THE NATURE OF CONSTRAINTS ON LIBYAN ECONOMIC DEVELOPMENT AND THE IMPLICATIONS FOR DUAL SECTOR DEVELOPMENT THEORY

by

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B.A. (Hons), Oxford University, 1968

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in the Department

of

Economics and Commerce

SIMON FRASER UNIVERSITY

August, 1970

APPROVAL

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Degree: Master of Arts

Title of Thesis: The Nature of Constraints on Libyan Economic Development and the Implications for Dual Sector Development Theory

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ABSTRACT

The process of development is often analized in terms of a dual sector model. The purpose of this thesis is to argue first, that the classical and neo-classical dual sector models are logically inconsistent with certain aspects of the experience of economic growth and development, and second, that such models may lead to the prescription of non-optimal policy recommendations. To avoid these failings, a modification of the dual sector model is suggested. It is assumed that the elasticity of substitution between different labor skills is zero rather than unity. To show that such an assumption might be justified, the Libyan economy is analized in terms of the potential constraints on its development. In Section 1, the traditional dual sector model is examined to show the assumptions implicit in this type of analysis; in Appendix A, a theoretical model of the Libyan economy is constructed to define the framework within which the analysis of constraints is carried out; to demonstrate the importance of the supply of skilled labor or other potential constraints (the supply of capital and the ability to import) are examined in Sections 2 and 3 respectively; in Section 4, the constraint imposed by the labor supply is isolated; and in Section 5, the optimum allocation of labor between sectors is calculated; and in Section 6, tentative conclusions are discussed.

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SECTION 1:

THE TRADITIONAL DUAL SECTOR MODEL

> "The process of economic development may be studied as an increase in income per head or as an increase in the role of industrial activity relative to that in agriculture."[1]

In both classical and neo-classical analysis, the economy of the underdeveloped country is divided into two distinct sectors, the traditional and the advanced, or 'capitalistic' sectors. With varying degrees of approximation, these are assumed to be synonymous with agriculture and manufacturing respectively. However, Jorgenson admits:

> "It is clear that industry includes a good many traditional activities and that these activities have many characteristics of the backward sector; similarly, the agricultural sector may include a relatively advanced sub-sector."[2]

In Libya, the agricultural sector is particularly backward and can, without too much inaccuracy, be equated with the traditional sector.

Production in the traditional sector is usually assumed to be a function of land and labor alone. Any agricultural

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1. Dale W. Jorgenson, "Surplus Agricultural Labor and the Development of a Dual Economy", Oxford Economic Papers, 1962, p. 288.
2. Ibid., p. 291.

activity which used capital is assumed to be part of the advanced sector.[1] This results in an unfortunate split in the agricultural sector. There is an important distinction between transforming a sector and shifting resources between sectors, as Schultz argues.[2] This is especially true when specific constraints on movement between sectors are assumed. These constraints could be in the form of barriers to migration; or, as in the case under consideration, of different skill requirements between sectors.

Diagram 1 summarizes the important stages of development in the classical dual sector model as advanced by Fei and Ranis.[3] At the initial point the population OA is engaged in agriculture producing AS, each worker being paid an institutional wage at subsistence level of AS. (AS = AX/OA). The marginal product of those laborers beyond OD is zero, as shown in Diagram 1.2 on the MP curve ADUV. Let us assume that a modern manufacturing sector, whose demand curve for labor is shown in Diagram 1.1, is started exogeneously. During the first phase of development, the

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1. W. A. Lewis, "Economic Development with Unlimited Supplies of Labor", The Manchester School, Vol. 22, 1954, p. 146. J. C. H. Fei and G. Ranis, Development of the Labor Surplus Economy, Homewood, 1964, p. 16. D. W. Jorgenson, "The Development of the Dual Economy", Economic Journal, Vol. 71, 1961, p. 311.

2. T. W. Schultz, Transforming Traditional Agriculture, Yale U.P., New Haven, 1964, Ch. 7.

3. J. C. H. Fei and G. Ranis, "A Theory of Economic Development, A.E.R., Vol. LI, 1961, p. 535.

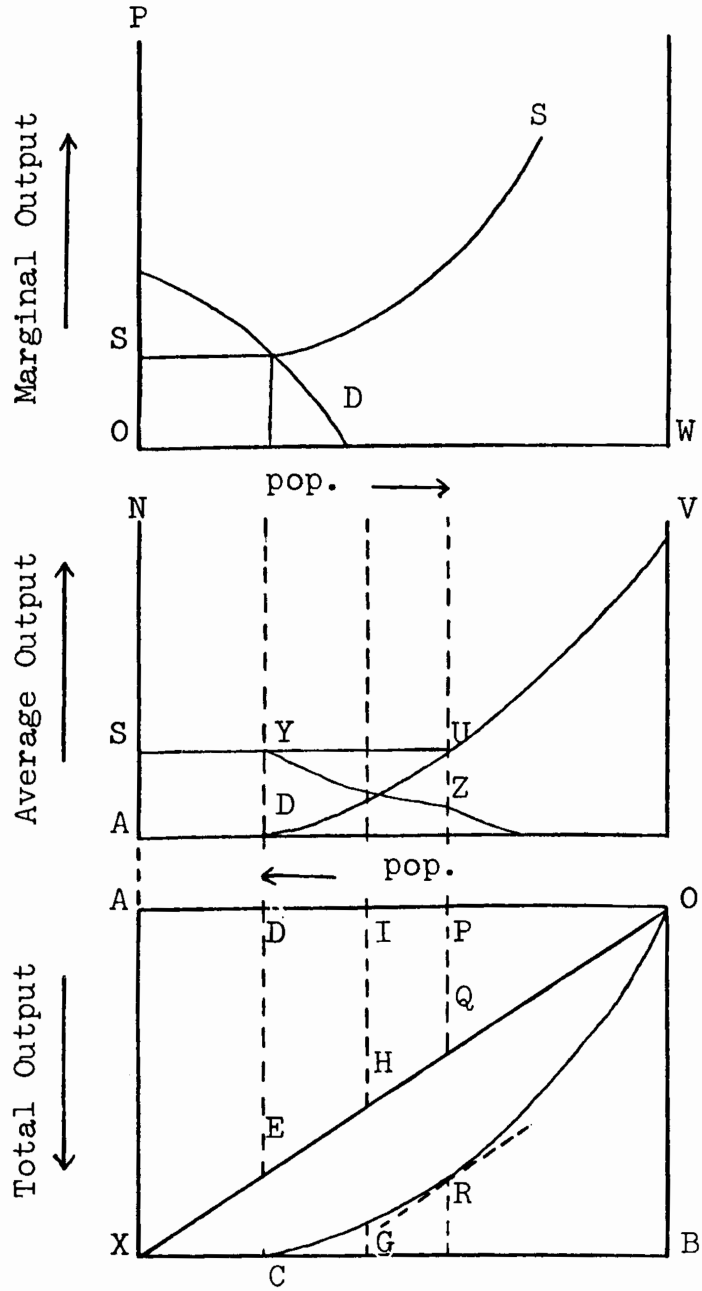
DIAGRAM 1:

THE DUAL SECTOR MODEL[1]

1.1 Industry

1.2 Agriculture

1.3 Agriculture



1. Source, J. C. H. Fei and G. Ranis, "A Theory of Economic Development", American Economic Review, Vol. LI, 1961, p. 535.

agricultural labor force falls to OD with no loss of output. An agricultural surplus appears since the remaining farmers are paid a fixed wage. The surplus is shown in Diagram 1.3 as the vertical difference between the total wage of consumption line, OQHEJX, and the output curve, ORGCFX. This surplus will be used, directly or indirectly, to feed the industrial workers, and the curve SYZO in Diagram 1.2 measures the agricultural surplus divided among these laborers. This surplus could be redistributed from the agricultural to the industrial sector; either by government taxation, or through the landlords, tribal chiefs, or peasant proprietors investing their rent directly in industrial enterprizes or buying the output of the modern sector. For the sake of simplicity:

> "...we can picture each allocated worker as carrying his own subsistence bundle with him."[1]

In phase 2 each migrating agricultural worker, since his marginal product is positive, causes total agricultural production to fall. Phase 2 is completed when the agricultural labor force has fallen to OP where the marginal product equals the institutional wage. Any further reduction in agricultural output causes wages in agriculture to rise; and in order to attract workers, the wages in industry will also rise. This is known as the commercialization point

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1. J. C. H. Fei and G. Ranis, 1961, Op. Cit., p. 538.

since both sectors can run on the capitalist principle of paying workers according to their marginal product.

> "When capital catches up with labor supply an economy enters upon the (third) phase of development. Classical economics ceases to apply; we are in the world of neo-classical economics, where all the factors of production are scarce, in the sense that their supply is inelastic. Wages are no longer constant as accumulation proceeds; the benefits of improved technology do not all accrue to profits; and the profit margin does not necessarily increase all the time..."[1]

The neo-classical model differs from the classical model in two important features. First, the marginal product of labor in agriculture is assumed to be positive at the initial phase, and second, the real wage is assumed to be variable at all stages of development. These assumptions do not alter the basic propositions which we are considering. One conclusion from both dual sector models remains abundantly clear; the pace of development is determined by the rate of capital accumulation in the advanced sector, the more rapidly investment occurs in manufacturing the more rapidly will total output grow. Investment in agriculture is not considered a relevant part of the development program. Schultz summarizes this doctrinal approach as follows:

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1. W. A. Lewis, Op. Cit., p. 26-27.

> "...the opportunity for growth from agriculture is among the least attractive of the sources of growth; agriculture can provide a substantial part of the capital that is required to mount industrialization in poor countries; it can provide an unlimited supply of labor for industry; it can even supply much labor at zero opportunity cost because a considerable part of the labor force in agriculture is redundant in the sense that its marginal productivity is zero."[1]

The dual sector analysis argues that the active constraint on the rate of industrialization is the supply of capital. Indeed, it has become almost axiomatic that less-developed countries suffer from a scarcity of capital. A few examples from the extensive literature on the subject will illustrate this point.

> "The labor surplus nature of such a dualistic economy is underlined by the fact that, given existing production conditions in the two sectors, labor is a non-scarce factor while capital is extremely scarce."[2]

One of the determinants of the Rostovian 'take-off' is that 'productive investment' must rise from 5% to 10% of output.[3] W. A. Lewis argues:

> "The central problem in the theory of economic development is to understand the process by which a community which was previously saving

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1. T. W. Schultz, Op. Cit., p. 8.
2. J. C. H. Fei and G. Ranis, 1964, Op. Cit., p. 3.
3. W. W. Rostow, The Stages of Economic Growth, Cambridge, 1967, Ch. 4.

> and investing 4 or 5 per cent of its national income or less, converts itself into an economy where voluntary saving is running at about 12 or 15 per cent of national income or more. This is the central problem because the central fact of economic development is rapid accumulation of capital."[1]

The emphasis on capital and the comparatively scant treatment accorded to labor by development theorists, has been due in part to the popularity and simplicity of applying Hicksian and Harrod-Domar types of growth models to economies. It is also due to the very nature of aggregate production functions. Traditionally, the factors of production are homogenized and divided into land, labor, capital, and technological change.[2] With land in fixed supply, and technological change difficult to quantify, observers concentrated on labor and capital. As Schultz cogently argues, the misconception of traditional agriculture led to the conclusion that there was a surplus of labor and thus to the belief that lack of capital was the constraint on development.[3]

The dual sector model, therefore, describes development as a process by which, through liberating capital from the agricultural sector, the economy not only maximizes output,

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1. W. A. Lewis, Op. Cit.
2. This is discussed in the survey article by R. C. O. Matthews and F. Hahn, reprinted in Surveys of Economic Theory, Volume II, St. Martins Press, New York, 1966.
3. T. W. Schultz, Op, Cit., Ch. 4.

but also moves steadily from a position of under or unemployment to one of full employment. Such a course has rarely been the experience of developing countries. The emergence of a manufacturing sector has often been accompanied by the creation of a significant number of unemployed people living in an urban environment. This phenomenon is of sufficient importance and frequency to merit a deeper consideration of the basic assumptions of these models.

The dual sector theorist might explain this phenomenon in one of two ways:

1. Market imperfections in the labor market in the modern sector. This might be in the form of restrictive practices by trade unions which raise the wage rate above the market equilibrium, or minimum wage legislation by the government. In either case, the result would be unemployment in the modern sector.

2. The premature 'commercialization' of the agricultural sector. If landowners start paying workers according to their marginal product before phase 2 is completed, that is, while there is still more than OP workers in the agricultural sector in Diagram 1.3, then those workers who are offered less than subsistence might migrate towards the city to try their luck rather than die of starvation on a capitalistic farm.

An economy with traditional agriculture, no minimum wage legislation, and urban unemployed, would be totally inexplicable within the classical dual sector framework. However, even with these 'market impurities' present, certain other phenomena would prove hard to explain. For example:

1. The existence of many job vacancies for skilled workers in the midst of unemployment.

2. The expensive, and often subsidized, importation of skilled foreign labor into an underdeveloped country suffering from unemployment.

The frequency with which this type of behavior is observed in the labor markets of underdeveloped countries provide the intuitive reasons for formulating an alternative theoretical model. There seems to be two alternative approaches.

The first is to explain unemployment in terms of the substitution of capital for labor. Given the generally accepted 'abundancy' of labor, further assumptions have to be made. One might, for example, assume capital-using technological change, or an elasticity of substitution between capital and labor of less than unity. The most usual explanation offered for the adoption of capital intensive techniques is that it is a response to a shortage of skilled labor. Thus Baer and Herve argue:

> "It is clear that the industrial push is in the direction of adopting modern techniques of a

> labor saving type both in new industries and in the modernization of older industries. Does this trend fly in the face of rational use of the most abundant factor of production? The dilemma that most developing countries seem to face is an abundant unskilled labor supply, on the one hand, and, on the other hand, the fact that older, more labor-intensive techniques of production are of an inefficient nature, i.e. producing a low return on capital invested in them."[1]

Hirschman states that the shortage of managerial and skilled personnel implies that development should be "machine paced" rather than "operator paced".[2]

Both of these statements implicitly assume two things. First, that the labor force is not one homogeneous 'input' which can easily be manipulated between sectors, but is stratified into skill divisions; and second, that the elasticity of substitution between these skill divisions is less than one. We shall focus on the importance of this latter assumption, and on the ability of the dual sector model either to explain the course of Libyan economic development or to arrive at the optimum policy conclusions.

The importance of education and skill attainment in economic growth has been stressed before. Denison attempted to include changes in the average education level within

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1. W. Baer and M. E. Herve, "Employment and Industrialization in Developing Countries", Quarterly Journal of Economics, Vol. LXXX, 1966, p. 26.
2. A. O. Hirschman, The Strategy of Economic Development, Yale U.P., New Haven, 1958, p. 145.

the structure of the Cobb-Douglas function.[1] However, such an approach is not useful in this case, since we are concerned with the allocation of labor between sectors and with the supplies of specific skills. Bruno has shown that, under certain conditions, skilled labor may have a high shadow price in the development of the Israeli economy.[2]

It is interesting to note that in those economies where the supply of labor is the active constraint on growth, that the traditional 'manpower' planning approach to education spending is no longer applicable since one cannot derive a meaningful optimum growth rate for which to plan. Instead, if an input-output planning model is used, education levels will have to be included in the matrix as activities.

The assumption that the elasticity of substitution between labor skills is zero has important policy implications. In the following analysis it will also be assumed that the relationship between the quantity of input and the quantity of output is unchanged; that is, there are

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1. E. F. Denison, The Sources of Economic Growth in the United States and the Alternatives Before Us, Supplementary Paper No. 13, New York, Committee on Economic Development, 1962.

2. M. Bruno, "A Programming Model for Israel", in I. Adelman and E. Thorbecke, eds., The Theory and Design of Economic Development, Johns Hopkins Press, Baltimore, 1966.

fixed 'input coefficients'. These two assumptions allow a potential conflict between the two policy goals of full employment and output maximization, as shall be explained below. This difficulty in arriving at investment decisions was isolated by Galenson and Liebenstien.

> "One can easily visualize situations in which the maximum labor absorption criterion would not maximize the addition to total output."[1]

It will be shown that, in the case of Libya, the attainment of both these goals would require investment in the agricultural sector. A conclusion which is contrary to the policy recommendations offered by dual sector theorists to reach the same goals.

The way in which fixed input coefficients can create unemployment can be illustrated with a simple example. Assume that 'labor' is the only input, and that it is divided into two classes, skilled and unskilled. In the modern sector, a certain quantity of output requires 10 skilled laborers and 40 unskilled laborers; while in the traditional sector, the same value of output would require 90 unskilled laborers and 10 skilled laborers. The average product of 'labor' in the modern sector is twice the

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1. W. Galenson and H. Liebenstein, "Investment Criteria, Productivity and Economic Development", Quarterly Journal of Economics, Vol. LXIX, 1955, p. 348.

average product of labor in the traditional sector, according to the homogeneous dual sector meaning. If the government wishes to produce an extra unit of output from the modern sector, then the number of laborers must be increased by 10 skilled and 40 unskilled from the traditional sector. However, since one unit of output requires 10 skilled and 90 unskilled, the removal of all 10 skilled and 40 of the unskilled will leave the remaining 50 unskilled laborers unemployed; assuming that there are no reserves of skilled labor in this sector. In addition, although the average product of the 50 laborers was doubled by moving to the modern sector, total output in this example remained unaltered.

It is important to show that a model can not only logically explain the phenomena for which it was formulated, but also that it can provide a means of explaining actual cases, or at least it is not inconsistent with empirical evidence. It was to provide a test for the hypothesis outlined above that the example of Libya was chosen.

Libya is a sparsely populated, highly underdeveloped country. The agricultural sector has not be 'commercialized' and has a very low per capita value added; about 2/3 of the per capita value added in the manufacturing sector. The massive oil finds in the early sixties have supplied the government with large amounts of capital. This foreign capital has removed, for growth rates below 10%, the most frequently examined constraints on economic development, the supply of capital and the balance of payments, as is shown in Sections 2 and 3. Yet, Libya has experienced a relatively slow rate of growth of real output in the non-petroleum sectors as can be seen in Table VII; and also a fairly high rate of unemployment (between 8% and 10%) and underemployment (21% of the labor force; 82,531 workers are in the service industry and a further 47,257 workers are roughly catalogued as others) as can be seen in Table IX. Concurrently, aliens constitute 22%, 12%, and 15% of the three highest skill categories respectively, while only comprising 4.5% of the entire labor force, as can be seen in Table VIIIA.

Therefore, a strong a priori possibility exists that the supply of skilled labor may be an active constraint on Libyan economic development. Higgins summarizes this in his study of Libya:

> "The implications of the Lewis model is that if capital were as unlimited as labor, growth would go merrily along without let or hinderance. Few countries seemed closer to fulfilling the conditions of his model than Libya before the discovery of oil; but once capital was available in truly large quantities it immediately became apparent that labor far from being unlimited, was the major bottleneck for growth."[1]

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1. B. Higgins and J. Royer, "Economic Development with Unlimited Supplies of Capital: The Libyan Case", The Libyan Economic and Business Review, Vol. III, 1967, p. 29.

In the following Sections the maximum possible growth rate allowed by the supplies of imports and capital are calculated to determine whether these factors, often used to explain the slow growth rate in underdeveloped countries, account for the relatively stagnant growth rate (0.1%) of the manufacturing sector.

The supply and demand functions of these inputs are assumed to be linear. This was done partly for lack of data and partly for ease of calculation. In the case of the import constraint, a high proportion of raw materials and machinery are imported, 80% and 95% respectively; as can be seen in Table VA. Assuming this fraction constant may lead to an overestimate of import requirements, which implies a lower rate of growth than is actually possible, a bias against the object of the analysis which is to show that the low rate of growth in Libya cannot be explained through balance of payments considerations.

Similarly the estimation of the potential supplies of capital probably underestimates the actual supply, since private savings are ignored and the government's revenue from the oil exports are assumed to be a constant fraction of the oil output. However, it now seems possible that the royalty rate will be raised, in view of the political aims of the revolutionary government.

A general model of the Libyan economy within which the supply and demand functions of the inputs considered in the following Sections are assumed is presented in Appendix A. This includes the objective function and specific constraints within which policy conclusions would be arrived at. Such a model allows the inclusion of those conditions specific to Libyan development and relevant to the problem under examination.

In Section 2, the first of the possible constraints, the ability to import, is examined.

SECTION 2:

THE IMPORT CONSTRAINT 1964-74

In view of the absence of data, it is necessary to make certain assumptions. The first is that the value of oil output is given from 1964-74. This implies the following: (a) oil output will not be affected by any action taken by the Libyan government; and (b) oil output will not be seriously affected by any discoveries elsewhere in the world.

There are grounds for making both of these implicit assumptions. Royalties were raised considerably during 1965 with no downward effect on the output of petroleum. Political action by the government, now, would be unlikely to affect output before 1974. As Libyan oil is relatively clean, large oil discoveries in North America are unlikely to affect the price of Libyan oil as much as the price of other, less clean oils; especially as pollution becomes an increasingly important issue in those countries which import and refine crude oil.

The second assumption it is necessary to make is that there is a constant relationship between oil output and oil exports. As Libyan domestic consumption of oil was less than 2% of output in 1967, even large changes in domestic consumption will not significantly affect the functional relationship between oil exports and oil output; inspite of the relatively rapid rate of expansion in the transportation sector.[1]

The third assumption it is necessary to make is that exports are only of oil. This was only 99% true in 1968, but the non-oil exports are growing at a much slower rate than oil exports, and thus, the error falls over the time period.[2] With these three assumptions, the value of Libyan exports in 1964-74 can be computed; see Diagram 1 and Table 1. This is based on the following function:

$$E_t = x_0 \, Xo_t \qquad (1)$$

where E_t is the value of oil exports in year t, and Xo_t is the value of oil output in year t, and $x_0 = 0.99$.

To calculate the rate of increase of GNP that would require a level of imports equal to this level of exports, it is necessary to derive a functional relationship between the rate of growth of GNP and the level of imports.

Import requirements are divided up into two components, raw materials (R_t) and capital machinery (Mi_t). The following functions were assumed:

$$R_t = x_1 \, X_t \qquad (2)$$

$$Mi_t = x_2 \, (X_{t+1} - X_t) + dK_t \qquad (3)$$

where X_t is GNP in year t, K_t is the value of the capital

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1. Bank of Libya - Economic Bulletin, November - December 1968, no. 6, p. 144.
2. Ibid., Table 23.

stock in year t, and d is the rate of depreciation. Tables VA and VB show the estimation of the coefficients x_1 and x_2; $x_1 = 0.0625$ and $x_2 = 0.50$ approximately. Both of these were assumed fixed over the time period.

To determine the optimum level of imports of consumption goods, it was assumed that the fraction of total imports which consisted of consumption goods in 1964-66 represented the optimum. The function:

$$Mi_t + R_t = x_3 M_t \qquad (4)$$

where M_t is the total value of all imports, was solved for x_3, as can be seen in Table VB; $x_3 \approx 0.60$.

It was assumed that the relationship between exports and income retained abroad was linear, and was described by the following function:

$$En_t = 0.99 \; Xo_t \; (1 - x_4) \qquad (5)$$

where En_t is the value of exports <u>net</u> of income retained abroad; $x_4 \approx 0.25$.

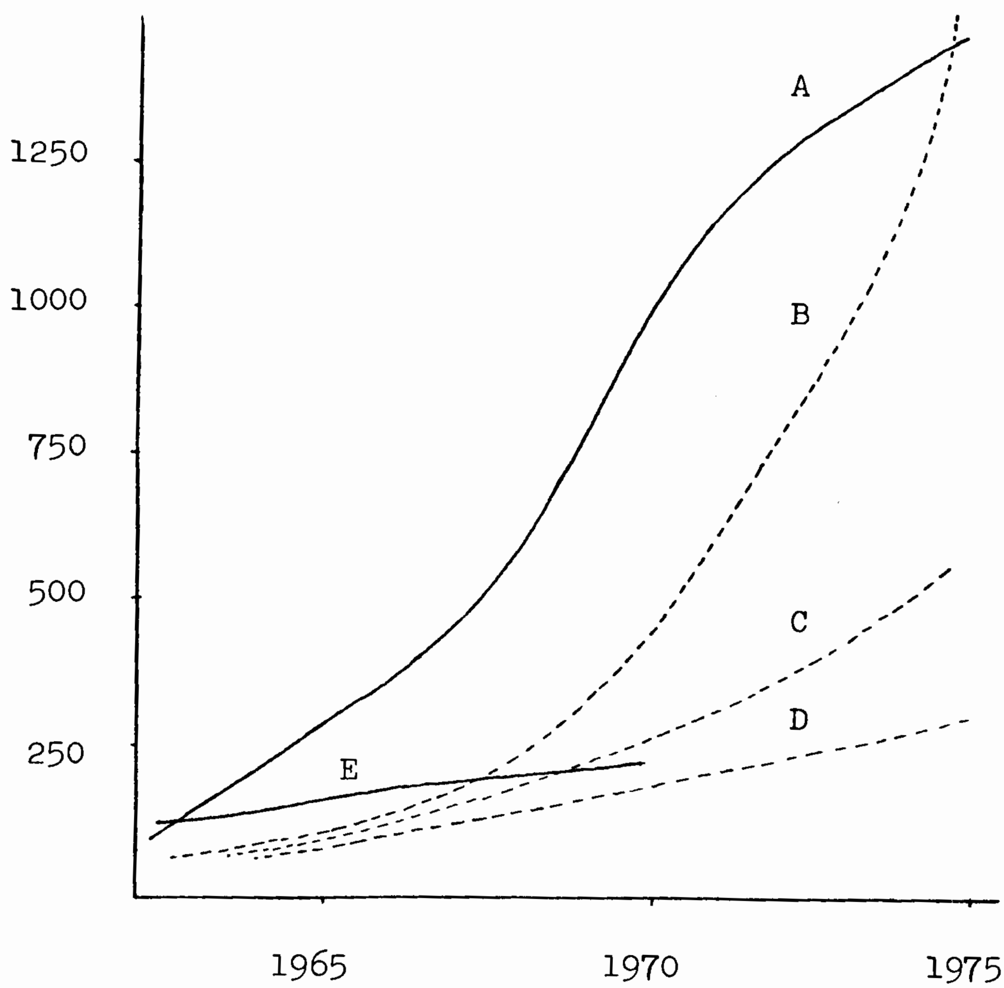
Therefore there will be a constraint on growth when

$$x_1 Xt + x_2(X_{t+1} - X_t) + dK_t > x_3[x_0 Xo_t(1 - x_4)] \qquad (6)$$

Table VI shows that even allowing a 5% per annum rise in the price of capital machinery, there is no constraint on a 20% per annum rate of growth of GNP. Diagram 2 plots the required intermediate imports for growth rates of 20%, 25%, and 33% against the value of exports.

DIAGRAM 2:

IMPORT REQUIREMENTS



A. Actual exports.

B. Imports required for 33% per annum growth rate.

C. Imports required for 25% per annum growth rate.

D. Imports required for 20% per annum growth rate.

E. Actual imports.

It is therefore assumed that balance of payments considerations do not impose an active constraint below a 20% per annum growth rate. In Section 3, we shall examine the constraint imposed by the availability of capital.

SECTION 3:

THE SAVINGS OR CAPITAL CONSTRAINT 1964-74

Identification of the savings function in Libya is difficult, due in part to the lack of adequate statistics. Government oil revenues are a function of oil exports and constitute approximately 90% of total government receipts. They are assumed to be determined by the following function:

$$Gr_t = x_5 x_0 Xo_t \qquad (7)$$

where Gr_t is government revenue in year t, and $x_5 = 0.50$.[1]

The proportion of government revenue diverted to development needs between 1964 and 1967 was approximately half; that is, revenue not spent on current expenditure. The government has an express policy of setting aside 70% of its revenues for development purposes. Failure to achieve this goal so far has been principally due to the high rate of inflation, increased defense costs, and a sharp rise in the amount of aid given to other Arab nations following the 1967 war.[2]

However, only 33% of development expenditure is spent on direct investment, the rest being spent on special

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1. Quarterly Review of Economics, Economics Intelligence Unit, no. 1, p. 12.
2. Ibid., no. 1, p. 12; no. 2, p. 9.

projects, social overhead capital, income transfer payments, and subsidies to the agricultural sector. Thus, the functional relationship between government revenue and government savings was assume to be:

$$Gs_t = x_6 Gr_t \tag{8}$$

where Gs_t is government savings in year t, and x_6 is 0.166. In view of the very high rate of growth of oil output, and thus government development funds, the government's marginal propensity to save may be increasing, which would mean that x_6 may lead to an underestimate of government resources.

The value of x_6 was estimated assuming a zero quantity of private savings. Although this is approximately true for personal savings, Bank of Libya statements indicate a certain amount of corporate savings. This again leads to a downward bias in the estimation of the availability of capital, although part of the corporate savings may come from government grants and subsidies. In view of the lack of adequate data, equation (8) presents the closest possible approximation of the supply of capital.

Table VC shows the estimated value of government savings, and thus investment in non-petroleum sectors. Investment in the petroleum sector was assumed to be determined exogeneously. There were several reasons for this assumption. First, the quantity of output changes rapidly with only marginal changes in the quantity of capital employed because of the nature of the productive process itself. Second, we have assumed that the quantity of output from this sector is determined exogeneously. Third, investment is financed largely from outside Libya, and was largely carried out before 1964.[1]

The average and marginal capital/output ratios are calculated in Table IV. These figures underestimate these ratios since rented capital was not included in the figures for the value of the capital stocks. This was estimated to be worth an additional £L13,000,000, which raises the aggregate ratio to 175:100.[2] The maximum possible growth rate of GNP given this supply of capital is calculated in Table VC. In Section 4, it is assumed that at any growth rate below the minimum of the two rates analized in Sections 2 and 3, capital and imports are 'free' goods.

1. Bank of Libya - Economic Bulletin, November - December 1968, no. 6, p. 23.

2. Based on an estimate in Estimates of GNP of Libya 1964-66, Ministry of Economy and Trade, Kingdom of Libya, 1967.

SECTION 4:

THE LABOR SKILL CONSTRAINT 1964-74

The purpose of this section is to determine the growth rates of the labor inputs and the maximum possible growth rate of total output given these growth rates.

The projected outputs of the education streams from 1964-74, computed by A. N. K. Nair, themselves based on current capacity and government planning, were taken as the basic data for this analysis.[1] This can be seen in Tables IIB - IIE. The general function for the calculation of the total supply of labor of skill i, L_i, in year t was assumed to be:

$$L_{it} = X_{it} + 1/t^*_{i+1} \cdot Y_{i+1} \cdot X_{(i+1)t} + L_{it-1} \qquad (9)$$
$$- d\, L_{it-1} - (1 + Y_{i+t}) \cdot X_{(i+1)(t+t_{i+1})} - x_i \cdot X_{it}$$

where X_{it} is the number graduating in level i in year t; t^*_{i+1} is the average time taken to complete the level of education immediately above i (this allows the number dropping out to be spread over the actual time taken to complete the course rather than the official duration of

1. A. N. K. Nair, Libya's Manpower Resources and Educational and Training Needs, Department of Economy and Trade, March 1967, Unpublished.

the course, which gives a more accurate measure of the number dropping out from the level above); Y_{i+1} is the number of failures in level i+1 expressed as a percentage of the total graduates; d is the death and retirement rate, and x_1 is the fraction of graduates of level i who do not enter the labor force.[1] This was most of the female graduates at the primary level. Tables IIA - IIE shows the results of these calculations.

There is no data for education levels of the labor force by sector; there is, however, more disaggregated data on skill levels, as can be seen in Table VIIIA. In order to convert the supplies of educated workers into supplies of labor skills, the following functional relationships were assumed. This was done by comparing Table VIIIA with Table IIA.

$$\text{(a)} \quad N_{0t} = x_0(L_{2t} + L_{3t} + L_{4t}) \qquad (10)$$

$$\text{(b)} \quad N_{1t} = x_1(L_{2t} + L_{3t} + L_{4t})$$

$$\text{(c)} \quad N_{2t} = x_2(L_{1t} + L_{2t} + L_{3t} + L_{4t})$$

where N_{0t} is the supply of workers in skill division (0) in

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1. This was computed by comparison with the U.A.R., Tunisia, and Morocco for which figures were available. It is lower than the average death rate since the average age of the population with each level of education was below the average age of the whole population under consideration.

year t and L_{2t} is the supply of labor with intermediate education in year t, $x_{(0)}$ was calculated to be 0.53, $x_1 = 0.24$, $x_2 = 0.33$.[1] The basis for these assumptions was that the total numbers of workers in skill divisions (0) - (2) approximately equalled the total number of people who had graduated from primary school or better. Workers in skill divisions (1) and (0) were assumed to require at least an intermediate school certificate. $x_0 - x_2$ were assumed fixed, which is probably unrealistic, but in the absence of any trend statistics it was the only possible assumption. For ease of calculation, the supply of workers to skill division (3) - (y) was assumed to be the residual. It was calculated as the total labor force $\bar{L}_t(1+p)^t$ after the supplies of $N_{(0)} - N_{(2)}$ have been subtracted; $\bar{L}$ is the total labor force in the base year and p is the rate of labor force growth.[2]

Based on these functions and the calculations in Table IIA, the rate of growth of each labor input (skill - supply) was computed. See Table X.[3]

If one assumes fixed input coefficients and zero

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1. See Table VIIIA.

2. The labor force was calculated to grow at 2.8%, 0.2% less than the population since the number in school, during this period is rising rapidly.

3. These calculations assume a constant proportion of government expenditure spent on education and thus the capital constraint will not become operative through the reallocation of resources.

substitution between inputs, then the maximum growth rate of gross value added would be the rate of the slowest growing skill supply. Even allowing an aggregate productivity increase each year of 3% or 4% with input coefficients falling by 3% or 4% per annum, the maximum possible growth would be 5.5% - 6.5% with no extra imported labor.

With substitution downwards between labor inputs, the maximum growth rate of inputs can be calculated by solving the following functions for the unknowns N_{0t}, N_{1t}, N_{2t}:

$$\text{(a)} \quad N_{0t} + N_{1t} + N_{2t} + N_{(3-Y)t} = L_t \qquad (11)$$

$$\text{(b)} \quad N_{0t}/N_{0(t-1)} = N_{1t}/N_{1(t-1)}$$

$$\text{(c)} \quad N_{1t}/N_{1(t-1)} = N_{2t}/N_{2(t-1)}$$

In this case, the maximum growth rate of inputs per annum is approximately 3%.

Although there are inadequate statistics on relative wage movements, the implications of these calculations are, intuitively, in disagreement with the actual Libyan experience during 1964-66. Table X indicates that the unskilled division is the slowest growing and therefore the constraining input. In fact, there has been unemployment amoung skill divisions (3) - (Y), and considerable difficulty experienced in filling vacancies in divisions (0), (1), and (2). This is reflected in the high percentage of aliens in these divisions, as can be seen in Table VIIIA.[1]

It therefore seems fair to assume that labor skill input coefficients have been changing relative to each other. The maximum rate of growth of gross value added, based on various assumptions on changing skill input coefficients, will now be determined.

The oil sector is omitted from the analysis for four reasons. First, the output of the oil industry is assumed determined exogeneously. Second, the industry predicts no appreciable increase in labor requirements for 1966-74 and the input coefficients are thus changing rapidly and irregularly. Third, the oil sector imploys only 2% of the labor force. Fourth, the Libyan government's concern is to increase the growth rate of non-petroleum sectors.

For the purpose of analizing relative changing input coefficients, Table VIIIB was constructed, showing the numbers of workers of different skill levels per 1,000 workers employed. There is no data for any other period than 1964 in Libya, and thus no way of measuring rates of change. The comparison of absolute numbers between countries is not reliable because of the great difference in classification and the differences between industrial

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1. 10% of the total labor force is unemployed and the majority of these are unskilled. Source, General Population Census, 1964. Ministry of Economy and Trade - Kingdom of Libya, 1967.

structures and the levels of development. The only data available of changing skill mixture per 1,000 workers is for developed western countries between 1951 and 1961; i.e. England and Wales, Sweden and Finland, the United States and Canada.[1] The rise in numbers of the equivalents of skill divisions (0), (1), and (2) per 1,000 employed over the ten year period was 30%.[2]

Based on this assumption, the required mixture of skills for 1974 was constructed, as can be seen in Table VIIIB, line b). Applying the linear functions 11 (a) - (c) to the 1974 skill supplies gives the actual skill mix in 1974, as can be seen in Table VIIIB, line a).

Comparison of lines a) and b) in Table VIIIB shows that it is the supplies of skills (0) and (2), not the supply of skills (3) - (Y) which impose the active constraint. With zero substitution between skills, the maximum possible growth rate will be the growth rate of division (2) labor, about 3.5% per annum over the ten year period, net of aggregate productivity increases. This would create considerable unemployment among the other sectors, (18% of the

1. M. A. Morowitz, M. Zymelman, I. L. Hernstadt, Manpower Requirements for Planning, Department of Economics, Northeastern University, Appendix A, Unpublished.

2. This does not conflict with some rules of thumb relating annual rates of increase in required numbers of high level manpower, derived by R. Harbison in "Lectures on Labor Force and its Employment", International Institute for Labor Studies, Geneva, 1963, pp. 40-41.

total labor force). With substitution downwards, that is with unemployed of a high labor skill able to work in jobs of a lower skill classification, the growth rate is 0.2% higher and the unemployment rate is 2% less.[1]

This analysis is highly aggregative and assumes that the sectoral <u>structure</u> of the Libyan economy is similar to those used for comparison. To avoid this, the average rate of increase in skill mixture per 1,000 is calculated by sector, the aggregate average skill needs per 1,000 is calculated for Libya, assuming that each sector's share of the labor force remains constant, the result is shown in line c) of Table VIIIB.

The coefficients thus calculated are lower than in line b) because Libya has a much higher proportion of the labor force in agriculture, and at a much lower skill level, than the countries used for comparison. The maximum growth rate is now 4.5% per annum and the unemployment rate 8%, in 1974.

Thus, even with these assumptions, the growth rate is considerably below the growth rate possible within the previously considered constraints. This indicates that the

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1. All of these calculations are based on the assumption that there is no net increase in the number of foreign labor. If the proportion of foreign labor remains constant, then the average per annum growth rate is 4.1% and the unemployment rate in 1974 is 11%.

original assumptions of a non-homogeneous labor force and fixed input coefficients may be able to explain the Libyan experience.

It is possible then that the supply of skilled labor may impose an active constraint on the rate of growth in Libya. A more detailed analysis is not possible because of the lack of any disaggregated data. In Section 5, the optimum distribution of the labor force between sectors is calculated since this provides a test of the validity of the traditional policy recommendation of concentration on the modern sector.

SECTION 5:

THE OPTIMUM DISTRIBUTION OF LABOR

In the previous Section it was shown that the assumptions of a non-homogeneous labor force and fixed input coefficients are not inconsistent with the Libyan experience. How does this affect the policy decisions? Is it still necessary to invest as much as possible in the modern manufacturing sector to maximize output? To answer this, the optimum distribution of labor between sectors will be calculated. In a fixed coefficient model, where the shadow price of capital implied by analysis in the previous sectors is zero, the optimum distribution of labor will also determine the optimum distribution of capital.

An input output table was constructed for the agricultural (1), manufacturing (2), construction (3), and services (4) sectors, using the four labor skills identified and calculated in Section 4 as the only inputs. To compute the input coefficients, the number of workers of each skill per 1,000 in each sector was divided by the value added per 1,000 workers.[1]

To estimate the available skilled workers, it was

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1. These were, in thousands of £L, 160, 359, 451, and 400 in sectors 1 to 4 respectively.

necessary to subtract from the total supplies the number of workers of each skill used in those sectors not in the input output table. This was done by assuming that each of these sectors continued at the rate it grew from 1964-68. Their skill mix was estimated and their total labor demands were subtracted from the total skill supplies (calculated in Tables IIA - IIE).

The problem, then, is to maximize total output, given that a certain number of people of each skill level, in fixed proportions, are necessary to produce a certain value of output. Output is constrained by the available supplies of the inputs. The objective is to maximize the total value of output.

Algebraically the problem can be formulated as follows.

$$\sum_{i=1-4} X_i$$

where

$$X_1 = 0.0000253L_{11} + 0.0000190L_{21} + 0.0000759L_{31} + 0.006209L_{41}$$
$$X_2 = 0.0000529L_{12} + 0.0000278L_{22} + 0.0000474L_{32} + 0.001504L_{42}$$
$$X_3 = 0.0001478L_{13} + 0.0000850L_{23} + 0.0002218L_{33} + 0.001394L_{43}$$
$$X_4 = 0.0001000L_{14} + 0.0000400L_{24} + 0.0004000L_{34} + 0.001960L_{44}$$

where L_{ij} is the number of workers of skill division i in sector j.

This is subject to the constraints that the total number of workers of each skill employed by all the sectors should not exceed the supply.

$$X_1(0.0000253)+X_2(0.0000529)+X_3(0.0001478)+X_4(0.0001) \leq 13{,}000$$

$$X_1(0.0000190)+X_2(0.0000278)+X_3(0.0000850)+X_4(0.00004) \leq 3{,}000$$

$$X_1(0.0000759)+X_2(0.0000474)+X_3(0.0002218)+X_4(0.0004) \leq 12{,}500$$

$$X_1(0.0062090)+X_2(0.0015040)+X_3(0.0013940)+X_4(0.00196) \leq 384{,}000$$

Geometrically, the problem is easier to understand. Unfortunately, with four constraints and four sectors, the problem can only accurately be represented in four dimensions. However, Diagrams 3 and 4 show a simplified version of the analysis.

In Diagram 3, only two sectors and two inputs are shown. Skilled labor is shown on the horizontal axis and unskilled labor on the vertical axis. The rays OA and OB represent the productivity of the two inputs when used in the production of agriculture and manufacturing respectively. The quantity produced can be calculated by measuring along the rays. These rays pass through the right angle of the L-shaped isoquants which fixed input coefficients imply. As should be expected, the OA ray uses relatively more unskilled labor, and the OB ray uses relatively more skilled labor. The input supply constraints are represented by the horizontal line passing through L_0' and by the vertical line passing through L_1'. The area OA'EM' represents attainable output

DIAGRAM 3:

FIXED COEFFICIENT OUTPUT MAXIMIZATION A

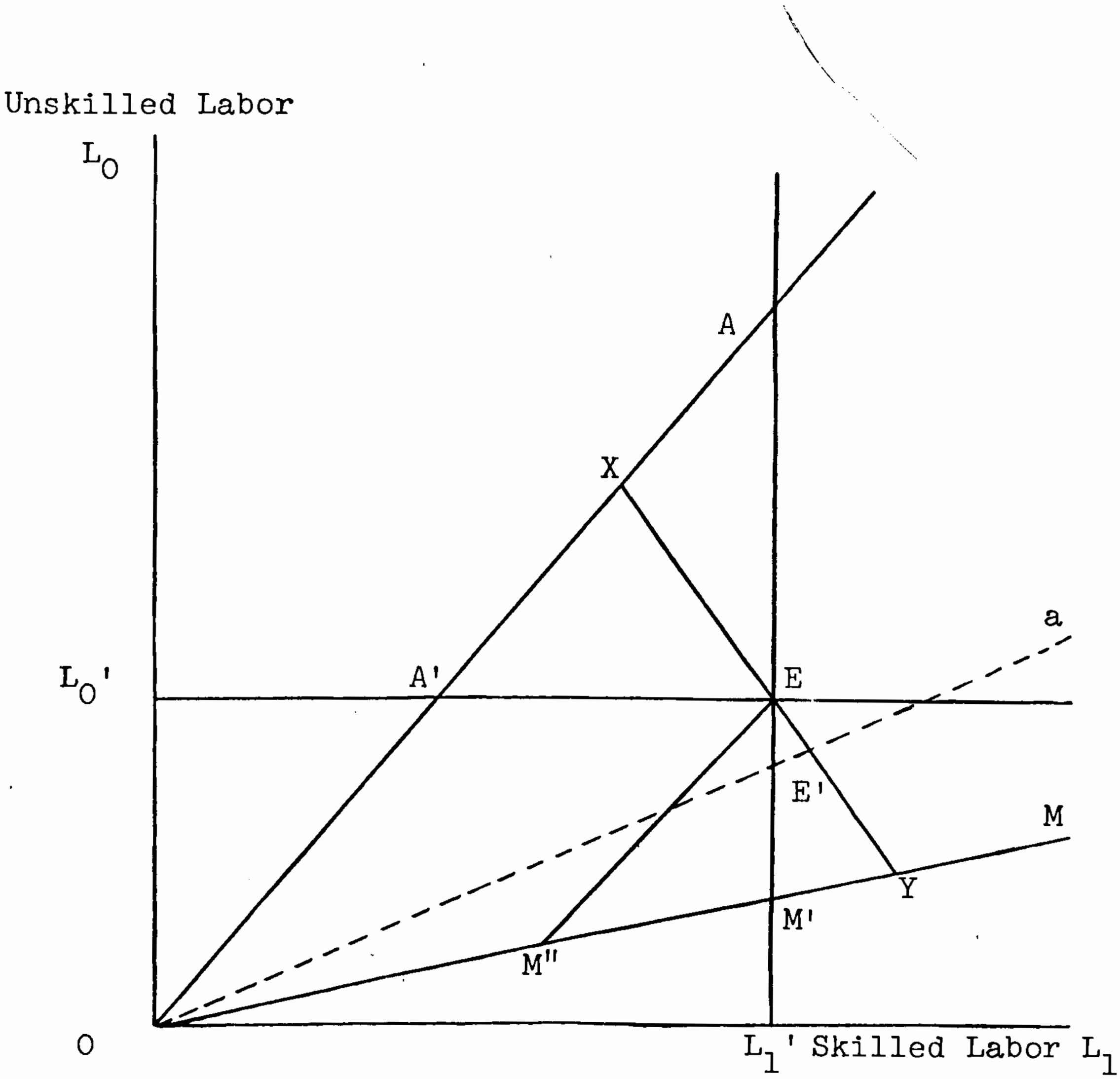
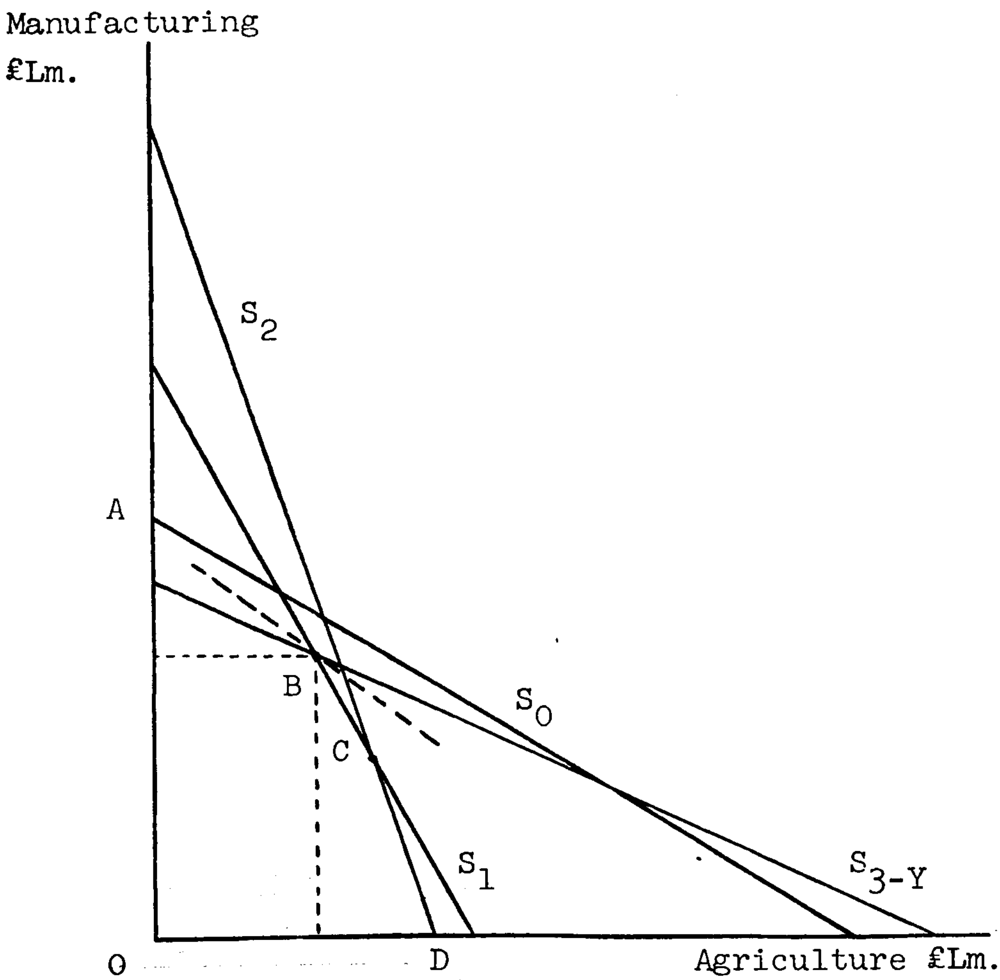


DIAGRAM 4:

FIXED COEFFICIENT OUTPUT MAXIMIZATION B



and input utilization points. E will tend to be the output maximization point. This can be seen if an isoproduct curve is drawn between a point on each of the rays (XY). If this slopes downward from left to right, then point E will represent the point of contact between the area of possible output and the highest possible isoquant.

The relative amounts of agricultural and manufacturing output were calculated by constructing a line EM″ parallel to the ray OA. The length of EM″ measures the value of agricultural output, and the length OM″ measures the value of manufacturing output in the optimum solution. As the diagram is drawn, E is between OA and OM. This is not necessary; if OA represents the 'input mix' for agricultural production, and if the isoquant were at the same angle (XY), then the optimum solution would be complete specialization in the agricultural sector, and EE′ unskilled workers would be unemployed. It should be noticed that as the skilled labor constraint is relaxed, the optimum solution, ceteris paribus, will involve a larger manufacturing output, the sector with the higher skill requirement, and lower agricultural output.

Diagram 4 shows the problem in a different form. Although there are still only two sectors considered, all four labor skill constraints are represented. The constraints are constructed by calculating the maximum possible output of each sector given the supply of the labor skills (S_{ij}/a_{ij}).

These values are marked on the axes and connected by a straight line. All points on, or within, this line are feasible output combinations given that particular skill constraint. When all four lines are drawn, the feasible output combinations must lie simultaneously within all four lines; this being the shaded area in the diagram. The curve ABCD represents the production possibility frontier.

Since output on both axes is measured in the same units (£L), the optimum solution, i.e. the point where the total value of output is maximized, can be calculated by drawing a field of lines sloping downward from left to right at an angle of 45°. These represent isoquant curves (measured in £L rather than physical units of output) or more understandibly, price lines in traditional production possibility analysis. Corner B is the point of contact between the production possibility frontier and the isoquant the furthest away from the origin, and therefore the maximum possible output. Such a corner will usually be the point of intersection of only two of the constraint lines. Thus, the other two constraints (in the diagram and in the actual solution the supply of labor of skill divisions (0) and (2)) are 'not active' and thus some of the labor in these divisions is unemployed.

The shadow price of the fully employed labor skill divisions, or active constraints, can be seen as the amount by which the value of total output would rise if the constraint line were to shift outwards by the amount of one extra worker.

The basis of the input output analysis is, therefore, to determine the allocation of labor between sectors which will maximize total output. The following results were obtained.

X_1 - Agriculture - £L62,789,800

X_2 - Manufacturing - £L78,668,800

X_3 - Construction - £L0

X_4 - Services - £L0

Skill Division (0) - 5,244 employed, 7,7756 unemployed.
Skill Division (1) - 3,000 employed, 0 unemployed.
Skill Division (2) - 6,976 employed, 5,523 unemployed.
Skill Division (3) - 384,000 employed, 0 unemployed.

The shadow prices of the two fully emplyed inputs were:

Skill Division (1) - £L3,267
Skill Division (3) - £L61

The maximization procedure was repeated with a 5% and a 10% increase in the value added per 1,000 in the manufacturing sector, and there was no appreciable (less than 3%) increase in the number of workers employed in that sector. Although, the 'shadow price' of skill division (1) rose by almost 5% and 10% respectively. There was already a bias in favor of the manufacturing sector since the value added figure was calculated as an extrapolation from data for those firms which supplied census data and which tended to be larger companies with a correspondingly larger value added per 1,000 coefficient. The figure for agriculture, on the other hand, was calculated by the government, assuming that those employed in agriculture formed a residual. The agricultural labor force, therefore, includes both some unemployed and some unemployable.

Certain obvious shortcomings contained in these results must be noted. First, it is clear that output in the construction and services sectors cannot be zero in an optimum solution. These figures were a result of the lack of intersectoral coefficients which could not be included because of insufficient data. Nevertheless, this result is an example of the logical contention of this thesis. These two sectors exhibited the highest per capita value added, therefore showing that this figure cannot alone be used as the criterion for making investment decisions and demonstrating the potential importance of labor skill requirements. Although the absolute value added figure is therefore not particularly interesting, the relationship between this figure and the current output shows that, in the optimum solution, agricultural output would be quadrupled and manufacturing output increased sixfold. That is, the agricultural sector should be expanded at two thirds the rate of the manufacturing sector. This result, it should be stressed, was obtained with output maximization as the solitary goal; introduction of employment considerations would indicate an even stronger emphasis on agriculture. It is interesting to note that this solution also gives a very low rate of unemployment; only 13,279 workers unemployed, compared with around 40,000 currently.

Second, the optimum result indicates that nearly 8,000 of the highest skill category are unemployed. This is clearly unreasonable since workers in this category are more than qualified to perform jobs in the lower, fully employed category. To avoid this difficulty, the optimization problem was repeated with the two upper skill levels combined, the input coefficients and the skill supplies added, and the service sector omitted; since there may be no optimum solution if the number of constraints is less than the number of activities. This gave the following results:

X_1 - Agriculture - £L413,864,060

X_2 - Manufacturing - £L149,960,106

X_3 - Construction - £L0

Skill Division (0) and (1) - 16,000 employed, 0 unemployed.

Skill Division (2) - 10,213 employed, 2,287 unemployed.

Skill Division (3) - 384,000 employed, 0 unemployed.

This indicates a trebling of agricultural output and a twelve fold increase in manufacturing output in the optimum allocation of labor.

Although this is considerably different from the previous result, it still demonstrates that investment in agriculture is justified not merely to stimulate the agricultural surplus to allow the rate of industrialization to increase (as in the traditional capital-shortage model), but also as the only way to maximize output in an economy faced with a shortage of the necessary skills. Instead of development being paced by the availability of capital, it may indeed be paced by the supplies of skilled labor. Given this constraint, emphasis on industrialization might lead to unemployment and underemployment.

SECTION 6:

CONCLUSIONS

The quality of the data prevents any positive conclusions from being asserted with specific reference to Libya. The purpose of this section is to explore some of the possible implications for development theory and policy.

If the assumptions of fixed input coefficients and a non-homogeneous labor supply are accepted, then the creation of unemployment as part of the development process can logically be explained. It is also important to notice that the market system offers no mechanism, in the short run, by which the economy can avoid unemployment. In fact, even with no market imperfections, unemployment can be seen as an inevitable part of the development process. This is because the loss of output and unemployment can be regarded as externalities in the modern sector factor market and will, therefore, not affect hiring decisions in that sector. This can be seen if the example in Section 1 is re-examined. The 10 skilled and 40 undkilled workers who shifted to the modern sector could be paid twice the wage that they were offered in the agricultural sector. It is impossible for the latter sector to offer competitive wages unless the remaining 50 unskilled workers are paid nothing. The manufacturing sector will therefore be able to continue to bid away laborers, and will do so, at the expense of agricultural output and unemployment until the terms of trade have moved so much in favor of agriculture that a competitive wage can at last be offered in that sector.

Simply aiming at the maximization of output, a 'rule of thumb' investment criterion, would be that it pays to invest in the modern sector only if the ratio of per capita value added in the traditional and modern sectors is greater than the greatest ratio of labor input coefficients in the two sectors.

Certainly the rapid growth of the 'service' sector which often typifies development, may be the result of unemployment in the agricultural sector caused by the over-investment (in terms of the objective function) in manufacturing. The unemployed would tend to drift towards the large urban centers with their employed compatriots since cities usually provide better facilities for them.

Another possible consequence of the growth of the manufacturing, and the dilution of the skills of the agricultural sector, may be the consolidation of agrarian land in fewer and fewer hands as the more skilled farmers, perhaps the peasant proprietors, migrate to the modern sector. To show this, however, it would be necessary to show a relationship between property ownership and the migration rate.

In the long run, there are two tendencies which will alleviate the problem. First, the introduction of labor skill saving techniques, and second, the increasing of the supplies of skilled labor. The pace of industrialization must be measured by the rate at which the supplies of skilled labor increase as well as by the rate of technological change. The supply of skilled labor, within the assumptions made in Section 4 would take almost eight years, for skill division (1). If investment is decided for periods less than this, the supply must be considered as given. This rules out the possibility of learning by doing, or, 'on the job' training, which might be significant sources of skilled and semi-skilled labor. However, it is extremely difficult to estimate the supply functions of labor trained in this way. If the rate of skill creation by these means is different in each sector, then investment decisions should be modified accordingly. Thus, if the rate at which skilled labor is produced, per 1,000 £L of output, is more rapid in the manufacturing than the agricultrual sector, then an optimum solution <u>over time</u> might indicate a higher rate of investment in the former sector than if there was no on the job training. The higher the time discount rate and the longer such training required, the less important it would become.

This raises the problem of the availibility of investment opportunities in agriculture. For 1970, the Libyan government has set aside £L50 million for agricultural development.

> "But how can one spend £L50 million on the sheep dunes and cabbage-patches of Libyan agriculture? Even cous-cous, the country's basic food, is imported."[1]

There are, in fact, a number of land reclamation and well-drilling, desalination and irrigation schemes planned. Although cost-benefit analyses have shown these to have a low rate of return, it is difficult to include the benefits of increased employment of labor which could not be employed in the manufacturing sector in such analyses.[2] However, such investment schemes only have to maintain the current per capita value added to help maximize output, and incidently, to minimize unemployment. Capital, as has been seen in terms of this model, has a zero shadow price and thus the cost of using capital on such projects is the current interest rate.

It is important to stress that the policy implications of this model are not simply to invest in agriculture, but to invest in agriculture at the same time as expanding the manufacturing sector. The degree to which investment in agriculture is carried out depends upon the planning price on unemployed workers in the objective function and on the time discount rate as well as on the skill coefficients and the supplies of labor skills.

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1. F. Hope, in The New Statesman, July 22, 1970, p. 728.
2. W. C. Wedley, Ph.D. Thesis, Unpublished.

There are other less quantifiable advantages to expansion of agriculture. Movement between sectors is usually accompanied by geographic and cultural relocation. This has private and social costs. Transforming the agricultural sector may avoid some of these costs-migration costs; rehousing, overcrowding of urban facilities, etc.[1]

There will also be the added advantage that the minimization of urban migration may create a politically more stable environment and reduce the social conflict usually associated with the concentration of unemployed urban workers.

In summary, then, we have constructed a model which 'de-homogeneizes' the labor force, and which shows a potential constraint on economic development, not included in the traditional dual sector approach. The assumptions were applied to the Libyan economy, assuming simple linear relationships, and carried out in only a partial equilibrium analysis. It was shown, within these limitations, that neither the supply of capital, nor the balance of payments appeared to be the active constraints on Libya's growth of non-petroleum sectors. The supply of labor of certain skill levels may pose an active constraint. In veiw of this, the optimum allocation of labor was determined using only labor skill supplies as constraints. It was found that this would

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1. T. R. Gregori and O. Pi-Sunyer, Economic Development: The Cultural Context, Wiley, New York, 1969.

have entailed an expansion of the number employed and the level of employment in the agricultural sector, as well as in the manufacturing sector, at the expense of the service and transportation sectors.

Human capital and its accumulation may be as important a determinant of development as the more usually examined alternative, a physical capital.

TABLE I:

PROJECTED GROWTH IN OIL EXPORTS 1964-74

(1)	(2)	(3)	(4)	(5)	(6)
1964	1,146,528	313,878	216,400	-	75.2
1965	1,319,600	442,388	280,331	28%	125.4
1966	1,695,935	547,027	350,557	25%	178.0
1967	2,212,469	625,493	415,282	18%	223.4
1968	2,800,000	914,775	603,751	46%	326.7
1969	3,400,000	1,131,500	746,790	24%	404.1
1970	4,200,000	1,387,000	915,420	23%	495.4
1971	4,650,000	1,615,125	1,065,982	16%	576.8
1972	5,100,000	1,779,375	1,174,375	10%	635.5
1973	5,550,000	1,943,625	1,282,792	9%	694.1
1974	6,000,000	2,107,875	1,391,197	9%	752.8

(1) Year.

(2) Number of barrels per day at the end of the year. Source 1964-68, Bank of Libya - Economic Bulletin, September - October 1968, no. 5. Source 1968-70, estimated by Oil and Gas Journal, 1969, p. 83.

(3) Annual total of barrels (in thousands).

(4) Value of annual oil production (in thousands of £L).

(5) Percent increase in value.

(6) Government revenue (in millions of £L). After 1965, approximately $1.00 per barrel (£L1 = $2.80).

TABLE IIA:

PROJECTED SIZE OF CITIZEN LABOR FORCE
AND EDUCATION LEVEL 1964-75

(1)	(2)	(3)	(4)	(5)	(6)
1964	372,783	34,499	15,954	4,750	1,523
1965	383,221	35,637	16,733	5,166	1,687
1966	393,951	36,395	16,956	5,222	1,862
1967	404,982	37,110	17,614	5,396	2,026
1968	416,321	37,928	18,294	5,603	2,271
1969	427,978	39,000	19,065	5,842	2,639
1970	439,961	40,310	19,888	6,397	3,095
1971	452,380	41,810	20,744	6,665	3,616
1972	465,047	43,526	21,694	6,967	4,180
1973	478,068	45,250	22,698	7,297	4,806
1974	491,454	46,998	23,718	7,652	5,498
1975	505,215	48,623	24,793	8,156	6,216

(1) Year. Source 1964, A. N. K. Nair, Libya's Manpower Resources and Educational and Training Needs, March 1967, p. 22, unpublished.
(2) Total labor force. Estimated to be growing at 2.8% (less than the population since those members of the labor force who are under 15 are assumed to be absorbed into the education system in this time span). This figure also excludes 4% - 5% of the labor force who represent the frictionally unemployed.
(3) Those with primary education.
(4) Those with intermediate education.
(5) Those with secondary education.
(6) Those with university education.

TABLE IIB:

ESTIMATED TOTAL NUMBER OF CITIZEN LABOR FORCE WITH PRIMARY EDUCATION 1964-75

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
64-5	8,232	993	1,176	517	7,194	34,499	35,637	9.4
65-6	9,098	1,000	1,200	540	7,700	35,637	36,395	9.1
66-7	9,626	1,075	1,225	561	8,300	36,395	37,110	9.1
67-8	10,363	1,105	1,255	585	8,800	37,110	37,928	9.1
68-9	11,108	1,184	1,280	600	9,340	37,928	39,000	9.1
69-70	11,838	1,269	1,300	640	9,850	39,000	40,310	9.1
70-1	12,576	1,355	1,330	662	10,361	40,310	41,810	9.3
71-2	13,313	1,440	1,370	697	11,050	41,810	43,526	9.4
72-3	14,051	1,525	1,410	732	11,710	43,526	45,250	9.4
73-4	14,788	1,610	1,470	770	12,410	45,250	46,998	9.5
74-5	15,600	1,725	1,560	820	13,220	46,998	48,623	9.7

(1) Year.
(2) Number graduating. Source, A. N. K. Nair, Op. Cit., p. 59.
(3) Number dropping out of higher level. Based on an estimate of 60% wastage at the intermediate level (assumed distributed evenly over the three years) and assumed to fall 50% by 1974.
(4) Number not entering work force. This includes those becoming frictionally unemployed and females. (This rises at a slower rate than the labor force because of the latter's increasing participation in economic activity.)
(5) Number dying or retiring. Based on data of other North African states.
(6) Number continuing to higher level. Based on an estimate of 60% wastage at the intermediate level (assumed distributed evenly over the three years) and assumed to fall 50% by 1974.
(7) Current work force.
(8) Total with primary education.
(8) = (2) + (3) + (7) - (4) - (5) - (6).
(9) (8) as a percentage of total labor force.

TABLE IIC:

ESTIMATED TOTAL NUMBER OF CITIZEN LABOR FORCE
WITH INTERMEDIATE EDUCATION 1964-75

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1964-65	2,789	200	245	1,970	15,954	16,733	4.4
1965-66	2,426	204	253	1,260	16,733	16,956	4.3
1966-67	3,041	223	256	2,350	16,956	17,614	4.3
1967-68	3,297	248	265	2,600	17,615	18,294	4.4
1968-69	3,552	273	274	2,780	18,294	19,065	4.4
1969-70	3,808	300	285	2,000	19,065	19,888	4.6
1970-71	4,064	320	298	3,230	19,888	20,744	4.6
1971-72	4,320	345	315	3,400	20,744	21,694	4.7
1972-73	4,575	359	330	3,600	21,694	22,698	4.7
1973-74	4,831	385	346	3,850	22,698	23,718	4.8
1974-75	5,175	412	362	4,150	23,718	24,793	4.9

(1) Year.
(2) Number graduating. Source, A. N. K. Nair, Op. Cit., p. 59.
(3) Number dropping out of higher level. Based on an estimate of 40% wastage at the secondary level (assumed distributed evenly over the three years) and assumed to fall 30% by 1974.
(4) Number dying or retiring. Based on data of other North African states.
(5) Number continuing to higher level. Based on an estimate of 40% wastage at the secondary level (assumed distributed evenly over the three years) and assumed to fall 30% by 1974.
(6) Current work force.
(7) Total with intermediate education.
(7) = (2) + (3) + (6) - (4) - (5).
(8) (7) as a percentage of total labor force.

TABLE IID:

ESTIMATED TOTAL NUMBER OF CITIZEN LABOR FORCE
WITH SECONDARY EDUCATION 1964-75

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1964-65	933	23	60	580	4,750	5,166	1.3
1965-66	829	24	65	720	5,166	5,222	1.3
1966-67	1,001	23	65	785	5,222	5,396	1.3
1967-68	1,117	31	70	870	5,396	5,603	1.3
1968-69	1,232	50	74	970	5,603	5,842	1.3
1969-70	1,350	58	80	1,075	5,842	6,397	1.4
1970-71	1,460	62	84	1,170	6,397	6,665	1.5
1971-72	1,582	69	89	1,260	6,665	6,697	1.5
1972-73	1,699	75	94	1,350	6,697	7,297	1.5
1973-74	1,815	79	99	1,440	7,297	7,652	1.5
1974-75	1,945	80	101	1,400	7,652	8,176	1.6

(1) Year.
(2) Number graduating. Source, A. N. K. Nair, Op. Cit., p. 59.
(3) Number dropping out of higher level. Based on an estimate of 35% wastage at the university level (assumed distributed evenly over the four years) and assumed to fall 25% by 1974.
(4) Number dying or retiring. Based on data of other North African states.
(5) Number continuing to higher level. Based on an estimate of 35% wastage at the university level (assumed distributed evenly over the four years) and assumed to fall 25% by 1974.
(6) Current work force.
(7) Total with secondary education. (7) = (2) + (3) + (6) - (4) - (5).
(8) (7) as a percentage of total labor force.

TABLE IIE:

ESTIMATED TOTAL NUMBER OF CITIZEN LABOR FORCE
WITH UNIVERSITY EDUCATION 1964-75

(1)	(2)	(3)	(4)	(5)	(6)
1964-65	184	20	1,523	1,687	0.40
1965-66	195	20	1,687	1,682	0.44
1966-67	186	21	1,862	2,026	0.49
1967-68	268	23	2,026	2,271	0.54
1968-69	393	25	2,271	2,639	0.60
1969-70	481	27	2,639	3,095	0.70
1970-71	530	29	3,095	3,616	0.80
1971-72	594	30	3,616	4,180	0.88
1972-73	657	31	4,180	4,806	1.04
1973-74	724	32	4,806	5,498	1.09
1974-75	750	32	5,498	6,216	1.23

(1) Year.

(2) Number graduating. Source, A. N. K. Nair, Op. Cit., p. 60.

(3) Number dying or retiring. Based on data of other North African states.

(4) Current work force.

(5) Total with university education.
(5) = (2) - (3) + (4).

(6) (5) as a percentage of total labor force.

TABLE III:

LABOR, LABOR OUTPUT RATIO, AND WAGE BILLS BY SECTOR 1964

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	31,092	NA	143,553	1,300	158	NA	216
2	238,181	16,665	10,300	2,600	13,490	1,281	16,855
3a	20,280	3,798	9,806	1,300	907	372	1,753
3b	5,234	3,216	14,521	1,500	151	207	327
4	9,182	2,644	7,000	600	676	360	1,077
5	2,567	552	880	60	1,355	588	2,730

(1) Sector.
 1 Agriculture.
 2 Petroleum and Mining.
 3a Large Manufacturing.
 3b Small Manufacturing.
 4 Construction.
 5 Electricity and Gas.

(2) Gross output (in thousands of £L). Source. Estimates of GNP of Libya 1964-66. Ministry of Economy and Trade - Kingdom of Libya, 1967.

(3) Wage bill (in thousands of £L). Source. Report of the Industrial Census, 1964. Ministry of Economy and Trade - Kingdom of Libya, 1967, p. 6 ff.

(4) Native labor force. Source. General Population Census, 1964. Ministry of Economy and Trade - Kingdom of Libya, 1967, p. 53.

(5) Foreign labor force. Source. Ibid.

(6) Per capita value added.

(7) Per capita wages.
$(3) \div [(4) + (5)]$.

(8) Per capita gross output (in £L).

TABLE IV:

VALUE ADDED, INVESTMENT, AND CAPITAL OUTPUT RATIOS IN SECTORS 2, 3, 4, AND 5 1964

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2a	161,200	91,276	49,848	47,000	56.4	76.0
2b	14,100	11,690	3,566	3,000	80.1	60.4
3a	9,000	12,512	650	410	139.0	158.5
3b	2,500	NA	NA	110	-	-
4	5,200	4,137	1,207	2,600	79.6	46.4
5	1,300	6,800	924	150	523.0	616.0
Total - 3b	190,900	126,415	56,219	53,270	66.2	65.1
3a + 4 + 5	15,500	23,449	2,781	3,850	151.2	72.2

(1) Sector.
2a Large Oil Companies.
2b Small Chartered Oil Companies.
3a Large Manufacturing.
3b Small Manufacturing.
4 Construction.
Data is only for 153 construction units. (Responsible for 37% of total construction value added.)
5 Electricity and Gas.

(2) Gross value added (in thousands of £L). Source. Estimates of GNP of Libya 1964-66. Op. Cit., Table (O-1).

(3) Capital stock (in thousands of £L). Source. Report of the Industrial Census, 1964. Op. Cit., p. 6 ff.

(4) Investment in the year 1964-65. Source. Ibid.

(5) Increase in value added in the year 1964-65. (After an allowance for a general 10% rise in prices had been made.)

(6) (3) as a percentage of (2).

(7) (4) as a percentage of (5). (Allowing for an estimated 15% depreciation.)

TABLE VA:

INPUTS OF RAW MATERIALS AND MACHINERY
AND IMPORT REQUIREMENTS 1964

Sector	Inputs of Raw Materials[1]	Inputs of Machinery[1]
Agriculture	1,002[2]	1,911[2]
Large Oil Companies	9,566	41,274
Small Chartered Oil Companies	870	3,000
Large Manufacturing	7,814	483
Small Manufacturing	2,344	100
Construction	6,500	1,100
Electricity and Gas	873	898
Commerce	0	2,500[3]
TOTAL	28,969	51,566
Less average retail and wholesale mark-up	2,500	5,000
TOTAL	26,469	46,566
Value of Imports	21,000	44,300
Imports as a percentage of total inputs	80	95
Imports as a percentage of Gross Domestic Product	6.25	12.45

1. (In thousands of £L). Source. Report of the Industrial Census, 1964. Op. Cit., p. 6 ff., (except where otherwise stated).
2. (In thousands of £L). Source. Bank of Libya - Economic Bulletin, September - October 1968, no. 5, p. 94.
3. Approximation based on net increase in number of vehicles, international prices, and 15% depreciation rate.

TABLE VB:

INCREMENTAL IMPORTED MACHINERY / OUTPUT AND RAW MATERIAL / OUTPUT RATIOS 1964-66

	1964	1965	1966
Imports of machinery[1]	44	48	52
Imports of raw materials[1]	21	22	24
Increase in GDP[1,2]	-	60	65
Imports of raw materials			
...as a percentage of GDP	6.2	5.2	4.8
...as a percentage of GNP	8.1	7.0	6.7
Imports of machinery covering depreciation[1]	15	16	-
Net imported machinery as a percentage of increase in GDP in the subsequent year[3]	48	49	-
Raw materials and capital imports as a percentage of the value of total imports	62	58	58

1. In millions of £L.
2. Allowing for a 10% rate of inflation.
3. Net of imports covering depreciation.

TABLE VC :

MAXIMUM POSSIBLE GROWTH RATE OF GNP
(EXCLUDING THE OIL SECTOR)
FULLY UTILIZING GOVERNMENT SAVINGS

(1)	(2)	(3)	(4)	(5)
1964-65	12.5	3.0	9.5	10
1965-66	20.9	4.5	16.4	16
1966-67	29.6	7.2	22.4	18
1967-68	37.2	12.1	25.1	17
1968-69	54.3	15.2	29.1	23
1969-70	67.3	21.7	45.6	22
1970-71	82.5	28.3	54.2	19
1971-72	96.1	36.4	59.7	20
1972-73	105.9	45.0	60.9	17
1973-74	115.7	54.7	61.0	14

(1) Year.

(2) Government savings (in millions of £L).

(3) Depreciation (in millions of £L).
(Assumed to be 15% of capital stock.)

(4) Maximum possible increase in GNP.
(4) = (3) - (2).
Based on an estimate of the marginal capital output ratio of 175:100.

(5) (4) as a percentage of GNP.

TABLE VI:

IMPORT REQUIREMENTS WITH VARYING
GROWTH RATES OF GNP 1965-74

		20%		25%		33%	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1965	200	25	37 39	26	49	28	75
1966	270	30	45 50	32½	65	37	90
1967	310	36	63 73	40	77	49	117
1968	470	43	72 84	50	101	66	155
1969	600	51½	84 103	62½	132	88	205
1970	700	62	105 136	78	156	117	277
1971	800	74	128 173	99	191	156	366
1972	900	89	141 200	124	240	208	470
1973	1,000	107	155 231	155	300	277	700
1974	1,100	128	171 255	194	370	369	970

(1) Year.
(2) Value of exports (in millions of £L).
(Including net factor income from the rest of the world.)
(3) Imports of raw material (in millions of £L).
(4) Imports of machinery (in millions of £L).
(The lower figure allows the price of imported machinery to rise by 5% per annum.)
(5) Imports of raw material (in millions of £L).
(6) Imports of machinery (in millions of £L).
(7) Imports of raw material (in millions of £L).
(8) Imports of machinery (in millions of £L).

TABLE VII :

GROSS AND NET DOMESTIC PRODUCT, AND RATES OF GROWTH, BY SECTOR ORIGIN 1964-66[1]

Sector	% of GDP	1964	% of growth 2	1965	% of growth 2	1966	% of GDP
Agriculture	8.8	22.7	-8	22.9	0.8	24.6	5.7
Petroleum	37.2	175.4	23.5	233.6	26.7	309.5	46.8
Manufacturing	4.5	11.5	0.3	12.8	0.1	14.1	3.2
Construction	5.8	14.9	50.0	23.9	38.5	35.5	8.2
Electricity & Gas	0.5	1.3	7.7	1.4	7.1	1.5	0.3
Transportation	5.8	14.8	6.0	17.2	8.1	20.3	4.7
Wholesale & Retail	9.6	24.8	1.0	27.5	11.2	33.3	7.7
Government	12.5	32.1	27.0	44.2	7.9	52.2	12.1
Banking	1.9	5.0	20.0	6.4	26.0	8.1	1.9
Private Ownership of Dwellings	13.4	34.6	0	37.0	0	39.6	9.2
GDP	131.0	337.1	27.0	426.9	26.2	538.7	125.0
Net Factor Income from rest of world	0	-79.8	0.5	-83.5	29.0	-107.9	0
GNP	100	257.3	33.4	343.4	25.5	430.8	100
At 1964 Prices	0	257.3	23.4	317.7	13.5	360.5	0

1. (In millions of £L.) Source, Estimates of GNP of Libya, 1964-66, Op. Cit.
2. Allowing for 10% per annum rate of inflation.

TABLE VIIIA:

TOTAL LABOR FORCE BY SKILL DIVISION 1964

	(1)	(2)	(3)	(4)	(5)
(0)	Professional & Technical	11,830	53	3,399	22
(1)	Administrative & Executive	5,420	24	768	12
(2)	Clerical	18,481	33	3,242	15
(3)	Sales Workers	23,291	41	1,058	4
(4)	Fishing, Hunting, & Farming	143,459	-	1,250	1
(5)	Mining & Drilling	6,925	-	329	5
(6)	Transport & Communications	15,653	-	545	3
(7) (8)	Craftsmen & Laborers	72,457	-	4,879	6
(9)	Services	39,095	-	1,048	3
(Y)	not otherwise classified	30,149	-	720	2
	TOTAL	372,783		17,559	4.5

(1) Skill Divisions. Source. General Population Census, 1964, Op. Cit., p. 45.

(2) Citizens. Source. Ibid.

(3) Divisions (0) and (1) as a percentage of $L_2 + L_3 + L_4$.
Divisions (2) and (3) as a percentage of $L_1 + L_2 + L_3 + L_4$.

(4) Aliens. Source. Ibid.

(5) (4) as a percentage of (2).

TABLE VIIIB:

NUMBER OF SKILLED WORKERS PER 1,000 WORKERS 1964

Sector	Division (0)	Division (1)	Division (2)	Division (3)-(Y)
Agriculture	3	2	7	988
Petroleum & Mining	212	75	75	638
Manufacturing	140	34	125	701
Construction	60	45	90	805
Electricity & Gas	140	100	120	740
Commerce	37	40	183	740
Transportation	42	20	60	878
Others	30	12	120	838
Average	38	15	55	892
Excluding sector 2	33	14	55	898
a) In 1974	38	17	57	884
b) Required[1]	44	18	73	864
c) Required[2]	41	15	61	880

1. Assuming a 33% increase in requirements for Divisions (0), (1), and (2).
2. Allowing for structure of Libyan economy.

TABLE IX:

LABOR FORCE BY SECTOR 1964

(1)	(2)	(3)	(4)	(5)
Agriculture	144,853	1,300	0.8	35.7
Petroleum and Mining	14,259	2,632	18.5	3.5
Manufacturing	29,377	2,830	9.7	7.2
Construction	31,434	1,388	4.4	7.7
Electricity and Gas	6,064	416	6.9	1.5
Commerce	26,735	1,921	7.2	6.6
Transportation	22,748	1,181	5.2	5.6
Services	82,531	4,884	5.9	20.4
Others	47,257	1,007	2.1	11.7

(1) Sector. Source. General Population Census, 1964, Op. Cit., p. 53.

(2) Number of citizen workers. Source. Ibid.

(3) Number of alien workers. Source. Ibid.

(4) (3) as a percentage of (2) + (3).

(5) (2) and (3) as a percentage of total labor force.

TABLE X:

PERCENTAGE INCREASE IN SUPPLIES OF SKILL DIVISIONS (0), (1), (2), AND (3)-(Y) 1964

Year	Division (0)[1]	Division (1)[2]	Division (2)[3]	Division (3)-(Y)
1964-65	4.0	4.3	4.2	2.5
1965-66	1.7	1.9	1.5	3.0
1966-67	4.0	4.2	3.2	2.7
1967-68	4.0	4.1	3.2	2.6
1968-69	5.0	5.1	3.5	2.6
1969-70	6.0	6.1	3.1	2.5
1970-71	5.3	5.5	4.5	2.4
1971-72	5.6	5.7	4.7	2.4
1972-73	6.0	6.2	4.7	2.3
1973-74	6.1	6.3	4.9	2.3

1. Based on the assumption that Division $(0)/L_2 + L_3 + L_4$ is constant and that there is no net increase in foreign labor.

2. Based on the assumption that Division $(1)/L_2 + L_3 + L_4$ is constant and that there is no net increase in foreign labor.

3. Based on the assumption that Division $(2)/L_1 + L_2 + L_3 + L_4$ is constant and that there is no net increase in foreign labor.

BIBLIOGRAPHY

Bank of Libya - Economic Bulletin, September - October 1968, No. 5.

Bank of Libya - Economic Bulletin, November - December 1968, No. 6.

W. Baer and M. E. Herve, "Employment and Industrialization in Developing Countries", Quarterly Journal of Economics, Vol. LXXX, 1966.

M. Bruno, "A Programming Model for Israel", in I. Adelman and E. Thorbecke, eds., The Theory and Design of Economic Development, Johns Hopkins Press, Baltimore, 1966.

E. F. Denison, The Sources of Economic Growth in the United States and the Alternatives Before Us, Supplementary Paper No. 13, New York, Committee on Economic Development, 1962.

Estimates of GNP of Libya, 1964-66, Ministry of Economy and Trade - Kingdom of Libya, 1967.

J. C. H. Fei and G. Ranis, Development of the Labor Surplus Economy, Homewood, 1964.

J. C. H. Fei and G. Ranis, "A Theory of Economic Development", American Economic Review, Vol. LI, 1961.

W. Galenson and H. Liebenstein, "Investment Criteria, Productivity and Economic Development", Quarterly Journal of Economics, Vol. LXIX, 1955.

General Population Census, 1964, Ministry of Economy and Trade - Kingdom of Libya, 1967.

T. R. Gregori and O. Pi-Sunyer, Economic Development: The Cultural Context, Wiley, New York, 1969.

E. E. Hagen, The Economics of Development, Homewood, 1968.

F. Hahn and R. C. O. Matthews, "Growth Theory", reprinted in Surveys of Economic Theory, Volume II, St. Martins Press, New York, 1966.

R. Harbison, "Lectures on Labor Force and its Employment, International Institute for Labor Studies, Geneva, 1963.

R. Harbison and C. A. Myers, Education, Manpower and Economic Growth, McGraw-Hill, New York, 1964.

B. Higgins, Economic Development, Norton, New York, 1968.

B. Higgins and J. Royer, "Economic Development with Unlimited Supplies of Capital: The Libyan Case", The Libyan Economic and Business Review, Vol. III, 1967.

A. O. Hirschman, The Strategy of Economic Development, Yale U.P., New Haven, 1958.

D. W. Jorgenson, "The Development of the Dual Economy", Economic Journal, Vol. 71, 1961.

D. W. Jorgenson, "Surplus Agricultural Labor and the Development of a Dual Economy", Oxford Economic Papers, 1962.

W. A. Lewis, "Economic Development with Unlimited Supplies of Labor", The Manchester School, Vol. 22, 1954.

G. Meier, ed., Leading Issues in Development Economics, Oxford, 1964.

M. A. Morowitz, M. Zymelman, and I. L. Hernstadt, Manpower Requirements for Planning, Department of Economics, Northeastern University, 1965, Unpublished.

A. N. K. Nair, Libya's Manpower Resources and Educational and Training Needs, Department of Economy and Trade, March 1967, Unpublished.

Oil and Gas Journal, 1969.

G. F. Papanek, "Development Problems Relevant to Agriculture Tax Policy", Papers and Proceedings of the Conference of Agricultural Taxation and Economic Development, Harvard Law School, 1954.

Quarterly Review of Economics, Economics Intelligence Unit, Number 1.

Quarterly Review of Economics, Economics Intelligence Unit, Number 2.

Report of the Industrial Census, 1964, Ministry of Economy and Trade - Kingdom of Libya, 1964.

W. W. Rostow, The Stages of Economic Growth, Cambridge, 1966.

T. W. Schultz, Transforming Traditional Agriculture, Yale U.P. New Haven, 1964.

The Libyan Economic and Business Review, Vol. I, 1965.

The Libyan Economic and Business Review, Vol. II, 1966.

The Libyan Economic and Business Review, Vol. III, 1967.

The Libyan Economic and Business Review, Vol. IV, 1968.

The Libyan Economic and Business Review, Vol. V, 1969.

W. C. Wedley, Ph.D. Thesis, Unpublished.

APPENDIX A

A MODEL OF THE LIBYAN ECONOMY

The first problem in the construction of a model of an economy is the identification of the objectives of the administrative body. It is necessary to allow for a certain degree of flexibility because of political and social considerations. This can be done by including in the objective function and in the specific constraints certain policy variables.

The policy goals of the Libyan government (that is, those goals not inconsistent with the government's past actions) were assumed to be the following.

1. The maximization of output over the planning period (from t = 1 to t = T).

2. The maximization of the number employed in each skill category.

3. The expansion of the agricultural sector in order to become less and less dependent on the oil sector (partly out of the belief that agriculture provides the only possible alternative to oil).

4. The strengthening of the sense of national identity. This is expressed in the granting of aid to other Arab states and the expansion of national defense expenditures.

5. The establishment of an equitable distribution of income.

6. The 'Libyanization' of the labor force.

Goals 1 and 2 were chosen as the objective function which was assumed to be:

$$\underset{t=1,2...T}{\text{Max}} \sum \frac{P_t.C_t + G_t - Gr_t - \sum_{i=15}^{20} P_{it}(S_{it} - \sum_{j=1}^{20} a_{ij}.X_{jt})}{(1 + r_1)^t}$$

where $$P_t.C_t = \sum_{j=1}^{20} P_{jt}.C_{jt}$$

where C_{jt} is the output of the jth sector of final goods, P_{jt} is the price of output of the jth sector in year t, G_t is government expenditure in year t, Gr_t is government revenue, S_{it} is the supply of the ith input, X_{jt} is the total output of the jth sector, a_{ij} is the quantity of the ith input required to produce £L1 of output in the jth sector, and r_1 is the community time discount rate.

The term

$$\sum_{i=15}^{20} P_{it}(S_{it} - \sum_{j=1} a_{ij}.X_{jt})$$

means that, if P_{it} (i = 15,...20) are positive, that unemployment will lower the value of the maximand. This allows a direct 'trade-off' between output maximization and employment maximization.

The third goal, the expansion of agriculture, could be included in the objective function by raising the planning price on output of the agriculture sector.

The fourth goal is included as a constraint that aid to other Arab states (A_t) and defense expenditures (Df_t) must equal a certain fraction of government receipts in any year. It is not clear whether this fraction (K_1) is a policy variable, since it is possible that political pressure from other states may determine it exogeneously.

a) $A_t + Df_t \geq K_1 . Gr_t \qquad (t = 1,2...T)$

The fifth goal, the attainment of an equitable distribution of income is difficult to formulate into a specific constraint. In this model it is interpreted as meaning that any subgroup 'p' of the population must receive a certain income either in wages Y_{pt} or in government transfer payments to that group G_{ypt}, which is greater than a certain fraction (α_1) of national income, and less than another fraction (α_2). This prevents any group earning too much or too little in terms of the welfare principles established by the government. In order to allow adjustment towards the ideal over time, it is possible to let the lower fraction, the minimum, grow (by r_2 per cent per annum) and the upper fraction shrink (by r_3 per cent per annum, where r_3 is negative). This income distribution constraint removes the necessity of a separate minimum consumption constraint. It can be written as follows:

b) $\alpha_1(1 + r_2)^t.(P_t \cdot C_t) \geq Y_{pt} + G_{ypt}(P_t \cdot C_t) \geq$

$\alpha_2(1 + r_3)^t.(P_t \cdot C_t) \quad (t = 1,2...T;\ p = 1,2...n)$

The goal of the 'Libyanization' of the labor force specifies that the ratio of foreign labor to the number of Libyan workers is less than some fraction (α_3) which can be allowed to fall (by r_4 per cent per annum).

c) $\sum_{j=1}^{20} a_{20j}.X_{jt} \;/\; \sum_{j=1}^{20} \sum_{i=15}^{19} a_{ij}.X_{jt} - \alpha_3(1 + r_4)^t$

$(t = 1,2...T)$

Further constraints are necessary for the proper functioning of the planning model. First it is necessary to specify that the use of an input should not exceed its supply:

d) $C_{it} + \sum_{j=1}^{20} a_{ij}.X_{jt} \leq S_{it} \quad (i = 1,2...20;\ t = 1,2...T)$

Then it is necessary to ensure that no output is negative:

e) $X_{jt} \geq 0$ $(j = 1,2...20;\ t = 1,2...T)$

Imports are limited to a certain fraction (α_5) of exports, which are assumed equal to the output of the oil sector (X_{5t}) minus the inputs of oil in other sectors.

f) $S_{3t} \leq \alpha_5(X_{5t} - \sum_{j=1}^{20} a_{5j} . X_{jt})$ $(t = 1,2...T)$

Finally, it is necessary to introduce a constraint on the supply of capital after the planning period is over, in order to ensure that the stock of capital is not run down during the last years in order to maximize the output of final goods. This is done by specifying that the rate of growth in the year after the end of the planning period exceeds some minimum rate α_6.

g) $\sum_{j=1}^{20} X_{jT+1} \geq \alpha_6 \sum_{j=1}^{20} X_{jT}$

The functional relationships of the planning model are layed out in the following pages. Equations 1a to 1c define components of government revenue and expenditure. Revenue is assumed a function of oil exports alone. Other possible sources, such as income tax and corporation tax, are negligible compared to the vast revenues from oil royalties. Equation 1b relates total government expenditure with total revenue, and 1c defines A_t and Df_t.

Equation 2a is the production function for all sectors except capital, which comes from the government, as shown by equation 2b.

Equations 3a to 3g define the supplies of inputs. 3a is an identity relating the supply of an input to the quantity produced and the amount going to final consumption.

Functional Relationships		No. of Equations
1. Government Revenue and Expenditure		
a) $Gr_t = \alpha\,[X_{5t} - a_{55}X_{5t}]$	$(t = 1,2\ldots T)$	1T
b) $G_t = \alpha_8 \cdot Gr_t$	$(t = 1,2\ldots T)$	1T
c) $A_t + Df_t = K_1 Gr_t$	$(t = 1,2\ldots T)$	1T
2. Production Function		
a) $X_{jt} = \text{Min}[S_{ijt}/a_{ijt}]$	$(i = 1,2\ldots 20)$ $(t = 1,2\ldots T)$ $(j = 1,3,4\ldots 20)$	19T
b) $X_{2t} = G_t - (A_t + Df_t) - \sum_{p=1}^{n} G_{ypt}$	$(t = 1,2\ldots T)$	1T
c) $X_{jt} = \sum_{j=1}^{20} a_{ij} \cdot X_{jt} + C_{jt}$	$(i = j)$ $(j = 1,2\ldots 20)$ $(t = 1,2\ldots T)$	
3. Input Supply Functions		
a) $S_{it} \equiv X_{jt} - C_{jt}$	$(i = j)$ $(t = 1,2\ldots T)$ $(i = 1,2\ldots 14)$	14T

b) $S_{15t} = X_{15t} - a_{15.16} \cdot X_{16+3} + (1 - d)S_{15.t-1}$ 1T

$- x_{15}X_{15t} + 1/4\ (a_{15.16} - 1) \cdot X_{16t}$

$(t = 1,2...T)$

c) $S_{16t} = X_{16t} - a_{16.17} \cdot X_{17t} + (1 - d) \cdot S_{16.t-1}$ 1T

$+ 1/4\ (a_{15.17} - 1) \cdot X_{17t}$

$(t = 1,2...T)$

d) $S_{17t} = X_{17t} - a_{17.18} \cdot X_{18t} + (1 - d) \cdot S_{17.t-1}$ 1T

$+ 1/4\ (a_{17.18} - 1) \cdot X_{18t}$

$(t = 1,2...T)$

e) $S_{18.t} = X_{18t} + (1 - d)\ S_{18.t-1}$ 1T

$(t = 1,2...T)$

f) $S_{19t} = L_0\ (1 + R_5)^t - \sum_{i=15}^{18} S_{it}$ 1T

$(t = 1,2...T)$

g) $S_{20t} = \alpha_3\ (1 + r_4)^t \sum_{i=15}^{19} S_{it}$ $(t = 1,2...T)$ 1T

Unknowns		No. of Unknowns
G	- Government revenue in year t	1T
G_{et}	- Government expenditure in year t	1T
$A_t + D_{ft}$	- Aid to other Arab States and defense expenditure in year t	20T
C_{jt}	- Output of the j^{th} sector that are final (consumption) goods in year t	20T
X_{jt}	- Total output of the j^{th} sector in year t	20T
S_{it}	- Total supply of the i^{th} input in year t	20T

Parameters

$\alpha_1, \alpha_2 \ldots \alpha_9$ - policy variables

K_1 - exogeneously determined constant

r_1 - rate of discount of consumption over time

r_2 and r_3 - rate at which maximum and minimum fraction of national income that any given fraction of pupulation can earn, decrease and increase respectively, over time

r_4 - rate at which the fraction of the labor force in any one sector that can be foreign increases or decreases over time (r_1 - r_4) are policy variables

R_5 - rate of growth of labor force

L_0 - labor force in first year of planning period

Y_{pt} - income of section p of the population in time t

G - net government income transfers to section p of the population in time t

P_{jt} - planning price given to output of the j^{th} sector in time t

d - death rate

Sectors (Inputs) Implied by the Equations for the Planning Model of the Libyan Economy

1. Water
2. Government Investment, Capital (Savings)
3. Imports
4. Agriculture
5. Petroleum
6. Manufacturing
7. Construction
8. Power
9. Transport
10. Marketing
11. Government Services
12. Banking and Insurance
13. Ownership of Private Dwellings
14. Capital Goods
15. Labor (with primary education L_1)
16. Labor (with intermediate education L_2)
17. Labor (with secondary education L_3)
18. Labor (with university education L_4)
19. Labor (uneducated L_0)
20. Labor (foreign L_f)