THE DEMAND FOR ENERGY IN A SMALL DEVELOPING ECONOMY: THE CASE OF CYPRUS

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I. INTRODUCTION

Cyprus is a small island in the Eastern Mediterranean with an estimated population of 630,000. Despite the outbreaks of inter-ethnic animosities since independence from the British in 1960, culminating in the artificial division of the island along ethnic lines in 1974, the economy has shown remarkable vitality and growth over the long run. This paper examines the plight of such a small economy in the wake of the 1973 OPEC oil price increase and the ensuing world energy crisis.

The traditional backbone of the Cyprus economy has been the export of agricultural produce and mineral ores, with more recent reliance on tourism for foreign exchange. The search for an industrial base in the economy has been successfully pursued with exports of cement, footwear and clothing featuring prominently in the post- 1974 period. Manufacturing is currently responsible for about 18% of employment and output in Cyprus. Over the long-run the economy has grown at an average rate of 7% per annum between 1960 and 1974, while in 1977 and 1978 growth reached the spectacular heights of 15% and 8% respectively. The result has been rapidly rising living standards in Cyprus, with per capita income in the Governmentcontrolled sector of the island approximataly $2500 in 1979.

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There are no known on—or off-shore deposits of traditional fossil fuels and Cyprus is almost exclusively dependent on imported crude oil to meet its energy needs. Inadequate rainfall does not allow the utilisation of hydroenergy and all electricity is generated from oil—burning thermal stations. A small amount of solar energy is used for water heating, mainly for domestic purposes.

Since 1972 crude oil has been processed at the Cyprus Petroleum Refinery, which is owned and operated by a consortium of multinational companies and the Government.

The recent growth bonanza and new found affluence in Cyprus overlap to some extent with the period of OPEC oil price increases. Industrialization has meant increasing reliance on imported energy with rather severe implications for the balance of payments. In 1979 the value of oil constituted over 12% of the total bill for imports and 35% of the foreign exchange earnings from exports. Increasing real incomes have induced a rising demand for energy-consuming domestic appliances and new cars, adding an additional burden to external indebtedness.

As the real price of oil is expected to continue to rise during the 1980s there is likely to be a severe constraint on the future economic development of the island. At the same time there are imposing limitations on the freedom of policy-makers to change the direction and recent pattern of development, especially in the medium term. This consideration is particularly relevant for a small economy, so exposed to the vagaries of external demand for its produce and its tourist facilities.

In part II we review the historical pattern of demand tor energy products in Cyprus. This is followed in Part III by an econometric exercise where we illustrate the measure of reliance on energy from estimates of the price and income elasticities of demand for various energy products. A technique is employed which allows us to test whether there were any structural clanges in the demand functions for these products following the 1974 war and the OPEC—induced, worid energy crisis. In the final section we consider the implications of our results for the future development strategy of Cyprus, especially as they relate to an energy policy for the island.

II. THE STRUCTURE OF ENERGY DEMAND

Structural changes, which have seen increasing urbanization together with the rise of industry and the relative decline of agriculture in the last two decades, are reflected in the growth in per capita consumption of electricity and petroleum products.

Table I illustrates the increasing dependence of the Cyprus economy on energy supplies. Per capita energy consumption has increased by a factor of four during this period of two decades.

Table I. Per Capita Energy Consumption in Cyprus, 1960 - 1979

Year	Quantity		Value (at Constant 1967 Prices)		
	Electricity (kwh)	Petroleum Products (metric tons)	Total (CE)	Electricity (CE)	Petroleum Products (CE)
1960	305	.29	13	3	10
1965	403	.38	16	4	12
1970	750	.53	23	7	16
1975	946	.67	39	11	28
1979	1.359	.93	54	15	39

Source : Annual Reports of Electricity Authority of Cyprus and oil companies. Data on petroleum products exclude Heavy Fuel Oil used for the production of electricity.

NOTE : From 1974 data refer to the Government controlled area of the island only.

Structural changes in the demand of petroleum products reflect underlyng changes in the economic structure and are reported in Table 2. Benzine, used for motor vehicle transportation and kerosene, used for household cooking and heating have suffered a relative decline in importance largely at the expense of Heavy

Table 2. Total Consumption of Petroleum Products, by Quantity and Percentage Attributable to Main Products, 1960 - 1979

Year	Quantity ('OOOs Metric Tons)	Percentage Attributable to :					
		Benzine	Kero-sene	Gas Oil	Light Fuel Oil	Heavy Fuel Oil	L.P.G.
1960	238	24	9	25	8	33	1
1965	321	20	7	29	10	33	3
1970	506	19	3	25	8	41	4
1975	535	15	2	20	8	50	5
1979	780	13	1	19	10	52	4

Source : As Table I, but total quantity includes Heavy Fuel Oil used in electricity generation.

NOTE : From 1974 data refer to the Government controlled area of the island only.

Fuel Oi 1 or Mazut, which is used in generating electricity and in producing cement. Gas oil, used in heavy transport has declined slightly in relative importance while the consumption of Liquified Petroleum Gas (LPG) has marginally increased its overall share. The share of Light Fuel Oil, used in the brick and mining industry has been stable.

Changes in the sectoral consumption of electricity are illustrated in Table 3.

Table 3. Total Consumption of Electricity, by Quantity and Percentage Breakdown Sector of Activity, 1960 - 1979

Year	Quantity (Millions kWh)	Percentage Consumption by :			
		Domestic	Commercial	Industrial	Other
1960	178	24	40	30	6
1965	238	27	41	25	7
1970	461	26	34	33	7
1975	475	26	33	35	6
1979	682	26	31	35	8

Source : Annual Reports of the Electricity Authority of Cyprus.

NOTE : 'Other' includes consumption for irrigation and public lighting. From 1974 data refer to the Government controlled area of the island only.

While all sectors have experienced rapid increases in their consumption of electricity the share of the industrial sector has grown at the expense of the Commercial sector, reflecting the successful programme of industrialization in the island.

Having shown both the rapid growth in the consumption of energy products and changes in the structure of demand we turn to estimate a model of energy demand for Cyprus.

III. A MODEL OF ENERGY DEMAND FOR CYPRUS

The demand for energy is a derived demand, derived from the accumulation of power - using appliances by households and tools, machines and equipment by firms. In the short run the demand for energy will be determined by the rate of utilization of this stock of durable goods and in the longer run by the level of this stock, which grows through time as the economy develops. (Balestra 1967).

Therefore, the long run development path chosen by Cyprus will have a great bearing on the quantities and types of equipment chosen, which in turn will influence the level and kinds of energy demands.

In the shorten run, however, the demand for the services of installed capital equipment is mainly a function of two factors, the running costs which include energy costs, and the income of households and the output of firms. If we assume that fuel consumption is a proxy for the demand for the services of capital equipment then we shall specify the demand for energy as a function of its price and an indicator of household income and output of firms, or Gross Domestic Product (GDP).

In order to project alternative energy scenarios for the future we shall estimate the price and income elasticities of demand for a number of energy products. Yet, the income or output elasticity of demand will change over time for a number of reasons. Technological progress will introduce more efficient, energy - saving equipment so that energy consumption per unit of output will decline. As the economy grows and the sectoral composition of output changes, often as a result of the development strategies pursued by the government, energy consumption per unit of output will change as some sectors are more intensive users of energy. And energy conservation campaigns, which urge citizens nor to waste fuel, will reduce the consumption of energy per unit of GDP[1].

Some of these factors will reduce and others increase the energy intensity of output and some may not change autonomously but because of governmant policies or because of underliying price changes.

As a resuit of the 1974 war, the loss of 40% of the land area by the government, the redistribution of two - fifths of the island's population along ethnic lines, significant structural changes have taken place. In order to relieve large scales unemployment in the immediate attermath of the war the government promoted the development of labourintensive manufacturing industries. The textiles, clothing and footwear Industries have experienced relatively high growth while the more traditional agro-industries, such as vine products and fruit have declined. The agricultural sector has shrunk because of the loss of large areas of the most fertile land and mines were either lost or contracted as deposits of exploitable ores became depleted.

1. For example, from September 1979 until May 1980 a rotating weeken driving ban on odd -and even—numbered private motor vehicles operated in Cyprus until it was declared unconstitutional by the Supreme Court. Officials claim that the system reduced gasoline consumption by as much as 6 % for this period,

In order to incorporate these structural changes into our model of energy demand, and to test for any difference in the energy intensity of output we have estimated two forms of the demand function. The first hypothesizes a parallel shiff down in the function after 1974, as the population of the government controlled sector of the economy was reduced by almost 20% and the land ate a by 40%, but the underlying income and price elasticities remained unchanged.

All of the aggregate data on energy consumption and GDP relate only to the government controlled area of the island after the war. Therefore, to take account of this and to test our hypothesis we have introduced a dummy variable Wt, into our demend equation, which equals one tor the post -war years and zero in the pre-war years.

The demand function is assumed to take the following form :

$$D_t = A\gamma^{\alpha}tPt^{\beta}e^{wt}Ut \qquad (1)$$

where Dt is energy consumption, Yt is GDP, Pt is the unit price of energy, e is the base of natural logarithms and W_t is the dummy variable representing the post—war years. A is a constant term and tl-t is a random disturbance.

Our second model hypothesizes that, because of the structural changes taking place in the economy in the post-war period, and because of the greater energy—consciousness in the years following the OPEC - induced world energy crisis, the underlying income and price elasticities of energy demand are different in the two periods. In order to test these hypotheses we introduced two interaction terms, (Yt X Wt) and (Pt xWt) into the equation as shift parameters on the α and β elasticities.

The model then becomes :

$$Dt = A\gamma^{a}tPt^{\beta}e^{\gamma w} \mid (\gamma t)^{\alpha'}w_t \mid (Pt)^{\beta'}wtU_t \qquad (2)$$

Double-teg trasformations yield equations which are amenable to estimation with ordinary least squares methods. We should note that various time periods are honogeneous except for the factors explicity appearing in the function. As we have seen since the underlying conditions of an explicit relationship change through time, estimates obtained from time series are s h o r t - r u n elasticities.

The estimating equations are :

$$\text{In } Dt = \ln A + a\ln Y_t \beta \ln Pt + \gamma Wt \qquad (\Gamma)$$

and

$$\ln Dt = \ln A + a\ln Y_t + \beta \ln P_t + \gamma W_t + a' W_t \ln Y_t + \gamma' W_t \ln P_t \qquad (2')$$

In equation (Γ) the constant income and price elasticities of demand for both pre - and post-war periods are α and β respectively, γ is a parameter shifting the function vertically between the two periods.

Equation (2') yields two demand functions where *a* measures the difference between the income elasticity of energy demand in the post -war years, α the income elasticity for the pre-war years, and $(\alpha+\alpha')$ the income elasticity for the post - war period. A similar interpretation follows for the price elasticities of demand β and $(\beta+\beta')$.

Single equation methods of estimation are justified since the prices of energy products are not determined endogenously in the model. All prices are administered by the Cyprus Government and so our treatment of prices as exogenously determined and not by a two -way causation between demand and supply is justi-

We estimated six equations for electricity demand according to consumer type. They are : Domestic ; Commercial ; Industrial ; Irrigation ; Public Lighting and Total Consumption. The data on consumption in kilowatt hours and unit market prices cover the 20 year period 1960 to 1979 and were compiled from the Annual Reports of the Cyprus Electricity Authority.

Petroleum based energy products are : Benzine (Gasoline) ; Kerosene ; Fuel Oil ; Liquified Petroleum (LPG) and Gas Oil. The data were compiled from import statistics, local production and sales of petroleum products. Gross National Product is taken from the Cyprus National Accounts and all GDP and fuel prices were deflated to 1967 prices using the GDP deflator.

The income and price elasticities of demand derived from (Γ) are all reported in Table 4, while only where we found significant coefficients for the interaction terms a' and β' in equation (2') do we report the results.

The models have a high explanatory power judged by the size of the coefficients of multiple determination, R^2s, and the significance of the estimated coefficients of the explanatory variables. From the examination of the residuals most

2. A recent survey of energy use estimated that one- third of all households use some solar energy for water — heating (Republic of Cyprus 1979).

Table 4. Income and Price Elasticities of Demand for Energy Products in Cyprus

Product	α	α′	β	β′	γ	R′	D.W.	Equation
Electricity								
Domestic	.77		-1.26		.162	.993	1.63[b]	(1)
	(9.23)		(8.76)		(6.76)			
Commercial	.73		-1.18		.296	.976	1.83[a]	(2)
	(7.12)		(4.26)		(5.32)			
	.84	-.38	-.95	.28	1.56	.982	1.75[b]	(2′)
	(6.26)	(1.85)	(2.64)	(.44)	(.70)			
Industrial	1.48		-.18		.44	.958	1.55[b]	(3)
	(12.68)		(.36)		(2.15)			
	1.46	-.56	-.99	1.63	-.27	.974	1.42[b]	(3′)
	(12.50)	(1.81)	(1.50)	(1.88)	(.03)			
Irrigation	2.02		1.18		.55	.600	2.40[a]	(4)
	(3.19)		(.97)		(1.71)			
Public Lighting	1.41		-1.00		.35	.935	1.21[b]	(5)
	(7.48)		(1.64)		(2.16)			
	1.60	-1.38	-.79	.49	6.37	.981	1.66[b]	(5′)
	(11.08)	(4.96)	(1.58)	(.69)	(2.49)			
Total Electricity	.98		-1.04		.39	.985	2.02[a]	(6)
	(9.37)		(4.04)		(7.15)			
	.94	-.18	-1.22	1.16	-1.37	.995	1.69[b]	(6′)
	(7.38)	(.97)	(3.92)	(2.34)	(.75)			
Petroleum :								
Benzine	.76		-.85		.35	.928	.55[c]	(7)
	(6.70)		(1.97)		(1.52)			
	.56	-16	-2.05	2.42	-10.97	.975	1.90[b]	(7′)
	(6.35)	(.81)	(5.54)	(4.42)	(3.48)			
Kerosene	-.74		-.17		-.52	.965	2.07[a]	(8)
	(9.39)		(.97)		(7.58)			
Gas Oil	.99		-.26		.09	.974	1.66[b]	(9)
	(21.40)		(2.24)		(1.67)			
Light Fuel Oil	1.27		-.27		.32	.868	1.59[b]	(10)
	(7.63)		(.41)		(1.26)			
Heavy Fuel Oil	1.24		.24		.16	.966	2.93[b]	(11)
	(13.27)		(1.47)		(.93)			
L.P.G.	.79		-1.73		.04	.977	1.52[b]	(12)
	(2.57)		(6.78)		(.48)			

NOTE : D.W : Durbin—Watson statistics a = accept no autocorrelation ; β = test is inconclusive ; c = accept autocorrelation. Numbers in parentheses are t — statistics.

of the Durbin—Watson statistics indicate either an inconclusive test for autocorrelation or an acceptance of the null hypothesis of no autocorrelation. There-

fore, in some cases, while the estimated coefficients are unbiased their Y values may be artificially inflated because the standard errors of the estimators are understated.

For electricity demand the estimated income elasticities are always highly significant and range from an estimated low of 0.73 for Commercial consumers to a high of 2.02 for Irrigation power, with the industrial electricity of almost 1.5. Only for Domestic and Commercial demand is the price elasticity significant and with the 'correct' sign, indicating that price increases have induced a switch to alternatives and/or conservation measures by these consumers. Together, these sources of demand are responsible for over one - half of total electricity consumption, so that this result is encouraging for these concerned with the search for energy—conservation policies.

One possible alternative source of energy for water -heating has been solar energy, which has experienced significant growth in recent years[2]. We shall say more about solar heating in the following section.

The price elasticity for industrial demands is always insignificant a result explained, no doubt, by the lack of viable power alternatives for consumers in this rapidly expanding sector.

The shift dummy variable W on the intercept term for the post-war years is often positive and significant, which runs counter to our a priori expectations. We had expected the electricity demand functions to have shifted down in the post-war period. Perhaps this result is partly explained by a changed pattern of development in post-war years, with a structural shift to more energy-intensive industries. For example, the production of cement is very energy-consuming, and this sector has grown rapidly in recent years to satisfy the booming'construction sector and export demand. At the same time with the increase in the standard of living there has been an expansion in the use of durable consumer goods, such as washing machines, air—conditioners and recording systems.

The coefficient (a') of the shift dummy variable on income or GDP in our second model is negative for the post-war years for Commercial and industrial users, although only significant at the 10% level in equations (2') and (3'). This result offers some slight encouragement to policy makers indicating a reduced marginal energy intensity of output, with the elasticities failing from 0.84 and 1.46 to 0.46 and 0.9 for Commercial and Industrial demand rerspectively. For the relatively small Public Lighting sector there seems to have been a reduction in the amount of electricity consumption as GDP has grown for the post-war years.

The second part of Table 4 reports the income and price elasticities of demand

for the various petroleum products. The income elasticities for industrial fuels are almost always in excess of one indicating a more than proportionate increase in petroleum based products for a given percentage rise in GDP.

The relatively high income elasticity for Gas Oil, which is used in the heavy transport sector reflects the growing importance of this sector as the economy expands. The income-elasticity for Benzine used in private autos is lower whille Heavy Fuel Oil, which is responsible for a significant part of the total consumption of petroleum products for use mainly in generating electricity exhibits an income elasticity of demand well in excess of one.

In general the demand for petroleum products appears responsive to price changes as judged from the correct 'negative' signs obtained for the β coefficients, or price elasticities. However, other than for LPG, demand appears as relatively price inelastic given the small size of the coefficients.

Our attempt to examine differential changes in the price and income elasticities in the post-war period proved to be unsuccessful. Only in the case of Benzine in equation (7') was there a significant coefficient for an interaction term, β', but we obtain the 'wrong' sign.

Nor, in most cases, were we able to capture any structural shifts in the demand functions in the crisis years as reflected in the values and significance of the γ coefficients. However, in equation (7'), perhaps as a result of the world -wide publicity given to energy conservation measures, the demand for Benzine appears to have shifted down in the post-1974 years.

The decline in the demand for kerosene is captured by the signficantly negative coefficient of γ, as consumers were switching to more modern forms of heating and cooking. As a result the income elasticity of demand for this product is negative.

Rather disturbing for policies of energy conservation are the relatively large income elasticities and relatively small or insignificant price elasticities of demand for the major petroleum products. These results are indicative of the lack of viable substitutes for both industrial and domestic consumers in Cyprus.

IV. SUMMARY AND POLICY ISSUES

Our relatively simple model has had a high measure of success in explaining year to year changes in the demand for energy products in Cyprus. However, we have been unable to take account of lagged adjustments and responses in consum-

ption to income and price changes since our data were available only on an annual basis. Therefore, the policy implications of our results are necessarily restricted.

Per capita energy consumption in Cyprus is relatively low, amounting to about 1810 kgs. of coal equivalent, which is about equal to that of Greece, but only one - half that of Japan, one - third of the level in the U.K. and West Germany and one - six amount of the U.S.A. and Canada (UN Statistical Yearbooks).

As the island proceds to realize its goal of expanding its industrial base there is a certain inevitability that its per capita consumption of energy products will increase in the pattern of the more advanced countries. And over the shorter run our reults suggest that as the economy expands it induces a more than proportionate increase in the consumption of petroleum based products. The lack of viable alternative sources of energy means that the demand functions are necessarily price inelastic, with the exception of electricity demand.

The predicted real price increases of oil during the 1980s will place severe downward pressures on the growth path of the economy because of the balance of payments constraint. And the freedom of policy - makers to depart radically from the pattern of development in the last 20 years is strictly limited by the openness of the Cyprus economy, and its over - exposure to the influence of external demand.

Policies that induce energy conservation would appear to offer the greatest scope for some marginal reduction in energy consuption in the medium term. Our results indicate that some of the major consumers of electricity are responsive- to price, which we expect induces measures for conservation. The major issue for policy is to raise the awareness of other consumers and to increase their opportuni ties to save on energy.

For example, greater use of solar energy, largely for water heating, can offer some scope to reduce the consumption of thermal electricity, given that the island basks in sunshire for most the year. In the transportation field improvements to the anachronistic road system would save fuel while replacement of an obsolete power generating station is planned to become operational by 1983. And an introduction of rules for heating insulation in buildings willsave fuel.

Other than for expansion of the use of solar heating, opportunities for the development of alternativa energy forms in Cyprus are limited. The island is too small to support a nuclear plant and rainfall too sparse to allow hydroelectricity to be considered viable.

However there is some research underway into the possible development of

non - conventional forms of energy. For example, biogas may be produced from animal dung for use in cooking and lighting, while the Energy Research Group of the local Higher Technical Institute is experimenting in the application of grape marc, or fruit - refuse from wine - making, for heating purposes. In addition some consideration is being given to the conversion of oil-fired electricity generating stations to imported coal.

Whille such developments are to be commended their impact on energy supplies will necessarily be very marginal. For the foreseeable future, the policy alternatives open to such small countries as Cyprus, with no indigenous conventional forms of energy, are very small. Reliance on imported oil at the price dictated by the OPEC - cartel cannot be avoided.

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