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A Trade Link Model between Sudan and the Kingdom of Saudi Arabia, 1963 - 1982

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Abstract. A trade link model connecting the economies of Sudan and Saudi Arabia is presented in this paper. The idea is to guage the degree of interdependence between the two neighboring economies. Two econometric models – one for each country – were constructed and coupled through appropriate trade variables. The resultant models were then simulated over alternative bilateral trade paths and the effects were traced through each economy. Results obtained confirm the conjecture of a growing dependence of the Sudan economy on that of Saudi Arabia. No significant dependence in the opposite direction was obtained. Consequently, the Sudan economy is being made increasingly vulnerable to favorable or unfavorable shocks affecting the Saudi economy. Policy measures designed to promote bilateral trade will strengthen the degree of dependence and serve to increase income and welfare in the two economies.

Introduction

The current study describes a prototype trade model linking Sudan to Saudi Arabia through trade flows covering the period 1963-1982. The prime motivation of the paper lies in the fact that Saudi Arabia has grown over the years to be the principal trade partner of the Sudan. Consequently, shocks occurring in the Saudi economy were readily transmitted to the economy of the Sudan. The transmission mechanism worked its way through the trade links, migration and capital movements. While migration and capital movements were largely unidirectional in character with migration from Sudan to Saudi Arabia and capital transfers in the opposite direction, the trade flows were somewhat bilateral in nature and working in both directions- thus increasing the dependency between the two countries. Hence, an analysis of the trade linkages existing between the two countries becomes imperative in order to understand the degree of interdependence existing between the two economies and for the exploration of the possibilities of trade expansions between the two neighboring countries.

Approaches to the study of trade linkages are varied. One approach relies on the study of trade shares whereas another uses formal econometric modelling for the construction and coupling of trade models at various world and regional levels. Examples at the world level are the various LINK models [1,2] whereas examples of regional trade models are the famous COMET and INTERPLAY models for the EEC [3,4], the PIDE and ESCAP models for some Asian countries [5] and other models for the Pacific region and Latin America.

Our work here is a scaled down version of these latter econometric efforts where we confine ourselves to the study of trade linkages between two countries only via their trade flows. No attempt was made to integrate capital and migration linkage because of some conceptual difficulties and data limitations. The model consists of two submodels each pertaining to one of the two countries. Each country submodel is built along the conventional Keynesian income identity lines and estimated via techniques of Two Stage Least Squares (2SLS). The two models are then simulated over alternative paths of trade link variables in order to elicit dynamic responses of some relevant endogenous variables to these 'exogenous' trade variations.

The first section of the paper reviews the development of trade relations between the two countries and considers the relative trade shares of each with respect to the other and with respect to other countries or other groupings of the world as well. Section two consists of the description of the structure of the Sudanese submodel. It reports and analyzes the results of the estimation phase on the model while section three discusses the Saudi submodel along lines similar to those of the Sudanese submodel. Section four then reports on the dynamic policy simulation experiments conducted on the models and reports their findings. A final section then concludes the study.

1. Trade between Sudan and the Kingdom of Saudi Arabia

Trade between Sudan and the Kingdom of Saudi Arabia is comparatively an ancient phenomenon. The proximity of the two countries to each other was a major factor in establishing trade relations in the past and the situation of Sudan along traditional pilgrim routes from west and central Africa to the Holy City of Makkah, only helped to strengthen these relations. However, the volume of trade between the two neighboring countries was small in magnitude and consisted primarily of commodities traded during the annual season of Hajj.

In recent times, both countries began to sustain sizable foreign trade sectors and a higher degree of openness with the advent of modernization in their respective

economies. A glance at Table A.1, appendix A would suggest that in the case of Sudan, the degree of openness of the economy as measured by the percentage ratios of exports and imports to the Gross Domestic Product were significant, though somewhat declining over the past two decades. In the case of Saudi Arabia, the dependence on foreign trade is much more pronounced with trade activities overwhelming other activities in the economy. This marked dependence of the Saudi economy on foreign trade is a comparatively recent phenomenon occurring particularly in the last two decades with the oil boom. Consequently, Saudi trade began to evolve in absolute volume and magnitude with the rest of the world and its economy became increasingly open to outside influences.

Trade between Sudan and Saudi Arabia then began to increase due to the emergence of Saudi Arabia as a major trade market both at the world and regional scales. This was further strengthened by the physical presence of a large number of Sudanese nationals working in the Kingdom and importing a significant proportion of commodities to their country of origin from Saudi Arabia because of availability and the relatively low transport costs incurred in due process. Indeed, for the Sudan there was a marked evolution resulting in a change of structure in its trade relations, with traditional trade partners receding in their shares and with the Kingdom overtaking them as a major trading partner over a very short period of time.

This could be seen quite easily with reference to Table A.2 of appendix A. Saudi Arabia was importing only 6.1% of Sudan's exports in the year 1976 but surpassed the block of EEC countries by the year 1982 and assumed for the first time ever the role of the principal importer of Sudan's exports with a percent contribution of 36.7% as compared to the EEC block's contribution of 25.8% in the same year. Even before that particular year, 1982, Saudi Arabia was the principal importer of some of Sudan's main individual export items like Durra (sorghum), sesame and livestock.

On the other hand, Saudi Arabia emerged as the second major exporter to Sudan, superceded only by the EEC block. On individual country basis, Saudi Arabia was the principal exporter to Sudan bypassing some traditional exporters to the Sudanese market like the USA, Japan and Egypt. Saudi's share in Sudan's imports market increased dramatically from 1% in 1978 to almost 15% in 1986. Imports of Sudan from the Kingdom were mostly Oil and its products- mainly fuel- plus transport equipments being mostly re-exports from Saudi Arabia to Sudan.

As with reference to the Saudi side of the picture, it could be seen from Table A.3 that the industrialized countries were always the major importers from Saudi Arabia. Their share in the total Saudi export sector ranged from 60.4% in 1976 to

75.3% in 1980 with crude and refined petroleum products comprising more than 90% of Saudi exports over the period. Of this group, we find that Japan was always the major individual importing country from Saudi Arabia. On the other hand, Saudi exports to Sudan have always constituted a very low share of their total exports; their proportion ranging from a small 0.02% to 0.3% over the period. Saudi exports to Sudan consisted predominantly of Oil and re-exports.

Imports of Saudi Arabia, which were mostly manufactured goods plus food products, also reflected a similar pattern and trend. The industrialized countries contributed a rising share ranging from 57.7% in 1974 to 80.6% in 1982. Of this, the USA was consistently the major exporter to Saudi Arabia followed closely by Japan. On the other side of the road, Sudan exports to the Kingdom were always low with a contribution of 0.2% to 2% to the Saudi imports market during the 1972-1982 period, happening with some fluctuations in relative share.

2. The Econometric Model of Sudan

2.1. Specification of the Model

The econometric model, used to represent the Sudanese economy, assumes the following structural form:

1. $C_1 = \alpha_{11} + \alpha_{12} Y_1 + \alpha_{13} C_{1,-1}$

2. $I_1 = \beta_{11} + \beta_{12} Y_1$

3. $G_1 = \gamma_{11} + \gamma_{12} GR_1$

4. $M_1^d = \delta_{11} + \delta_{12} Y_1 + \delta_{13} M_{1,-1}^d$

5. $\dot{P}_1 = \theta_{11} + \theta_{12} Y_1 + \theta_{13} (M_{12}/Y_1) + \theta_{14} \dot{P}_{1,-1}$

6. $X_{1ROW} = \omega_{11} + \omega_{12} YW + \omega_{13} (EXUV_1/P_1)$

7. $M_{12} = \eta_{11} + \eta_{12} Y_1 + \eta_{13} SRLS + \eta_{14} D + \eta_{15} (D * Y_1)$

8. $M_{1ROW} = \phi_{11} + \phi_{12} Y_2 + \phi_{13} TT_1$

9. $Y_1 = C_1 + I_1 + G_1 + X_1 - M_1$

10. $M_1 = M_{12} + M_{1ROW}$

11. $X_1 = X_{12} + X_{1ROW}$

12. $X_{1ROW} = M_{ROW1}$

Where the first subscript 1 attached to the parameters and the variables above refers to country 1 which is Sudan in this case and where the endogenous variables of the first submodel are:

C_1	Sudan's private consumption expenditures
I_1	Sudan's gross fixed capital formation
G_1	Sudan's public consumption expenditures
M_1^d	Sudan's money demand
P_1	Sudan's consumer price index
X_{1ROW}	Sudan's exports to the rest of the world
M_{12}	Sudan's imports from Saudi Arabia
M_{1ROW}	Sudan's imports from the rest of the world
Y_1	Sudan's GDP

And the predetermined variables of the model are:

$C_{1,-1}$	Lagged Sudan's private consumption
GR_1	Sudan's government revenue
$M_{1,-1}^d$	Lagged Sudan's money demand
$\dot{P}_{1,-1}$	Lagged Sudan's inflation
YW	World income
$EXUV_1$	Export unit value index of the Sudan
TT_1	Terms of trade of the Sudan
D	Dummy variable with the value of zero upto 1973 and one thereafter.

Also, the following variables appear in the model:

M_1	Total Sudan's imports

X_1 Total Sudan's exports

M_{21} Saudi Arabia's imports from Sudan

M_{ROW1} Rest of the world's imports from Sudan

As such the model consists of 12 structural equations of which 8 are behavioral and the rest are identities. The behavioral equations describe private consumption, investment, public consumption, money demand, prices and foreign trade flows. Equation 1 is a version of the conventional consumption function where real consumption C_1 is affected by current real income Y_1[(1)] and lagged consumption levels $C_{1,-1}$ which are intended to capture the effects of habit persistence and inertia. Equation 2 describes the behavior of investment in terms of current income whereas in equation 3 government consumption G_1 is treated as a function of government revenue GR_1. Equation 4 then specifies a money demand function where real money balances M_1^d depends on current real income Y_1 and lagged monies $M^d_{1,-1}$. Inflation is explained in equation 5 of the system where present inflation $\dot{P}_1$ depends on income levels Y_1 designed to capture pressure of demand effects, a degree of openness variables M_{12}/Y_1 relating to transmissions from Saudi Arabia *via* trade and lagged inflations $\dot{P}_{1,-1}$ to account for expectations formations. Also, money balances and the rate of interest variables were experimented with in order to capture the monetary aspects and the costs of credit acquisitions but both variables were insignificant and hence were dropped from the final specifications.

Equations 6-8 represent the foreign trade block where Sudan's exports to the rest of the world are a function of the world income YW and the ratio of prices $EXUV_1/P_1$. On the imports side equation 7 describes the relationship of Sudan's imports from Saudi Arabia M_{12} to its income Y_1, the exchange rate SRLS plus a dummy variable to account for possible structural shifts in trade during the oil boom era. Sudan's imports function from Saudi Arabia provides the linkage of the Sudan's model to that of Saudi Arabia. The last behavioral equation 8 describes in a similar fashion the process of the determination of Sudan's imports from the rest of the world M_{1ROW} which are held to depend on domestic income Y_1 and the terms of trade TT_1.

The next block of equations 9-12 contains some definitional identities of the model with the income identity in equation 9 denoting the process of 'domestic absorption'. Trade identities 10 and 11 represent Sudan's imports M_1 and exports X_1 as the sum of his trade with Saudi Arabia and his trade with the rest of the world.

(1) For lack of consistent data on disposable income in Sudan, we used the Gross Domestic Product (GDP) as an arguement in the estimated equations.

Equation 12 then is an *ex post* identity which states that Sudan's exports to the rest of the world X_{1ROW} are the rest of the world's imports from Sudan M_{ROW1}. These identities are of particular interest and use in the complete LINK model since they will provide one coupling mechanism between the model for Sudan and that for Saudi Arabia. Note that identities 10-12 are substituted in the model prior to the estimation phase.

2.2. The Estimated Model

Data covering the period 1963-1982 were obtained and used to estimate the parameters of the above model. Data prior to 1963 were not available in the case of Saudi Arabia whereas data past 1982 were not available in the case of Sudan. All the variables in the behavioral equations portion of the model were used in logarithmic form since various trials and comparisons with alternative linear forms proved the superiority of the double logarithmic specifications. The combination of logarithmic behavioral equations and linear accounting identities presents a source of essential variable nonlinearity in the endogenous variables of the model and hence in the model at large. Most of the variables were also converted into real terms by use of suitable deflators. A form of the 2SLS estimation method which corrects for autocorrelations via a Cochrane-Orcutt method was used to estimate the parameters of the model.(2). Various trials were made and the following reported model was selected as best according to the various Statistical and Economic criteria employed:

$$\begin{array}{llllll} 1) & \ln C_1 = & -1.546 & +0.683 \ln Y_1 & +0.492 \ln C_{1,-1} & \\ & & (-2.031) & (3.994) & (3.746) & \\ & & & & \bar{R}^2 = 0.912 & \\ & & & & \hat{\sigma} = 0.074 & \\ & & & & F = 99.764 & \\ & & & & d = 1.933 & \end{array}$$

$$\begin{array}{llll} 2) & \ln I_1 = & -4.728 & +1.271 \ln Y_1 \\ & & (-1.259) & (2.765) \\ & & & \bar{R}^2 = 0.584 \\ & & & \hat{\sigma} = 0.208 \end{array}$$

(2) The two models were estimated separately by 2SLS. A more efficient procedure would have been to stack the two models together and then to estimate them jointly by a suitable full information method. But, because of the data limitations and the subsequent degrees of freedom problems that might ensue if that path was followed, we were forced to rely on single equation 2SLS methods despite their relative inefficiency.

$F = 26.265$
$d = 1.883$
$\hat{\rho} = 0.440$
(2.134)

3) $\ln G_1 = \underset{(-0.452)}{-0.750} + \underset{(4.180)}{1.100} \ln GR_1$

$\bar{R}^2 = 0.464$
$\hat{\sigma} = 0.208$
$F = 17.471$
$d = 0.564$

4) $\ln M_1^d = \underset{(-1.421)}{-2.317} + \underset{(1.613)}{0.456} \ln Y_1 + \underset{(6.527)}{0.799} \ln M_{1,-1}^d$

$\bar{R}^2 = 0.942$
$\hat{\sigma} = 0.104$
$F = 155.388$
$d = 1.987$

5) $\ln \dot{P}_1 = \underset{(3.920)}{4.337} + 0.331 \ln Y_1 + \underset{(2.507)}{0.034} \ln (M_{12}/Y_1) + \underset{(3.813)}{-0.470} \ln \dot{P}_{1,-1}$
(-1971)

$\bar{R}^2 = 0.533$
$\hat{\sigma} = 0.073$
$F = 7.455$
$d = 2.150$
$\hat{\rho}_1 = 0.237$
$\hat{\rho}_2 = -0.311$

6) $\ln X_{1ROW} = \underset{(-4.333)}{-12.432} + \underset{(7.686)}{1.726} \ln YW + \underset{(2.703)}{0.582} \ln (EXUV_1/P_1)$

$\bar{R}^2 = 0.800$
$\hat{\sigma} = 0.175$
$F = 39.076$
$d = 1.443$

7) $\ln M_{12} = \underset{(2.516)}{61.612} \quad \underset{(-1.947)}{-5.842} \quad \underset{(-5.245)}{\ln Y_1 - 6.397} \quad \ln SRLS$

$\underset{(1.203)}{+7.874} \quad D^*\ln Y_1 \underset{-(1.161)}{-62.760} \quad D$

$\bar{R}_2 = 0.750$

$\hat{\sigma} = 1.344$

$F = 14.465$

$d = 2.089$

$\hat{\rho} = -0.309$ (1.415)

8) $\ln M_{1ROW} = \underset{(-4.898)}{-22.074} \quad \underset{(1.542)}{+1.297} \quad \underset{(5.298)}{\ln Y + 3.907} \quad \ln TT_1$

$\bar{R}^2 = 0.887$

$\hat{\sigma} = 0.369$

$F = 75.455$

$d = 1.169$

9) $Y_1 = C_1 + I_1 + G_1 + X_{12} + X_{1ROW} - M_{12} - M_{1ROW}$

where the t-ratios are listed in parenthesis below the estimated coefficients, $\bar{R}^2$ are the adjusted coefficients of determination, $\hat{\sigma}$ are the standard errors of the estimated equations, F the test statistics used to gauge overall model performance, d are the Durbin-Watson coefficients for autocorrelations and the $\hat{\rho}$s are the autocorrelation coefficients.

The first equation reported shows that real private consumption depends significantly on real income and lagged consumption. The overall fit of the equation was good and there was no evidence of a problem of autocorrelation. The short run income elasticity measure of consumption was 0.683 whereas its long run counterpart was 1.344. Consumption proved to have an inelastic response in the face of real income variations in the short run but the response turned out to be elastic in the long run.

In the investment equation initially many alternative specifications were tried but the overall picture remained somewhat the same. There was no evidence of accelerator mechanisms and the rate of interest variable used consistently had a wrong sign. A domestic credit variable was also insignificant in various trials. Hence

we opted for using the simplest specification tried which involved using income as the only determinant of investment in Sudan. The statistical fit was acceptable and the Y_1 variable was significant.

In the third equation of the model, Government consumption was revenue elastic with an elasticity coefficient of magnitude 1.100. statistically, the equation reflected a rather poor fit and a possibility of autocorrelated disturbances. However, alternative specifications tried on this equation did not fare much better in terms of statistical fit and economic plausability and hence we contended ourselves with reporting the results of the above simple specification.

The fourth equation contained the estimated demand for money function where income and lagged money were statistically significant and played a predominant role in explaining money variations. In other trials the interest rate coefficient possessed a wrong positive sign and was statistically nonsignificant at the 5% level. Similarly, the lagged price variable was nonsignificant and possessed a negative sign and hence both of these variables were subsequently discarded from the preferred specification. The generated income elasticity of demand was 0.456 in the short run and 2.269 in the long run. Such a low elasticity measure may imply that the 'room' for non-inflationary monetary expansion in Sudan may have been exhausted in the short run.

The prices equation was estimated subject to the presence of 2nd order autocorrelation. Its overall statistical fit was good and the coefficients were statistically significant. Real income- the 'demand-pull' variable- had a significant positive relationship with inflation. Also, lagged inflation- a variable which reflects an expected inflation mechanism- played a statistically significant negative role in explaining current inflation where it should be noted that during the sample period the inflation rate was moderate and fluctuating. An increase in the rate of inflation may have tended to fuel expectations about intervention policies designed to depress the inflation rate. The imported component of inflation variables proved to be a significant determinant of domestic inflation. The M_{12}/Y_1 variable- which accounted for the transmission of inflation from Saudi Arabia to Sudan via imports was positive and significant indicating that the inflation rate tended to increase with the degree of openness towards Saudi Arabia. Sudan's inflation rate was thus positively responsive to inflationary pressures generated via trade flows with Saudi Arabia. Most of this trade was in the form of re-exports of capital and luxury goods. These categories of goods normally possess an initial heavy component of imported inflation from their original countries of birth- mainly the West and Japan. Added to this, an own inflationary compo-

nent of Saudi Arabia plus a profit margin for the Saudi market and the result is a much larger imported inflation for the Sudan.

As for the trade block, the export function to the rest of the world yielded an elastic export demand with respect to the world's income- the elasticity coefficient being of magnitude 1.726. On the other hand, the estimated import functions, the first one-being for the imports of Sudan from Saudi Arabia- proved acceptable with an $\bar{R}^2$ equal to 0.750 indicating a statisfactory fit. Sudan's real income was an insignificant- though of correct positive value and elastic magnitude-determinant of his imports from Saudi Arabia. The predominant factor affecting these imports in this formulation was the exchange rate between the two countries as measured by the variable SRLS. As expected the lower the exchange rate, the higher the imports and vice versa. Other variables which could affect the level of this demand could have been the number (and remittances) of Sudanese working in Saudi Arabia which tend to particularly affect the volume of re-exports from Saudi Arabia to Sudan. However, reliable data on this variable were not available to us and we were more concerned with trade linkages than flows of funds types of linkages.

The last behavioral equation in the model was the imports from the rest of the world function. The equation was good in terms of statistical fit and the coefficients yielded correct signs and elastic magnitudes. Sudan's imports from the rest of the world thus proved to be driven by the Y_1 measure in this formulation and reflected a high elasticity of income demand to the rest of the world imports index, being of 1.297 value and to the terms of the trade with an elasticity index of magnitude 3.907.

The income equation needed to close the model warrants some discussion at this stage. The usual income identity would be linear in form in contrast to the structure of the model itself which was nonlinear. Explicit multipliers cannot be computed from the reduced form of the model in the conventional way but have to be simulated in the manner of Johnson and Klein [6], Kmenta and Smith [7], Friedman [8,9] and Pindyck and Rubinfeld [10]. An alternative way is to use a simple dynamical growth mechanism on income to complete the model. However, the resultant multiplier and simulation matrices obtained through such an approach tend to be sparse in nature and hence offer no interesting results.

To further verify the performance of the model, *ex post* 'historical' simulations were conducted with the model and compared to the original series of the various endogenous variables. Results of these simulations are summarized in Table 1.

Table 1. The Sudan model: Results of the historical simulations: original variables 1963-1982.

	RMSE	MAE	ME	TIC	R	β
C_1	621.503	498.478	484.985	0.118	0.835	1.288
I_1	105.558	79.431	60.327	0.186	0.618	1.348
G_1	84.973	66.099	25.800	0.079	0.512	0.483
M^d_1	267.519	209.409	209.409	0.159	0.943	1.585
P_1	9.020	7.606	4.238	0.040	0.699	1.080
X_{1ROW}	66.966	48.979	2.870	0.086	0.862	1.262
M_{12}	120.201	47.713	−2.774	0.494	0.568	0.323
M_{1ROW}	479.716	405.499	405.499	0.379	0.906	1.671
Y_1	659.303	551.656	551.656	0.097	0.796	0.950

where RMSE denotes Root Mean Square Error, MAE denotes Mean Absolute Error, ME denotes Mean (tracking) Error, TIC is the Theil Inequality Coefficient used to describe the simulation tracking performance of the individual equations, R is the correlation coefficient between actual and simulated and β is the regression coefficient of the actual on simulated.

The RMSE was always greater than the MAE and the ME was always less than the MAE. However, the ME was of the same magnitude as the MAE in the M^d_1, M_{1ROW} and the Y_1 series. The Theil Inequality Coefficient was also comparatively high for the M_{12} and the M_{1ROW} series reflecting a somewhat reduced performance of these simulated equations but they remained better as compared to a 'naive' no change model. This is further substantiated by the low R and β values indicating a somewhat relatively poor relationship between the actual and the simulated M_{12} series[3]. Despite the indications that imports from Saudi Arabia equation tended to perform relatively badly in tracking the original values of its variable as compared to other equations in the model, we note that its performance remained within acceptable bounds overall and hence we elected to keep it in its present form for future simulations on the model.

Overall, then, the model tended to reproduce the time paths for most of the endogenous variables in a reasonable fashion.

[3] There is also some evidence on a tendency to underestimate in the case of the M_{12} variable and to overestimate in the case of the Y_1 variable.

3. The Econometric Model of Saudi Arabia

3.1. The Specification of the Model

Except in some instances, the econometric model of Saudi Arabia resembles that of Sudan. It consists of 13 structural equations of which 8 are behavioral and the rest are identities. The behavioral equations describe private consumption, private investment, public expenditure, money demand, prices and the foreign trade sector. The functional form of the model is as follows:

1. $C_2 = \alpha_{21} + \alpha_{22} Y_2 + \alpha_{23} C_{2,-1}$
2. $I_2 = \beta_{21} + \beta_{22} Y_2 + \beta_{23} r + \beta_{24} GCR_2$
3. $G_2 = \gamma_{21} + \gamma_{22} Y_2 + \gamma_{23} OR_2 + \gamma_{24} OR_{2,-1}$
4. $M^d_2 = \delta_{21} + \delta_{22} Y_2 + \delta_{23} r + \delta_{24} M^d_{2,-1}$
5. $\dot{P}_2 = \theta_{21} + \theta_{22} G_2 + \theta_{23} \dot{PW} + \theta_{24} \dot{P}_{2,-1} + \theta_{25} \dot{P}_{2,-2}$
6. $X_{2ROW} = \omega_{21} + \omega_{22} YW + \omega_{23} EXUV_2$
7. $M_{21} = \eta_{21} + \eta_{22} Y_2 + \eta_{23} LSSR$
8. $M_{2ROW} = \phi_{21} + \phi_{22} Y_2$
9. $Y_2 = C_2 + I_2 + G_2 + X_2 - M_2$
10. $X_2 = X_{2i} + X_{2ROW}$
11. $M_2 = M_{21} + M_{2ROW}$
12. $M_{21} = X_{12}$
13. $X_{2ROW} = M_{ROW2}$

where the subscript 2 on parameters and variables indicates country 2 which is Saudi Arabia and where the endogenous variables are:

C_2	Saudi private consumption
I_2	Saudi private investment
G_2	Saudi government expenditure
M^d_2	Saudi money demand
$\dot{P}_2$	Saudi inflation rate

X_{21}	Saudi exports to Sudan
X_{2ROW}	Saudi exports to the rest of the world
M_{21}	Saudi imports from Sudan
M_{2ROW}	Saudi imports from the rest of the world
Y_2	Gross domestic product of Saudi Arabia

where as the predetermined variables are:

r	the rate of interest
LSSR	the exchange rate of Saudi Riyals per Sudanese pounds
$\dot{P}_{2,-1}$	Saudi one-period lagged inflation
$\dot{P}_{2,-2}$	Saudi two period lagged inflation
OR_2	Saudi oil revenue
$OR_{2,-1}$	Saudi lagged oil revenue
$C_{2,-1}$	Saudi lagged private consumption
GCR_2	Saudi government interest free credit to private investment
$\dot{PW}$	World inflation
$EXUV_2$	Export unit value index of Saudi Arabia
X_2	total Saudi exports
M_2	total Saudi imports

Again, equation 1 is the conventional consumption function where real consumption is held to be affected by current income and lagged consumption. Equation 2 is the investment equation which describes Saudi investment as a function of income, the interest rate and the government interest free credit granted to private investment. Equation 3, then, is the government expenditure function which describes government expenditure as a function of income, oil revenue and lagged oil revenues. Equation 4 is the demand for money equation where the demand for money is seen to be a function of real income, the rate of interest and lagged money demand. Equation 5 specifies the inflation function where different factors are thought to contribute to inflation in Saudi Arabia. These variables are government expenditure reflecting demand-pull causes, foreign inflation and lagged domestic inflations.

Equations 6-8, then, constitute the foreign trade equations. Equation 6 is Saudi Arabia's exports to the rest of the world where Saudi exports to the rest of the world are held to depend on world income and the Saudi Arabian export unit value index. Equation 7 represents Saudi imports from Sudan which are determined by the growth of income and the exchange rate of the Sudanese pound in terms of the Saudi Riyal.

Finally, equation 8 shows Saudi imports from the rest of the world as dependent on Saudi income where other tried variables like world inflation were insignificant in previous trials and hence were suppressed from the specification. A set of identities then follows to complete and close the Saudi model including the income identity 9 and the trade identities 10-13.

2.3. The Estimated Saudi Model

The form of 2SLS which corrects for autocorrelation was used again to estimate the parameters of the model. The following reported form was selected as best according to the various statistical and economic criteria which were employed to gauge its adequacy:

1. $\ln C_2 = \underset{(-.838)}{-0.171} + \underset{(1.402)}{0.142}\ \ln Y_2 + \underset{(7.323)}{0.888}\ \ln C_{2,-1}$

$$\bar{R}_2 = 0.967$$
$$\hat{\sigma} = 0.151$$
$$F = 210.651$$
$$d = 1.881$$

2. $\ln I_2 = \underset{(3.235)}{2.484} + \underset{(1.381)}{0.228}\ \ln Y_2 \underset{(-1.429)}{-\ 0.236}\ \ln r + \underset{(5.892)}{0.336}\ \ln GCR_2$

$$\bar{R}_2 = 0.972$$
$$\hat{\sigma} = 0.156$$
$$F = 187.197$$
$$d = 1.615$$
$$\hat{\rho} = \underset{(4.169)}{0.732}$$

3. $\ln G_2 = \underset{(-2.995)}{-3.023} - \underset{(4.006)}{0.582}\ \ln Y_2 + \underset{(1.955)}{0.297}\ \ln OR_2 + \underset{(3.518)}{0.520}\ \ln OR_{2,-1}$

$$\bar{R}_2 = 0.928$$
$$\hat{\sigma} = 0.154$$
$$F = 70.229$$
$$d = 1.240$$
$$\hat{\rho} = 0.874 \quad (8.560)$$

4. $\ln M_2^d = 4.205 + 0.156 \ln Y_2 - 0.207 \ln r + 0.951 \ln M_{2,-1}^d$
(0.421) (4.128) (−5.701) (24.983)

$$\bar{R}_2 = 0.993$$
$$\hat{\sigma} = 0.047$$
$$F = 775.157$$
$$d = 2.260$$
$$\hat{\rho} = -0.415 \quad (1.634)$$

5. $\ln \dot{P}_2 = 0.304 - 0.186 \ln G_2 + 0.424 \ln \dot{PW} + 0.980 \ln \dot{P}_{2,-1} - 0.307 \ln \dot{P}_{2,-2}$
(0.428) (−3.526) (3.501) (5.473) (-1.610)

$$\bar{R}_2 = 0.794$$
$$\hat{\sigma} = 0.044$$
$$F = 16.428$$
$$d = 2.595$$

6. $\ln X_{2ROW} = -15.815 + 2.450 \ln YW - 0.231 \ln EXUV_2$
(-3.021) (3.973) (-2.149)

$$\bar{R}_2 = 0.782$$
$$\hat{\sigma} = 0.123$$
$$F = 29.764$$
$$d = 1.695$$
$$\hat{\rho} = 0.547 \quad (2.627)$$

7. $\ln M_{21} = 4.753 - 0.345 \ln Y_2 + 2.468 \ln LSSR$
(2.123) (-1.553) (4.265)

$$\bar{R}_2 = 0.683$$
$$\hat{\sigma} = 0.392$$
$$F = 18.253$$
$$d = 1.503$$

8. $$\ln M_{2ROW} = \underset{(0.473)}{0.610} + \underset{(2.057)}{0.526} \ln Y_2$$

$$\bar{R}_2 = 0.867$$
$$\hat{\sigma} = 0.273$$
$$F = 105.670$$
$$d = 1.073$$
$$\hat{\rho} = 0.925 \quad (12.118)$$

9. $$Y_2 = C_2 + I_2 + G_2 + X_{21} + X_{2ROW} - M_{21} - M_{2ROW}$$

where the usual test statistics attached to the estimated equations are as defined above.

To examine the reported results, we notice that in the first equation real private consumption exhibited the expected pattern of response to both the real income and lagged consumption variables. An inflation rate variable which was introduced in the specification to account for the effect of uncertainty and transmission mechanisms on consumption was not significant in explaining the variations in real consumption as judged by the accompanying t-ratio; hence, it was dropped from the equation. The overall fit of the equation was good and there was no evidence of autocorrelation. The short run income elasticity measure of consumption was 0.142 and its long run income counterpart was 1.268. The last measure indicates that private consumption have a long run elastic response to variations in income.

Also, in equation 2, investment in Saudi Arabia reflected correct and generally plausible responses to its determinants: income, the rate of interest and the government interest free credit granted to the private sector variables. The overall fit of the equation was also good as judged by the relevant $\bar{R}^2$ statistic. The DW statistic, however, was a relatively low 1.615, but was still successful in rejecting the null hypothesis of positive autocorrelation at a 5% level of significance. It is of interest to notice that the rate of interest turned out to have some weight in explaining investment variations in Saudi Arabia in spite of the strong religious attitude against its use.

In equation 3, the government expenditure equation, all variables included in the specification were significant. However, while the theory of the demand for pub-

lic expenditure expected an elastic response of the government expenditure variable to income, the short run elasticity of G to Y was 0.582. As a special case for an oil producing nation, we introduced the oil revenue variable as a determinant of government expenditures. This variable proved to be significant in explaining variations in government expenditures. The short run elasticity of government expenditure with respect to oil revenue was 0.297 and its long run elasticity was 0.817.

In equation 4, the demand for money equation, all variables included in the equation were significant. The short run elasticity of income was a low 0.156 and its long run counterpart was 3.184. Also, of some interest, the rate of interest turned out to be significant in determining variations in money demand possessing an elasticity coefficient of magnitude 0.207 in the short run and of magnitude 4.224 in the long run.

The inflation rate equation 5 initially presented us with some problems. Different variables were tried to capture the effect of demand-pull factors. These variables included income, government expenditure and money supply. Only the government expenditure variable proved to be significant; however, the coefficient on this variable turned out to be negative. This may be explained by the effort made by the Saudi government to increase the productivity of all sectors during the inflationary period of 1973-1982 through direct investment and heavy subsidies which helped to a large extent in curbing inflation. Also, the elasticity of domestic inflation with respect to foreign inflation $\dot{P}W$ was low, being 0.424 in magnitude, in spite of the openness of the Saudi economy to the world through the foreign trade sector.

In equation 6, the export of Saudi Arabia to the Rest of the World equation, both variables included in the equation as determinants were significant and of correct signs and magnitudes. Saudi exports as expected a priori were positively related to the world income. As a matter of fact, the elasticity of Saudi exports with respect to world income was very high being 2.450, indicating a somewhat large relative response of Saudi exports, which consisted up till 1982 mainly of Oil, to growth in world demand. The Saudi export unit value index was also significant in explaining the variations in Saudi exports to the rest of the world. However, the elasticity of the Saudi exports to this index was only 0.231 in absolute value.

Imports from Sudan, in equation 7, were sensitive to variations in the Saudi income and in the exchange rate between the Saudi Riyal and the Sudanese Pound. However, the coefficient of income turned out to be negative. This may be explained by the fact that the increase in Saudi income during the boom era of 1973-1982 made the Saudis turn away of some traditional trade markets towards other western markets often with 'income' superior goods and services.

Lastly, equation 8 explains the imports of Saudi Arabia from the rest of the world. One variable dominates the others in explaining the variations in the imports of Saudi Arabia from the rest of the world. That variable was the Saudi Arabian income variable. Originally, we tried to include world inflation alongside the income variable but that variable turned out to be statistically nonsignificant in our runs. In fact, during the period 1973-1982, which was the boom era, Saudi imports from the rest of the world of all categories of capital and consumer goods were increasing at a high rate in spite of rising world inflation.

To verify the performance of the Saudi model, *ex post* 'historical' simulations were conducted and compared to the original series of the various endogenous variables present in the model. The results of these simulations are summarized in Table 2 below:

Table 2. The Saudi Model: Results of the historical simulations: original variables 1963-1982.

	RMSE	MAE	ME	TIC	T β
C_2	5.127	3.254	0.164	0.023	0.9550.977
I_2	0.136	0.112	-0.005	0.002	0.9941.046
G_2	6.652	4.792	2.507	0.008	0.9890.994
M_2^d	1.458	0.850	0.057	0.002	0.9981.006
P_2	4.284	3.513	0.080	0.002	0.8421.019
X_{2ROW}	29.932	23.717	1.590	0.014	0.8960.964
M_{21}	0.068	0.037	-0.007	0.194	0.8570.668
M_{2ROW}	8.157	5.235	3.633	0.039	0.9731.125
Y_2	178.705	164.880	-164.880	0.597	0.9361.278

As can be seen from the table, all statistics indicate a very good fit of the predicted to the actual. The margin of error as measured by TIC is very low in most of the cases, indicating that the estimated equations predicted economic reality extremely well. The value of TIC ranges from less than one percent in some instances to about 12 percent in others. Also, the rest of the accompanying statistics, with the relative exception of those for the income variable, reflected the same good fit of predicted to actual values.

A trade elasticity matrix was then derived from the foreign trade block of the above estimated models and presented in Table 3.

Table 3. The trade elasticity matrix.

	Sudan	KSA	ROW
Sudan	–	0.440	1.726
KSA	2.032[4]	–	2.450
ROW	1.297	0.953	–

where KSA is the Kingdom of Saudi Arabia and ROW is the Rest of the World. Read vertically, the entry 2.032 in the matrix for example, would show the effect of a one-percent increase in Sudan's income on imports from Saudi Arabia. Read horizontally, the entry 1.726 in the matrix for example, would show the effect of a one-percent increase in ROW's income on exports from Sudan. Thus, the income elasticities obtained are of correct signs and reasonable magnitude. High income elasticities of trade were experienced in the case of Sudan's imports from Saudi Arabia and the Rest of the World. In the other direction Saudi Arabia's, trade with Sudan proved to be inelastic. The Saudi Arabian market is a highly competitive market for the Sudanese commodities. In addition to this factor, Saudi Arabia has generally followed a successful import-substitution policies for the kind of commodities traded with Sudan which are largely agricultural and livestock in nature. Other practical considerations, like the reliability of the import market, may have also contributed in this 'performance' of trade with other parts of the world.

4. Dynamic Policy Simulations

The next step consisted of subjecting the models to shocks on certain selected exogenous variables and assessing the deviations of the disturbed solutions from the undisturbed ones. This enables us to examine the impact of autonomous changes in exogenous variables on the time paths of selected endogenous variables and hence the derivation of implicit dynamic elasticities and multipliers. Ideally, this procedure would allow us to calculate the response of a shock in one country on the economy of the other.

4.1. Simulations of the Sudan Model

The simulations undertaken and reported on the Sudan model were the result of certain shocks affected on the Sudan-Saudi Arabia trade variables- in particular the X_{12} variable. Other simulations were also conducted to see the effect of exogenous

[4] After 1973

disturbances on the respective endogenous variables of the model(s), but these results are not reported here where we confine ourseleves to trade effects.

The trade shocks introduced were of the following sizes and magnitudes:

1. A shcok of 10% increase in a particular time period 1975.
2. A continual shock of 10% increase through a certain time period 1975-1982.

In discussing the results of these simulations, we elected to report them in series form and not as elasticities or multipliers- the reason being that, the series would enable us to see more clearly the dynamic behavior of the responding variable through time.

Thus firstly the simulated values of X_{12} were generated from the Saudi model by virtues of the fact that $X_{12} = M_{21}$, a stimulus of 10% was applied on them and then the shocked series were fed into the Sudan model. Tracing the effects on the Sudan endogenous variables, the following pattern, shown in Table 4, emerged:

Table 4. Dynamic paths of the Sudan model simulations from a single-shot trade shock.

	ΔY_1	ΔC_1	ΔI_1	ΔG_1	ΔM_1^d
1975	1.56917	0.790137	0.156523	0	0.154274
1976	0.935885	0.887355	0.0955759	0	0.226203
1977	1.05190	1.00341	0.108306	0	0.304967
1978	1.19982	1.15268	0.125717	0	0.395806
1979	1.29653	1.28957	0.136925	0	0.49631
1980	1.33310	1.37320	0.139290	0	0.580808
1981	1.30813	1.39023	0.134982	0	0.648162
1982	0.536022	0.857087	0.0500714	0	0.533912
	$\Delta \dot{P}_1$	ΔX_{1ROW}	ΔM_{12}	ΔM_{1ROW}	
1975	0.0200536	0	0.00154349	0.191100	
1976	0.00159532	0	0.000984688	0.134111	
1977	0.0114886	0	0.0011518	0.170615	
1978	0.00805605	0	0.00289069	0.206266	
1979	0.0107172	0	0.00763069	0.298339	
1980	0.0107631	0	0.0227663	0.336017	
1981	0.0110997	0	0.0295412	0.376261	
1982	0.00429608	0	0.275240	0.120429	

Referring to the above table, it could be clearly seen that the response of the Sudanese endogenous variables was of the correct direction and magnitude. Output and its components of consumption and investment, money and prices plus the trade block variables all tended to increase through the period 1975-1982.

As for the duration of the after effects, it was not easy-because of the short time periods involved- to judge if the Sudan economy has shown a tendency to return to its normal trend paths of output and inflation. Initially, we would expect the effect of the one period single-shot to taper off and die rather quickly. But, apart from a common noticeable dip in the last year of 1982 for all the variables, there was some fluctuation in the simulated series refecting a tendency on their part to persist. The persistence of the effect of the above shock may be attributable to the various structural rigidities ailing the Sudanese economy and hampering its quick adjustments to shocks.

The second type of simulations affect on the Sudan model were the result of introducing a continuous shock of magnitude 10% on the X_{12} series obtained from the Saudi model. The shock lasted through the period 1975-1982 and the results of that on the Sudan endogenous variables were as listed in Table 5 below:

Table 5. Dynamic paths of the Sudan model simulations from a sustained trade shock 1975 – 1982

	ΔY_t	ΔC_t	ΔI_t	ΔG_t	ΔM_t^d
1975	1.56917	0.790137	0.156523	0	0.154274
1976	2.83132	1.83411	0.289112	0	0.412531
1977	4.21067	3.12032	0.433507	0	0.793408
1978	6.63071	5.08683	0.694795	0	1.40402
1979	10.2339	8.08456	1.08097	0	2.38277
1980	17.1868	13.5026	1.79649	0	4.14381
1981	24.2994	20.1030	2.50913	0	6.61489
1982	27.2401	24.5437	2.54776	0	9.05631
	$\Delta \dot{P}_t$	ΔX_{IROW}	ΔM_{12}	ΔM_{IROW}	
1975	0.0200536	0	0.00154349	0.191100	
1976	0.0242438	0	0.00297926	0.405683	
1977	0.0375430	0	0.00461179	0.682915	
1978	0.0572487	0	0.0159847	1.13999	
1979	0.0875180	0	0.06020933	2.35533	
1980	0.162516	0	0.294100	4.33401	
1981	0.222800	0	0.550468	6.99472	
1982	0.374968	0	14.0624	6.12857	

Again, the response of the Sudan model to the sustained shock was in the right direction and of the right magnitude. The size of the positive responses was much more pronounced now as compared to the previous case of the single-shot shock. Output increased significantly in response to the trade variations and a major portion of the impact was distributed to its consumption component which showed a marked increase in contrast to investment which increased modestly during the period. Sudan's government consumption was not affected by the disturbances in output since it was held to be purely exogenous from the outstart. Inflation, also, was markedly affected by the trade variations increasing by a wide range of 2%-37% during the period of simulation. This confirms our hypothesis that the Sudan economy may be extremely vulnerable to inflationary transmissions from its main trading partner-Saudi Arabia.

4.2. Simulation of the Saudi Model

After successful validation and sensitivity tests, the estimated values of the Saudi model were used to forecast the effects of a change in the value of the exports to Sudan variable on the GDP and other endogenous variables of the Saudi model.

First, we increased the value of X_{21} by 10% in 1975 and calculated the effect of this change on the Saudi endogenous variables. The results- shown in Table 6 show that only income has increased by a small 0.00054 (billions) as a result of that change in the exports variable. The other variables did not show any change in response to the trade variation and hence the effect on them is not shown in the table.

Table 6. Dynamic paths of the Saudi model simulations from a single-shot trade schock
1975 – 1982

	ΔY_2
1975	0.00054
1976	0
1977	0
1978	0
1979	0
1980	0
1981	0
1982	0

Second, we increased the same exports variable by 10% throughout the period 1975-1982. Results of this experiment in Table 7 show that GDP increased during the whole period. The increase in Saudi GDP was more pronounced during the latter stages indicating positive gains to the income of Saudi Arabia. Another endogenous variable to experience some change was the export to the Rest of the World. The values of X_{2ROW} changed for the period 1978-1982. However, the effect of the change was negative. An explanation of this is that the magnitude of the change in the GDP variable was less than the magnitude of the change in X_{21}. In other words, the increase in GDP was not enough to match the increase in X_{21}. This resulted in a negative effect on X_{2ROW}.

Money demand also changed, but the change was erratic. It showed a negative sign in 1977 and a positive in 1980. The other variables in the Saudi model showed no response to the trade variations and remained largely the same.

Table 7. Dynamic paths of the Saudi model simulations from a sustained trade shock. 1975 – 1982

	ΔY_2	ΔC_2	ΔI_2	ΔG_2	ΔM_2^d
1975	0.00054	0	0	0	0
1976	0.00062	0	0	0	0
1977	0.00065	0	0	0	-0.0001
1978	0.00127	0	0	0	0
1979	0.00280	0	0	0	0
1980	0.0050	0	0	0	0.00045
1981	0.00474	0	0	0	0
1982	0.06929	0	0	0	0
	$\Delta \dot{P}_2$	ΔX_{2ROW}	ΔM_{21}	ΔM_{2ROW}	
1975	0	0	0	0	
1976	0	0	0	0	
1977	0	0	0	0	
1978	0	-0.0002	0	0	
1979	0	-0.0010	0	0	
1980	0	-0.00549	0	0	
1981	0	-0.00889	0	0	
1982	0	-0.14787	0	0	

Conclusion

In the above analysis, we presented a LINK model connecting the economies of the Sudan and the Kingdom of Saudi Arabia through bilateral trade flows. The model was motivated by the fact that Saudi Arabia has grown over the years to be the main trading partner of the Sudan. The economy of the Sudan was thus made vulnerable to shocks emanating from the Saudi economy. On the other hand, we also expected the Saudi economy to exhibit some response to variations in the Sudanese economy.

To gauge the degree of interdependence existing between the two economies, we constructed submodels for each of the two countries. The two submodels were then connected via suitable import-export functions. Each of the two models was then estimated separately- for lack of enough degrees of freedom- and its performance evaluated according to the usual econometric criteria. The two models were then subjected to some bilatral trade shocks and the effects of these shocks were then traced through the two economies. Overall, the results obtained were largely similar to what was a *priori* expected. The variables related to the Sudan economy responded significantly and correctly- both in direction and magnitude- to trade shocks occurring in the Saudi economy. Such responses however, were generally lacking in the opposite direction where the Saudi economy- apart from some minor responses- remained largely insulated to trade shocks from Sudan. Thus a pattern of a leader-follower situation, with the Sudan being dependent on and exposed to the economy of Saudi Arabia, emerged.

One of the main conclusions of the paper is that, while bilateral trade is small at present, there is a possibility of increasing it through explicit policy actions. The simulations undertaken pointed out the fact that trade expansions will affect the economy of the Sudan positively while having no adverse effects on Saudi Arabia at worst. If specific policy measures were undertaken to vitalize trade in 'both' directions then the gains will be more substantial and comprehensive. Like Naqvi *et al.* [5], we conclude that,

> "... (bilateral) trade expansion is not a zero-sum game. All countries gain in terms of both greater (bilateral) trade and a faster growth in output ...".

Lastly, the above model- and elaborated variants thereof- could also be used to study and investigate questions of purchasing power parity, transmissions of inflation and the shape, degree and magnitude of interdependence in the emergant leader-follower case and hence to evaluate the effects of policy changes in one economy on that

of the other, *e.g.* the effect of increased Saudi government expenditures or of increased Saudization policy on the economy of Sudan. Such a study should draw on the techniques of optimal control and differential games theories and hence may lie outside the scope of the present work.

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Appendices

A. Tables

Below are tables referred to and used in section[1] of the paper:

Table A.1. Trade Ratios to GDP* Sudan

	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984
Exports	18.7	17.7	14.8	14.2	15.1	13.7	13.9	8.1	8.2	6.0	5.5	5.4	N.A.
Imports	18.8	21.3	20.6	15.6	16.7	13.2	12.4	14.8	14.6	13.9	15.9	13.9	N.A.
						Saudi Arabia							
Exports	N.A.	N.A.	57.3	62.2	60.5	61.3	70.0	127.1	82.1	61.3	94.1	51.7	35.6
Imports	N.A.	N.A.	19.0	22.3	17.8	18.4	16.7	10.2	18.7	30.7	26.0	26.6	31.9

* Source: International Monetary Fund, International Financial Statistics; various issues, selected years.

Table A.2. Percentage shares of major trading partners: Sudan**

	1972	1974	1976	1978	1980	1982	1984	1986
				a) Exports				
EEC				34.6	28.9	25.8	24.6	28.1
KSA				6.1	21.2	36.7	15.0	13.5
Japan				8.2	8.2	6.5	6.0	6.7
USA				2.3	2.4	2.6	2.8	5.4
India				3.9	0.4	0.4	0.4	0.5
China				10.4	9.2	5.1	4.3	0.1
Egypt				6.2	2.3	2.5	8.3	8.1
USSR				3.4	1.8	1.3	2.2	2.6
				b) Imports				
EEC				46.6	38.1	33.8	36.6	41.0
KSA				1.0	14.0	16.3	16.1	14.9
Japan				6.5	3.5	3.9	3.2	7.1
USA				7.3	8.0	8.8	6.9	7.7
India				4.8	2.1	2.3	1.9	2.2
China				5.0	7.9	2.2	2.0	2.8
Egypt				2.0	1.7	5.3	3.1	4.2
USSR				0.2	0.1	0.1	0.1	0.1

** Source: Bank of Sudan, Foreign Trade Statistics; various issues, selected years.

Table A.3. Percentage shares of major trading partners: KSA***

	1972	1974	1976	1978	1980	1982	1984	1986
				a) Export				
Industrialized	67.0	63.0	60.4	67.5	75.3	65.6		
USA	5.0	3.5	4.8	13.9	15.5	7.8		
Japan	15.1	16.0	20.0	20.4	17.4	23.8		
France	9.3	11.5	11.5	9.8	9.2	9.0		
Italy	11.2	10.3	6.4	0.5	6.1	5.0		
UK	8.1	9.3	4.9	3.8	3.5	2.9		
Middle East	3.5	3.2	3.0	3.2	3.1	4.7		
Sudan	0.2	0.03	0.02	0.02	0.3	0.3		
				b) Imports				
Industrialized	61.8	57.7	63.5	80.0	78.2	80.6		

Table A.3 (Contd.). Percentage shares of major trading partners: KSA***

	1972	1974	1976	1978	1980	1982	1984	1986
USA	19.5	17.1	18.7	21.0	20.0	21.0		
Japan	14.3	15.9	12.2	15.4	17.9	19.1		
Germany	6.3	6.1	8.3	10.8	9.1	11.0		
France	2.3	1.8	2.7	3.9	6.9	5.3		
Italy	4.0	2.8	4.9	7.2	7.3	6.1		
UK	7.3	4.8	5.9	7.4	6.5	6.6		
Middle East	18.0	22.4	13.5	2.9	3.3	2.9		
Sudan	0.7	0.6	0.2	0.3	0.6	0.5		

** Source: Directions of Trade Statistics; International Monetary Fund, various issues, selected years.

B. Data Appendix

B.1 *Income Variables*

The income variable used in both country submodels was the real Gross Domestic Product (GDP) variable. The Data were obtained in current form from the National Income Accounts published in various issues of the International Monetary Fund (IMF), International Financial Statistics (IFS) yearbooks, lines 90. The data were then deflated by appropriate price deflators.

B.2 *Prices*

The price variable used is the Consumer Price Index (CPI) obtained for both countries as in lines 64 of the IFS different issues. The CPI was used as a deflator for a number of variables in the study and also to construct a seperate inflation variable $\dot{P}$.

B.3 *Money*

The money concept used was that of Broad Money. Data were obtained from lines 35 of various issues of the IFS for both countries and then deflated by appropriate deflators.

B.4 *Foreign Trade*

Data on foreign trade variables, *i.e.* Imports and Exports plus bilateral trade flows between Sudan and the Kingdom of Saudi Arabia, were obtained from various yearbooks of the IMF, Directions of Trade Statistics (DOTS).

Foreign trade price indices used as explantories and deflators were obtained from the IFS yearbooks, pp. 1-10.

Similarly, Data on Terms of Trade were obtained from the same source, *i.e.* the IFS yearbooks.

B.5 ***Others***

Data on Consumption, Investment and Government Consumption were obtained from the National Accounts of the respective countries as pubished in lines 91-96 of the IFS yearbooks. Appropriate deflators were then employed on the variables to obtain their real measures.

Data on exchange rates were similarly obtained from the IFS yearbooks, lines ag-rh.

The rate of interest variable appearing in the Saudi Model is the Eurodollar interest rate whose data were obtained from the IFS.

Other Data sources used to supplement the above mentioned bases were:

- The Saudi Arabian Monetary Agency Annual Reports.
- The Bank of Sudan Annual Reports.

– Achievements of the Development Plans, Department of Statistics, Ministry of Planning, Kingdom of Saudi Arabia.

- Annual Reports, The Department of Statistics, The Republic of Sudan.

نموذج للربط التجاري بين السودان والمملكة العربية السعودية، ١٩٦٣ - ١٩٨٢م

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ملخص البحث. يطرح البحث نموذج للربط التجاري بين السودان والمملكة العربية السعودية بغرض تحديد درجة الاعتماد بين اقتصاديات الدولتين. ثم بناء نموذجين قياسيين - واحد لكل دولة - والربط بينهما عبر متغيرات التجارة الخارجية المناسبة كما تم استعمال النماذج المقاسة المتحصل عليها لأغراض المحاكاة حيث تم تتبع الآثار الناجمة عن بدائل للمسارات التجارية الحالية وذلك لكل اقتصاد على حده. وتشير النتائج على تزايد اعتماد الاقتصاد السوداني على نظيره السعودي ومن ثم تزايد إنكشافه للصدمات - الإيجابية والسلبية - التي يتعرض لها الإقتصاد السعودي. كما تشير النتائج إلى أن السياسات الإقتصادية التي تهدف إلى رفع مستوى التجارة بين البلدين سيكون لها أثر موجب وموات على الدخل والرفاه في كل من البلدين.