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ECONOMIC GROWTH CENTER

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CENTER DISCUSSION PAPER NO. 760

EXTERNAL SHOCKS AND STRUCTURAL ADJUSTMENTS: A DUTCH DISEASE DYNAMIC ANALYSIS

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June 1996

Note: Center Discussion Papers are preliminary materials circulated to stimulate discussions and critical comments. Professor Fardmanesh was a Visiting Fellow in the Economics Department at Yale University.

The author is grateful to T. N. Srinivasan, Shanta Devarajan, Ed Buffie and Ken Kletzer for their comments on earlier versions of this paper.

ABSTRACT

This paper develops a three-sector dynamic general equilibrium model of Dutch Disease for an oil-exporting small open economy. Agricultural, manufacturing and nontradable goods are distinguished. Sectoral capital stock adjusts gradually. Spiral or monotone adjustment paths occur depending on the typology of the economy. A more developed oil exporter could experience spiral adjustments; the short-run and long-run sectoral effects of an oil shock are qualitatively different. A less developed oil exporter would experience monotone adjustments; the short-run and long-run sectoral effects of an oil shock are qualitatively similar. The model developed can be applied to any `small' open economy adjusting to external revenues and terms of trade shocks.

KEY WORDS: **Dutch Disease, External Shocks, Structural Adjustment**

1. INTRODUCTION

The manufacturing sector expanded in most OPEC countries while their agricultural sector contracted following the oil boom in the 1970s (World Bank (1984)). Variations of the core model of Dutch disease have been used to explain this asymmetric behavior between the agricultural and manufacturing sectors in a comparative static framework (Neary and Van Wijnbergen (1986), Benjamin et al. (1988), and Fardmanesh (1990)). The question still remaining is: will the manufacturing sector ``crash" when the economy arrives at its new steady state? Answering this requires a dynamic model that captures the sectoral transition path to the post-boom steady state.

Existing dynamic models of an oil (energy) boom either do not analytically address the dynamic behavior of the sectoral output and the stability of the steady state (e.g., Bruno and Sachs (1982), Van Wijnbergen (1985), Bevan et al. (1987), Martin and Van Wijnbergen (1988), Benjamin (1990)),[1] or use a one-sector framework and abstract from the role of nontraded goods altogether (e.g., Buiter and Purvis (1983) and Sachs (1983)).

This paper provides a three-sector dynamic general equilibrium model of Dutch Disease for an oil shock (boom) and addresses the dynamic behavior of the sectoral capital stock and

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[1]Bruno and Sachs (1982) uses a three-sector traded-nontraded-energy simulation model and quantitatively assesses the adjustment path for the U.K. economy in the face of the North Sea oil discovery. Van Wijnbergen (1985) uses a dynamic two-sector traded-nontraded model and addresses the optimal savings response to temporary and permanent increases in oil revenues. Bevan et al. (1987) uses a CGE model which includes nontradables (services) among their thirty-six commodities, but addresses primarily the distributional aspects of the temporary (1976-79) coffee boom in Kenya. Martin and Van Wijnbergen (1988) uses a two-sector (tradable and nontradable sectors) model, but studies (simulates) the dynamics of pricing of the natural resource (gas) for Egypt. Benjamin (1990) adds the investment dimension in a two-period multisectoral CGE model of Dutch disease for Cameroon, but studies (simulates) the impact of various sectoral and macroeconomic policies.

output. In addition to considering the standard role of nontraded goods, a distinction is made between the manufacturing and agricultural tradable goods warranted by the asymmetric behavior of these sectors in the OPEC countries in the 1970s. Sectoral capital stock adjusts gradually creating dynamic behavior in the economy. Spiral or monotone adjustment paths occur depending on the typology of the oil-exporting economy, as evidenced by their experience in the 1970s.[2] A more developed oil exporter would experience spiral adjustments; the short-run and long-run sectoral effects of an oil shock are qualitatively different. A less developed oil exporter would experience monotone adjustments; the short-run and long-run sectoral effects of an oil shock are qualitatively similar. The analysis is symmetric with respect to the oil collapse of the mid 1980s; the sectoral adjustment paths for the case of oil price decreases of the 1980s would be identical to those discussed here but in the opposite direction. In the tradition of the Dutch Disease literature, this study concerns itself with the case of oil price increases. The model developed here is a general adjustment model and can be applied to any `small' open economy adjusting to external revenues and terms of trade shocks.

The model is described in part Two.[3] Part Three provides a discussion of the effects of the oil boom on the steady state capital stocks in the manufacturing and nontraded goods sectors (and of the sectoral outputs). This identifies the starting point of the adjustment path in the capital

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[2]World Bank (1987). The annual shares of agricultural, manufacturing and nontraded output to nonoil GDP for the period 1973-82 indicate a spiral adjustment in the more developed OPEC countries like Algeria and Venezuela and a monotone adjustment in the less developed OPEC countries like Ecuador, Indonesia, Kuwait, Libya, Nigeria and Saudi Arabia. The other oil-exporting countries can not be considered here for lack of data (e.g., Iran and Iraq), for lack of a significant (net) oil exports-GDP ratio in the 1970s (e.g., Cameroon, Malaysia and Mexico), or for lack of a `tangible' agricultural sector (e.g., Bahrain and United Arab Emirates).

[3]This model is a dynamic extension of the one in Fardmanesh (1990).

stocks (K^M - K^N) plane, being to the southwest of the new steady state for all OPEC countries except the very large exporters of oil Saudi Arabia and Kuwait. The characteristics of the adjustment paths of sectoral capital stocks, the dynamic variables, and of the sectoral output are discussed in part Four. Part Five summarizes the conclusions of the paper. Appendix A and B present the derivation of the parametric results for the steady state and for the transition period respectively.

2. THE MODEL

A perfectly competitive `small' open economy produces, in addition to oil, an agricultural traded product (A), a manufacturing traded good (M), and a nontraded good (N). Production in every (nonoil) sector is subject to constant returns to scale with a constant elasticity of substitution between the two inputs used. Production of A requires land (T) and labor (L); production of M and N requires capital (K) and labor. The manufactured output is used for both consumption and investment. The oil sector, due to its enclave nature, is not modelled; the oil revenues are modelled as transfers received form abroad as in the existing Dutch Disease analyses.

Labor which is used by all sectors can be shifted across sectors instantaneously (and costlessly). Land is specific to the A sector. The endowments of land and labor are, by assumption, fixed throughout.

Capital which is used by the M and N sectors constitutes the dynamic factor. Given the uncertainty regarding oil revenues (prices) in the future, it does not adjust to its post-boom level instantaneously. Capital, once installed, can not be shifted across sectors and is fixed at a given point along the transition path. But it can expand or contract as the economy moves towards its new steady state. Capital is assumed to depreciate at a constant rate, δ. At any point along the transition path, the desired change in the capital stock in each sector is determined by comparing the actual and long-run return to capital in the respective sector:[4]

$$\dot{K}^j = [(r^j/\tilde{r})-1].K^j, \qquad (j=M,N) \qquad (1)$$

where $\dot{K}^j$ and K^j are the change in the capital stock and the pre-existing capital stock in sector j ($j = M, N$) respectively, r^j denotes the actual return to capital in sector j ($j = M, N$), and $\tilde{r}$ is the long-run return to capital which is equalized across the economy and is given by:[5]

$$\tilde{r} = P^M.(\delta+\rho), \qquad (2)$$

where P^M is the (post-boom) price of M, ρ is the world interest rate, and δ is the rate of depreciation.

This investment behavior is a variation of Tobin's `q'.[6] The long-run return to capital is determined by its replacement costs. The actual return to capital, as a measure of profitability,

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[4]This formulation assumes that the speed of adjustment in the two sectors are equal. While considering different adjustment speeds may conceptually be more interesting, the parametric complexity of this study undermines the qualitative contribution of such a distinction.

[5]In the long run, the marginal revenue product of capital (the term on the left-hand side) equals the opportunity cost of capital usage (the term on the right-hand side).

[6]This descriptive investment rule can be considered a variation of the one used by Sachs (1983) derived from firm's decision to maximize its present value in the presence of linear adjustment costs. However, as allowing for (linear) adjustment costs would not change the results qualitatively, such costs are ignored here in order to simplify the (parametric) calculations.

would determine the market value of capital.[7] Only the present return to capital is taken into account and future capital gains (losses) are ignored implying static expectations. Capital adjustment costs are set equal to zero in order to simplify the calculations. Hence, (new) investment expenditures equal capital formation. The `small' open economy faces perfect international capital mobility: the domestic interest rate equals the world interest rate. Any gap between investment demand and domestic savings is closed by international borrowing and lending.

The economy moves through a sequence of `temporary' equilibria as capital stock in M and N sectors adjust from the initial to the new steady state. These equilibria are characterized by zero profit in all sectors, by full employment of all factors, and by the clearance of the nontraded goods market.

The condition that profits be zero, keeping in mind the sector-specificity of capital at a given point during the transition, yields:

$$C_1^A(w,v).w + C_2^A(w,v).v = P^A = 1, \qquad (3)$$

$$C_1^M(w,r^M).w + C_2^M(w,r^M).r^M = P^M \qquad (4)$$

$$C_1^N(w,r^N).w + C_2^N(w,r^N).r^N = P^N \qquad (5)$$

where w, v and r^j denote the returns to the factors L, T and K^j $(j = M,N)$ respectively; C^j is the

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[7]Since $r^j = P_j^M(\rho + \delta)$ where P_j^M denotes market price of capital for sector j $(j = M,N)$, then $q = P_j^M/P^M = r^j/\tilde{r}$.

(minimized) unit cost function associated with the production function in sector *j* (*j* = *A,M,N*); P^A, P^M and P^N are the market prices of agricultural, manufactured and nontraded goods. By small country assumption, the domestic prices (value-added) of *A* and *M* are exogenous. P^A equals one by choice of numeraire.

The requirement that all factors be fully employed at any `temporary' equilibria can be described by:

$$C_2^A(w,v).Q^A = \bar{T}, \qquad (6)$$

$$C_2^M(w,r^M).Q^M = K^M, \qquad (7)$$

$$C_2^N(w,r^N).Q^N = K^N, \qquad (8)$$

$$C_1^A(w,v).Q^A + C_1^M(w,r^M).Q^M + C_1^N(w,r^N).Q^N = \bar{L}, \qquad (9)$$

where Q^j (*j* = *A,M,N*) denotes output in sector *j*; *L* and *T* are, by assumption, fixed while K^M and K^N change.

The condition that the goods market clear, keeping in mind that the agricultural good is the numeraire, can be described by:

$$Q^N = D^N(P^N,P^M,Y), \qquad (10)$$

where Q^N and D^N denote the supply of and demand for the nontraded good. Although the interest rate and the rate of return on investment (savings) are not explicit arguments in the function describing the demand for the nontraded good, these factors influence consumption decisions by determining the national consumption expenditures, Y, which is given by:

$$Y = Q^A + P^M.Q^M + P^N.Q^N + R - P^M(\dot{K}^M + \delta K^M + \dot{K}^N + \delta K^N), \quad (11)$$

where R denotes the (post-boom) oil revenues net of the capital outflow (inflow) injected into the economy.

Throughout the analysis a circumflex (ˆ) denotes a proportionate change in the respective argument over time (a log-derivative with respect to time), e.g. $\hat{a} = d(\ln a)/dt$.

3. THE STEADY STATE IMPACT

The steady state impact of the oil shock (boom) on the sectoral capital stock (and output) is required for determining the location of the post-boom steady state in relation to the pre-boom one. Equation (2) requires that the relative change in the capital rental equal the relative change in the world price of manufactured good in the steady state. The relative change in the real wage (in terms of A) would then, due to the price magnification effect, equal the relative change in the world price of manufactured good as well. The wage-capital rental ratio and, hence, the capital-labor ratio in the M and N sectors remain intact in the long run. Thus:

$$\hat{K}^j = \hat{L}^j = \hat{Q}^j, \qquad (j = M, N).$$

More specifically, from Appendix A:

$$\hat{K}^M = \left(\frac{1}{\theta_L^A \Delta}\right)[[e^A L^A(\psi^N(\phi^N - \delta\beta^N) - 1)$$

$$- \theta_L^A L^N(\bar{\epsilon}_A^N + \psi^N a_M + e^A \psi^N \phi^A)].\hat{P}^M + [\theta_L^A L^N \psi^N].\frac{dR}{Y}], \qquad (12)$$

$$\hat{K}^N = (\frac{1}{\theta_L^A \Delta})[[-e^A L^A \psi^N(\phi^M - \delta\,\beta^M)$$

$$+ \theta_L^A L^M(\bar{\epsilon}_A^N + \psi^N a_M + e^A \psi^N \phi^A)].\hat{P}^M - [\theta_L^A L^M \psi^N].\frac{dR}{Y}], \qquad (13)$$

where

$$\Delta = L^M[\phi^N - \delta\,\beta^N)\psi^N - 1] - L^N[\psi^N(\phi^M - \delta\,\beta^M)] < 0.$$

and θ_i^j is the share of factor i in the value of output in sector j ($j = A,M,N$), e^A denotes the real product wage elasticity of supply in sector A, L^j is the labor share of sector j ($j = A,M,N$), ϕ^j is the output of the respective sector as a percentage of net national product ($j = A,M,N$), β^j is the post-boom steady state (replacement) investment in sector j ($j = M,N$) as a percentage of net national product, $\bar{\epsilon}_A^N$ and ψ^N are the compensated own-price and income elasticity of demand for the nontraded good, a_M denotes the ratio of the imported manufactured goods to (net) national product, and P^M is the increase in the world relative price of M to A associated with higher oil prices.

While K^N (Q^N) increases, K^M (Q^M) may increase or decrease in the post-boom steady state depending on the typology of the economy (Q^A unambiguously decreases).[8] Consequently, the starting point of the capital adjustment paths in the (K^M, K^N) plane is to the southwest or northwest of the new steady state. The latter would be the case only for less developed larger

[8]For a detailed derivation and discussion of these results, see Fardmanesh (1990).

exporters of oil like Saudi Arabia and Kuwait which would experience a decline in their *M* sector. The former, depicted in Figure 1, would be the case for most oil exporters whose *M* sector expands in the long run.

4. THE DYNAMICS

4.1 THE DYNAMIC CHARACTERISTICS OF THE SECTORAL CAPITAL STOCK

The changes in the actual return to capital in the manufacturing and nontraded sectors during the transition period is related to the changes in the capital stocks in these sectors, as derived in Appendix B:

$$\hat{r}^{M} = a.\hat{K}^{M} + b.\hat{K}^{N}, \qquad (14)$$

$$\hat{r}^{N} = c.\hat{K}^{M} + d.\hat{K}^{N}, \qquad (15)$$

As expected, changes in actual returns to capital in the manufacturing and nontraded sectors are negatively related to changes in the stock of capital in the respective sector ($a < O$, $d < O$). An increase in the stock of capital in each sector reduces the value marginal product of this factor in that sector--"the direct effect".[9] The impact of the changes in each sector's capital stock on the return to capital in the other sector--"the indirect effect"--seems to be ambiguous and to depend upon the relative magnitudes of the structural parameters of the oil-exporting economy.

The return to capital in the manufacturing sector is most likely inversely related to the stock of capital in the nontraded sector ($b < O$), particularly the larger are the marginal propensity

[9]The value marginal product of capital in nontraded sector decreases beyond the decline in marginal product of capital in this sector because the price of the nontraded good decreases with an expansion in this sector.

to consume nontraded goods, the compensated own-price elasticity of demand for these goods, and the elasticity of substitution between labor and capital in the manufacturing sector; and the smaller is the elasticity of substitution between labor and capital in the nontraded sector. When the capital stock in the nontraded sector increases, the rise in the marginal product of labor in this sector would offset the decline in the price of nontraded good caused by the increase in its supply. The value marginal product of labor in the nontraded sector increases as K^N increases, and labor is reallocated into this sector from the manufacturing (and agricultural) sector(s). The value marginal product of capital in the (contracting) manufacturing sector declines due to loss of labor.

The return to capital in the nontraded sector is most likely positively related to the stock of capital in the manufacturing sector ($c > O$); given the nontraded sector uses a significantly larger fraction of labor force than does the manufacturing sector, the elasticity of substitution between labor and capital in the manufacturing sector is larger than that in the nontraded sector, and the compensated own-price elasticity of demand for nontraded goods is small (inelastic) at such an aggregate level. A rise in K^M increases the marginal product of labor and, hence, the value marginal product of labor in the M sector. This entails a reallocation of labor into the manufacturing sector from the nontraded (and agricultural) sector(s). The value marginal product of capital in the (contracting) N sector, however, increases with loss of labor. The increase in the price of nontraded good required to eliminate the resulting excess demand for it would offset the decrease in its marginal product of capital caused by loss of (small) amount of labor to the manufacturing sector.

Finally, the actual return to capital in the manufacturing and nontraded sectors along the transition path as determined by the stocks of capital in these two sectors is derived by integrating

(14) and (15):

$$r^M = \tilde{r}.(K^M/\tilde{K}^M)^a.(K^N/\tilde{K}^N)^b, \qquad (16)$$

$$r^N = \tilde{r}.(K^M/\tilde{K}^M)^c.(K^N/\tilde{K}^N)^d, \qquad (17)$$

where the tilde (˜) denotes the (post-boom) steady state value for the respective variable.

The changes over time in the capital stocks of the manufacturing and nontraded sectors can be represented by a system of dynamic equations, substituting for r^M and r^N in (1) from (16) and (17):

$$\dot{K}^M = [(K^M/\tilde{K}^M)^a.(K^N/\tilde{K}^N)^b - 1].K^M, \qquad (18)$$

$$\dot{K}^N = [(K^M/\tilde{K}^M)^c.(K^N/\tilde{K}^N)^d - 1].K^N, \qquad (19)$$

The linearized approximation of this dynamic system around the (post-boom) steady state is:[10]

$$\dot{K}^M = a.(K^M - \tilde{K}^M) + (b\tilde{K}^M/\tilde{K}^N).(K^N - \tilde{K}^N), \qquad (20)$$

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[10]This is done by transforming it into a so-called `Perturbed' system which would consist of a linear part and of a non-linear part called the `Perturbation Term', by Taylor expansions of these equations around the new steady state, point ($\tilde{K}^N$,$\tilde{K}^M$), and by setting the `Perturbed Term' for small changes in the state variables to zero.

$$\dot{K}^N = (c\tilde{K}^N/\tilde{K}^M).(K^M - \tilde{K}^M) + d.(K^N - \tilde{K}^N), \qquad (21)$$

or, in matrix notation:

$$\dot{K} = [M][K - \tilde{K}], \qquad (22)$$

where M is referred to as the `state transition matrix'. The solution to this system would have the following form:

$$\begin{bmatrix} K^M(t) \\ \\ K^N(t) \end{bmatrix} = \begin{bmatrix} \Sigma m_i e^{\lambda_i t} + \tilde{K}^M \\ \\ \Sigma n_i e^{\lambda_i t} + \tilde{K}^N \end{bmatrix} \qquad (23)$$

where m, and n, are the solution to:[11]

$$(\lambda I - M) \quad = 0, \qquad (24)$$

and λ_i $(i = 1,2)$ denotes the characteristic roots (eigenvalues) of M and is given by:

$$\lambda_{1,2} = 1/2[(a + b) + [(a + d)^2 - 4(ad - bc)]^{1/2}]$$

The derivation of the exact dynamic adjustment path of the capital stocks in the manufacturing and nontraded goods sectors beyond general notation is not feasible, given the parametric nature of this analysis. The sign pattern of the state transition matrix M and, hence, the

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[11]Since matrix $(\lambda I - M)$ is singular, its determinant is zero, m and n are not independent and would constitute as many unknowns as the number of eigenvalues. Consequently, the system is not underdetermined and using the initial capital stocks in the two sectors (the initial conditions) for $t = 0$, m and n can be derived.

phase portrait of the above system is not unique, and depends on the typology of the economy. The characteristics of the adjustment path of the sectoral capital stocks and the (local) stability (convergence) of the post-boom steady state, however, can be determined from inspecting the possible configuration(s) that the characteristic roots of matrix M may take.

Theoretically, depending on the relative magnitudes of the structural parameters of the economy and, hence, on the relative magnitudes of the direct and indirect effects, the sectoral capital stocks can take one of the four different adjustment paths shown in Fig. 1. But, two of these can be ruled out on the basis of what they imply about the direct and indirect effects. It should be noted that the (local) stability/convergence of the new steady state is assured in all but one case by the fact that the trace of matrix M is negative,[12] as indicated by the direction of the arrows on the paths in Fig. 1. Should the long-run equilibrium be a saddle point, unless the initial bundle of capital stocks accidentally lies on the stable branch of the saddle path, the system would be unstable and the economy would not reach its new steady state. However, the case of a Saddle-point path can be ruled out because it requires that the indirect effects be of the same sign and that at least one of the indirect effects dominate its respective direct effect. It is implausible that an increase in the stock of capital in a sector would affect its own return by less than the return in another sector, especially at such an aggregate level. In addition, the indirect effects are most likely of the opposite signs.[13]

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[12]Since a and d are negative the trace of matrix M which is $(a + d)$ is negative as well.

[13]The sufficient condition is that the determinant of matrix M be negative. The eigenvalues would be real but opposite in sign, and the new long-run equilibrium point would be a saddle point with a stable branch consisting of all points that would eventually reach the (new) steady state.

The case of a straight-line path can be ruled out because it requires equal direct effects and no indirect effects.[14] To the extent that labor is used by both *N* and *M* sectors and labor and capital are substitutes, albeit to different degrees in the two sectors, the direct effects would differ and the indirect effects would exist.

Thus, the new steady state would be characterized by a convergent spiral or monotone adjustment path depending on the relative magnitudes of the direct and indirect effects, that is, depending on the typology of the economy. The interesting case of a spiral path would emerge if the symmetric direct effects are very similar and the asymmetric indirect effects are significant.[15] This holds where the manufacturing and nontraded sectors are of close level of development and share in the economy, that is, only in the more developed oil-exporting countries. In their case, the new steady state would be a spiral point with a (convergent) spiral adjustment path giving rise to the occurrence of (convergent) cyclical changes in the capital stocks in manufacturing and nontraded sectors during the transition period. In the case of less developed oil-exporting countries, the new steady state would be characterized by a convergent monotone adjustment path,[16] as their smaller manufacturing sector renders direct effects less similar and the indirect

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[14]In this case the determinant of M would be positive and the discriminant of matrix *M* would be zero $[(a + d)^2 - 4(ad - bc) = 0]$. The roots would be (negative) real and repeated. The point representing this steady state is called a `proper node' (Brauer and Nohel (1967)).

[15]This interesting adjustment path emerges if the characteristics roots of the system are complex conjugates of the form $h \pm vi$, where $h = (a+d)$, $i = (-1)^{1/2}$ and $v = [(a+d)^2 - 4(ad - bc)]$. Since $(a+d) < 0$ the system would have a "stable focus." For this to be the path the determinant of *M* must be positive but its discriminant must be negative $[(a + d)^2 - 4(ad - bc) < 0]$. The latter holds only if *b* and *c* are of opposite signs. This is also sufficient for the determinant of matrix *M* to be positive, given that a and *d* are negative.

[16]Necessary and sufficient for this to be the case is that both the determinant and the discriminant of matrix *M* be positive. The point representing this steady state is called an

effects less significant. The capital stock in their manufacturing and nontraded sectors change steadily toward the new steady state level.[17]

4.2 THE DYNAMIC CHARACTERISTICS OF THE SECTORAL OUTPUT

The changes in sectoral output along the transition path can be derived in terms of the changes in the state variables (K^M, K^N):[18]

$$\hat{Q}^A = e^A \, . \, (\theta_K^M/\theta_L^M) \, . \, (a\hat{K}^M + b\hat{K}^N), \tag{25}$$

$$\hat{Q}^M = [(ae^M\theta_K^M)/\theta_L^M + 1] \, . \, \hat{K}^M + [(be^M\theta_K^M)/\theta_L^M] \, . \, \hat{K}^N, \tag{26}$$

$$\hat{Q}^N = (e^N\theta_K^N/\theta_L^M) \, . \, (\theta_L^M c + \theta_K^M a) \, . \, \hat{K}^M$$

$$+ (1/\theta_L^M) \, . \, (\theta_L^M + e^N\theta_K^N\theta_L^M d + e^N\theta_K^N\theta_K^M b) \, . \, \hat{K}^N. \tag{27}$$

Integrating both sides of these equations in turn would yield the adjustment path of the sectoral outputs. The characteristics of these paths and their relation to those of the capital stocks, however, can be ascertained from these equations.

`improper node' (Brauer and Nohel (1967)).

[17]`Guesstimates' of the structural parameters, using World Development Report (1980) and World Tables (1987), and, hence, of the direct and indirect effects for OPEC countries indicate spiral adjustment paths for the more developed OPEC countries like Algeria, Iran, Iraq, and Venezuela. They indicate monotone adjustment paths for the less developed oil-exporting countries like Ecuador, Indonesia, and Nigeria which have a large agricultural sector and a relatively small oil sector as well as for the small-agriculture large exporters of oil like Kuwait, Libya and Saudi Arabia.

[18]By substituting in (B10), (B11) and (B12) for the changes in the price of the nontraded good and wages, using (B15) and (B16).

The agricultural output is negatively related to the stock of capital in manufacturing and nontraded sectors. An increase in the stock of capital in either sector reduces agricultural output by reallocating labor away from this sector. The agricultural output has the same adjustment characteristic as the capital stocks in the manufacturing and nontraded sectors but changes in the opposite direction. Consequently, in a more developed oil-exporting country, which experiences spiral adjustments, the agricultural output would expand at points during the transition period while it definitely contracts in the long run. In a less developed one, which experiences monotone adjustments, the agricultural output steadily decreases towards its new steady state as the capital stock in the manufacturing and nontraded sectors steadily expand and labor is continually reallocated away from the agricultural sector.

The impact on the manufacturing and nontraded output of the changes in K^M and K^N along the transition path is manyfold. A change in the stock of capital in each sector affects that sector's output in two opposing ways. An increase in K^M (K^N) leads to the expansion of the manufacturing (nontraded) sector by increasing its productive capacity. This also increases the real product wage that the producers in that sector face curbing the output expansion. By changing the wage rate, a change in the stock of capital in each sector also affects the output of the other sector. An increase in K^M (K^N) would be concomitant with a decline in the nontraded (manufacturing) output. However, as the output in each of the manufacturing and nontraded sectors is altered by an increase in its own capital stock more than by an increase in the other sector's capital stock, the characteristics of their output adjustment paths are similar to those of their own capital stock. That is, the output of the manufacturing and nontraded sectors in a more developed oil-exporting country follow a spiral adjustment path as do the stocks of capital in these sectors; its manufacturing (nontraded) sector may contract at points during the transition period while it would definitely expand in the long run. On the other hand, the output of the manufacturing and nontraded sectors in a less developed oil-exporting country follow a monotone adjustment path as do the stocks of capital in these sectors; its manufacturing (nontraded) sector expands steadily during the transition period toward the post-boom steady state level.

5. CONCLUSIONS

This paper has analytically addressed the question of how an oil-exporting `small' open economy adjusts to an exogenous oil shock (boom) using a three-sector dynamic general equilibrium model. The conventional Dutch Disease framework is used; tradables and nontradable goods are distinguished. Additionally, agricultural and manufacturing tradables are distinguished warranted by the asymmetric behavior of these sectors in developing oil-exporting countries. Adjustments of capital stock in the manufacturing and nontraded sectors to changes in return to capital are sluggish creating dynamic behavior in the economy.

Theoretically, depending on the relative magnitudes of the structural parameters of the economy, the sectoral capital stocks can take one of four different adjustment paths. The stability of the new steady state is assured in all but the case of saddle-point path. However, saddle-point and straight-line adjustment paths are ruled out by the implausible structural conditions they require. The sectoral capital stocks would be characterized by a convergent spiral or monotone adjustment path depending on the typology of the economy. The former would emerge where the manufacturing and nontraded sectors are of closer level of development and share in the economy, that is, in the more developed oil-exporting countries. The latter would emerge in the less developed oil-exporting countries.

The agricultural output has the same adjustment characteristic as the capital stocks but changes in the opposite direction. Consequently, in a more developed oil-exporting country with a spiral adjustment path, the agricultural output expands at points during the transition period while it definitely contracts in the long run. In a less developed oil-exporting country with a monotone adjustment path, the agricultural output steadily decreases towards its post-boom steady state; the capital stock in the manufacturing and nontraded sectors steadily expand and labor is continually reallocated away from the agricultural sector.

The manufacturing and nontraded output each has the same adjustment characteristic as its respective capital stock. Consequently, in a more developed oil-exporting country, these sectors contract at points during the transition period while they definitely expand in the long run. In a less developed small exporter of oil, the manufacturing and nontraded sectors steadily expand towards their post-boom steady state level. In a less developed large exporter of oil, however, the manufacturing sector contracts steadily towards its post-boom steady state level, as evidenced by the experience of the oil-exporting countries in the 1970s. The analysis is symmetric with respect to the oil collapse of the mid 1980s; the sectoral adjustment path for the case of oil price decreases would be similar to those discussed here but in the opposite direction.

The significance of establishing the occurrence of an spiral adjustment path for the more developed oil-exporting countries is clear; in their case the short-run and long-run sectoral impact of an oil shock can differ and any policy based on the short-run output behavior would be misleading. Also, it should be noted that the model developed in this paper can be applied to any `small' open economy adjusting to external revenues and terms of trade shocks.

APPENDIX A

Equation (2) and the price magnification effects yields:

$$\hat{w} = \hat{r} = \hat{P}^M = \hat{P}^N. \qquad (A1)$$

Totally differentiating (3) and (6), using the above result, the Allen-Uzawa definition of the elasticity of substitution,[19] and the adding-up conditions on them,[20] yields:

$$\hat{Q}^A = -e^A \hat{P}^M. \qquad (A2)$$

Totally differentiating (9), (10), and (11) modified for the steady state--the return to capital is equalized across the sectors and net investment equals zero--keeping in mind that $\hat{K}^j = \hat{Q}^j$ *(j =M,N)* and the expenditure and output share of N are equal, and substituting for $\hat{Q}^A$ from (A2) and for uncompensated demand elasticities from Slutsky decomposition, yields:

$$L^M \hat{K}^M + L^N \hat{K}^N = L^A e^A \hat{P}^M, \qquad (A3)$$

$$[\psi^N(\phi^M - \delta\beta^M)].\hat{K}^M + [\psi^N(\phi^N - \delta\beta^N) - 1].\hat{K}^N =$$

$$[\bar{\epsilon}_A^N + \psi^N a_M + \psi^N \phi^A e^A].\hat{P}M - [\psi^N].dR/Y. \qquad (A4)$$

The steady state impact of the oil shock (boom) on the sectoral capital stock (and output) can be obtained by considering (A3) and (A4) simultaneously.

---

[19] $\sigma_{ij} = (CC_{ij})/(C_iC_j)$ where σ_{ij} is the elasticity of substitution between factors *i* and *j*, and *C* is the (minimized) unit cost.

[20] where

$$\theta_L^A \sigma_{TL}^A + \theta_T^A \sigma_{TT}^A = 0, \; \theta_L^M \sigma_{KL}^M + \theta_K^M \sigma_{KK}^M = 0, \; \theta_L^N \sigma_{KL}^N + \theta_K^N \sigma_{KK}^N = 0.$$

APPENDIX B

Totally differentiating the price-equal-to-unit-cost equations, keeping in mind that the domestic relative price (value-added) of the manufactured good is exogenously determined by small country assumption and is constant along the transition path, yields:

$$\theta_L^A.\hat{w} + \theta_T^A.\hat{v} = 0, \qquad (B1)$$

$$\theta_L^M.\hat{w} + \theta_K^M.\hat{r}^M = 0, \qquad (B2)$$

$$\theta_L^N.\hat{w} + \theta_K^N.\hat{r}^N = \hat{P}^N, \qquad (B3)$$

where θ_i is the share of factor i in the value of output in sector j ($j = A,M,N$), and $\hat{P}^A$ is zero by the choice of numeraire.

On the other hand, the changes in the `temporary' equilibrium wages and price of the nontraded good are determined endogenously from the requirements that all factors be fully employed and that the nontraded good market clear.

Consider factor (land and capital) markets. The changes in the output of each sector can be obtained in terms of the changes in (minimized) unit costs associated with production in that sector and of the changes in the capital stock in the manufacturing and nontraded sectors, by totally differentiating (5), (6) and (7), bearing in mind that the endowment of land is fixed:

$$\hat{Q}^A = -\hat{C}_2^A, \qquad (B4)$$

$$\hat{Q}^M = -\hat{C}_2^M + \hat{K}^M, \qquad (B5)$$

$$\hat{Q}^N = -\hat{C}_2^N + \hat{K}^N. \qquad (B6)$$

Using the Allen-Uzawa definition of partial elasticity of substitution between factors, the changes in the (minimized) unit costs in each sector in turn can be related to the changes in factor prices. Finally, substituting for the change in the return to capital and land from (B1), (B2) and (B3), and eliminating the own-partial elasticity of substitution between factors by using the adding-up condition on the partial elasticities, the changes in the (minimized) unit costs in the three sectors over time are related to the changes in the real wage in the respective sector:

$$\hat{C}_2^A = e^A . \hat{w}, \qquad (B7)$$

$$\hat{C}_2^M = e^M . \hat{w}, \qquad (B8)$$

$$\hat{C}_2^N = e^N . (\hat{w} - \hat{p}^N), \qquad (B9)$$

where e^j denotes the real (product) wage elasticity of supply in sector j.

Finally, the output changes along the transition path can be described in terms of the changes in the real wage in the respective sector and of the changes in the capital stock in the manufacturing and nontraded sectors, using (B4), (B5) and (B6), and substituting for the changes in the unit costs from (B7), (B8) and (B9):

$$\hat{Q}^A = -e^A . \hat{w}, \qquad (B10)$$

$$\hat{Q}^M = -e^M . \hat{w} + \hat{K}^M, \qquad (B11)$$

$$\hat{Q}^N = -e^N . (\hat{w} - \hat{P}^N) + \hat{K}^N. \qquad (B12)$$

Consider the labor market. Totally differentiating (8), then substituting for the changes in minimized unit costs from (B7), (B8) and (B9), for the changes in the return to capital and land from (B1), (B2) and (B3), and for the changes in the sectoral output from (B10), (B11) and (B12), the requirement that all factors be fully employed at `temporary' equilibria is expressed in the following reduced form:

$$\hat{w} = b^N . \hat{P}^N + (L^M/E) . \hat{K}^M + (L^N/E) . \hat{K}^N, \qquad (B13)$$

where b^N denotes the proportional contribution of the nontraded sector to the wage elasticity of the aggregate demand for labor *(E)*.

To summarize, an increase in the price of the nontraded good and in the capital stock in either the manufacturing or nontraded sector along the transition path increases the demand for labor leading to higher wages. Therefore, the change in wages is a weighted sum of the changes in the nontraded goods prices and capital stock in the manufacturing and nontraded sectors. The weight on the nontraded goods price is the proportional contribution of this sector to the wage elasticity of the aggregate demand for labor.

Consider the market for the nontraded good. Substituting for the uncompensated price elasticities from the Slutsky decomposition,[21] and for the change in national consumption

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[21]That is,

$$\epsilon_j^N = \bar{\epsilon}_j^N - \alpha_j \psi^N \ (j{=}A,M,N), \ where \ \bar{\epsilon}_A^N + \bar{\epsilon}_M^N + \bar{\epsilon}_N^N = 0.$$

expenditures using (11),[22] the requirement that the market for the nontraded goods clear at the `temporary' equilibria yields:

$$(\bar{\epsilon}_N^N + \psi^N e^N \phi^N - \psi^N \mu \phi^N - e^N).\hat{P}^N + (-\psi^N \phi^N e^N - \psi^N \phi^A e^A$$

$$-\psi^N e^M \phi^M + \psi^N \mu \phi^M \theta_L^M + \psi^N \mu \phi^N \theta_L^N + e^N).\hat{w} =$$

$$(-\psi^N \phi^M + \psi^N \beta^M).\hat{K}^M + (1 + \psi^N \beta^N - \psi^N \phi^N).\hat{K}^N, \qquad (B14)$$

where ϕ^j is the output of the respective sector as a percentage of national consumption expenditures (j = A,M,N), β^j is the (replacement) investment in sector j ($j = M,N$) as a percentage of (post-boom steady state) national consumption expenditures, $\bar{\epsilon}_N^N$ and ψ^N are the compensated own-price elasticity and the income elasticity of demand for the nontraded good,

and $\mu = (\dfrac{1}{\rho + \delta})$.

The impact of the changes in the capital stock in the manufacturing and nontraded goods sectors on the price of the nontraded goods and wages along the transition path, as determined by the equilibrium conditions that all factors be fully employed and that the market for the nontraded goods clear, may now be obtained from equations (B13) and (B14), considered simultaneously:

$$\hat{P}^N = (1/\theta_L^M).[(\theta_K^N \theta_L^M c - \theta_L^N \theta_K^M a).\hat{K}^M + (\theta_K^N \theta_L^M d - \theta_L^N \theta_K^M b).\hat{K}^N], \qquad (B15)$$

$$\hat{w} = (-\theta_K^M/\theta_L^M).(a\hat{K}^M + b\hat{K}^N), \qquad (B16)$$

where

$$a = [-\theta_L^M/(\theta_K^M AE)].[-L^M e^N(1-C_N) - L^M \mu C_N + L^M \bar{\epsilon}_N^N - b^N \psi^N E(\phi^M - \beta^M)] < 0,$$

$$b = [-L^N \theta_L^M/(\theta_K^M AE)].[(\sigma_{LK}^N \psi^N \beta^N)/\theta_K^N + \sigma_{LK}^N(1-C_N) + \bar{\epsilon}_N^N - \mu C_N]$$

$$c = [1/(\theta_K^N AE)].[-\psi^N E(1-\theta_L^N b^N)(\phi^M - \beta^M) + \psi^N L^M \phi^A e^A$$

---

[22]After substituting for the changes in sectoral output from (A10), (A11) and (A12), for the changes in capital stocks in the manufacturing and nontraded sectors from (1), and for the changes in return to capital in each sector from (A2) and (A3).

$$+\psi^{N}L^{M}\phi^{M}\theta_{L}^{M}(\sigma_{LK}^{M}-\mu\theta_{K}^{M})/\theta_{K}^{M}-\theta_{L}^{N}L^{M}\bar{\epsilon}_{N}^{N}-\theta_{L}^{N}L^{M}\sigma_{LK}^{N}(1-C_{N})]$$

$$d = [1/(\theta_{K}^{N}AE)].[E(1-C_{N})[1-\theta_{L}^{N}b^{N}(1+\theta_{K}^{N})]+\psi^{N}\beta^{N}E(1-\theta_{L}^{N}b^{N})$$

$$+\psi^{N}\phi^{A}e^{A}L^{N}+\psi^{N}L^{N}\phi^{M}\theta_{L}^{M}(\sigma_{LK}^{M}-\mu\theta_{K}^{M})/\theta_{K}^{M}-\theta_{L}^{N}L^{N}\bar{\epsilon}_{N}^{N}] < 0$$

and[23]

$$A = [-e^{N}(1-b^{N})(1-C_{N})+\bar{\epsilon}_{N}^{N}-\psi^{N}b^{N}e^{A}\phi^{A}$$

$$-\psi^{N}\phi^{N}\mu(1-\theta_{L}^{N}b^{N})-\psi^{N}b^{N}\phi^{M}(e^{M}-\mu\theta_{L}^{M})] < 0.$$

Equations (B15) and (B16) may in turn be used to derive the change in the actual return to capital in the manufacturing and nontraded sectors over time, in terms of the changes in the state variables (K^{M}, K^{N}), using (B2) and (B3). Also, by substituting in (B10), (B11) and (B12) for the changes in the price of the nontraded good and wages, using (B15) and (B16) we obtain the changes in the sectoral output along the transition path.

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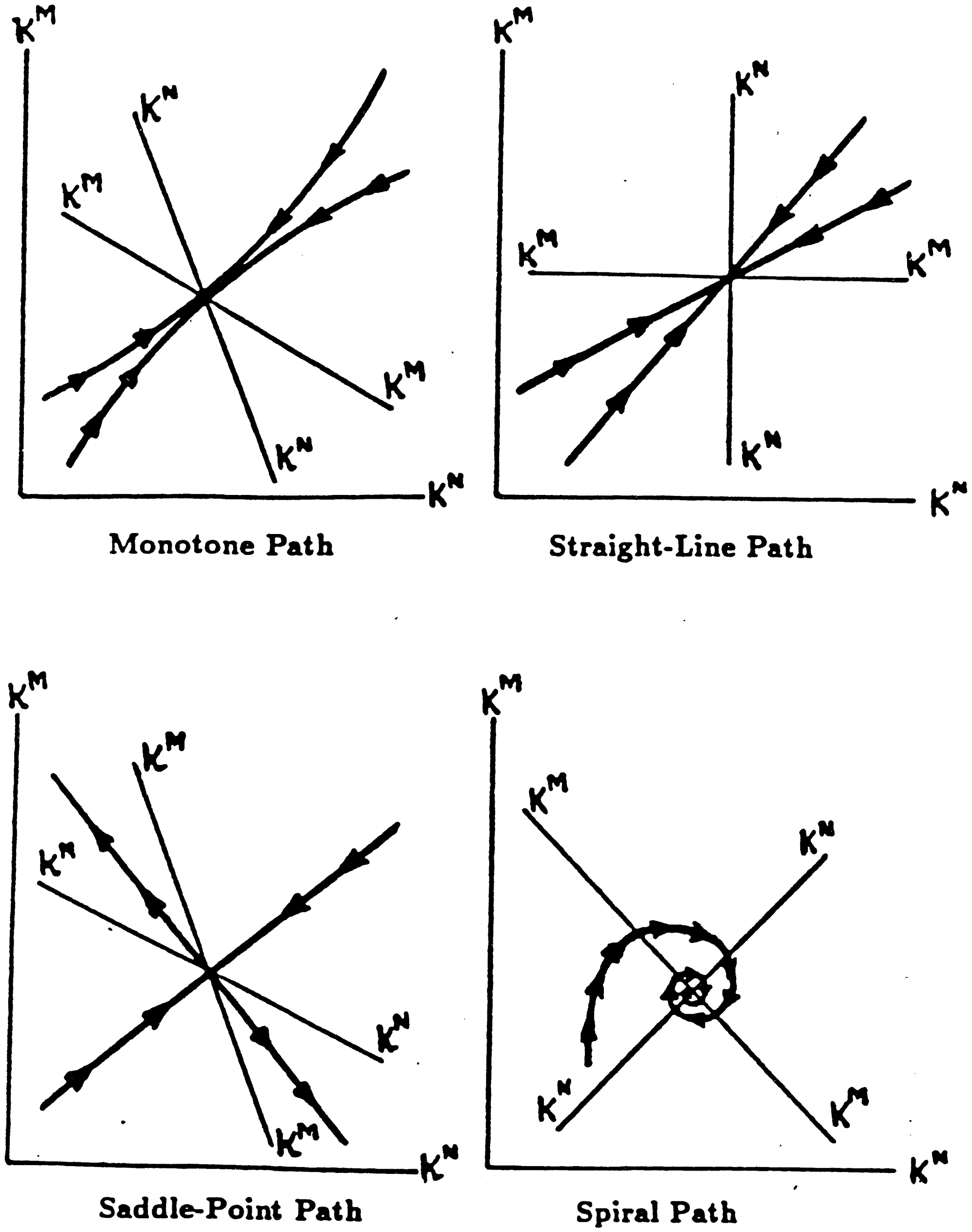
[23]The sufficient condition for $A < 0$ is:

$$\sigma_{LK}^{M} > \theta_{L}^{M}/(\rho+\delta)$$

Figure 1. The Dynamic Adjustment Path of the Sectoral Capital Stock



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