks are permitted to do a larger fraction of the mining jobs, blacks move from European agriculture to mining (as the sizeable output changes indicate).[47] Rural nonwhite wage-earners gain from the movement, and urban white wage-earners are hurt to the extent that their supply is augmented by the former white miners.

Z_m and Z_o. Marginally opening up skilled jobs to nonwhites in the manufacturing and "other" sectors has little impact on outputs or incomes. With Z_x fixed, the new skilled nonwhites must come from the pool of existing urban unskilled nonwhites. Urban nonwhites gain slightly, and skilled urban whites lose slightly. But in neither column is any elasticity bigger in absolute value than 0.2.

Z_x. Opening the cities to nonwhites, again marginally, draws them largely from European agriculture, not mining. Rural nonwhites are significantly helped by this; significantly hurt are the urban nonwhites — those who were already in the cities, not of course the new arrivals. White skilled labor is benefited, as the scarcity of skilled labor is enhanced by the influx of new unskilled labor.

Figures IV-1 through IV-5 show how GDP moves for a broad range of movements of each of the Z values (still one at a time).[48] Only for Figure IV-1 does the choice of A_b matter, and all four cases are shown there. Dropping Z_b to zero raises GDP by barely R1.0 billion. Raising Z_g half the

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47. In fact, some of such job growth as this would be filled by urban workers, but the stylized structure of the model precludes that.

48. The curves in those figures are drawn only for the production function parameter cases where all the elasticities of substitution are equal to 1/2 or all equal to 2.

FIGURE IV-1

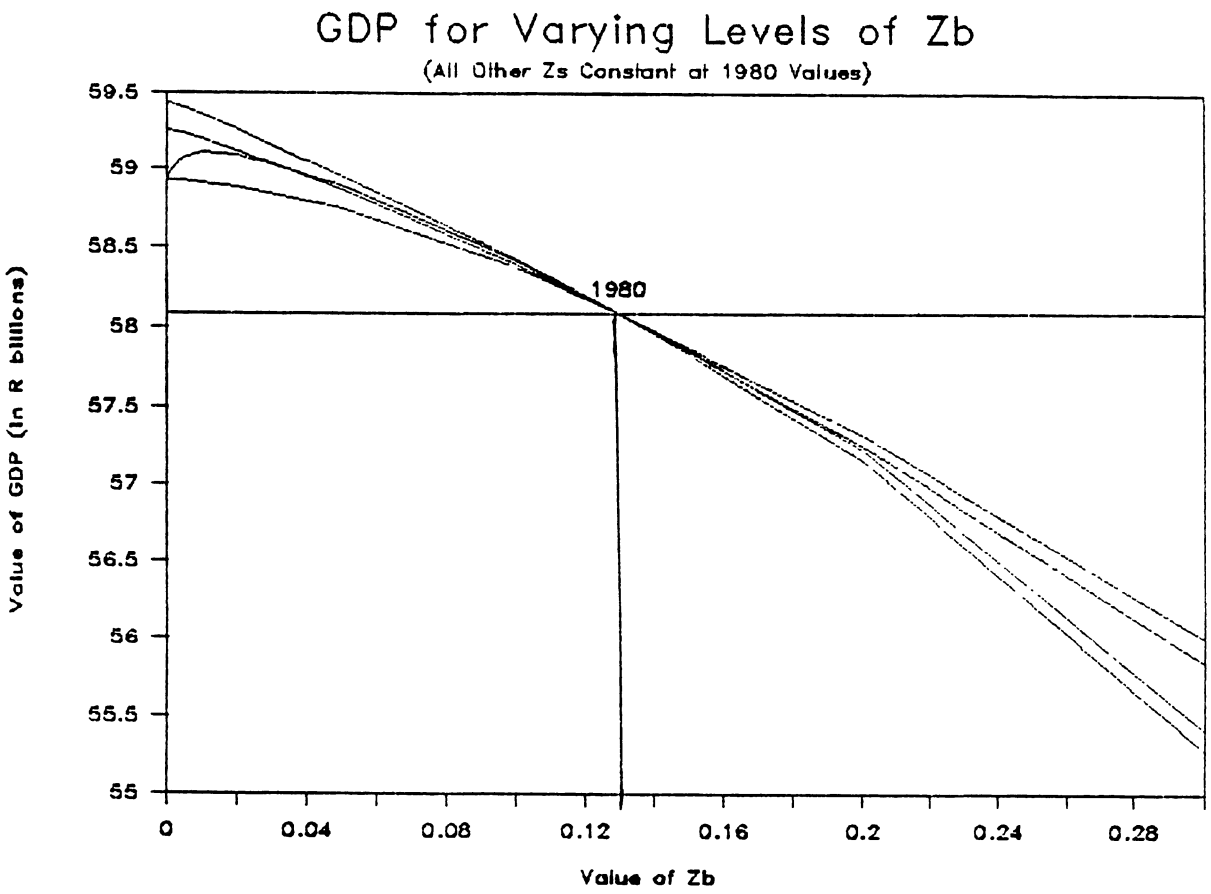

GDP for Varying Levels of Zb
(All Other Zs Constant at 1980 Values)
59.5
59
58.5
58
57.5
57
56.5
56
55.5
55
1980
0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
Value of GDP (in R billions)
Value of Zb

FIGURE IV-2

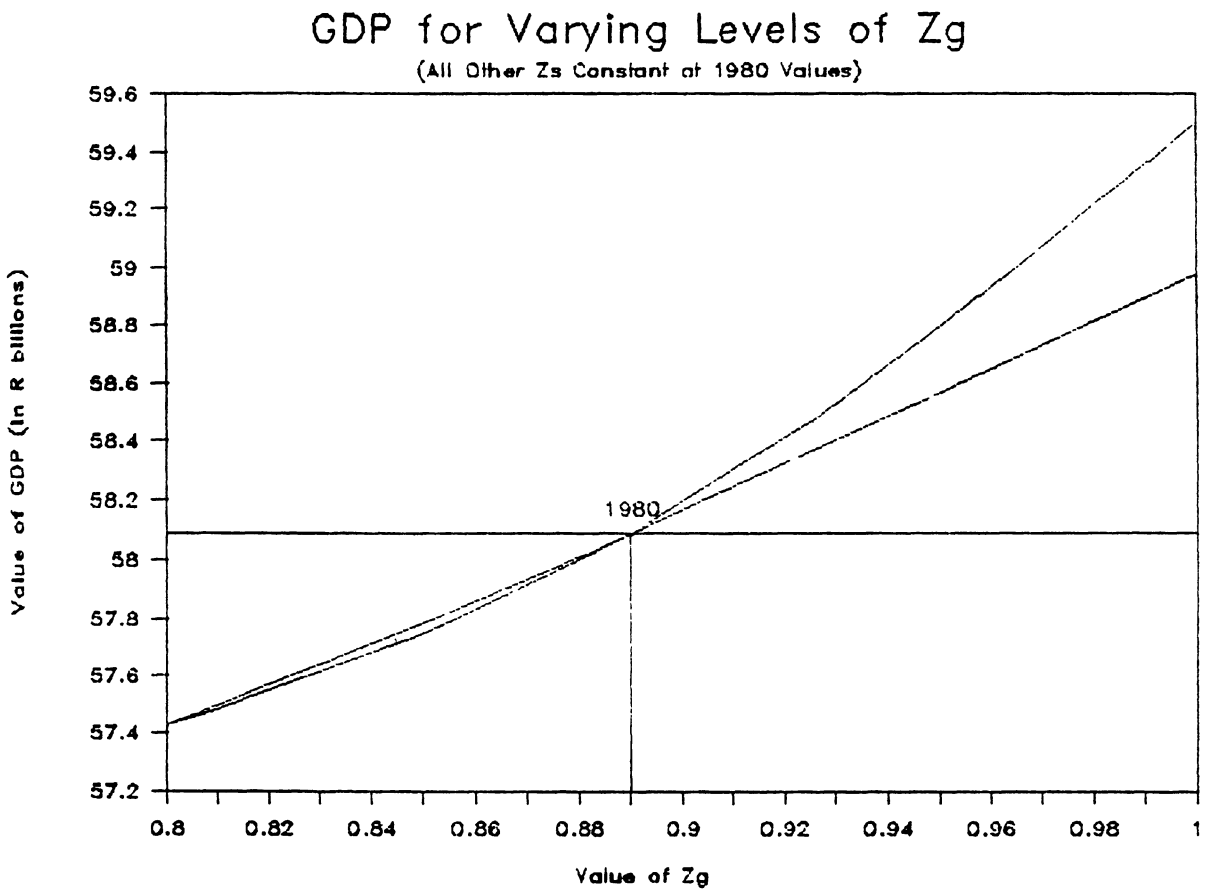

GDP for Varying Levels of Zg
(All Other Zs Constant at 1980 Values)
Value of GDP (in R billions)
59.6
59.4
59.2
59
58.8
58.6
58.4
58.2
58
57.8
57.6
57.4
57.2
1980
0.8
0.82
0.84
0.86
0.88
0.9
0.92
0.94
0.96
0.98
1
Value of Zg

FIGURE IV-3

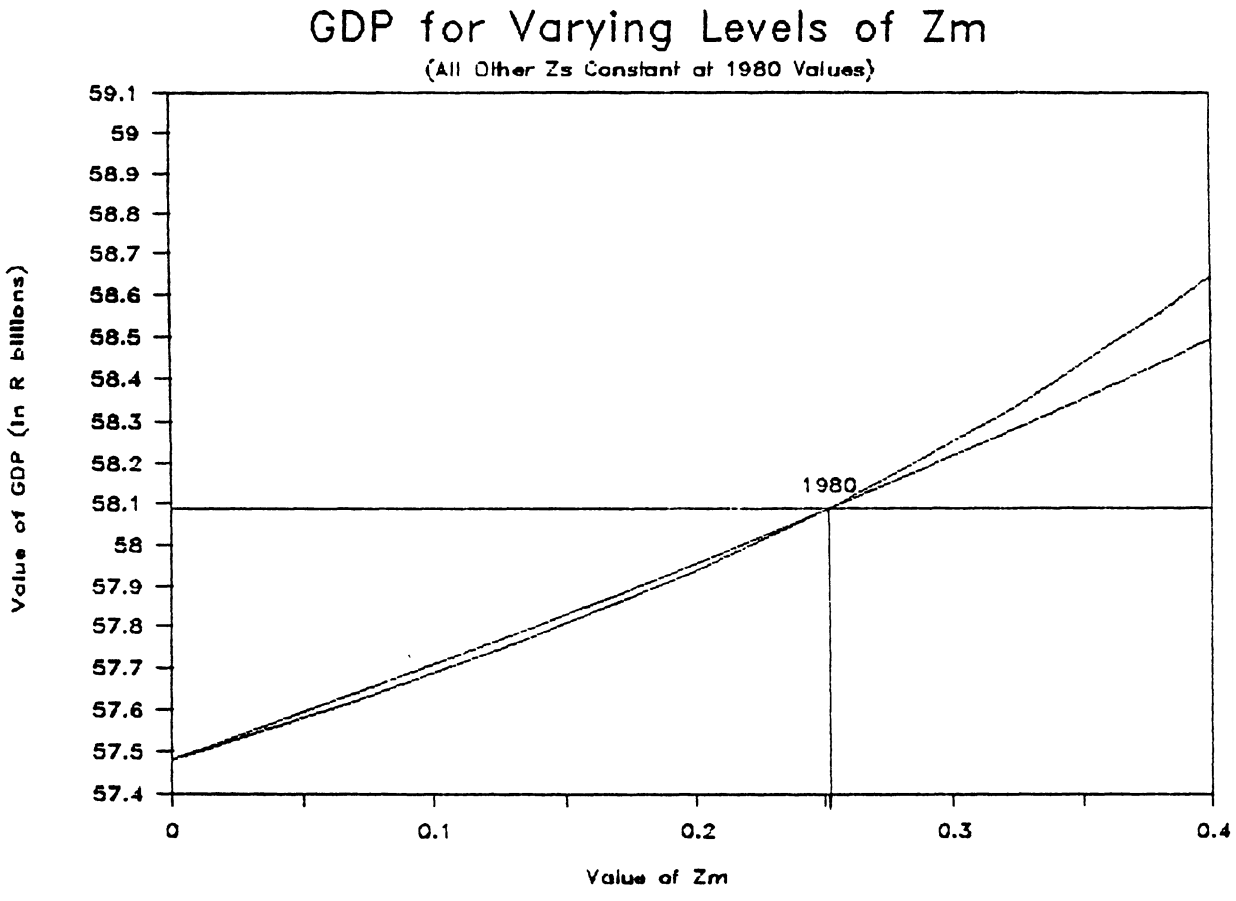

GDP for Varying Levels of Zm
(All Other Zs Constant at 1980 Values)
Value of GDP (in R billions)
59.1
59
58.9
58.8
58.7
58.6
58.5
58.4
58.3
58.2
58.1
58
57.9
57.8
57.7
57.6
57.5
57.4
1980
0
0.1
0.2
0.3
0.4
Value of Zm

FIGURE IV-4

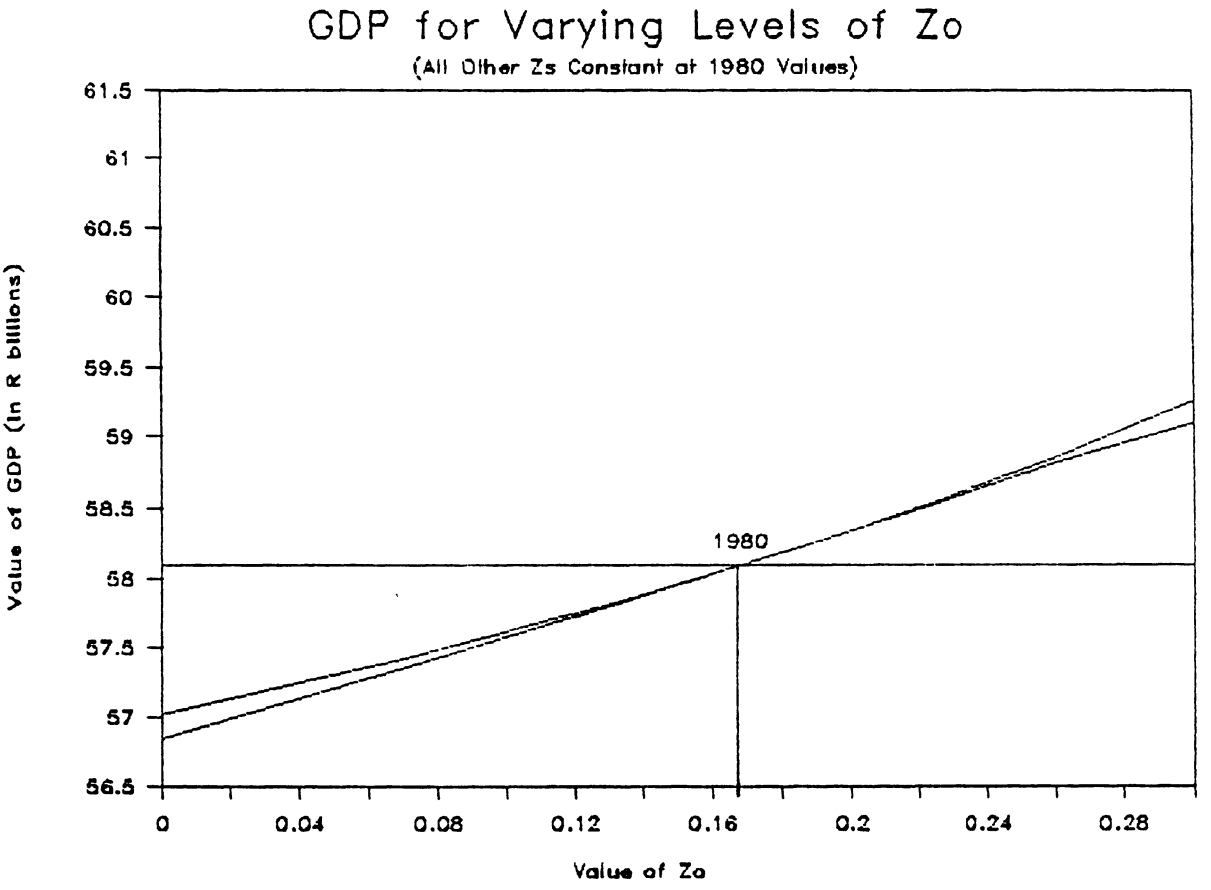
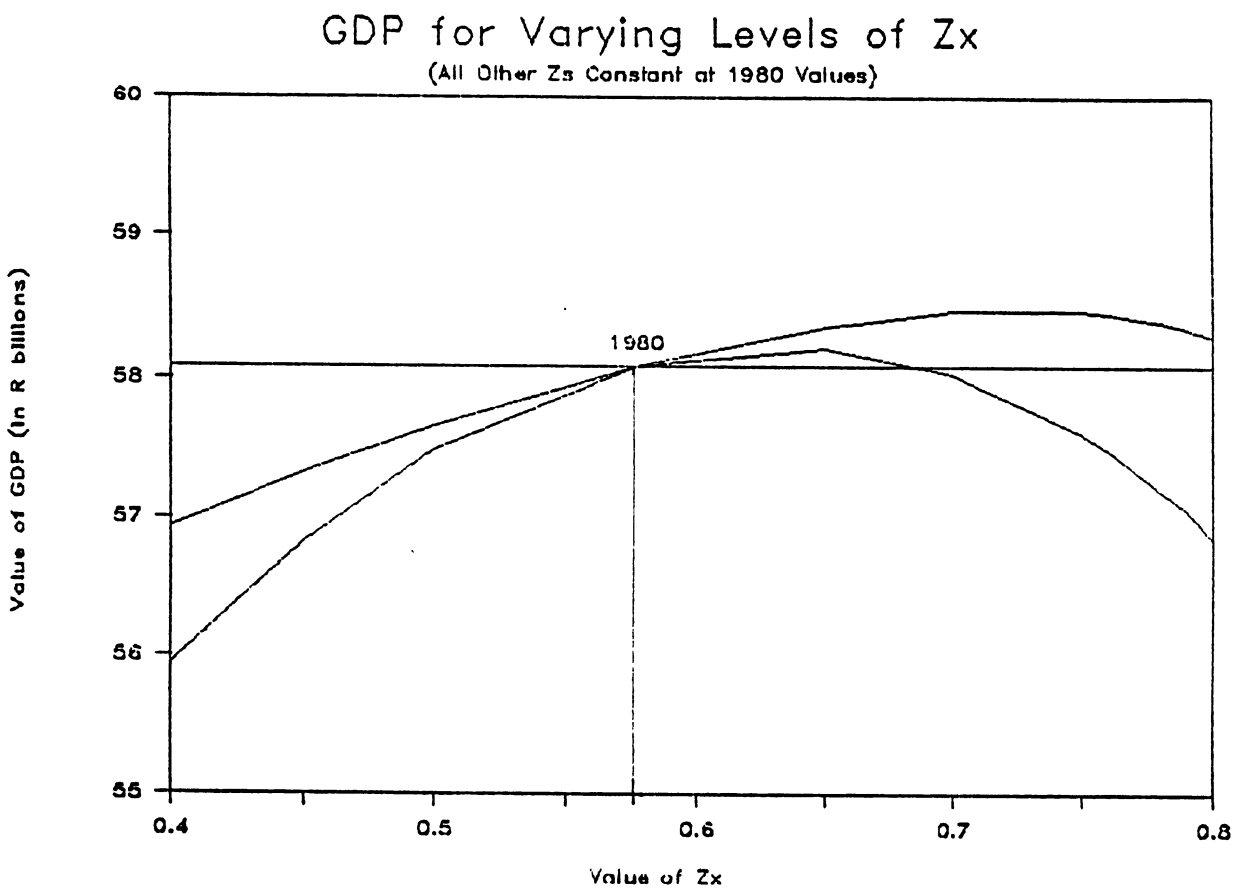

GDP for Varying Levels of Zo
(All Other Zs Constant at 1980 Values)
Value of GDP (In R billions)
61.5
61
60.5
60
59.5
59
58.5
58
57.5
57
56.5
1980
0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
Value of Zo

FIGURE IV-5


GDP for Varying Levels of Zx
(All Other Zs Constant at 1980 Values)
60
59
58
57
56
55
1980
0.4
0.5
0.6
0.7
0.8
Value of GDP (in R billions)
Value of Zx

way to one increases GDP by less than R1.0 billion. A 50% increase in either Z_m or Z_o raises GDP by around R0.5 billion. And no change in Z_x can raise GDP by as much as R1.0 billion.

Is there a lesson from all this one-at-a-time examination of the "dismantling" of the apartheid restrictions. Even sizable improvements in the network of labor-market constraints have small effects on total output and its distribution when the changes are made in piecemeal fashion. The network is too intertwined and interactive for single changes to do much. For example, consider the increase in Z_x, the fraction of nonwhites permitted into the cities. How productive can this be when the new entrants must be drawn from European agriculture and mining (since Z_b is unchanged) and are constrained to take unskilled jobs (since Z_m and Z_o are unchanged)? More than marginal, piecemeal change is needed if apartheid's creation is to be significantly transformed.

V. Simulations: Who Wants What Labor-Market Restrictions?

Real knowledge of the role of the different white groups in the determination of the many apartheid restrictions on the allocation of nonwhite labor would require not only political analysis but also historical research. Neither has been more than touched on here. But the model and its numerical potential can tell us what kind of labor-market restrictions would serve to maximally promote the economic interests of particular groups within the white community of South Africa. Where the restrictions that maximize the well-being of a particular group and the observed restrictions are similar, the similarity suggests that the group played an important historical role in the introduction of those restrictions or at least plays an important political role in their continuation. In this section, we pursue hints of this nature.

The pursuit is straightforward. The incomes of various white groups, and combinations of groups, are maximized using the model of Section II with respect to the choice of all five of the Z values, subject only to three restrictions. One, the values of the Zs must lie between zero and one.[49]

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49. The constraints on the feasible Z values are in fact somewhat narrower. For example, the sum of Z_b and Z_x must be less than one. But such complications do not become relevant in any of the actual maximizations

Two, we constrain the feasible values of the Zs to those for which every income group continues to earn positive income.[50] And three, the directions of the pressures of apartheid must not be reversed, lest we lose a sense of the realities involved.[51]

The various white interest groups examined are shown in the first column of Tables V-1 and V-2. The values of the five Zs that maximize each white sub-group's total income are shown in Table V-1. Note that two numbers, separated by a slash (/), are given whenever different Z values emerge under different combinations of production function parameters.

There is a great deal of spread, across different production function assumptions, in the maximizing values of the Zs in Table V-1. But a few broad generalizations can be drawn.[52] Almost no one wants to keep blacks in the reserves (at least for reasons of economic self-interest), but the different white groups have very different ideas about where they should go. Manufacturing and "other" capital want nonwhites extensively let into the cities and into skilled jobs in their own sectors. White farmers, urban unskilled white labor, and mining capital want them kept out of the cities

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conducted. Notice also that we are ignoring any political, technical, or educational constraints to the setting of the Zs; this is done quite intentionally, in order to uncover the interests of the different interest groups. Constraints on the rate of training that would be needed to move massive numbers of nonwhites into skilled positions will be considered in Section VI.

50. Constraining the labor variables to be non-negative is sufficient to insure this.

51. In the model, this means: 1) requiring $Y_n^{bla} < Y_n^{rur} < Y_n^{urb}$, for otherwise urban nonwhites must be prevented from returning to the rural areas and rural nonwhites from returning to the reserves; 2) requiring $Y_w^u < Y_w^s$, for otherwise skilled whites must be prevented from masquerading as unskilled; and 3) requiring $2.5Y_n^{urb} < Y_w^s$, for otherwise skilled nonwhites would be paid more than skilled whites. Not only does this third condition reflect political feasibility, it also reflects the sense of the job ladder, since skilled nonwhites are doing less skilled jobs than skilled whites (within the category of skilled labor). The number, 2.5, in the third inequality is chosen arbitrarily; any number slightly larger than the values of D_{nsm} and D_{nso} would do.

52. The maximizing values of the Zs for each of the white groups are discussed and explained in detail in Appendix D.

Table V-1

Labor-Market Restrictions Preferred by White Groups[1]

Maximizing White Income Group	Values of the Zs that Would Be Selected[2]				
	Z_h	Z_g	Z_m	Z_o	Z_x
Actual 1980 Value	0.13	0.89	0.25	0.17	0.58
Farmers	0.00/0.06	0.00	0.00	0.00	0.05/0.23
Labor:					
Mining	0.00	0.00/0.86	0.00	0.00	0.05/0.73
Urban					
Unskilled	0.00/0.77	0.00/0.86	0.00	0.00	0.05/0.23
Skilled	0.00	0.00	0.00/0.47	0.00/0.11	0.73/0.93
Capital:					
Mining	0.00/0.01	1.00	0.00	0.00	0.06/0.31
Manufacture	0.00	0.00	0.96/1.00	0.00	0.83/0.97
"Other"	0.00	0.00	0.00	0.67/0.69	0.89/0.97

Notes:
1. The values of the five Zs are those that maximize the relevant white group's income. (See text for constraints on the maximization.)
2. A slash [/] indicates that the maximizing values of the Z differed according to whether all Es were set at -0.5 or all at +1.0.

(and out of skilled work). The interest of mining capital only diverges in that it would like to increase the fraction of mining jobs done by nonwhites.[53]

The four columns of Table V-2 show the changes that each group's maximization would make on the incomes of various groups: 1) the percentage increase of the maximizing group's own income if it had this chance to select the five Zs; 2) the percentage change in the total income of all other whites (including farm and resource rents and returns to capital, where relevant); 3) the percentage change in the incomes of all nonwhites (including those in the Black agricultural sector); and 4) GDP. These percentages also are given as ranges (separated by a slash) where different results have emerged from different production function combinations.

The white group that would be most clearly able to improve its lot, were it to get free reign over the Z values, is white farming. The other groups with such ability are white mining labor and white urban unskilled labor. No other group we have examined here would be able, by choice of Zs, to raise its own income by as much as two thirds. There is a less clear pattern to the damage one white group could do to all other whites' incomes -- usually the damage is less than one fifth.

Were white groups able to choose Z values, it would make a big difference to nonwhites. The Z choice of manufacturing and "other" capital actually would raise the incomes of nonwhites, through their increased access to urban and skilled jobs. A choice by mining capital would hurt nonwhites, but not by as much as would a choice by white mining labor, white unskilled labor, or farming.[54] In general, GDP would be lowered by the Z choices of mining

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53. It may seem surprising that under any circumstances white mining labor or white skilled labor would want to increase the fraction of its jobs turned over to nonwhites. But, as nonwhites are added, the weighted average wage rate of such labor (both white and nonwhite) falls and the total demand for that kind of labor thereby rises. When the production function elasticity of substitution is high, this demand increase outweighs the initial loss; when the elasticity of substitution is low, it does not.

54. The choice of Z values that would be made by urban skilled labor might even benefit nonwhites through increasing the flow of nonwhites into urban jobs.

Table V-2

Impact of Preferred Restrictions on Different Income Shares

Maximizing White Income Group	Effect of the Chosen Zs on Income Shares (% Change from 1980)[1]			
	Own Group	Other Whites	Nonwhites	GDP
Farmers	+76/+239%	-23/-12%	-30/-29%	-19/-15%
Labor:				
Mining	+38/+251	-7/-4	-38/+27	-11/-8
Urban				
Unskilled	+94/+104	-29/-9	-41/27	-29/-11
Skilled	+12/+28	-11/-4	-38/+5	-8/+2
Capital:				
Mining	+21/+22	-11/-14	-13/-8	-6/-5
Manufacture	+45/+63	-8/-6	+2/+61	+3/+15
"Other"	+23/+53	-15/-10	+43/+70	+9/+15

Notes: 1. The slash [/] indicates the maximizing values of the Z differed according to whether all Es were set at -0.5 or all at +1.0.

capital, white mining labor, urban unskilled white labor, or farming; GDP would be raised by the Z choices of manufacturing or "other" capital.[55]

The broad outline of the political economics are clear. No one has an economic motive for keeping the population of the Black reserves so high. Urban skilled labor stands between the allied interests of manufacturing and "other" capital and the allied interests of farmers, mining labor, and urban unskilled labor with respect to the extent to which nonwhites should be let into urban and skilled jobs. Unfortunately, a closer analysis of this political side of the choices cannot be conducted without greater information about the sectoral production functions involved — as it is, too many of the Z choices are heavily dependent on the production function parameters being assumed. [56]

VI. Simulations: What Would a Free Labor Market Look Like?

The world is not either-or and there is no realism in the question, what would a free labor market have looked like in South Africa in 1980? The transition there will either be piecemeal and gradual, over a long period of time, or be accompanied by such upheavals and fresh distortions that the model constructed here will give little idea of the emergent economy's workings. Nevertheless, as an exercise in estimating the inefficiencies and redistributions of apartheid, we now simulate the outcome of the model under the idealized circumstances that all the artificial labor-market restrictions were absent in 1980.

It is not enough merely to adjust one's mind-set to admit interest in such counter-factuals. There are practical problems as well in such exercises. First, the labor-market distortions are not the only ones that

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55. Note that the impact of the Z choice by urban skilled labor depends upon the production function parameters considered.

56. Unlike Sections IV and VI, this section offers the interested reader little chance to participate through the use of Eureka. As an example of the models used, the program for maximizing total urban white skilled labor incomes with respect to several of the Z values (others have to be assumed) is given in Appendix F (file name: MAXUSWL), but we found it very difficult to locate solutions with Eureka in this case.

exist in the South African economy. There are two other kinds: 1) market interventions have been made independently of the labor-market distortions, either for other purposes or as other ways of discriminating against nonwhites in the economy -- two important examples that are relevant here are the racial ownership pattern of land and the differential access of the races to education; and 2) there are secondary distortions that flow from the labor-market misallocations -- for example, neither the volume nor the allocation of capital is the same as it would have been if a free market in labor had long been effective. The simulations we are about to undertake, with the model of this paper, cannot consider these other distortions and hence, implicitly, must hold them all constant. In an important sense, then, we are simulating no more than a partly free-market economy, and the results are lower-bound estimates of what could be achieved by the removal of all apartheid restrictions.

The second practical problem is the treatment of skills and the ability of the economy to transform unskilled (nonwhite) labor into skilled labor.[57] Education and the ability to do skilled work are complexly intertwined, and this model contains none of this complexity. If we simply remove all the Z constraints from the model, thinking that is what a free market would achieve, we would find in our simulations that all wage rates were driven to equality (subject to the unexplained D wage differentials and the differentials due to education); not only would white and nonwhite wages become equal but also skilled and unskilled wages would become equal. The simulated economy would simply transform unskilled workers into skilled workers until the marginal productivities of the two kinds of labor were equalized. This ignores two problems: 1) some nonwhites will never be able and willing to do skilled work (a fact we have already incorporated into the model for unskilled white labor); and 2) the skilling of the nonwhite work force will take time and education, neither of which is our model capable of handling.

This problem, the rate of skilling of nonwhites, does not pervade the entirety of the model. With respect to two of the labor-market restrictions, it does not apply at all, namely Z_b and Z_x, the flow of nonwhite labor in and

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57. This is not a problem (here) with white labor, for we have simply taken as given the number of whites who are unwilling or unable to become skilled labor. We will continue to take this same number as given.

out of the Black homelands and the flow of nonwhite labor in and out of the so-called "white urban areas". But genuine questions arise about the extent to which, even with no formal restraints, nonwhites could quickly increase their participation in the mining sector (g), where they already hold nearly 90% of the jobs, and in the skilled labor of the manufacturing (m) and "other" (o) sectors, where they currently do around 20% of the jobs.

We will try to encompass this problem with two simulations, one that constrains the free-market solution to a modest increase in Z_g, Z_m, and Z_o, and one that permits a much greater increase. These will be called the simulations with "slow skilling" and "fast skilling":

-- The "slow skilling" simulation will allow nonwhites in the mining sector to move into half the jobs now held by whites there.[58] Meanwhile, in the manufacturing and "other" sectors, the "slow skilling" simulation assumes that nonwhites could move quickly into 10% more of the skilled jobs than they now (1980) hold.[59]

-- The "fast skilling" simulation will allow nonwhites in the mining sector to move into <u>all</u> the jobs now held by whites there.[60] In the manufacturing and "other" sectors, the "fast skilling" simulation assumes that nonwhites could move quickly into 20% more of the skilled jobs than they now hold.[61]

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58. Z_g will be permitted to rise from its base 1980 fraction, .890, to .950. In terms of effective laborers -- i.e. taking account of the extra six years of schooling of the average white -- Z_g will be permitted to rise from .851 to .931.

59. Z_m and Z_o, now .252 and .168, respectively, could therefore rise as high as .352 and .268, respectively. In terms of effective labor, this means that Z_m could rise from its current .192 as high as .277, and that Z_o could rise from its current .125 as high as .205.

60. Z_g will be permitted to rise from its base 1980 fraction, .890, as high as one. This means that Z_g can rise as high as one in terms of effective laborers as well.

61. Z_m and Z_o, now .252 and .168, respectively, could therefore rise as high as .452 and .368, respectively. In terms of effective labor, this means that Z_m could rise from its current .192 as high as .368, and that Z_o could rise from its current .125 as high as .291.

Beyond these problems, the adaptation of the model of Section II to a situation without labor-market restrictions is fairly straightforward. The wage differential between unskilled urban whites and unskilled urban nonwhites disappears (i.e. the parameter, F, in equation (20) becomes one). The rural-urban unskilled wage differential among nonwhites also disappears. Thus, $Y_n^{rur} = Y_n^{urb} = Y_w^u$.[62] Nonwhite urban skilled wages remain higher than these by the extent of the skill differentials (D_{nsm} and D_{nso}).[63] Skilled white wages (Y_w^s) will still be higher than all of the other wage rates because of skilled whites' continued -- albeit reduced -- dominance in scarce skills. The complete model for the simulations of this section is written out in Appendix E.[64]

Table III-1 showed the actual outputs and incomes generated in the South African economy in 1980 by sector and race. Table III-2 showed the actual sectoral allocations of labor by race in 1980. These provide the benchmark for the subsequent comparisons. The two comparisons to be examined in this section are the total removal of all labor-market barriers, first with "slow skilling" and then with "fast skilling". Of the 64 combinations of production function parameters, we will look in each case at only one, that which causes the smallest increase in GDP. For each of the skilling assumptions, the smallest GDP increase occurs with the combination when all the sectoral elasticities of substitution are one half.[65] This should be no surprise since low elasticities of substitution mean that marginal products decline rapidly as one adds particular factors of production.

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62. And all these three wage rates also equal Y_n^{bla} if there is anyone left in the Black reserves after free exodus is permitted.

63. We assume that these differentials remain unchanged, but the assumption can be defended only on grounds of inertia where ignorant. The sudden skilling of large numbers of nonwhite workers could drive these differentials either down or up, perhaps dramatically.

64. The bare model, which is also capable of being solved with "Eureka", is shown in Appendix F (file name: FREEVARY) to permit the interested reader to check the results of this section or to explore new dimensions.

65. And A_b is unity. Recall that an elasticity of substitution of one half means a value of E in the production functions of +1.

The "slow skilling" assumption. The levels and percentage changes (from actual 1980) are shown, for sectoral outputs and racial incomes, in Table VI-1 and, for labor allocations, in Table VI-2. Relaxation of all the labor-market constraints, together with the "slow skilling" rate of assimilation of nonwhites into skilled jobs, raises GDP by 5.7%.[66] (See Table VI-1.) Output goes to zero in Black agriculture, declines by nearly one fifth in European agriculture, rises slightly in mining, and increases dramatically in the manufacturing and "other" sectors (by 6.4% and 12.3%, respectively). This is the efficiency gain. Income redistribution also occurs. Nonwhite incomes rise by 7.3%, while white incomes rise by only 5.1%. But this overall figure for white incomes hides a great deal of reallocation of incomes among whites. Unskilled white incomes fall by 43.8% and white farm incomes (the imputed returns to white labor, capital and land in European agriculture — i.e. IF00) fall by 30.6%, while total profit (which is assumed to be all white-earned) rises by 13.7% and white skilled labor incomes increase by 2.3%.

The causes of these changes are readily seen by looking at the labor allocations in Table VI-2. Once permitted to exit, nonwhite labor completely leaves the Black agricultural sector and also exits to a lesser extent (going from 19% of the nonwhite labor force to 14%) from European agriculture. Nonwhites increase their share of the mining labor force, largely replacing whites who move to skilled jobs in the "other" sector. Finally nonwhites move extensively into the so-called "white urban" sectors — i.e. manufacturing and "other" — increasing both their skilled and their unskilled employment there.

Not all nonwhites gain by this complete removal of labor-market barriers. "Urban" nonwhites, both skilled and unskilled, are less well off after the massive influx of new nonwhites from the rural sectors. Specifically, the nonwhite wage rate changes are shown below (in R 000s and with the unexplained wage differentials, i.e. the D parameters, assumed unchanged):

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66. The GDP increase can reach as high as 6.9% when other production function parameters are inserted, along with the "slow skilling" assumption.

Table VI-1

South African Economic Structure, Slow Skilling Simulation[1]

	Sector						Race	
	Agriculture Black	Agriculture Euro.	Mining	Manuf.	"Other"	Row Totals	Nonwhite	White
Wage Income								
Skilled	—	—	—	4.224	13.744	17.967	2.696	15.271
Unskilled	—	1.919	2.604	2.624	7.348	14.496	13.095	1.401
Nonwage Income								
IFOO	0.000	0.888	—	—	—	0.888	0.000	0.888
Profit	—	—	10.889	7.128	10.019	28.036	—	28.036
Column Totals	0.000	2.808	13.493	13.976	31.110	61.387 (=GDP)	15.791	45.596

Percentage Change from 1980 Base

	Sector						Race	
	Agriculture Black	Agriculture Euro.	Mining	Manuf.	"Other"	Row Totals	Nonwhite	White
Wage Income								
Skilled	—	—	—	2.2%	9.3%	7.6%	52.3%	2.3%
Unskilled	—	-9.6%	-1.4%	-6.3%	-1.5%	-3.5%	4.5%	-43.8%
Nonwage Income								
IFOO	-100.0%	-30.6%	—	—	—	-47.5%	-100.0%	-30.6%
Profit	—	—	0.9%	14.9%	30.6%	13.7%	—	13.7%
Column Totals	-100.0%	-17.5%	0.5%	6.4%	12.3%	5.7% (=GDP)	7.3%	5.1%

Note: 1. See Table III-1 for definitions of terms.

Table VI-2

Allocation of Labor in South Africa, Slow Skilling Simulation

(As Percentage of Total Labor Supply by Race)

	Agriculture					
	Black	Euro.	Mining	Manuf.	"Other"	Totals
Nonwhite Labor	0%	14%	12%	19%	55%	100%
Unskilled				17%	49%	
Skilled				2%	6%	
White Labor	--	1%	3%	20%	77%	100%
Unskilled				3%	12%	
Skilled				17%	64%	

Percentage Change from 1980 Base

	Agriculture					
	Black	Euro.	Mining	Manuf.	"Other"	Totals
Nonwhite Labor	-100%	-25%	11%	22%	31%	0%
Unskilled				18%	26%	
Skilled				61%	92%	
White Labor	--	0%	-49%	-1%	4%	0%
Unskilled				0%	0%	
Skilled				-1%	4%	

Notes: See, Table III-2 for definitions of terms.

Labor Type	1980 Wage Rate	Simulated Wage Rate
L_{ne}	1.632	1.979
L_{ng}	2.052	2.488
L_{num}	2.484	2.059
L_{nuo}	2.388	1.979
L_{nsm}	4.848	4.018
L_{nso}	5.820	4.823

Finally, it is interesting to examine certain aggregates of the economy, before and after these changes. The ratio of wages (white and nonwhite, including farm incomes) to GDP falls from 57.54% to 54.33%, owing to the overall boost in profits. The ratio of all white wages to all (white and nonwhite) wages (again including farm incomes as wages) falls from 55.97% to 52.65%, showing the relative shift from white to nonwhite laborers. Finally, the ratio of total white incomes (i.e. wage, farm, and profit) to GDP falls from 74.66% to 74.28%, indicating that the gains to profit almost exactly equal the losses to unskilled white labor (and farmers).

The "fast skilling" assumption. The levels and percentage changes (from actual 1980) are shown, for sectoral outputs and racial incomes, in Table VI-3 and, for labor allocations, in Table VI-4. Relaxation of all the labor-market constraints, assuming the "fast skilling" rate of assimilation of nonwhites into skilled jobs, raises GDP by 8.6%.[67] (See Table VI-3.) Output again goes to zero in Black agriculture, declines by more than one third in European agriculture, again rises slightly in mining, and increases even more dramatically in the manufacturing and "other" sectors (by 9.3% and 18.9%, respectively). The efficiency gain of freeing the labor market is even larger if nonwhites can move more extensively into the skilled jobs from which they were previously barred. Even greater income redistribution occurs with the "fast skilling" assumption. Nonwhite incomes rise by 34.1%, while white incomes actually decline, by 0.1%. But the near constancy of this overall figure for white incomes hides a huge reallocation of incomes among whites. Unskilled white incomes fall by 61.2%, white farm incomes (the imputed return to white labor, capital and land in European agriculture — i.e. IFOO) fall by

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67. The GDP increase can reach as high as 10.7% when other production function parameters are inserted, along with the "fast skilling" assumption.

Table VI-3

South African Economic Structure, Fast Skilling Simulation[1]

	Sector						Race	
	Agriculture Black	Agriculture Euro.	Mining	Manuf.	"Other"	Row Totals	Nonwhite	White
Wage Income								
Skilled	—	—	—	3.907	13.261	17.169	5.073	12.095
Unskilled	—	1.660	2.594	2.930	8.447	15.631	14.663	0.968
Nonwage Income								
IFOO	0.000	0.593	—	—	—	0.593	0.000	0.593
Profit	—	—	10.915	7.528	11.231	29.675	—	29.675
Column Totals	0.000	2.253	13.509	14.366	32.939	63.067 (=GDP)	19.736	43.331

Percentage Change from 1980 Base

	Sector						Race	
	Agriculture Black	Agriculture Euro.	Mining	Manuf.	"Other"	Row Totals	Nonwhite	White
Wage Income								
Skilled	—	—	—	-5.5%	5.5%	2.8%	186.6%	-19.0%
Unskilled	—	-21.8%	-1.8%	4.6%	13.2%	4.0%	17.0%	-61.2%
Nonwage Income								
IFOO	-100.0%	-53.7%	—	—	—	-65.0%	-100.0%	-53.7%
Profit	—	—	1.2%	21.3%	46.4%	20.3%	—	20.3%
Column Totals	-100.0%	-33.8%	0.6%	9.3%	18.9%	8.6% (=GDP)	34.1%	-0.1%

Notes: 1. See Table III-1 for definitions of terms.

53.7%, and white skilled labor incomes fall by 19.0%; only (white) profit income rises, by 20.3%.

To see the causes of these changes, look at the labor reallocations in Table VI-4. As with the "slow skilling" simulation, nonwhite labor completely deserts the Black agricultural sector; nonwhite labor in European agriculture also declines a great deal, from 19% of the nonwhite labor force to 10%. Nonwhites take over all the mining jobs, replacing whites who move to skilled jobs in the "other" sector. Finally nonwhites move extensively into the so-called "white urban" sectors -- i.e. manufacturing and "other"; they increase both their skilled and their unskilled employment there but most spectacularly their skilled employment (the percentage increases are 142% and 213%, respectively).

With "fast skilling" as with "slow skilling", not all nonwhites gain by this complete removal of labor-market barriers -- but the "fast skilling" assumption comes close to making all nonwhites gainers. The "urban" nonwhites, both skilled and unskilled, are less well off by only a few percentage points after the massive influx of new nonwhites from the rural sectors. The nonwhite wage rate changes are shown below (in R 000s and with the D parameters assumed unchanged):

Labor Type	1980 Wage Rate	Simulated Wage Rate
L_{ne}	1.632	2.332
L_{ng}	2.052	2.933
L_{num}	2.484	2.427
L_{nuo}	2.388	2.333
L_{nsm}	4.848	4.736
L_{nso}	5.820	5.686

Next, let us look again at certain of the aggregates of the economy, before and after the "fast skilling" changes. The ratio of wages (white and nonwhite, including farm incomes) to GDP falls from 57.54% to 52.95%, owing to the sizeable increase in profits. The ratio of all white wages to all (white and nonwhite) wages (again including farm incomes as wages) falls from 55.97% to 40.90%, showing the immense relative shift from white to nonwhite labor incomes. The ratio of total white incomes (i.e. wage, farm, and profit) to

Table VI-4

Allocation of Labor in South Africa, Fast Skilling Simulation

(As Percentage of Total Labor Supply by Race)

	Agriculture					
	Black	Euro.	Mining	Manuf.	"Other"	Totals
Nonwhite Labor	0%	10%	13%	20%	58%	100%
Unskilled				16%	48%	
Skilled				4%	10%	
White Labor	--	1%	0%	20%	79%	100%
Unskilled				3%	12%	
Skilled				17%	67%	

Percentage Change from 1980 Base

	Agriculture					
	Black	Euro.	Mining	Manuf.	"Other"	Totals
Nonwhite Labor	-100%	-45%	21%	24%	37%	0%
Unskilled				12%	23%	
Skilled				142%	213%	
White Labor	--	0%	-100%	-1%	7%	0%
Unskilled				0%	0%	
Skilled				-1%	9%	

Notes: See Table III-2 for definitions of terms.

GDP falls from 74.66% to 68.71%, indicating that the gains to whites through increases in profit, large as they are, do not come close to offsetting the losses to unskilled white labor, skilled white labor, and white farmers.

Finally, let us look at the Lorenz curves that emerge from removing the apartheid labor-market restrictions. Figure VI-1 shows the Lorenz curves for labor incomes only.[68] Each relaxation of the restrictions, from 1980 to the "slow skilling" simulation and from the "slow skilling" to the "fast skilling" simulation, unambiguously reduces labor-income inequality. The first relaxation, to the "slow skilling" job structure, makes its principal impact in the lower left part of the Lorenz curve, as it permits the poorest of the nonwhites to escape from the Black agricultural areas and to relocate as unskilled laborers in mining and even the "urban" sectors. The second relaxation, to the "fast skilling" job structure, makes its biggest impact in the upper right part of the curve, where large numbers of previously suppressed nonwhite skills blossom and the incomes of skilled workers are thereby brought down.

Figure VI-2 shows the same Lorenz curves, but with profit income also included.[69] These Lorenz curves behave very much like the previous ones until the final few percentage points of the cumulative labor force are reached, where they begin to cross. The post-apartheid income distributions do not dominate the 1980 base distributions in the sense that the Lorenz curves do not lie for their entirety above the 1980 Lorenz curve. The explanation is profit. The infinitesimal number of white profit-collectors are made much better off by the transition; when the very poor and the very rich both gain at the expense of the middle income groups, Lorenz curves generally cross and

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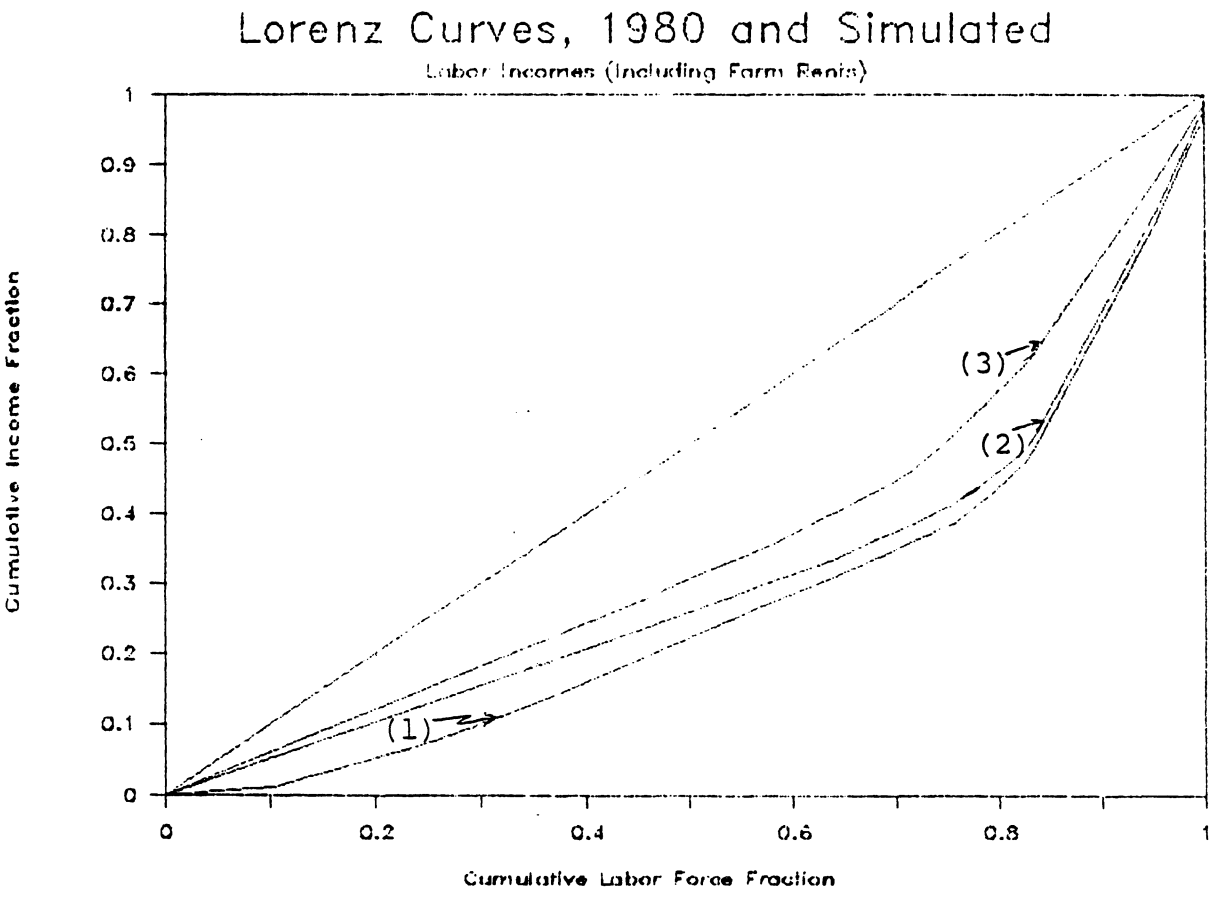
68. Recall that farm incomes (IF00) -- part land rent, part return to capital, and part labor income -- are included in these labor incomes.

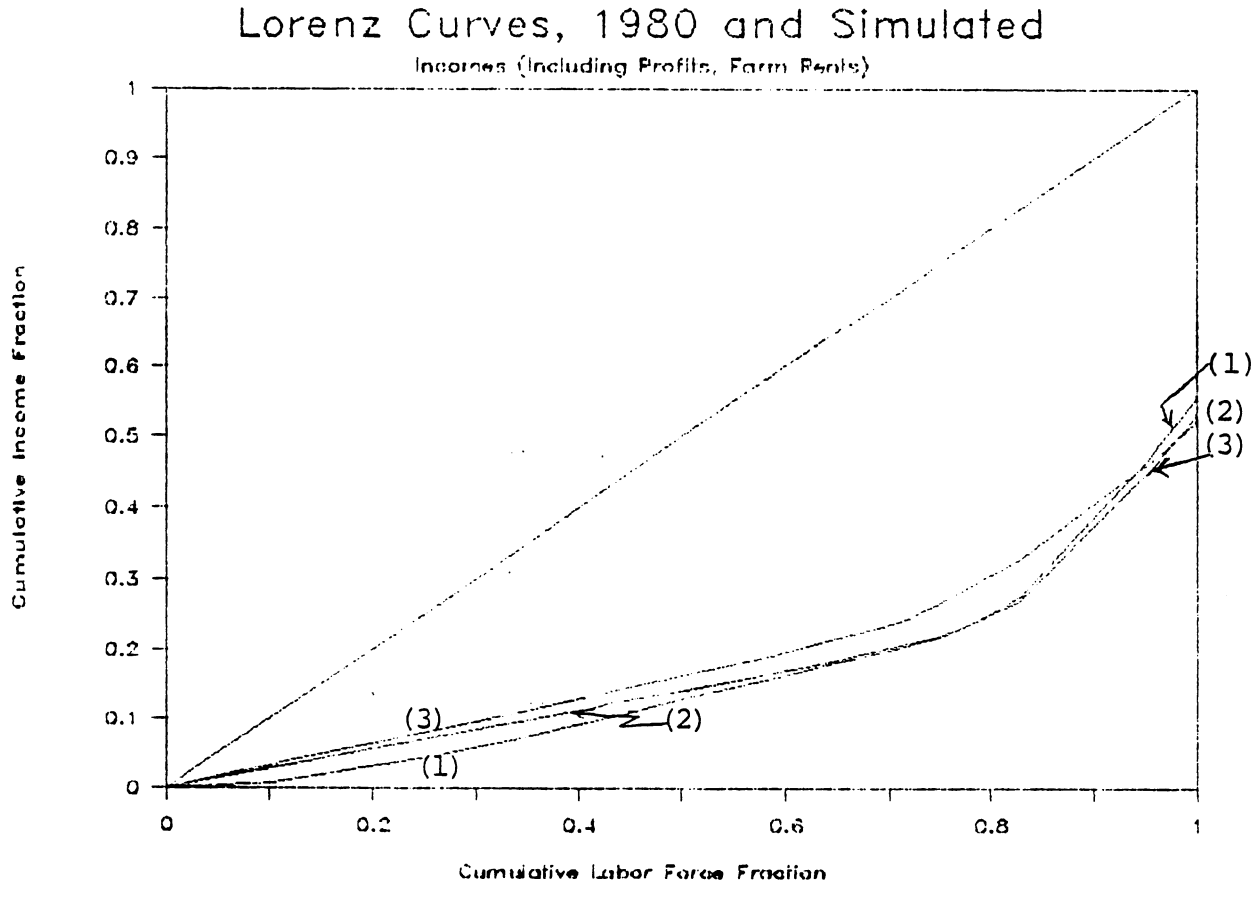
69. We have no information on the distribution of profit income across wage-earners and non-wage-earners, so we simply assume that all profit is earned by an infinitesimal number of white persons (which explains why the Lorenz curves appear to terminate below the point (1, 1). The distance between the apparent termination and unity is the profit share of GDP.

Figure VI-1



Notes:
1. 1980 Base
2. "Slow Skilling" Simulation
3. "Fast Skilling" Simulation

Figure VI-2



Notes:
1. 1980 Base.
2. "Slow Skilling" Simulation
3. "Fast Skilling" Simulation

proclaim uncertainty about whether the income distribution has become less inequitable or not.[70]

Actually, it is possible to make welfare statements about crossing Lorenz curves. Efficiency and equity comparisons can be made simultaneously through the use of "generalized Lorenz curves", which are ordinary Lorenz curves with the values on the vertical axis converted to absolute income figures by being multiplied throughout by the mean income per capita.[71] Dominance for such "generalized Lorenz curves" is formally equivalent to second-order stochastic dominance -- which means preferred for a widely acceptable set of utility and social welfare functions.

Figure VI-3 shows the "generalized Lorenz curves" for the three situations we have been discussing -- there is <u>almost</u> dominance, in the sense that a risk-averse person of (ex ante) indeterminate race, class, and skill, facing random relocation to South Africa, would prefer the "fast skilling" economy there to the "slow skilling" economy, and the latter in turn to the actual 1980 economy. The "almost" in the preceding sentence is necessary because there is a slight crossing at the 99.9% (labor force) point -- reflecting the extent to which the free-labor-market simulations drive down white farmer incomes.[72]

Removal of the apartheid restrictions, whether with "slow skilling" or with "fast skilling" transfers of jobs to nonwhites, leads to dramatic

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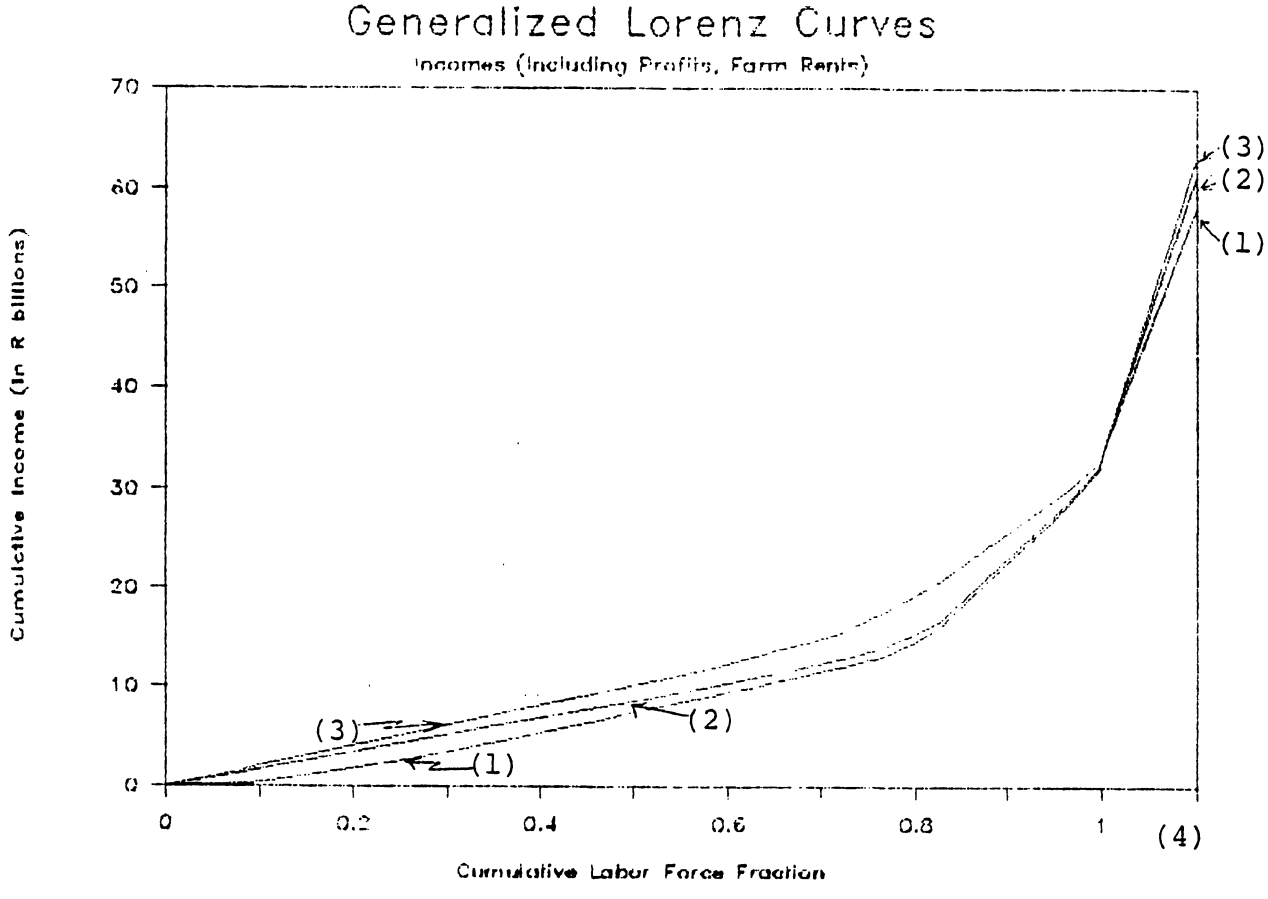
70. These Lorenz curves cross twice, although the second crossing is made invisible by the infinitesimal number of profit-receivers.

71. Such "generalized Lorenz curves" of course still begin at (0, 0), but they do <u>not</u> terminate at (1, 1). Rather they terminate at (1, mean income per capita). Since population (i.e. labor force) is fixed throughout the simulations done here, we will multiply the Lorenz curve ordinates (i.e. cumulative percentages for incomes including profits) by total GDP to reach "generalized Lorenz curves", which means that they terminate at (1, GDP). Those drawn in Figure VI-3 in fact terminate at (1 + a little, GDP) so that the profit share can be more clearly discerned.

72. From a total of R1.280 billion in 1980 to R0.888 billion in the "slow skilling" simulation and to R0.593 billion in the "fast skilling" simulation. White farmers might begin to exit under these circumstances, and nonwhite farmers might once again begin renting and farming "white land", but our model makes no provision for either de facto or de jure land redistribution.

Figure VI-3



Notes:
1. 1980 Base.
2. "Slow Skilling" Simulation.
3. "Fast Skilling" Simulation.
4. The region to the right of 1 represents profits.

increases in GDP and in the equity of its distribution. Furthermore, the reader should be reminded, the GDP changes estimated here are almost certainly lower-bound estimates, for three reasons: 1) the production function parameters applied in this section are those that yielded the smallest GDP increases, with other choices producing GDP increases of up to R1.2 billion more (in the "fast skilling" simulation); 2) the removal of labor-market restrictions would probably be accompanied by the breakdown of other, non-labor-market apartheid restrictions that would add to and interact with those simulated here; and 3) in addition to the short-run effects simulated, long-run changes in education, land ownership, and capital allocation would quickly begin to come into play, bringing further GDP increases and income redistributions.

VII. Summary and Concluding Comments

For so long a paper, it should be a little embarrassing to state that it can be briefly summarized. But for those who have read carefully, a brief summary is probably all that is needed; and for those who have not, a brief summary is probably all that is wanted.

A model of the South African labor markets was produced (Section II) that was, while very simple, too complex to yield general qualitative implications.[73] This model identified four ways in which non-market forces, both legal and (increasingly) informal, restrict the mobility of nonwhite labor in South Africa: 1) the extent to which nonwhite labor is free to leave the designated rural "homeland" areas (captured in the Z_b variable of the model); 2) the extent to which nonwhite labor has access to the better jobs in the mining sector (the Z_g variable); 3) the extent to which nonwhites can ascend to skilled jobs in the manufacturing and "other" sectors (Z_m and Z_o); and 4) the extent to which nonwhites can acquire residency rights in the urban areas and hence access to "urban" jobs (Z_x). The data of 1980 were then used

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73. As did its generative predecessors, the much more simple models of Porter (1978), Lundahl (1982), and Lundahl and Wadensjo (1984).

to "calibrate" this model -- that is, the data were used to insure that the assumed model indeed generated the observed 1980 data (Section III).[74]

The first set of simulations involved piecemeal changes in the labor-market restrictions (Section IV). When only one of the five restrictions (i.e. the Zs, seen as parameters of apartheid) was marginally altered, rarely was the (absolute value of the) elasticity of any important economic outcome as high as one. Changing the restrictions one at a time just does not lead to much change in the overall economic picture -- the elasticity of GDP, for example, with respect to the five Zs is never higher than 0.1. And, with few exceptions, sectoral outputs and wage rates are also unresponsive. The simulations support what is often said: apartheid cannot be dismantled bit by bit.

Next, the question was raised, what kinds of labor-market restrictions (again, the Zs, now seen as choice variables) would the various white sub-groups choose if each (in turn) had the power to choose them so as to maximize its own income (Section V)? None of the white sub-groups, we discovered, has a strictly economic motive for keeping so many blacks in the reserves as are in fact found there in 1980. Beyond that, the interests of the various white sub-groups diverge. Urban (i.e. manufacturing and "other") capital would like to expand the entry of nonwhites into the cities and into skilled jobs. White farmers, white mining labor, and white urban unskilled labor would like to keep nonwhites out of the cities and out of skilled jobs. White urban skilled labor stands between these groups, wanting some influx of nonwhites into the urban areas, primarily (but not necessarily entirely) for unskilled work there to enhance the relative scarcity of white skilled labor. Mining capital, not surprisingly, is primarily interested in turning mining jobs over to nonwhites.

Finally, we looked at a simulation of a system of perfectly free labor markets, where the Zs emerge as solution variables -- incidentally and unimportantly as firms and workers all seek optimization in unfettered labor markets (Section VI). These simulations displayed the extent of the inefficiency and of the redistribution inherent in the restricted labor

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74. Also Appendices A, B, and C.

markets. Depending upon whether nonwhites are able to move slowly or rapidly into newly opened skilled job opportunities, GDP rises by about five to ten percent.[75] Rural nonwhite wage rates rise dramatically, by up to one half, urban nonwhite wage rates (both skilled and unskilled) fall somewhat. White profit is increased much, white skilled incomes are affected little, and white unskilled labor and white farming is seriously hurt by the emergence of free labor markets. The Gini coefficient of the labor-income-only Lorenz curve falls from .45 in 1980 to .38 (with "slow skilling") or .29 (with "fast skilling"). Because profit actually increases with the freeing of the labor markets, the Gini coefficient of the both-labor-and-profit-income Lorenz curve falls much less, from .68 in 1980 to .67 (with "slow skilling") or .61 (with "fast skilling"). The combined effects of the efficiency gains and the redistributions, as seen in the "generalized Lorenz curves", suggest that the free-market simulations (almost) completely dominate the 1980 situation.

It is obligatory in efforts like these to conclude with some observations about what remains to be done. Here, such observations carry the additional advantage of reminding the reader, once more, of what has not been done. There are, of course, inevitably many directions in which this research has not gone; the actual explorations are limited only by one's time and by one's faith that the model can generate interesting results. But some things not done that could be done stand out:

1. The data underlying all the simulations are those of 1980. While there are advantages to choosing that year, data from other years should be explored, if only to reassure ourselves that 1980 and its data are not atypical of the period. More and better data would mean more than just increased confidence in the simulations. The parameters of the production functions could rest more on fact and less on presumption;[76] unemployment, of both nonwhites and unskilled whites, could be considered rather than just

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75. The "slowly or rapidly" refer to the "slow skilling" and the "fast skilling" assumptions.

76. While the assumed values of the E parameters do not seem to have sensitively affected most of the results, we were never able to examine the effects of the assumption of the same elasticity of substitution between the two kinds of labor (skilled and unskilled) and between each kind of labor and the (assumed constant quantity of) other factors.

assumed away; wage differentials between sectors and between skilled and unskilled nonwhites could be meaningfully incorporated rather than just assumed constant even under radically differing circumstances; etc.

2. Capital is implicit in the model throughout (buried in the C parameters of the production functions). Neither changes in the volume of capital nor reallocations of capital among sectors occur in any of the simulations. Reliable capital stock data are difficult to find, but not impossible. One way to include explicit consideration of capital would be to make the same "small open economy" assumption about capital as we did for the sectoral outputs of South Africa and to calibrate the 1980 data with an equation requiring the equality of the value of the marginal product of capital with the international rate of return to capital (perhaps with a risk factor to reflect the special conditions of South Africa today). With such treatment, we could have asked two additional kinds of questions: to what extent does apartheid distort capital allocations, and to what extent would redistribution of the ownership of physical capital improve the income distribution?

3. The treatment of human capital in this monograph is terribly simplistic. Not only is it impossible to ask interesting questions about the effects of (hypothetical) reallocations of human capital (or educational investments), but the interrelation of educational attainment and job qualification is assumed very unrealistically to be additive and separable.[77] If one more sector could be added to the model, one that provides education -- and perhaps other welfare services -- on a policy rather than a profit basis would be the compelling choice.[78]

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77. Nowhere does the shortcoming of this assumption become more clear than in Section VI, where the "slow skilling" and "fast skilling" assumptions need to be added quite arbitrarily simply because the model cannot contemplate limits to the rate at which relatively uneducated people can take on more skilled jobs.

78. There are two technical directions in which this kind of modeling could go, with the gain of realism, but at the cost of immense complexity. One is to introduce time and explore the dynamics of phased removal of nonwhite restrictions, of the gradual improvement of nonwhite education, and of the growth of nonwhite saving and wealth in response to improved economic opportunities and well-being. The other is to introduce a non-traded-goods sector (which in turn requires the introduction of complete

We come to the end of a long road. Is there a short, simple conclusion? We think so. Total removal of the labor-market restrictions that apartheid has proliferated by itself could raise GDP by several (5-10) percentage points and could raise the standard of living of nonwhite workers -- some of whose incomes might rise by as much as one half. Some whites would actually gain -- those who earn profit. Some would not be hurt, or would not be hurt much -- skilled whites. And some would suffer serious declines in their living standards -- white farm owner/operators and unskilled whites. But much inequality would remain. And it cannot be removed without venturing where this model does not, into the racial reallocation of ownership of land, physical capital, and most importantly human capital. Concern with these is the next concern of those who would contemplate South Africa without apartheid.

> The judge thinks that he is just when he compares
> the oil of another's lamp
> with the light of his own.
>
> Rabindranath Tagore[79]

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sets of demand equations, probably by race as well as by class) and explore the changes in the composition of South Africa's production that follow from redistribution of income.

79. Tagore, 1928, p. 198.

Appendix A: Data Sources

The South African data for 1980, used in this paper, are derived from numerous sources. This means that we have risked inconsistency across sources, but we found it necessary if we were to achieve the coverage and reliability needed.[1]

Our principal problem arose with the "Black agriculture" sector. The Department of Statistics of the Republic of South Africa publishes annual statistics on most of the aspects of the nation's economy needed here. However, since 1976, it has excluded from its reports statistics on "homelands" once they had been declared independent by the South African government. This exclusion would have been of little consequence if the data on the "independent states" had been listed separately or published elsewhere. Unfortunately, the agency also ceased collecting data on these regions. Data on the "Black" regions began being collected under the initiative of the Tomlinson Commission in 1950-51. This function was later taken over first by the Bureau for Economic Policy and Analysis (BEPA) and then by the Bureau for Economic Research, Cooperation, and Development (BENSO). The statistical methods used by the Department of Statistics and by BENSO differ, and indeed the statistical techniques used by BENSO have been seriously questioned (Abedian, 1983).

Two concerns dictated the choice of 1980 as the base year. First, we wanted the base year to be recent enough to portray the economic position of apartheid as it exists "today". And second, we needed a year in which sufficient data existed that we could be confident in the numbers we ultimately selected. 1980 was the most recent year that fulfilled the second criterion.

The data used are given in Table A-1 and explained in the remainder of this appendix. All the base data are for 1980 and are in annual rate. Value data are in Rands, the South African unit of currency. The international value of the Rand fluctuated greatly in the years around 1980, but as a

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1. Others have trod a similar path: "The key to the use of many, if not most, South African statistics is to recognize their limitations and generally to treat them as flawed orders of magnitude..." (Savage, 1986, pp. 184-185).

mnemonic approximation, one Rand can be thought of as one U.S. dollar. Output values (Q) are in billions of Rands, income (i.e., wage rate) values of (Y) are in thousands of Rands. Labor supply quantities (L) are in millions of person-years.

Table A-1

South African Economy — 1980[1,2]

Variable	Agriculture: Black	Agriculture: European	Mining[4]	Manufacturing	"Other"[5]
Output	0.414	3.403	13.432	13.139	27.701
$Labor_{nu}$	0.902	1.301	0.731	0.995	2.696
$Labor_{wu}$	--[3]	0.014	0.090	0.061	0.221
$Labor_{ns}$	--	--	--	0.101	0.220
$Labor_{ws}$	--	--	--	0.300	1.089
$Wage_{nu}$	0.459	1.632	2.052	2.484	2.388
$Wage_{wu}$	--	--[6]	12.684	5.412	4.620
$Wage_{ns}$	--	--	--	4.848	5.820
$Wage_{ws}$	--	--	--	12.144	10.368

Notes:

1. Labor is in millions of workers, wages in thousands of 1980 Rands, and outputs (at factor cost) in billions of 1980 Rands.
2. Labor and wages, in agriculture and mining, have been counted in one skill category only, called "unskilled" in the table.
3. No whites work in Black agriculture.
4. Includes gold, diamond, coal, and other mining and quarrying.
5. Includes construction; electricity, gas, and water; transport and communications; trade and finance; and public administration and defense.
6. There is no entry here since the breakdown of white income into wages, land rent, and capital earnings was unavailable in this sector.

Output (i.e. Value Added). All figures are from I.B.R.D. (1983) except for the output of "Black" agriculture (Q_b). These are shown for the various homeland regions in Table A-2.

Table A-2

Output of "Homeland" Regions

(Value added in R millions)

Homeland	Output
Bhoputhatswana	35
Ciskei	11
GazanKulu	16
KaNgwane	8
KwaZulu	119
Lebowa	64
QwaQwa	1
Transkei	148
Venda	12
Total	414

Source: Survey, 1983, p. 363.

Labor. The total white and nonwhite labor figures are from South, 1982. The percentage distribution between skilled and unskilled jobs, for both whites and nonwhites, is derived from the occupational distribution by population group in South, 1983, p. 503. We classified transport, service, production, and laborer as unskilled and professional, managerial, clerical, sales, foreman/supervisor, and artisan as skilled. With this categorization, about 73% of the skilled jobs are done by whites and about 5% of the unskilled. The fact that we group "blacks", "coloreds" and "Asians" together under nonwhites is not to suggest that they form a homogeneous group. Important differences between and within each group exist, as evidenced by Table A-3. Nonwhite labor in Black and European agriculture is from Apartheid, 1983, p.41. White labor in European agriculture is from Abstract, 1985, Table 4.

Table A-3

Labor Breakdowns by Race, Skill, and Sector[1]

	Total Employed	Skilled	Unskilled
		Mining[2]	
Whites	0.090	--	0.090
Blacks	0.716[3]	--	0.716
Colored	0.013	--	0.013
Asians	0.002	--	0.002
		Manufacturing	
Whites	0.360	0.300	0.061
Blacks	0.772	0.041	0.731
Colored	0.228	0.035	0.192
Asians	0.097	0.025	0.072
		"Other"	
Whites	1.311	1.089	0.221
Blacks	2.335	0.124	2.212
Colored	0.455	0.071	0.384
Asians	0.135	0.035	0.100

Notes:
1. All labor in millions of workers.
2. All mining labor counted here under unskilled.
3. Includes 0.220 foreign workers.

Wages. The wage figure given for nonwhite labor in Black agriculture is the calculated average product in this sector (i.e. 414/.902); it is not the figure used in the text for Y_n^{bla}.[2] Nonwhite wages in European agriculture include in-kind as well as cash payments (Survey, 1981, p.157).[3] The remaining wage data (i.e. median pay by race and skill) were taken from Survey, 1983, p. 125 and I.L.O., 1981, p. 52.

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2. See Appendix C.

3. The average monthly wage for farm laborers in Swartland, Ruens, Eastern Free State, Western Transvaal, North Western Free State, and Transvaal Highland was converted into an annual figure.

Next, we calculated the ratio of the skilled wage to the unskilled wage for each racial subgroup:

Whites	2.243
Blacks	2.139
Coloreds	2.203
Asians	2.441

We then calculated the total wage bill for each racial group (I.L.O., 1981, p. 52 and the labor data already gathered). This left only the problem of solving for one unknown, the unskilled wage, from one equation.[4] For white labor in the manufacturing sector, for instance, the following equation is used:

(A1) $(\text{Wage}_{ws})(\text{Labor}_{ws}) + (\text{Wage}_{wu})(\text{Labor}_{wu})$ = (average white wage in manufacturing)(total white labor in manufacturing), or

(A2) $[(2.243)(0.300) + (0.061)](\text{Wage}_{wu}) = (0.917)(0.361)$,

which yields $\text{Wage}_{wu} = 0.451$. Multiplying this white unskilled wage rate, Wage_{wu}, by 2.243, we get $\text{Wage}_{ws} = 1.012$ as the white skilled wage rate. Multiplied by 12 to put them in annual terms, these are the wage data used in the text. This procedure was followed for each of the relevant sectors.

To do these same calculations for nonwhite labor, we weighted the wages by the proportion of each racial subgroup at each of the two skill levels we consider. The implicit assumption that the wage differentials between the two skill levels for each racial subgroup are the same across sectors is not serious. After all, the focus of this study is on nonwhites as a group, not on the composition of the three subgroups. Table A-4 gives the racial composition of skilled and unskilled jobs in various sectors, and Table A-5 the racial breakdown of the average monthly wages, which have been used in the estimation of the nonwhite average monthly wage.

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4. The skilled wage can then be solved for by simple substitution.

Table A-4

Percent Racial Composition of Skilled and Unskilled Job in Various Sectors

	Blacks	Coloreds	Asians
		Mining	
Total	98.02%	1.73%	0.25%
		Manufacturing	
Skilled	40.50%	35.00%	24.70%
Unskilled	73.50%	19.30%	7.20%
		"Other"	
Skilled	54.00%	30.90%	15.10%
Unskilled	82.00%	14.30%	3.70%

Table A-5

Average Monthly Wage

(in Rands)

	Blacks	Coloreds	Asians
		Mining	
Total	168.00	310.00	433.00
		Manufacturing	
Skilled	437.73	457.78	511.03
Unskilled	204.64	214.01	209.39
		"Other"	
Skilled	406.67	499.14	733.33
Unskilled	190.12	226.00	300.48

Appendix B: Production Function Parameters

There are five sectors in the model, and in each of them a constant-elasticity-of-substitution (CES) production function is assumed to be adequate to capture the relationship between the flows of labor input(s) and the value of output. For three of the sectors ("Black" agriculture, "European" agriculture, and mining), only one kind of labor is considered; for these, the CES production functions each contain three parameters (A, C, and E, with appropriate subscripts). For the other two sectors (manufacturing and the "other" sectors), both skilled and unskilled labor are considered; then, a fourth parameter appears (B). Here, we use the data of the base year, 1980, to make empirical estimates of some of these parameters.[5]

The precise estimation procedure differs slightly among the five sectors, but each follows roughly the same course. The base-year data on value of output and on labor input(s) permit us to estimate one of the parameters. The observed wage and the assumption that this wage rate equals the value of the marginal product of that labor permit us to estimate one more parameter (or two more parameters in those production functions with two kinds of labor). There remains, in general, only one unidentified parameter.[6]

We are free to choose which single parameter should remain unidentified, and for each sector we choose E -- the parameter that is related to the elasticity of substitution.[7] In the discussion of each of the sectors below, the estimates of A and C (and sometimes B) are given for a range of assumed values of E.[8] The estimated production functions are pictured for each sector at values of E of plus one (elasticity of substitution equal to 1/2) and of

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5. See Appendix A for the base-year data, its derivation, and its sources.

6. The exception to this procedure is Black agriculture, for reasons to be discussed shortly.

7. Recall that in a CES production function (as we have written it) the elasticity of substitution among the various factors is equal to (1/(1+E)).

8. The possible range of E is from minus one to plus infinity. The negative values indicate elasticity, and the positive values inelasticity in the degree of substitutability among the factors. The estimates at a value of E equal to zero are not reported because the CES production function changes form at that value (to the Cobb-Douglas).

minus 1/2 (elasticity of substitution equal to 2). These are the values of E used in the simulations of the text. This range should be sufficiently wide to give a good indication of the degree to which the results of the simulations depend upon the E value assumed.[9]

1. Black Agriculture (b). The production function is

$$(B1) \qquad Q_b = A_b[(L_{nb})^{-E_b} + C_b]^{-1/E_b}.$$

To estimate the three parameters (A_b, B_b, and C_b), there is only one piece of information from the 1980 data — namely, the value of output (Q_b) and the quantity of labor input (L_{nb}). There are few meaningful wage data that emanate from the African agricultural areas and still fewer efforts to estimate shadow wages there. This means that two of the three parameters must be assumed, or guessed at from extraneous information. For a variety of assumed values of A_b and E_b, Table B1 shows the estimate of C_b implied by the 1980 output and labor data.

Figures B1 - B4 show the average and marginal products of labor for four of the A_b, E_b, and C_b values in Table B1. These values of the three parameters are:

Figure	A_b	E_b	C_b
B1	1.00	1	1.307
B2	10.00	1	23.046
B3	0.01	-0.5	5.485
B4	0.10	-0.5	1.085

This range of values of A_b and E_b (with the implied values of C_b) should encompass the reality of the production function in these areas, and all four will be utilized in the simulations of the text.

2. European Agriculture (e). The production function is

$$(B2) \qquad Q_e = A_e[(L_{ne} + L_{we})^{-E_e} + C_e]^{-1/E_e},$$

and the condition that the wage rate equal the marginal product of labor is

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9. Rarely do empirical estimates of the elasticity of substitution in sectoral production functions fall below 1/2 or rise above 2. See, for examples, the following and the studies cited therein: Wallis, 1979, Chapter 2; Mayes, 1981, Chapter 3; and Intriligator, 1978, Chapter 8.

TABLE B1

Implied Values of Cb
(for various assumed values of Ab and Eb)

Eb =	Ab = 0.0001	0.001	0.01	0.1	1	10	100
-1.00	*********	413.098	40.498	3.238	ERR	ERR	ERR
-0.99	*********	388.887	38.984	3.179	ERR	ERR	ERR
-0.95	*********	305.396	33.461	2.949	ERR	ERR	ERR
-0.90	*********	225.710	27.619	2.680	ERR	ERR	ERR
-0.80	781.788	123.130	18.740	2.195	ERR	ERR	ERR
-0.70	339.400	66.974	12.618	1.773	ERR	ERR	ERR
-0.60	147.039	36.231	8.397	1.405	ERR	ERR	ERR
-0.50	63.393	19.397	5.485	1.095	ERR	ERR	ERR
-0.40	27.017	10.178	3.474	0.806	ERR	ERR	ERR
-0.30	11.195	5.127	2.086	0.562	ERR	ERR	ERR
-0.20	4.310	2.358	1.126	0.349	ERR	ERR	ERR
-0.10	1.310	0.837	0.461	0.163	ERR	ERR	ERR
-0.05	0.522	0.357	0.210	0.079	ERR	ERR	ERR
-0.01	0.088	0.063	0.039	0.015	ERR	ERR	ERR
0.01	ERR	ERR	ERR	ERR	0.008	0.031	0.055
0.05	ERR	ERR	ERR	ERR	0.040	0.167	0.311
0.10	ERR	ERR	ERR	ERR	0.082	0.365	0.721
0.20	ERR	ERR	ERR	ERR	0.172	0.870	1.976
0.30	ERR	ERR	ERR	ERR	0.271	1.568	4.155
0.40	ERR	ERR	ERR	ERR	0.381	2.532	7.936
0.50	ERR	ERR	ERR	ERR	0.501	3.862	14.489
1	ERR	ERR	ERR	ERR	1.307	23.046	240.437
2	ERR	ERR	ERR	ERR	4.605	582.215	********
4	ERR	ERR	ERR	ERR	32.530	**********	
8	ERR	ERR	ERR	ERR	**********		
16	ERR	ERR	ERR	ERR	**********		
32	ERR	ERR	ERR	ERR	**********		

NOTES: 1. *** means the number is 1,000 or larger.

2. ERR means the implied value of Cb is negative. Such values mean negative and/or rising values for the marginal product of labor.

3. The implied value of Cb is zero for all assumed values of Eb when the assumed value of Ab is equal to 0.459 (= 0.414/0.902).

Figure B1

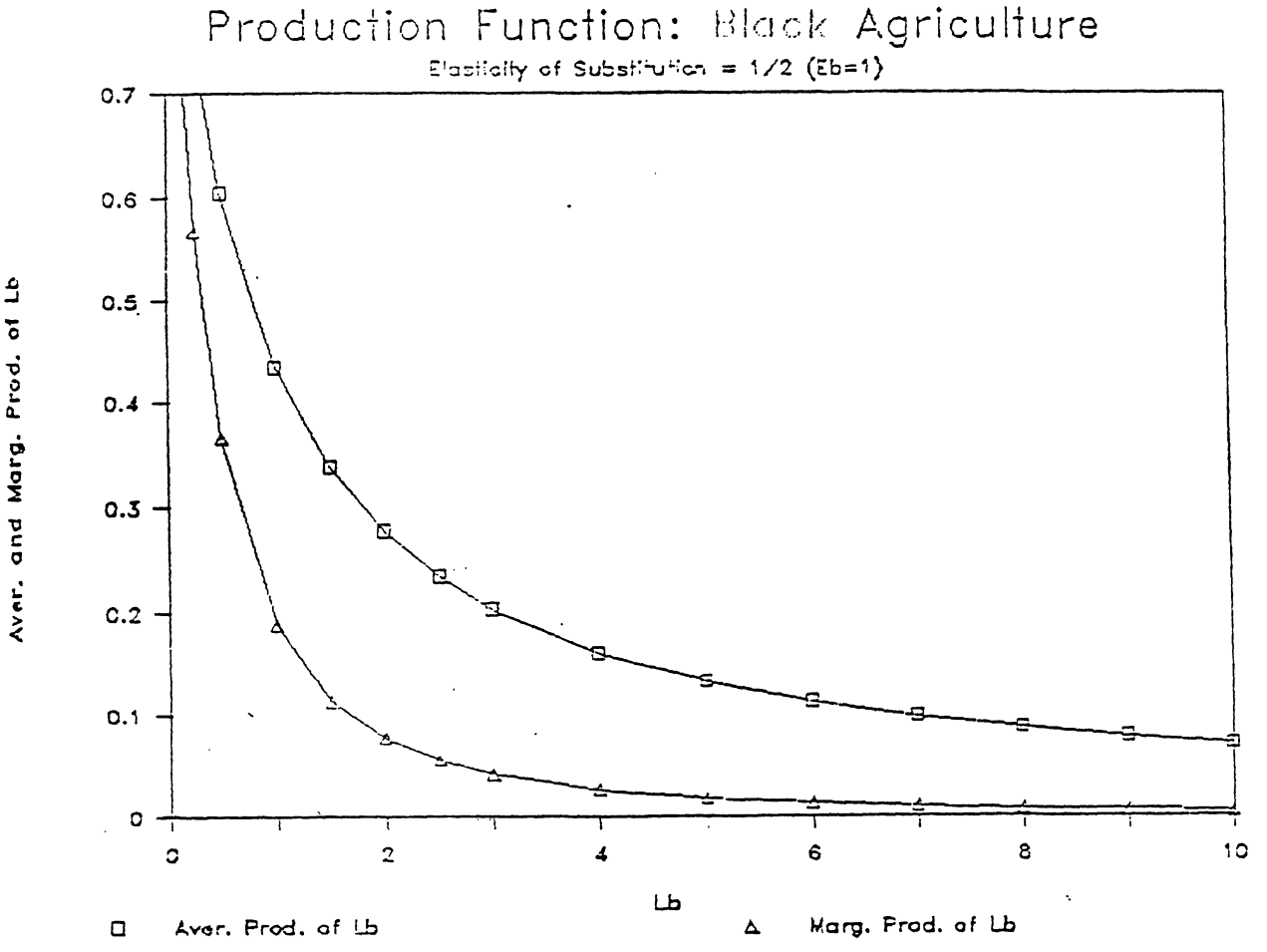

Production Function: Black Agriculture
Elasticity of Substitution = 1/2 (Eb=1)
Aver. and Marg. Prod. of Lb
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
Lb
Aver. Prod. of Lb
Marg. Prod. of Lb

Figure B2

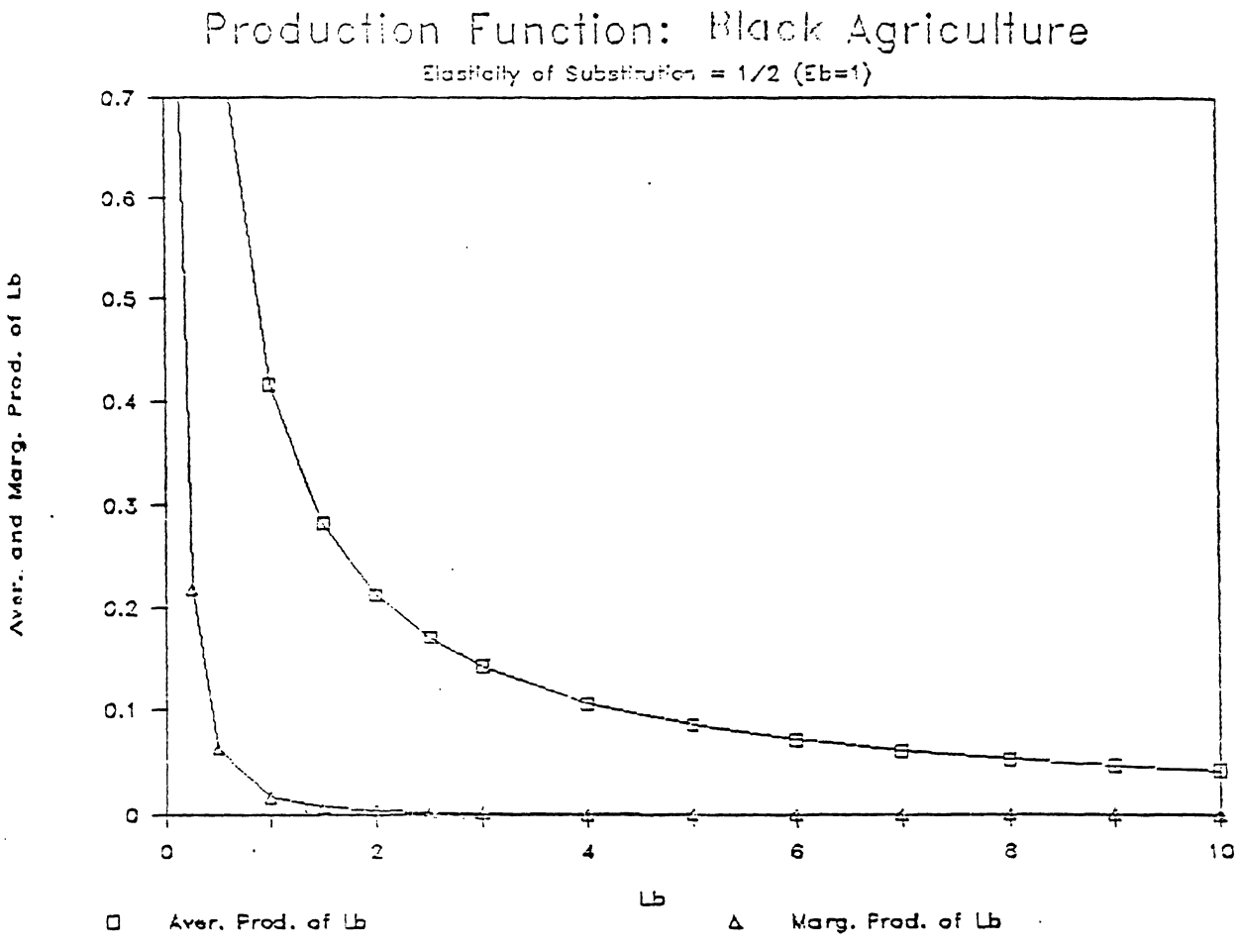

Production Function: Black Agriculture
Elasticity of Substitution = 1/2 (Eb=1)
Aver. and Marg. Prod. of Lb
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
Lb
Aver. Prod. of Lb
Marg. Prod. of Lb

Figure B3

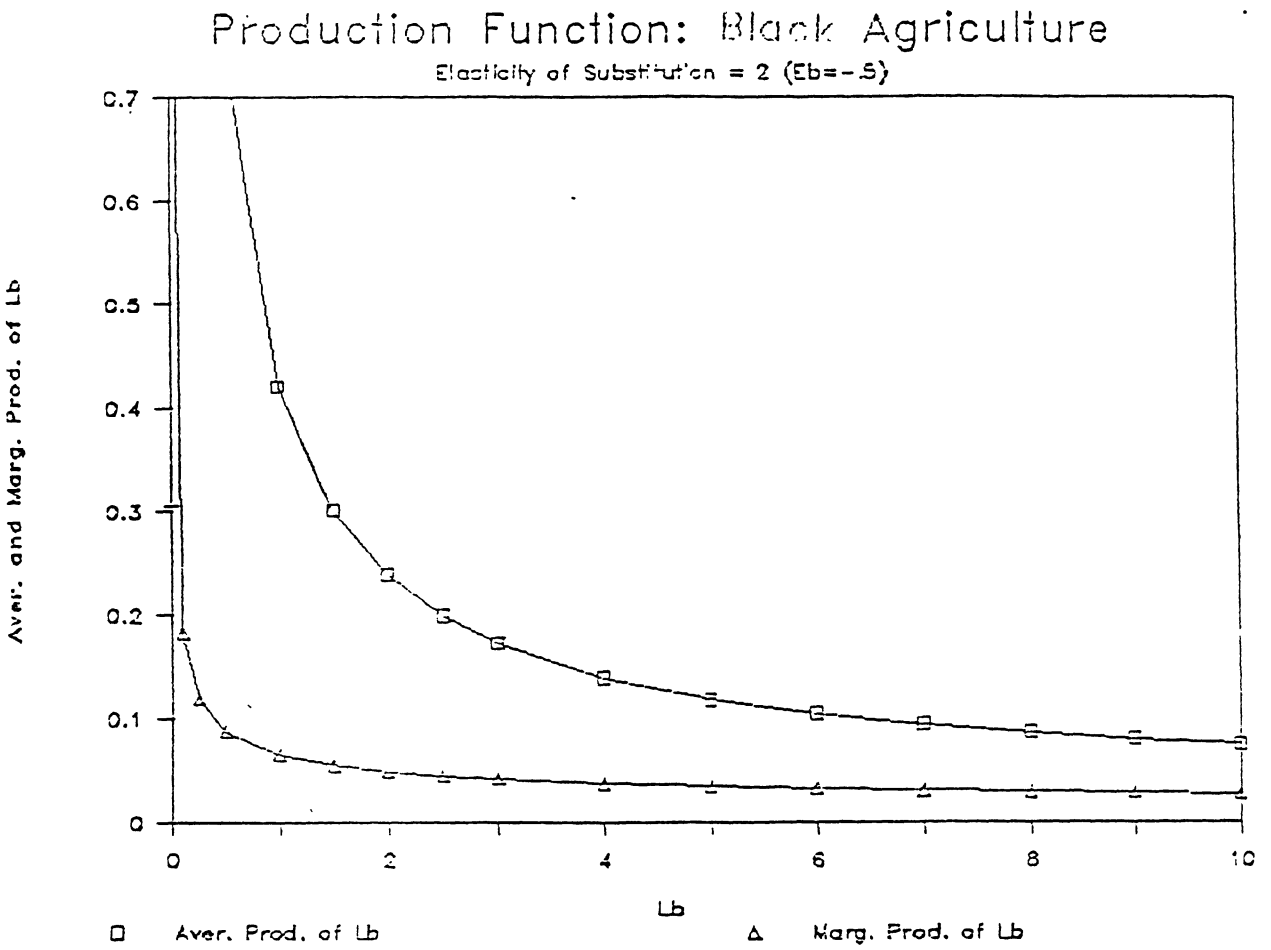
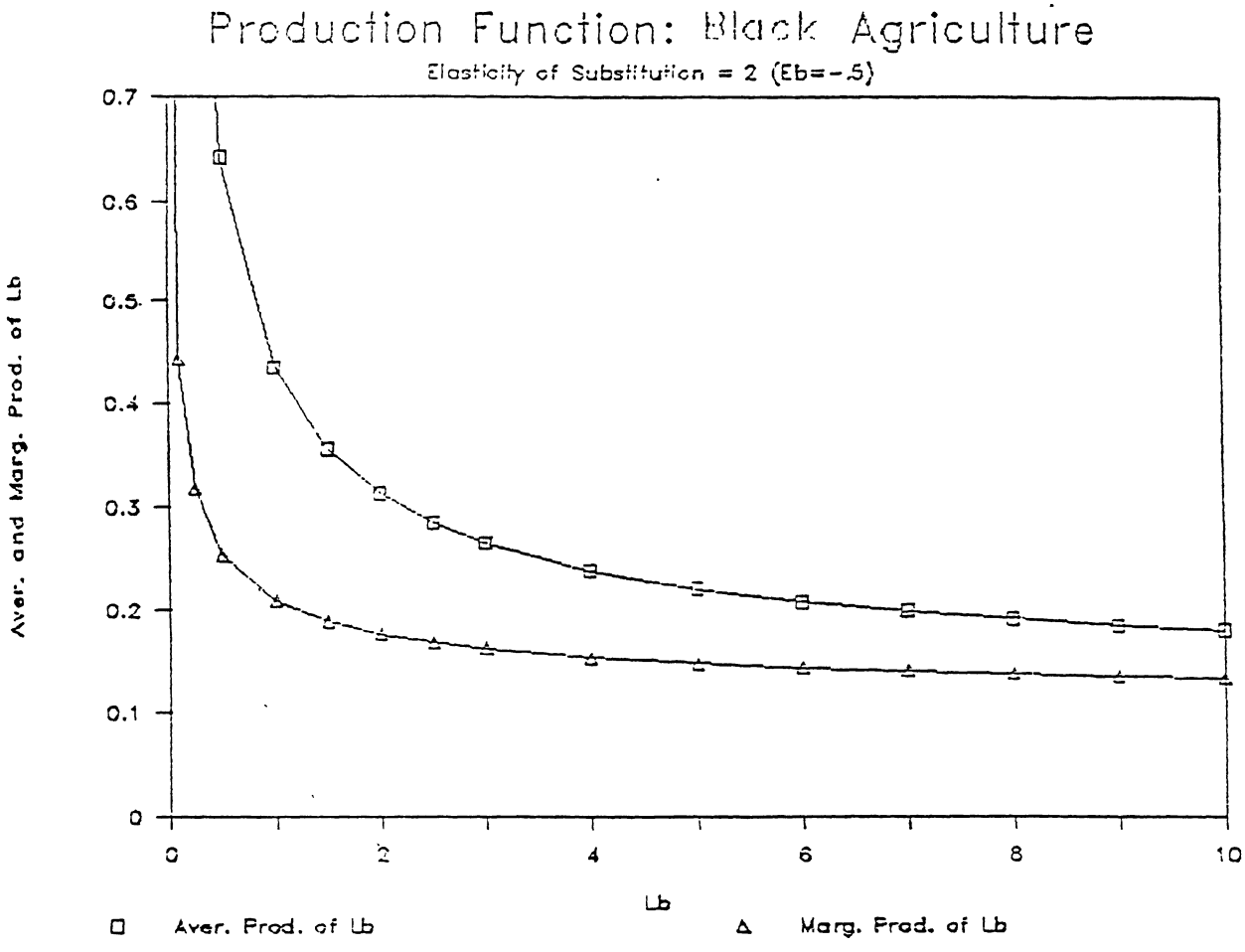

Production Function: Black Agriculture
Elasticity of Substitution = 2 (Eb=-.5)
Aver. and Marg. Prod. of Lb
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
Lb
Aver. Prod. of Lb
Marg. Prod. of Lb

Figure B4


Production Function: Black Agriculture
Elasticity of Substitution = 2 (Eb=-.5)
Aver. and Marg. Prod. of Lb
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
Lb
Aver. Prod. of Lb
Marg. Prod. of Lb

(B3) $$Y_n^{rur}=A_e[1+C_e(L_{ne}+L_{we})^{E_e}]^{-(1+E_e)/E_e}.$$

If a value of E_e is assumed and the 1980 base-year data inserted, the above two equations yield estimates of A_e and C_e. These are shown in Table B2 and the production functions pictured in Figures B5 and B6 for values of the elasticity of substitution at 1/2 and 2.

3. Mining (g). Both white and nonwhite labor are used in this sector, and the formulation of the production function considers the two to be perfect substitutes for each other. The production function is

(B4) $$Q_g = A_g[(L_{ng} + L_{wg})^{-E_g} + C_g]^{-1/E_g},$$

and the wage condition is

(B5) $$Z_g D_{ng} Y_n^{rur} + (1-Z_g) D_{wg} Y_w^s = A_g[1+C_g(L_{ng}+L_{wg})^{E_g}]^{-(1+E_g)/E_g}.$$

The fact that the marginal product of labor is set equal to the weighted average of the wage rates of the two races of labor reflects the condition imposed on the mine-owners that black and white labor must be hired in fixed proportions.[10]

The 1980 data for white labor must be adjusted to allow for the fact that white workers on average have six years more schooling than nonwhites. At our assumed 6% rate of return to each year's additional education, the 90 thousand white mining workers become 128 thousand "effective workers".[11] And accordingly, the average annual white wage rate in mining of R12.684 becomes a wage rate of R8.942 per effective worker. In solving equations (B4) and (B5), the figures for effective workers and their wage rate must be used.[12]

---

10. The ratio is Z_g nonwhite to $(1-Z_g)$ white. Note that the same sort of condition as (B5) would appear if we were to assume that nonwhite and white labor were perfect complements in production, rather than perfect substitutes. This softens the harshness of the assumption. (See text for the definition, and Appendix C for the 1980 values, of the D parameters.)

11. 128 equals 90 times 1.06 to the sixth power.

12. To be consistent, the fraction of nonwhites in the total mining labor force (Z_g) must also be recalculated using effective workers. The 1980 value of Z_g then falls from .890 to .851.

TABLE B2

Implied Values of Ae and Ce
(for various assumed values of Ee)

Ee =	Ae =	Ce =
-1.00	1.632	0.764
-0.99	1.624	0.762
-0.95	1.593	0.754
-0.90	1.551	0.743
-0.80	1.456	0.723
-0.70	1.342	0.703
-0.60	1.204	0.684
-0.50	1.034	0.665
-0.40	0.823	0.647
-0.30	0.562	0.629
-0.20	0.263	0.612
-0.10	0.027	0.595
-0.05	0.000	0.587
-0.02	0.000	0.582
0.02	**********	0.575
0.05	23807.311	0.571
0.10	247.661	0.563
0.20	25.260	0.547
0.30	11.802	0.532
0.40	8.067	0.518
0.50	6.421	0.503
1	4.067	0.438
2	3.237	0.332
4	2.888	0.190
8	2.728	0.062
16	2.651	0.007
32	2.613	0.000

NOTE: 1. *** means the number is 1,000,000 or larger.

Figure B5

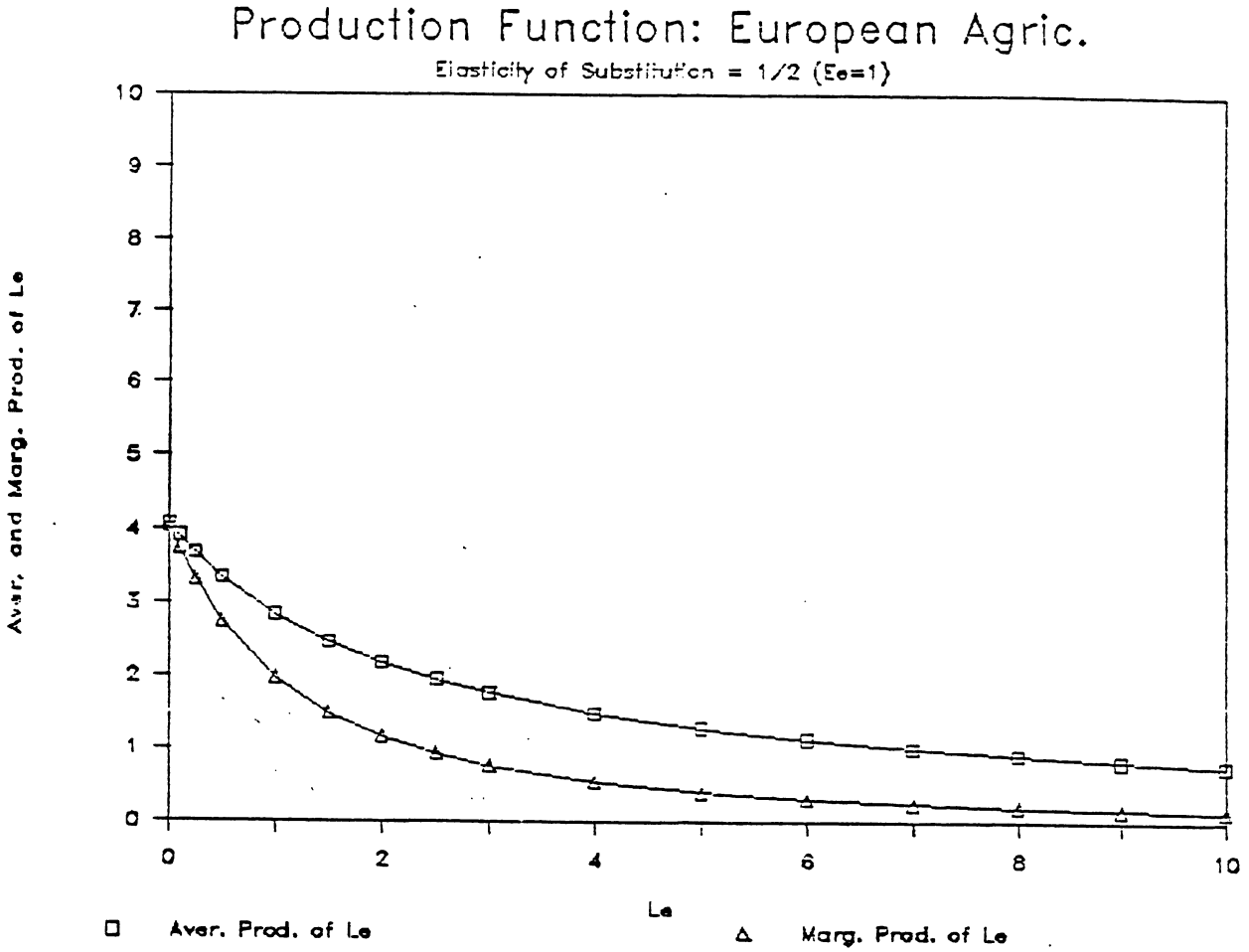
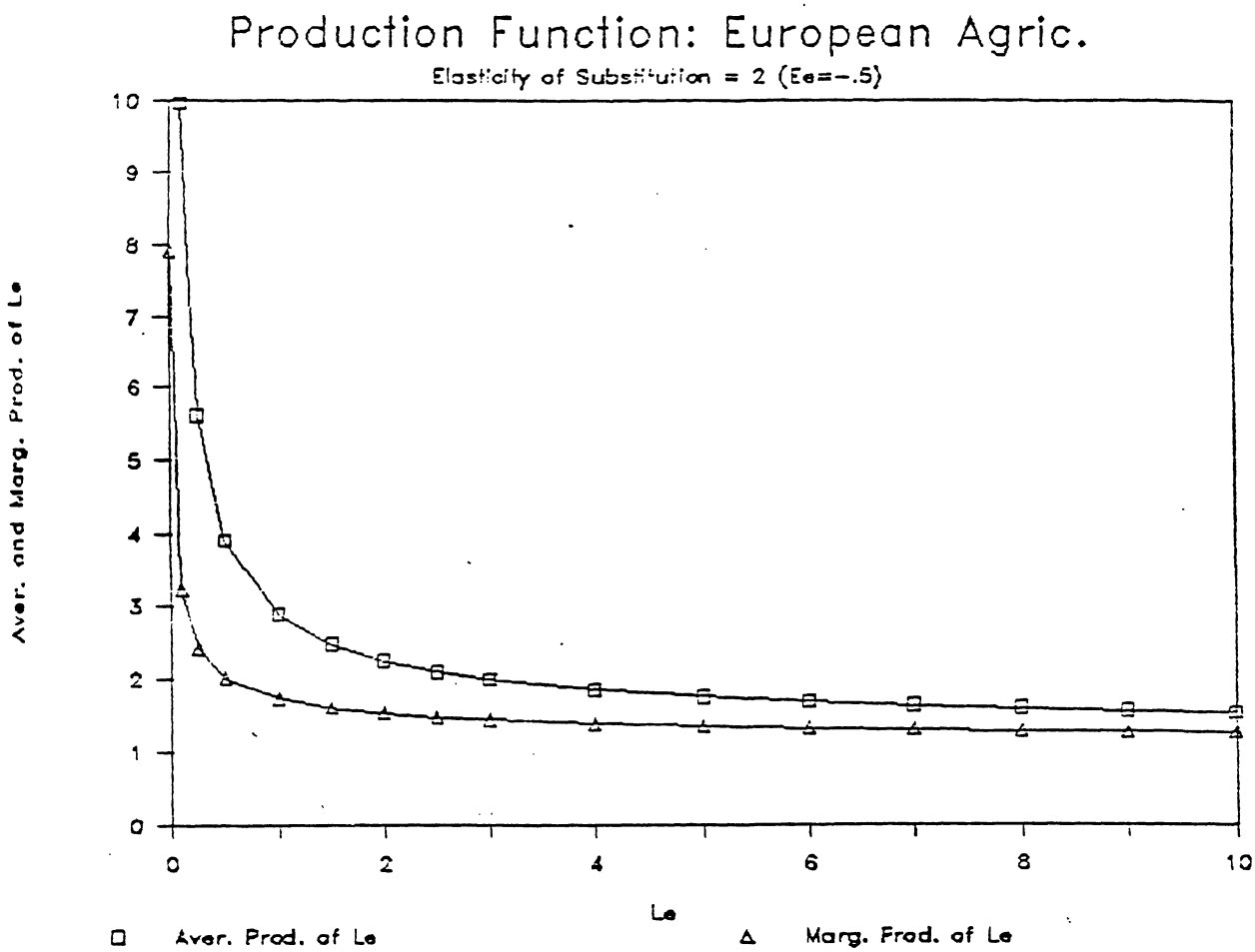

Production Function: European Agric.
Elasticity of Substitution = 1/2 (Ee=1)
Aver. and Marg. Prod. of Le
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
Le
Aver. Prod. of Le
Marg. Prod. of Le

Figure B6


Production Function: European Agric.
Elasticity of Substitution = 2 (Ee=-.5)
Aver. and Marg. Prod. of Le
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
Le
Aver. Prod. of Le
Marg. Prod. of Le

The values of A_g and C_g implied by various assumed values of E_g are shown in Table B3, and the production functions are pictured in Figures B7 and B8 for two values of the elasticity of substitution (i.e. values of 1/2 and 2).

4. Manufacturing (m). The production function is

$$(B6) \qquad Q_m=A_m[B_m(L_{num}+L_{wum})^{-E_m}+(L_{nsm}+L_{wsm})^{-E_m}+C_m]^{-1/E_m}.$$

Note that there are now two kinds of labor, skilled and unskilled, imperfectly substitutable for each other.[13] This necessitates the introduction of another parameter, B_m.

The two conditions (one each for skilled and for unskilled labor) equating the observed wage rate with the relevant marginal product of labor are

$$(B7) \qquad D_{num}Y_n^{urb}=A_mB_m[B_m+C_m(L_{num}+L_{wum})^{E_m}+\{(L_{num}+L_{wum})/(L_{nsm}+L_{wsm})\}^{E_m}]^{-(1+E_m)/E_m};$$

and

$$(B8) \qquad Z_mD_{nsm}Y_n^{urb}+(1-Z_m)D_{wsm}Y_w^s=$$
$$A_m[1+B_m\{(L_{nsm}+L_{wsm})/(L_{num}+L_{wum})\}^{E_m}+C_m(L_{nsm}+L_{wsm})^{E_m}]^{-(1+E_m)/E_m}.$$

Notice here that the left-hand (i.e. the wage) sides of these two equations are conceptually different. This reflects the two different ways in which apartheid enforces the employment of whites despite their higher wage rates. In the unskilled labor category, all the jobs are reserved for whites until all whites seeking such jobs are employed; only then may employers hire nonwhites at their lower wage rates. This means that, at the margin, the relevant wage rate to equate to the value of the marginal product is the wage rate of nonwhite unskilled labor. In the skilled labor category, however, certain jobs are entirely reserved for whites, while the rest (at the lower rungs of the skilled part of the job ladder) are entirely open to nonwhites. If we assume that these two parts of the skilled labor force must be expanded or contracted together (i.e. the two are perfect complements), then at the relevant margin employers are hiring partly a nonwhite skilled worker (Z_m) and

---

13. But whites and nonwhites are perfect substitutes for each other within each skill class. This obviously inaccurate assumption proves troublesome in Section VI, when more than marginal changes in the labor-market constraints are considered, and constraints on this substitutability are there added.

TABLE B3

Implied Values of Ag and Cg
(for various assumed values of Eg)

Eg =	Ag =	Cg =
-1.00	3.076	3.508
-0.99	3.026	3.513
-0.95	2.824	3.534
-0.90	2.568	3.561
-0.80	2.049	3.616
-0.70	1.532	3.672
-0.60	1.040	3.728
-0.50	0.605	3.785
-0.40	0.268	3.843
-0.30	0.069	3.902
-0.20	0.005	3.962
-0.10	0.000	4.023
-0.05	0.000	4.054
-0.02	0.000	4.072
0.02	**********	4.097
0.05	**********	4.116
0.10	**********	4.148
0.20	53174.964	4.211
0.30	3536.526	4.276
0.40	912.035	4.342
0.50	404.457	4.408
1	79.542	4.757
2	35.274	5.540
4	23.490	7.514
8	19.169	13.822
16	17.316	46.772
32	16.458	535.535

NOTE: 1. *** means the number is 1,000,000 or larger.

Figure B7

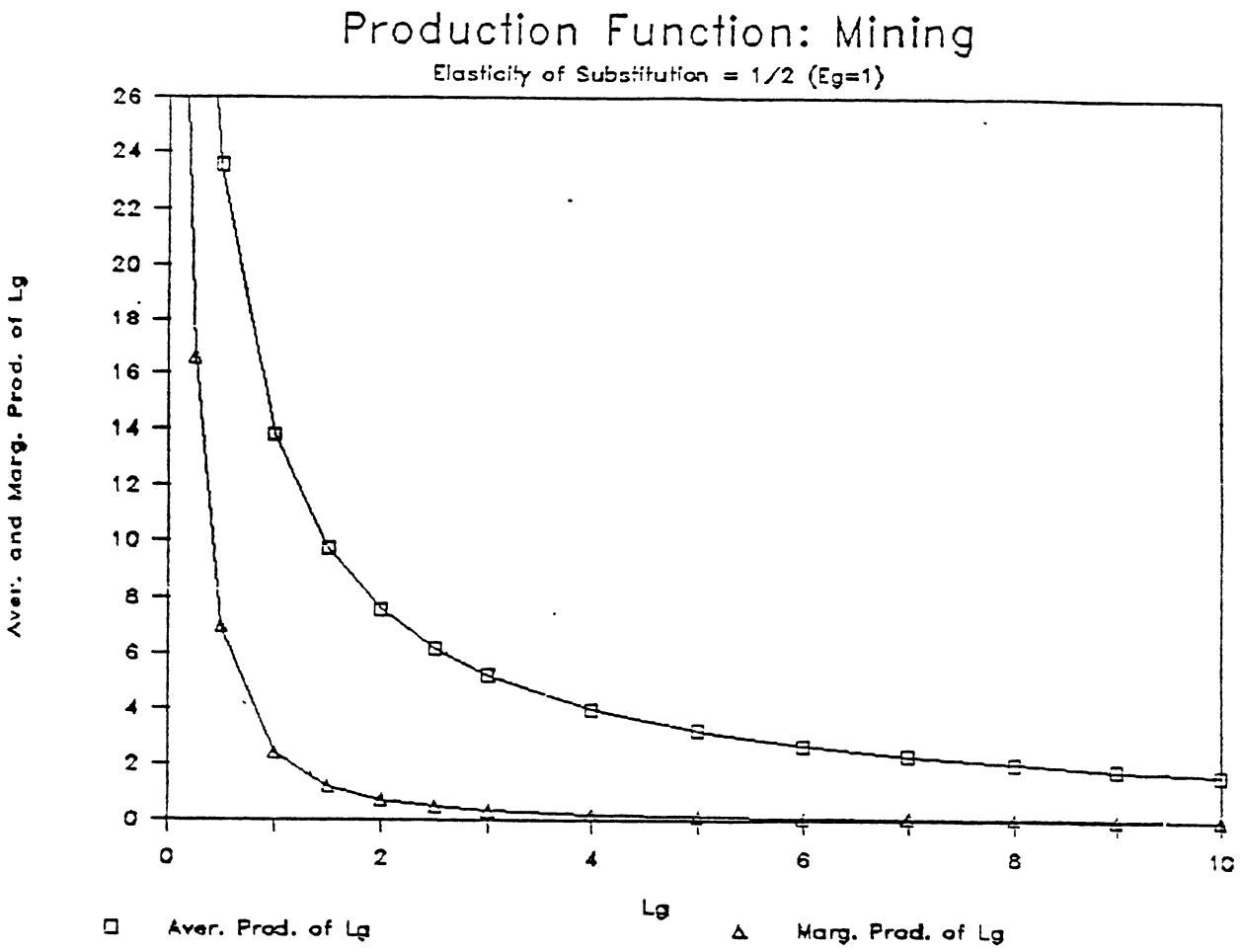
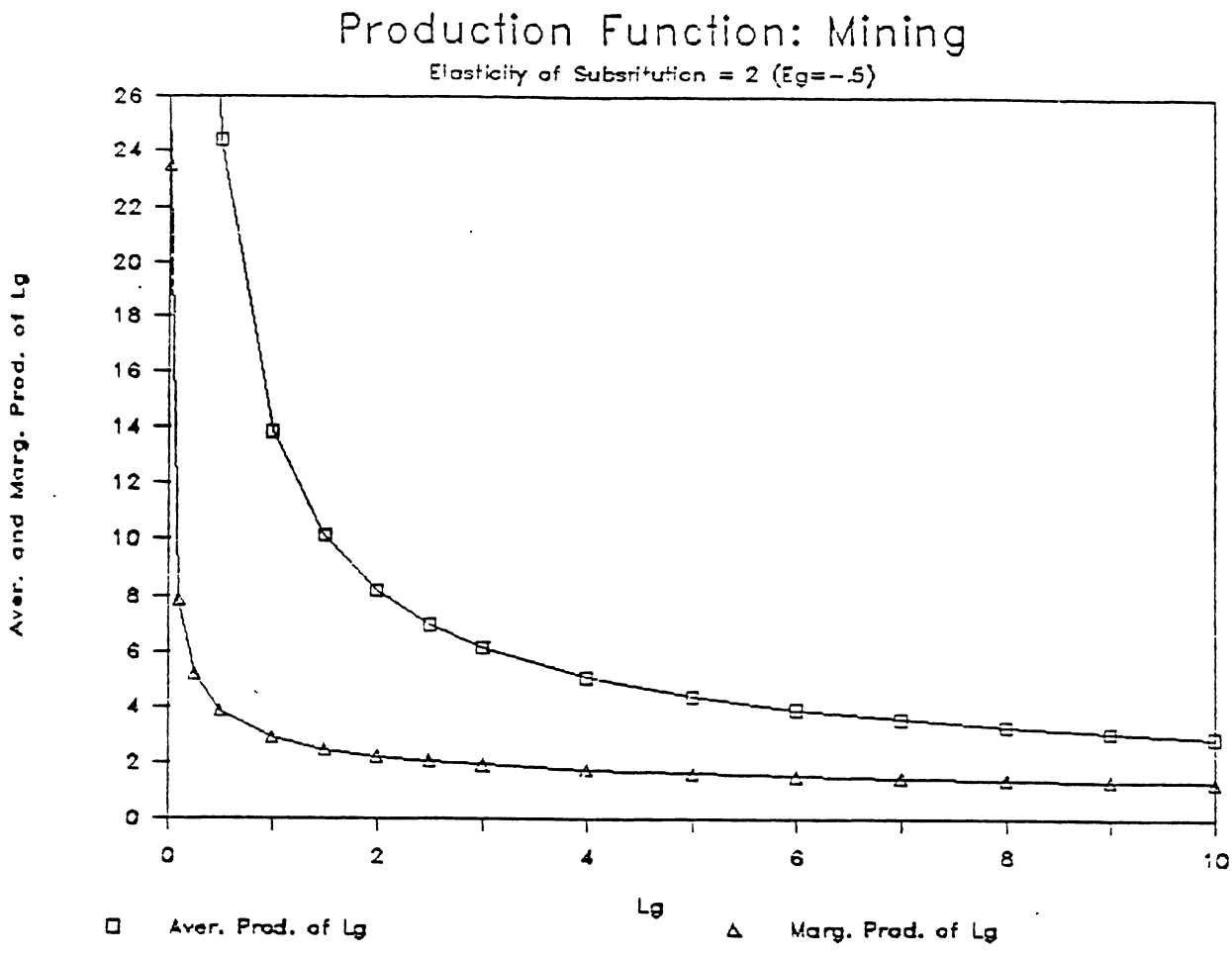

Production Function: Mining
Elasticity of Substitution = 1/2 (Eg=1)
Aver. and Marg. Prod. of Lg
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
Lg
Aver. Prod. of Lg
Marg. Prod. of Lg

Figure B8


Production Function: Mining
Elasticity of Substitution = 2 (Eg=-.5)
Aver. and Marg. Prod. of Lg
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
Lg
Aver. Prod. of Lg
Marg. Prod. of Lg

partly a white skilled worker ($1-Z_m$). Thus equation (B8) utilizes a weighted average of the two wage rates of such workers.

Here, too, white labor must be adjusted for education. This means that the white labor figures are multiplied by 1.06 to the sixth power, and the white wage figures are divided by 1.06 to the sixth power in order to calculate the effective-worker figures. The corrections are shown below:

Variable	For Actual Labor	For Effective Labor
L_{wum}	61 thousand	87 thousand
L_{wsm}	300 thousand	426 thousand
$D_{wum}Y_w^u$	R 5.412	R 3.815
$D_{wsm}Y_w^s$	R12.144	R 8.561
Z_m	0.252	0.192

The implied values of A_m, B_m, and C_m are shown in Table B4 and two production functions pictured in Figures B9 and B10.

5. "Other" Sectors (o). The statistical procedures are exactly the same here as in the manufacturing sector. The production function and the two wage conditions are exactly like equations (B6) - (B8) with the subscript o replacing the subscript m throughout. The corrections needed to convert actual white labor and wage rates into effective values are:

Variable	For Actual Labor	For Effective Labor
L_{wuo}	221 thousand	313 thousand
L_{wso}	1089 thousand	1545 thousand
Y_w^u	R 4.620	R 3.257
Y_w^s	R10.368	R 7.309
Z_o	0.168	0.125

The implied values of A_o, B_o, and C_o are shown in Table B5, and two of the production functions are displayed in Figures B11 and B12.

TABLE E4

Implied Values of Am, Bm, and Cm
(for various assumed values of Em)

Em =	Am =	Bm =	Cm =
-1.00	7.849	0.316	0.805
-0.99	7.758	0.319	0.810
-0.95	7.385	0.328	0.831
-0.90	6.902	0.340	0.859
-0.80	5.878	0.365	0.915
-0.70	4.781	0.393	0.976
-0.60	3.630	0.422	1.041
-0.50	2.469	0.454	1.110
-0.40	1.385	0.487	1.183
-0.30	0.528	0.524	1.261
-0.20	0.077	0.563	1.345
-0.10	0.000	0.605	1.434
-0.05	0.000	0.627	1.481
-0.02	0.000	0.641	1.510
0.02	**********	0.659	1.549
0.05	**********	0.674	1.579
0.10	**********	0.699	1.630
0.20	8103.682	0.751	1.738
0.30	1178.947	0.807	1.854
0.40	449.676	0.867	1.976
0.50	252.199	0.932	2.107
1	79.329	1.335	2.904
2	44.491	2.742	5.515
4	33.319	11.570	19.891
8	28.834	205.918	258.754
16	26.823	65229.799	43785.755
32	25.871	**********	**********

NOTE: 1. *** means the number is 1,000,000 or larger.

Figure B9

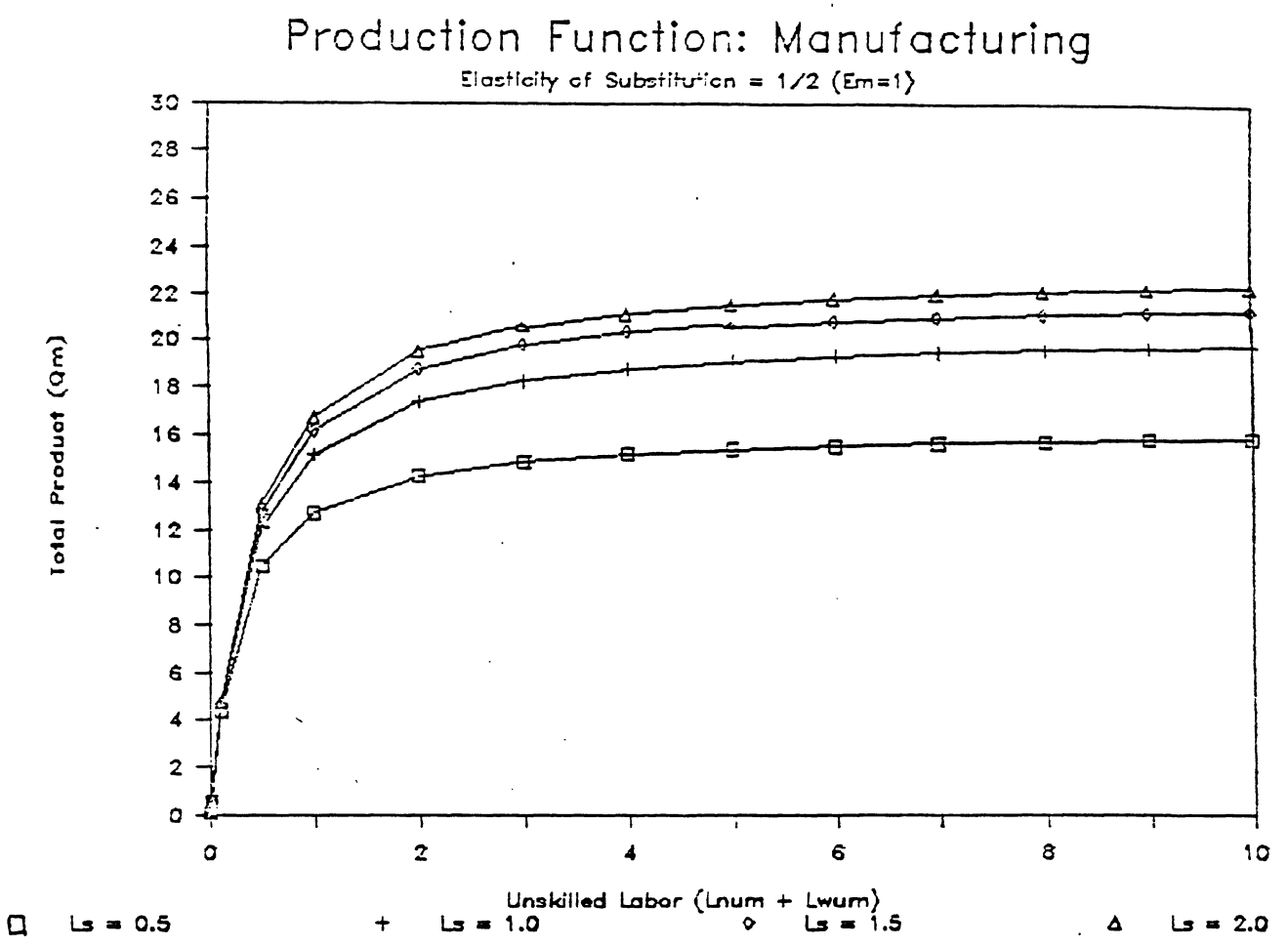

Production Function: Manufacturing
Elasticity of Substitution = 1/2 (Em=1)
Total Product (Qm)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
Unskilled Labor (Lnum + Lwum)
Ls = 0.5
Ls = 1.0
Ls = 1.5
Ls = 2.0

Figure B10

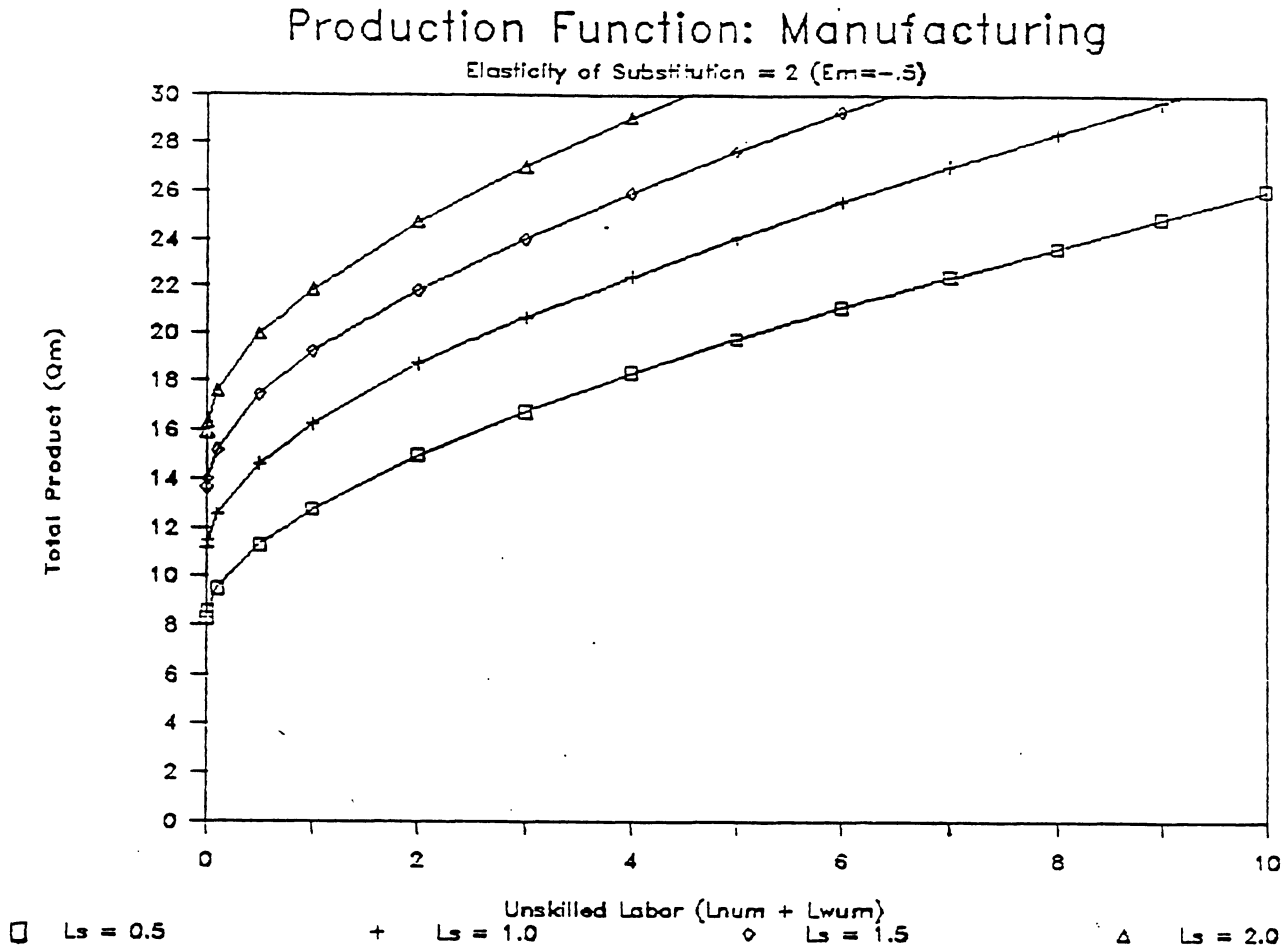

Production Function: Manufacturing
Elasticity of Substitution = 2 (Em=-.5)
Total Product (Qm)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
Unskilled Labor (Lnum + Lwum)
Ls = 0.5
Ls = 1.0
Ls = 1.5
Ls = 2.0

TABLE B5

Implied Values of Ao, Bo, and Co
(for various assumed values of Eo)

Eo =	Ao =	Bo =	Co =
-1.00	7.123	0.335	1.115
-0.99	7.067	0.337	1.109
-0.95	6.833	0.344	1.084
-0.90	6.525	0.354	1.054
-0.80	5.847	0.373	0.995
-0.70	5.077	0.393	0.940
-0.60	4.207	0.415	0.888
-0.50	3.233	0.438	0.839
-0.40	2.178	0.462	0.793
-0.30	1.127	0.487	0.749
-0.20	0.302	0.514	0.708
-0.10	0.006	0.542	0.669
-0.05	0.000	0.557	0.650
-0.02	0.000	0.566	0.639
0.02	**********	0.578	0.625
0.05	**********	0.587	0.614
0.10	42365.437	0.603	0.597
0.20	815.473	0.636	0.564
0.30	218.546	0.671	0.533
0.40	113.138	0.708	0.503
0.50	76.216	0.747	0.476
1	34.588	0.975	0.358
2	23.301	1.663	0.203
4	19.124	4.835	0.065
8	17.326	40.888	0.007
16	16.491	2924.463	0.000
32	16.089	**********	0.000

NOTE: 1. *** means the number is 1,000,000 or larger.

Figure B11

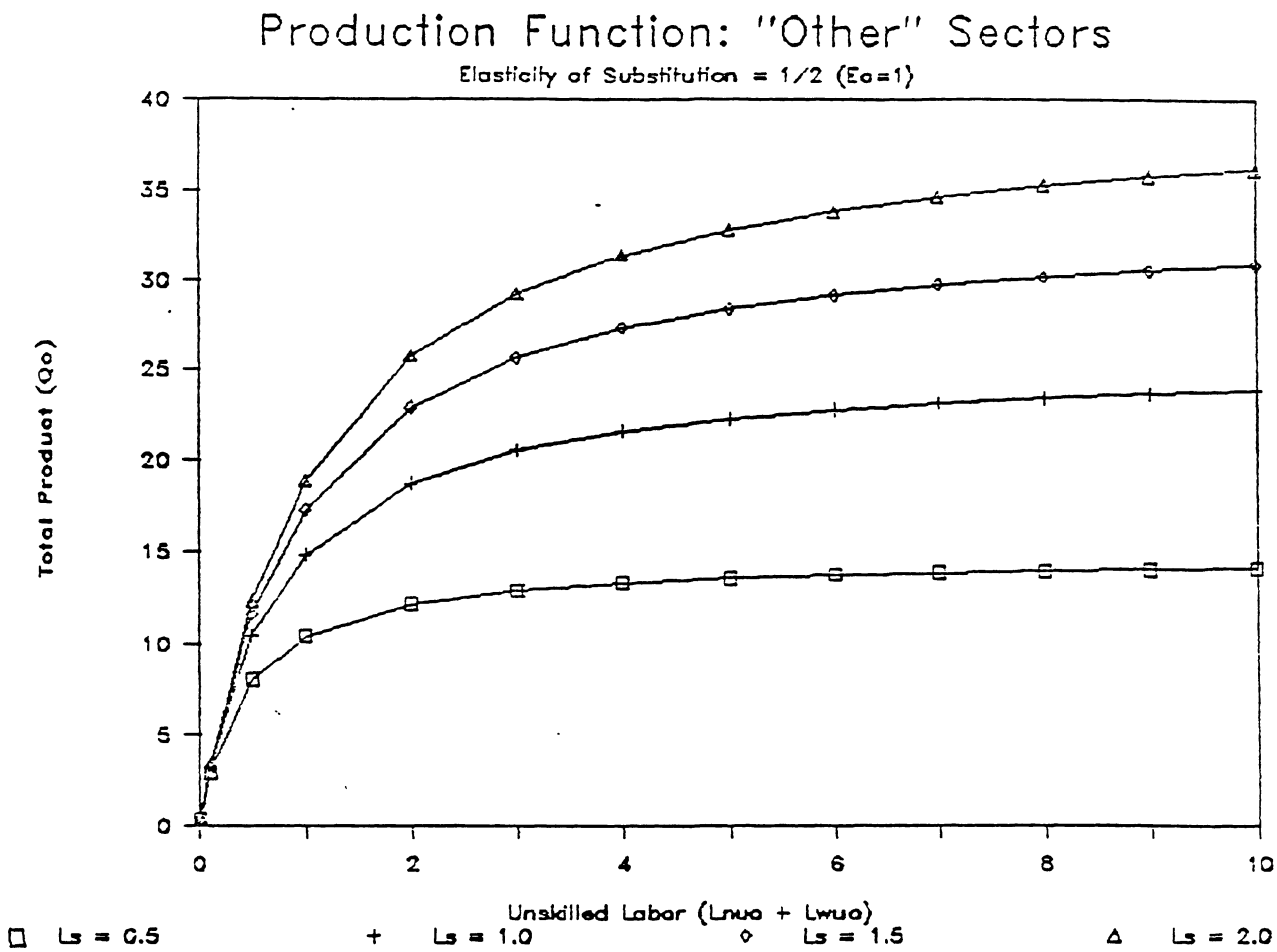
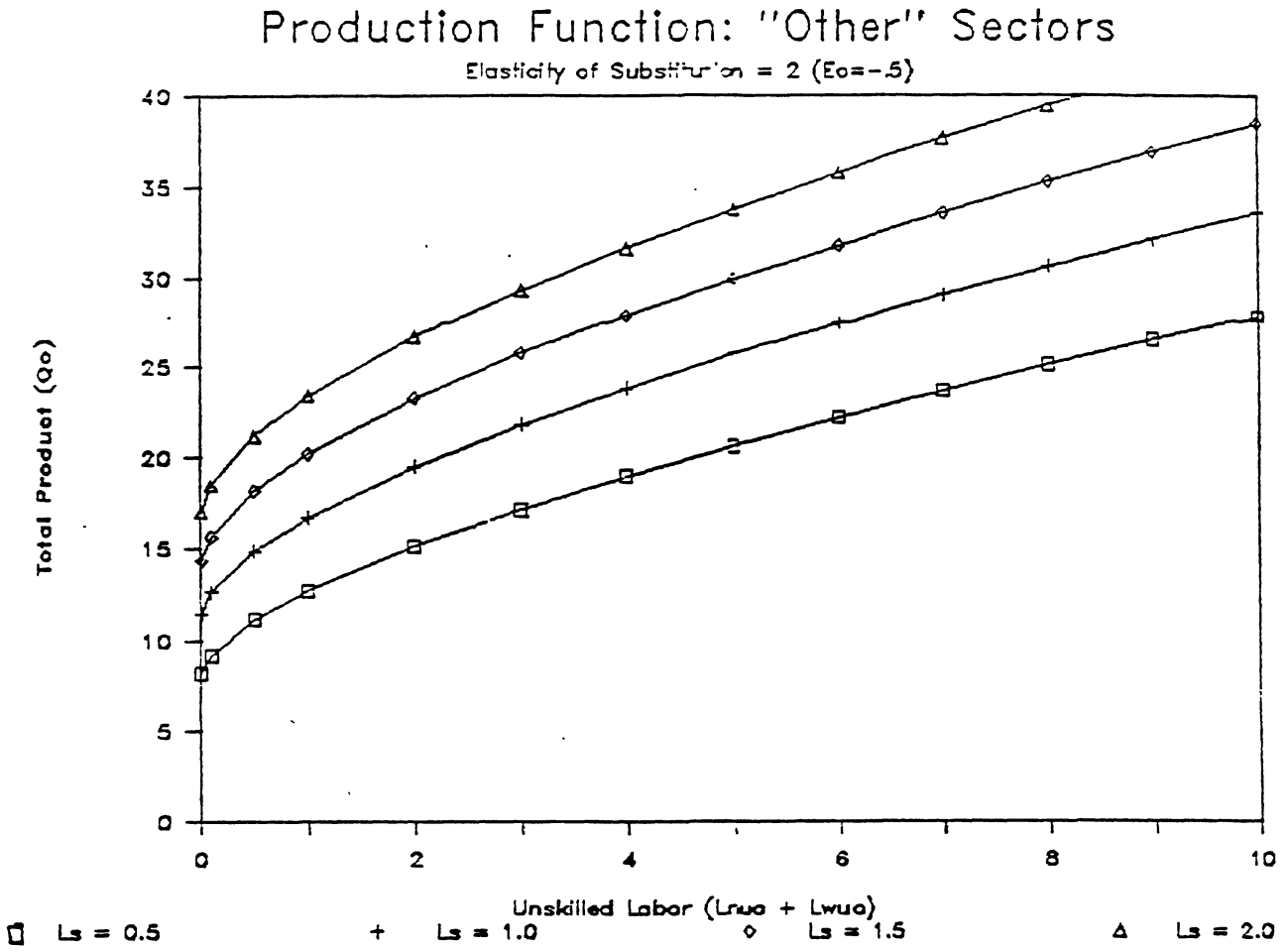

Production Function: "Other" Sectors
Elasticity of Substitution = 1/2 (Eo=1)
Total Product (Qo)
0
5
10
15
20
25
30
35
40
0
2
4
6
8
10
Unskilled Labor (Lnuo + Lwuo)
Ls = 0.5
Ls = 1.0
Ls = 1.5
Ls = 2.0

Figure B12


Production Function: "Other" Sectors
Elasticity of Substitution = 2 (Eo=-.5)
Total Product (Qo)
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
Unskilled Labor (Lruo + Lwuo)
Ls = 0.5
Ls = 1.0
Ls = 1.5
Ls = 2.0

Appendix C: Other Empirical Content

The purpose of the paper and its simulations is to compare the existing (1980) situation in South Africa with a variety of counterfactual situations in which the various restrictions on nonwhite labor movements and allocations are altered. It is therefore necessary to "calibrate" the model of Section II to the data of 1980. Here, only the base-period parameters and variables will be discussed — the raw data and its sources and complications are treated in Appendix A.

The production functions of each of the five sectors each contain three or four parameters (A, C, E, and sometimes B) in addition to the labor inputs.[14] But the output and input data of 1980, plus the assumed equality then of wage rates and marginal products of labor, greatly reduce the extent to which these parameters can vary. Appendix B derives these parameter constraints and shows the range of production functions that will be used in the simulations. In general, only the (assumed constant) elasticity of substitution is free to vary, and values of that parameter of 1/2 and 2 will be examined.[15]

Only in the case of agriculture in the Black reserves (subscript b) is the production function not reduced to one parameter, owing to the absence of labor market data there. There, the parameters, A and E, are both free to vary and a range of four cases is considered in the simulations.[16]

Thus, in the simulations, as many as 64 combinations of production functions could be considered — four for Black agriculture and two for each of the other four sectors.[17] The table below summarizes the twelve relevant production functions to be utilized:

---

14. Equations (1) - (5) of Section II.

15. E is the parameter that relates to the elasticity of substitution, and values for it of -1/2 and 1 will be examined.

16. E is still assumed to lie between -1/2 and 1, as in the other four production functions.

17. See Appendix B for discussion and derivation of these production functions.

Table C-1

Production Function Parameters Utilized

Sector	(Subscript)	A	B	C	E
Black Agriculture	(b)	0.010	--	5.485	-0.5
		0.100	--	1.085	-0.5
		1.000	--	1.307	1
		10.000	--	23.046	1
European Agriculture	(e)	1.034	--	0.665	-0.5
		4.067	--	0.438	1
Mining	(g)	0.605	--	3.785	-0.5
		79.542	--	4.757	1
Manufacture	(m)	2.469	0.454	1.110	-0.5
		79.329	1.335	2.904	1
"Other" Sectors	(o)	3.233	0.438	0.839	-0.5
		34.588	0.975	0.358	1

Note: -- means not applicable (i.e. only one kind of labor is used).

The population in South Africa in 1980 was about 29 million people (including 4 million in the "independent" homelands). The measured labor force was, however, only 8.721 million. These consisted of 1.775 million white workers (L_w), of whom 14 thousand were farmers (L_{we}), 61 thousand were unskilled workers in manufacturing (L_{wum}), and 221 thousand were unskilled workers in "other" sectors (L_{wuo}). The nonwhite labor force was 6.946 million (L_n).[18]

We turn next to the quantitative restrictions on nonwhite labor allocations. These are multifarious and often obscure in the South African economy, but we choose to highlight five. One, the fraction of nonwhite laborers that are required to stay inside the Black reserves (i.e. working in the Black agriculture sector) -- Z_b. Two, the fraction of the jobs in the mining sector that the job-reservation system there permits to be done by

---

18. These L values are needed in equations (6) - (8) and equations (16) and (17).

nonwhite labor -- Z_g. Three, the fraction of the skilled jobs in manufacturing done by nonwhites -- Z_m. Four, the fraction of skilled jobs in "other" sectors done by nonwhites -- Z_o. And five, the fraction of the nonwhite labor force with "section 10" access to manufacturing and the "other" sectors (together called the "white urban" sectors). In 1980, the values of these fractions:

Z Fraction	in Actual Labor	in Effective Labor
Z_b	.130	.130
Z_g	.890	.851
Z_m	.252	.192
Z_o	.168	.125
Z_x	.578	.578

In the basic model, the actual 1980 replication of Section III, where the model is solved as 28 equations in 28 variables, the above values of the Zs are substituted into inequalities (13) through (17) as both the lower and upper limits on the Z variables.[19]

There is also a racial quantitative allocation for unskilled laborers in both the manufacturing and "other" sectors in that white applicants go to the front of the relevant queues. The parameter that this constraint involves appears in the price equation, equation (18), whereby the white workers earn a wage rate that is F times that of nonwhites. In 1980, the value of F was 1.935.[20] Unskilled whites then earned roughly double the wage of unskilled nonwhites.

The model incorporates five basic wage income variables, Y (and many wage differential coefficients, D, to be discussed shortly):

---

19. When free labor markets are considered, on the other hand, the above 1980 values of the Z ratios will be ignored, and all the Zs will emerge, through market forces, of course between zero and one. In fact, in Section VI, limits on the rate of job-upgrading of nonwhites will be considered and will appear as constraints on some of the Zs; but then the limits are no longer artificial.

20. This is the F value in the "other" sector -- which is the one that is normalized.

Y_n^{bla} -- the value of the marginal product of labor in Black agriculture (in thousands of Rands per annum). Its value in 1980 depends upon which of the four production functions for Black agriculture are used:

Assumed E_b	Assumed A_b	Estimated Y_n^{bla}
-.50	.01	R0.068
-.50	.10	R0.214
1	1.00	R0.211
1	10.00	R0.021

Note that the estimates of Y_n^{bla} in the final column of the above table are estimates of the value of the marginal product of labor there (as opposed to the average product there -- see Appendix A -- known in 1980 to be R0.459). They vary quite a bit -- indeed, there is an order of magnitude between the highest and the lowest. In the simulations, we would use these estimates if we wanted to divide Black agricultural income between the share attributable to labor and the share attributable to other factors. But the variance of these estimates discourages this, and there is little purpose to it, anyway, since the two shares are usually received by the same people. What Y_n^{bla} does disclose is the opportunity cost of the migration of a family's marginal worker from the homelands to one of the "modern" sectors.

Y_n^{rur} -- the wage rate of nonwhite labor in the "rural white" sectors of the economy (in thousands of Rands per annum). More precisely, it is the wage rate of nonwhites in the unskilled jobs of European agriculture and, with the appropriate (D) differential, mining. In 1980, the value of Y_n^{rur} was R1.632.

Y_n^{urb} -- the wage rate of nonwhite labor in the "urban white" sectors of the economy (in thousands of Rands per annum). More precisely, it is the wage rate of nonwhites in the unskilled jobs of the "other" sector and, with appropriate differentials, unskilled jobs in manufacturing and skilled jobs in both these sectors. In 1980, the value of Y_n^{urb} was R2.388.

Y_w^u — the wage rate of white unskilled labor.[21] Its value in 1980 was R4.620 per annum.[22]

Y_w^s — the wage rate of white skilled labor.[23] The value in 1980 was R10.368 per annum.

Each of the other seven wage income variables is derived as a relative differential to one of the above five Y values. These differentials are denoted D with an appropriate subscript. The definitions of these differentials and their 1980 values are given in the table below:

Definition of the D Variables	1980 D Values
$Y_{ng} = D_{ng}Y_n^{rur}$	$D_{ng} = 1.257$
$Y_{num} = D_{num}Y_n^{urb}$	$D_{num} = 1.040$
$Y_{nsm} = D_{nsm}Y_n^{urb}$	$D_{nsm} = 2.030$
$Y_{nso} = D_{nso}Y_n^{urb}$	$D_{nso} = 2.437$
$Y_{wum} = D_{wum}Y_w^u$	$D_{wum} = 1.171$
$Y_{wg} = D_{wg}Y_w^s$	$D_{wg} = 1.223$
$Y_{wsm} = D_{wsm}Y_w^s$	$D_{wsm} = 1.171$

Since we will assume that these values of D are due to extraneous factors and persist despite changes in the job rules of the various counterfactual simulations, we should take a minute to reassure ourselves that the above D values make sense. Among rural nonwhites, mine workers earn a wage one fourth higher than workers in European agriculture ($D_{ng} = 1.257$). This differential seems reasonable: such farm workers are generally illiterate, rustic, and/or old. Unskilled nonwhites earn about the same wage in manufacturing as in the "other" sector ($D_{num} = 1.040$). Skilled work pays two to two-and-a-half times as much as unskilled work ($D_{nsm} = 2.030$ and $D_{nso} = 2.437$), a plausible premium

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21. In the "other" sector. The wage rate of unskilled white labor in manufacturing is tied to it through a wage differential, D.

22. Note that the ratio of the 1980 value of Y_w^u to the 1980 value of Y_n^{mod} is the 1980 value of F (i.e. 4.620/2.388 = 1.935).

23. Again, in the "other" sector, with the white skilled wage rate in manufacturing and mining tied to it through differentials, D.

.for the marketable skills, regular attendance, and careful application that such workers must display.

The differentials for white workers are much smaller. Unskilled whites earn somewhat more in manufacturing than in the "other" sector (D_{wum} = 1.171); and skilled whites earn the same differential in manufacturing compared to skilled whites in the "other" sector (D_{wsm} = 1.171). The aggressive and well-organized white miners earn nearly one fourth more than skilled whites in the "other" sector (D_{wg} = 1.223) and slightly more than skilled whites in manufacturing (1.223 vs. 1.171).

The fact that the ratios of skilled to unskilled wages are similar now (i.e. in these 1980 data) for whites and nonwhites lends some support for the assumption, otherwise bald, that the values of D_{nsm} and D_{nso} would not change if all apartheid restrictions on nonwhite labor were removed (as is done in the simulations of Section VI).

Appendix D: Maximizing Incomes of White Subgroups

In Section V, the values of the five Zs that maximize the incomes of various white subgroups are derived and presented. Here, we look in detail at each of those subgroups and their preferred Z values. The purpose is to make intuitively clear the level and the spread (where the values vary greatly across production function assumptions) of these maximizing values of the Zs.

White Farmers. These farmers' incomes are larger the more nonwhite laborers are urged and/or pushed onto their farms. The maximizing Zs are all zero, tempered only slightly by two things: 1) some nonwhite labor may have to be kept (or more accurately, permitted to stay) in the Black reserves to prevent the marginal product of labor there from rising above the wage the white farmers are paying, which would draw labor back to the reserves; and 2) some nonwhite labor must be permitted into the cities (though in unskilled jobs only) in order to prevent the wage of white skilled workers there from falling to the level of the white unskilled wage there.

White Mining Labor. The spread of the maximizing Zs in the case of the white mineworkers indicates that they face two very different kinds of strategies, with their preference between them basically dependent on the

elasticities of the production functions faced. The only two consistent elements of the two strategies are: 1) the desire to empty the Black reserves to provide labor for the other four sectors, and 2) the determination to keep nonwhites out of skilled jobs in the manufacturing and "other" sectors. When the elasticities of substitution are low, nonwhite labor is steered to European farming and unskilled urban jobs (i.e. not to mining); the skilled wage is driven up by this influx of unskilled labor, and the white mineworkers take all the mining jobs and a high wage, too. When the elasticities of substitution are high, the strategy of white mining labor is quite different. Now, nonwhite labor is kept out of the urban areas, forcing down the rural nonwhite wage. These low-paid nonwhites are permitted to continue to hold a vast majority of the mining jobs, but their low wages greatly expand the demand for white labor there in the remaining jobs. Although the skilled white wage declines slightly, the numbers of white miners are expanded greatly.[24]

White Urban Unskilled Labor. Different production function parameters lead to different results with respect to whether most of the nonwhites are kept in the reserves or permitted into mining jobs, but there is no ambivalence about the urban part of the maximizing allocation from the viewpoint of unskilled whites. Nonwhites are permitted into the urban sectors only in sufficient numbers to keep the skilled white wage from falling to the level of the unskilled white wage; and no nonwhites are permitted into skilled jobs.

White Urban Skilled Labor. This group would like to let the nonwhites out of the reserves, and permit them to flood into the cities, largely if not entirely for unskilled work. This enhances the scarcity of the skilled workers, and hence their incomes. The maximizing values of all the Zs make clearest sense when the inelastic CES production functions (E=1) are used: $Z_b = Z_g = Z_m = Z_o = 0$, and $Z_x = .73$. But when the elastic production functions are applied, an apparent anomaly appears. The optimizing values of Z_m and Z_o rise above zero (to 0.47 and 0.11, respectively). Why should skilled whites invite nonwhites into skilled jobs? Recall that the demand for skilled labor

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24. And recall, it is the total income of white miners, not their wage rate, that is being maximized here. For discussion of this difference, see the paragraphs on White Urban Skilled Labor, below.

is determined by the weighted average of the skilled white and the skilled nonwhite wage rates. Nonwhites earn much lower wages. As they are increased, this weighted-average skilled wage rate falls, the total demand for skilled labor increases greatly (when production functions are elastic), and skilled whites actually gain from the entry of the nonwhites into skilled jobs. In short, skilled whites may want some skilled jobs turned over to skilled nonwhites, provided they are poorly enough paid.

White Mining Capital. This interest is clear -- to remove the color bar that prevents more complete use of nonwhite labor in the mines. But mining capital would also like to let relatively few nonwhites into the cities because that restriction increases mining capital's labor pool and hence lowers the wages nonwhite miners must be paid.

White Manufacturing Capital. Manufacturing capital wants nonwhites to be drawn into the city in sufficient numbers to bring down the gaps between rural and urban nonwhite wages and between unskilled and skilled white wages. In short, manufacturing profit is served by increases in Z_x and Z_m.

White "Other" Capital. The strategy here is the same as for manufacturing capital except that it is now Z_o, rather than Z_m, whose increase is desired.

Appendix E: The Model Without Labor-Market Restrictions

In Section VI, the artificial labor-market restrictions are removed. This requires changes in many of the equations (and inequalities) of the model presented in Section II. Here, those changes are spelled out. The equation numbering here follows that of Section II, with identical equations identically numbered and altered equations indicated with a prime (').

The production functions for the five sectors are unaffected by the removal of labor-market restrictions:

$$(1) \qquad Q_b = A_b[(L_{nb})^{-E_b+C_b}]^{-1/E_b};$$

$$(2) \qquad Q_e = A_e[(L_{ne}+L_{we})^{-E_e+C_e}]^{-1/E_e};$$

$$(3) \qquad Q_g = A_g[(L_{ng}+L_{wg})^{-E_g+C_g}]^{-1/E_g};$$

(4) $Q_m = A_m[B_m(L_{num}+L_{wum})^{-E_m}+(L_{nsm}+L_{wsm})^{-E_m+C_m}]^{-1/E_m}$; and

(5) $Q_o = A_o[B_o(L_{nuo}+L_{wuo})^{-E_o}+(L_{nso}+L_{wso})^{-E_o+C_o}]^{-1/E_o}$.

Neither are the labor-market summation identities affected:

(6) $L_{nb}+L_{ne}+L_{ng}+L_{num}+L_{nsm}+L_{nuo}+L_{nso}=\bar{L}_n$ and

(7) $L_{we}+L_{wg}+L_{wum}+L_{wsm}+L_{wuo}+L_{wso}=\bar{L}_w$.

Nor are the definitions of the Zs:

(8) $L_{nb} = Z_b(\bar{L}_n)$;

(9) $L_{ng} = Z_g(L_{ng} + L_{wg})$;

(10) $L_{nsm} = Z_m(L_{nsm} + L_{wsm})$;

(11) $L_{nso} = Z_o(L_{nso} + L_{wso})$; and

(12) $L_{num}+L_{nuo}+L_{nsm}+L_{nso} = Z_x(\bar{L}_n)$.

The constraints on the Zs, expressed in equations/inequalities (13) - (17), certainly do change. Under apartheid, they are fixed by custom and/or law, whereas in a free market they will be determined by the equalities of marginal products and wages, bounded only by zero and one and constrained only by the ability of particular labor to do particular jobs. Let us look at each Z in turn:

Z_b -- Either Y_n^{bla} becomes in a free market as high as Y_n^{rur} or there will be no labor willing to stay in the Black reserves. Formally, (13) becomes

(13') $Z_b(Y_n^{rur} - Y_n^{bla}) = 0$,

$Z_b \geq 0$, and

$Y_n^{rur} \geq Y_n^{bla}$.

Z_g -- Since nonwhite labor is cheaper than white labor, mine-owners faced with a free labor choice will increase the nonwhite fraction of their work force as much as the ability to upgrade nonwhites permits. This fraction is written Z_g^{max}, and

(14') $Z_g = Z_g^{max}$.

The numerical values to be employed for Z_g^{max} are discussed and given in the text.

Z_m -- Here too, the only constraint on the replacement of white skilled workers by nonwhites is their ability to gain the necessary skills quickly:[25]

(15') $Z_m = Z_m^{max}$.

See the text for the numerical values of Z_m^{max}.

Z_o -- Here too:

(16') $Z_o = Z_o^{max}$.

See the text for the numerical values of Z_o^{max}.

Z_x -- With "section 10" regulations removed, the fraction of the nonwhite labor force in the "white areas" is unconstrained:

(17') $0 < Z_x < 1 - Z_b$.

Equations (18) - (21) are unaltered, except that F = 1 in equation (20) once the special arrangements for unskilled whites are removed:

(18) $L_{wum} = \bar{L}_{wum}$;

(19) $L_{wuo} = \bar{L}_{wuo}$;

(20') $Y_w^u = Y_n^{urb}$ (i.e. F = 1); and

(21) $L_{we} = \bar{L}_{we}$.

Similarly, there are no changes in the writing of equations (22) - (28), which posit the equality of the marginal product of labor with its wage for the various sectors and skill classifications:

---

25. This is technically true only as long as the wage of skilled nonwhites is less than that of whites, but that situation holds in all the simulations of Section VI.

$$(22) \qquad Y_n^{bla} = A_b[1+C_b(L_{nb})^{E_b}]^{-(1+E_b)/E_b};$$

$$(23) \qquad Y_n^{rur} = A_e[1+C_e(L_{ne}+L_{we})^{E_e}]^{-(1+E_e)/E_e};$$

$$(24) \qquad D_{num}Y_n^{urb} = A_mB_m[B_m+C_m(L_{num}+L_{wum})^{E_m}+ \{(L_{num}+L_{wum})/(L_{nsm}+L_{wsm})\}^{E_m}]^{-(1+E_m)/E_m};$$

$$(25) \qquad Y_n^{urb}=A_oB_o[B_o+C_o(L_{nuo}+L_{wuo})^{E_o}+ \{(L_{nuo}+L_{wuo})/(L_{nso}+L_{wso})\}^{E_o}]^{-(1+E_o)/E_o};$$

$$(26) \qquad Z_gD_{ng}Y_n^{rur}+(1-Z_g)D_{wg}Y_w^s=A_g[1+C_g(L_{ng}+L_{wg})^{E_g}]^{-(1+E_g)/E_g};$$

$$(27) \qquad Z_mD_{nsm}Y_n^{urb}+(1-Z_m)D_{wsm}Y_w^s = A_m[1+B_m\{(L_{nsm}+L_{wsm})/(L_{num}+L_{wum})\}^{E_m} +C_m(L_{nsm}+L_{wsm})^{E_m}]^{-(1+E_m)/E_m};$$

and

$$(28) \qquad Z_oD_{nso}Y_n^{urb}+(1-Z_o)Y_w^s = A_o[1+B_o\{(L_{nso}+L_{wso})/(L_{nuo}+L_{wuo})\}^{E_o} +C_o(L_{nso}+L_{wso})^{E_o}]^{-(1+E_o)/E_o}.$$

But the interpretation of equations (26) - (28) is different. Under apartheid, the Zs in these equations represented the maximum fraction of nonwhite workers that were permitted to be hired; with free markets, permission is not required. But our assumption about the rate at which nonwhites can acquire the skills needed for skilled jobs means that, within the category of skilled labor, employers must continue to hire whites and nonwhites in proportions determined by the ability of each group to perform the needed skills. Thus, the Zs in these equations proxy not law but a rate-of-skilling assumption.

Since nonwhite workers would no longer be constrained in their movements between country and city, there is one final equation needed, which has no counterpart in the apartheid model of Section II:

$$(29') \qquad Y_n^{rur} = Y_n^{urb}.$$

A rural-urban differential could be introduced to reflect differences in non-pecuniary benefits (or costs), but currently observed South African differentials offer few clues what it might be, so we ignore the possibility.

This completes the free-market model. It contains the same 28 variables in the model of Section II. The relevant 28 equations here are equations (1) - (12), (13') - (16'), (18) - (19), (20'), (21) - (28), and (29').

Appendix F: "Eureka" Programs

The minimal basic models of the text can both be solved on a PC with the aid of "Eureka", a software creature of Borland International.[26] The involved reader is invited to check, to experiment, and to boldly go where we have not — the starter programs being given on the next three pages.[27]

The basic model with labor-market restrictions, that presented in Section II, is shown first (file name: APARTHEI). The maximizing model needed in Section V is hinted at next (file name: MAXUSWL). Finally, the free-market model explored in Section VI is written out (file name: FREEVARY).

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26. 4585 Scotts Valley Drive, Scotts Valley, California 95066. The cost is $39.95 under the Scholar Program.

27. For serious or extensive work, a mainframe is really necessary. "Eureka" has a tendency to get carried away if the initialized values of the variables are not carefully and closely chosen; and it has not the capacity to carry out the subsequent share and Lorenz calculations (though any spread-sheet program will).

```
**********************************************************************
Eureka: The Solver

Name of input file: A:\APARTHEI
**********************************************************************


;The model below is written in labor "efficiency units", which means that
;white labor measures have been multiplied by (1.06^6) to account for their
;greater education.  The initial values are the actual 1980 values.
            $ substlevel = 1
            $ maxtime =2000
GDP=Qb+Qe+Qg+Qn+Qo
Qb=b()
   b()=1*((Lnb)^(-1)+1.306811)^(-1)
  ;b()=10*((Lnb)^(-1)+23.045942)^(-1)
  ;b()=.01*((Lnb)^(.5)+5.484546)^(2)
  ;b()=.1*((Lnb)^(.5)+1.084962)^(2)
Qe=e()
   e()=4.067154*((Lne+.019859)^(-1)+.438084)^(-1)
  ;e()=1.033796*((Lne+.019859)^(.5)+.665032)^(2)
Qg=g()
   g()=79.541593*((Lng+Lwg)^(-1)+4.757202)^(-1)
  ;g()=.665066*((Lng+Lwg)^(.5)+3.785197)^(2)
Qn=n()
   n()=79.328793*(1.335664*(Lnun+.086530)^(-1)+(Lnsn+Lwsn)^(-1)+2.904009)^(-1)
  ;n()=2.468836*(.453569*(Lnun+.086530)^(.5)+(Lnsn+Lwsn)^(.5)+1.109595)^(2)
Qo=o()
   o()=34.588232*(.974896*(Lnuo+.313493)^(-1)+(Lnso+Lwso)^(-1)+.358040)^(-1)
  ;o()=3.232714*(.437774*(Lnuo+.313493)^(.5)+(Lnso+Lwso)^(.5)+.839389)^(2)

Lnb+Lne+Lng+Lnun+Lnsn+Lnuo+Lnso=6.946
Lwg+Lwsn+Lwso=2.517671-.019859-.086530-.313493
Yuw=1.363868*Yurbn

Lnb/6.946=.129859
Lng/(Lng+Lwg)=.851320
Lnsn/(Lnsn+Lwsn)=.191813
Lnso/(Lnso+Lwso)=.124662
(Lnun+Lnuo+Lnsn+Lnso)/6.946=.577599

Yblan=deriv(b(),Lnb)
Yrurn=deriv(e(),Lne)
1.040201*Yurbn=deriv(n(),Lnun)
Yurbn=deriv(o(),Lnuo)
(Lng/(Lng+Lwg))*1.257353*Yrurn+(Lwg/(Lng+Lwg))*1.223380*Ysw=deriv(g(),Lng)
(Lnsn/(Lnsn+Lwsn))*2.030151*Yurbn+(Lwsn/(Lnsn+Lwsn))*1.171296*Ysw=deriv(n(),Lnsn)
(Lnso/(Lnso+Lwso))*2.437186*Yurbn+(Lwso/(Lnso+Lwso))*Ysw=deriv(o(),Lnso)

GDP:=58.089
Lnb:=0.902   :   Lne:=1.301    :    Lng:=0.731    :    Lnsn:=0.101
Lnso:=0.220  :  Lnun:=0.995    :   Lnuo:=2.696
Lwg:=.128    :  Lwsn:=0.426    :   Lwso:=1.545
Yrurn:=1.632 : Yurbn:=2.388
Yuw:=3.257   :   Ysw:=7.309
```

```
**********************************************************************
Eureka: The Solver ---

Name of input file: A:\MAXUSWL
**********************************************************************

;The model below is written in labor "efficiency units", which means all
;white labor measures have been multiplied by (1.06^6) to account for their
;greater education.  The initial values are the solution values for all E=1.
;The MAX program works best (i.e. at all) when not all Zs are let loose at
;once; here, Zb and Zg are assumed to be zero.  USWL means incomes of Urban
;Skilled White Labor.
                $ substlevel = 1
                $ maxtime = 2000
                $ penalty = 10000
$ MAX (USWL).
USWL=Ysw*(1.171296*Lwsm+Lwso)
Qe=e()
   e()=4.067154*((Lne+.019859)^(-1)+.438084)^(-1)
  ;e()=1.033796*((Lne+.019859)^(.5)+.665032)^(2)
Qg=g()
   g()=79.541565*((Lwg)^(-1)+4.737202)^(-1)
  ;g()=.605006*((Lwg)^(.5)+3.725197)^(2)
Qm=m()
   m()=79.328793*(1.335664*(Lnum+.086530)^(-1)+(Lnsm+Lwsm)^(-1)+2.904003)^(-1)
  ;m()=2.468836*(.453569*(Lnum+.086530)^(.5)+(Lnsm+Lwsm)^(.5)+1.109595)^(2)
Qo=o()
   o()=34.588232*(.974896*(Lnuo+.313493)^(-1)+(Lnso+Lwso)^(-1)+.358040)^(-1)
  ;o()=3.232714*(.457774*(Lnuo+.313493)^(.5)+(Lnso+Lwso)^(.5)+.839389)^(2)

Lne+Lnum+Lnsm+Lnuo+Lnso=6.946
Lwg+Lwsm+Lwso=2.517871-.019859-.086530-.313493
Zm=Lnsm/(Lnsm+Lwsm)
  Zm>0  :  Zm<.30
Zo=Lnso/(Lnso+Lwso)
  Zo>0  :  Zo<.30
Zx=(Lnum+Lnuo+Lnsm+Lnso)/6.946
  Zx<1  :  Zx>.60
Yrurn=deriv(e(),Lne)
1.040201*Yurbn=deriv(m(),Lnum)
Yurbn=deriv(o(),Lnuo)
Yurbn>Yrurn    :    Ysw>2.5*Yurbn
1.223380*Ysw=deriv(g(),Lwg)
Zm*2.030151*Yurbn+(1-Zm)*1.171296*Ysw=deriv(m(),Lnsm)
Zo*2.437186*Yurbn+(1-Zo)*Ysw=deriv(o(),Lnso)

USWL:=19.166
Lne:=1.897   :   Lnsm:=0.000   :    Lnso:= 0.000   :   Lnum:=1.384   :   Lnuo:=3.665
Lwg:=0.317   :   Lwsm:=0.409   :    Lwso:= 1.373
Yrurn:=1.202 :  Yurbn:=1.202   :     Ysw:=10.352
Zm:=0.000    :     Zo:=0.000   :      Zx:=0.727
```

```
**********************************************************************
Eureka: The Solver

Name of input file: A:\FREEVARY
**********************************************************************


;The parameter k represents the fraction of the maximum skilled jobs that
;nonwhites are able to do once a free labor-market appears.  k=0 means they
;are able to do no more than they were allowed to do under apartheid
;restrictions.  k=1 means they are able to do all the mining jobs and 20%
;more of the skilled jobs in manufacturing and "other" than they were
;permitted to do under apartheid.  "Fast skilling" is k=1; "slow skilling"
;is k=0.50.  The initial values are the solution values for all E=1 (Ab=1)
;and k=.5.
              $ substlevel = 1
              $ maxtime = 2000
       k=0.50
GDP=Qb+Qe+Qg+Qm+Qo

Qb=b()
   b()=1*((Lnb)^(-1)+1.306811)^(-1)
  ;b()=10+((Lnb)^(-1)+23.045942)^(-1)
  ;b()=.01*((Lnb)^(.5)+5.484546)^(2)
  ;b()=.1*((Lnb)^(.5)+1.084962)^(2)
Qe=e()
   e()=4.067154*((Lne+.019859)^(-1)+.438084)^(-1)
  ;e()=1.033796*((Lne+.019859)^(.5)+.665032)^(2)
Qg=g()
   g()=79.541593*((Lng+Lwg)^(-1)+4.757202)^(-1)
  ;g()=.605006*((Lng+Lwg)^(.5)+3.785197)^(2)
Qm=m()
   m()=79.328793*(1.335664*(Lnum+.086530)^(-1)+(Lnsm+Lwsm)^(-1)+2.904009)^(-1)
  ;m()=2.468836*(.453569*(Lnum+.086530)^(.5)+(Lnsm+Lwsm)^(.5)+1.109595)^(2)
Qo=o()
   o()=34.588232*(.974896*(Lnuo+.313493)^(-1)+(Lnso+Lwso)^(-1)+.358040)^(-1)
  ;o()=3.232714*(.437774*(Lnuo+.313493)^(.5)+(Lnso+Lwso)^(.5)+.839389)^(2)

Lnb+Lne+Lng+Lnum+Lnsm+Lnuo+Lnso=6.946
Lwg+Lwsm+Lwso=2.517871-.019859-.086530-.313493
Lng/(Lng+Lwg)=(1-k)*.851320+k
Lnsm/(Lnsm+Lwsm)=(1-k)*(.101/(.101+.425556))+k*.367677
Lnso/(Lnso+Lwso)=(1-k)*(.220/(.220+1.544767))+k*.291023

Yuw=Yurbn   :   Yrurn=Yurbn   :   Lnb*(Yrurn-Yblan)=0   :   Yrurn>=Yblan

Yblan=deriv(b(),Lnb)   :   Yrurn=deriv(e(),Lne)   :   Yurbn=deriv(o(),Lnuo)
1.040201*Yurbn=deriv(m(),Lnum)
1.257353*(Lng/(Lng+Lwg))*Yrurn+(Lwg/(Lng+Lwg))*1.223380*Ysw=deriv(g(),Lng)
(Lnsm/(Lnsm+Lwsm))*2.030151*Yurbn+(Lwsm/(Lnsm+Lwsm))*1.171296*Ysw=deriv(m(),Lnsm)
(Lnso/(Lnso+Lwso))*2.437186*Yurbn+(Lwso/(Lnso+Lwso))*Ysw=deriv(o(),Lnso)
Zx=(Lnsm+Lnum+Lnso+Lnuo)/6.946

GDP:=61.386
Lnb:=0.000   :   Lne:=0.970   :   Lng:=0.814   :   Lnsm:=0.163   :   Lnso:=0.423
Lnum:=1.177  :   Lnuo:=3.399  :   Lwg:=0.065   :   Lwsm:=0.420   :   Lwso:=1.613
Yblan:=1.000 :  Yrurn:=1.979  :   Ysw:=7.256   :    Zx:=0.743
```

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