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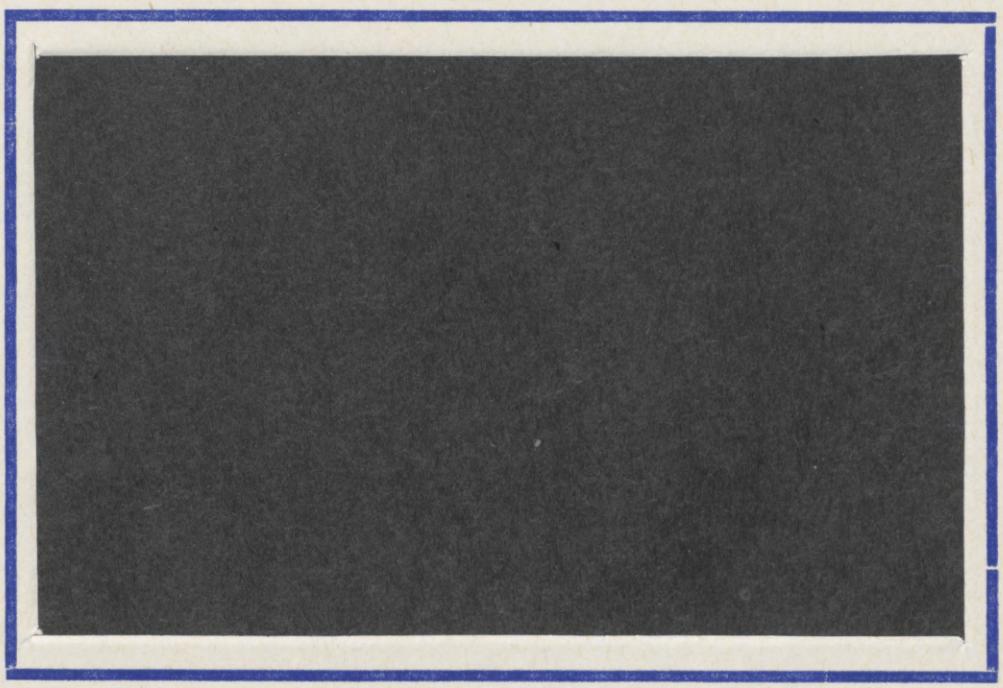

מכון למחקר כלכלי ע"ש ד"ר ישעיהו פורדר ז"ל

ע"י אוניברסיטת תל-אביב

POSSIBLE CONSEQUENCES OF RESTRICTING THE IMPORT OF OIL

by

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Working Paper No. 30-79
October, 1 9 7 9

* *I would like to thank Mr. Zfi Leheman for his helpful assistantship.*

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POSSIBLE CONSEQUENCES OF RESTRICTING THE IMPORT OF OIL

For an open economy which imports most of its oil from abroad and for which oil is the major source of energy the danger of a cut of imports of oil is always behind the door. The reasons for the cut might be political (partial embargo as an arm twister) or economic(a rise in oil prices which the importing country cannot pay). Fishelson (1978 and 1979) dealt with similar issues and provided results with regard to the sensitivity of the Israeli economy to restrictions on the import of oil. In the present study we follow a parallel line of thought and apply the restrictions to the economic structure that prevailed in 1975. In particular, since we assume that the economic structure is presented by linear relations, and substitution between inputs in the production process is not allowed, the model is a short-run model. The short-run assumptions impose further restrictions on the analysis. The private consumption of various goods and services could not be changed drastically since the substitution among consumption goods hardly takes place and a major reduction in the absolute level of (real) consumption would result in a break-down of the social system, the outcome of which would be a new socio-economic order. Thus, present (1975/6) patterns of production, consumption and overall usage of products is a limit on the tolerable decline of the import of oil.

In the next section we briefly describe the economic model used for estimating the effects of restrictions of oil imports on the economy. The following section contains the empirical results. We conclude with a Summary section.

THE MODEL OF THE ECONOMY

The functioning of the economy is described by an input-output table. Hence, the input-output coefficients are constants. For the prices prevailing at year t, each input-output coefficient represents a given amount of a real quantity. This real quantity is not known to us, but as long as all prices are constant the input-output coefficients represent the same real quantities. Furthermore, the total quantities transferred across sectors and from the sectors to final uses are exactly proportional to the nominal values of the transactions. Thus, under the assumption of overall constancy of prices, flows proportional to those of the input-output table can be viewed as of the same proportional flows of real quantities of goods and services. By extending the assumption of constant prices to the primary and external factors of production (labor, capital and imports) and to institutional behavior (taxes and subsidies) the entire economic system is then presented in real terms.

Economic theory assures us that the results of optimal central planning and of a free competitive market would lead to an identical allocation of resources and to the same maximum of returns to the primary factors of production. Given this property, if the correct objective function is formulate, one can reach this optimal solution by using conventional optimization techniques. Since the returns to the primary factor "imports" leave the country and the returns to the "government" factor are later netted out from the returns to domestic labor and capital, it seems that a reasonable objective function to optimize is that of maximizing the returns to labor and capital given that the returns per unit of labor and per unit of capital are constant. This also implies the maximization of the employment of domestic labor and capital. *

* An implicit assumption is that the economy is in equilibrium in the sense that the the returns per unit of labor and per unit of capital are the same in all sectors.

Given the short-run nature of the model and its being a one-period model, the real output of each sector is limited by its capital stock. The putty-clay assumption on investment implies no transferability of capital across sectors. Hence, the planner is faced by the following restricted maximization problem.

$$\underset{X_j}{\text{Max}} \sum_{j=1}^{I} R_j X_j$$

Subject to

$$\text{(1)} \qquad \sum_{i=1}^{I} a_{ij} X_j \leq X_j \qquad j = 1,2,\ldots,i\ldots I$$

$$k_j X_j \leq K_j \qquad j = 1,\ldots,I$$

$$m_f X_f \leq M_f$$

where R_j are the returns to domestic labor and capital per unit of output of product j. X_j is the total number of units of product j to be produced. a_{ij} is the number of units of product j needed in the production of one unit of product i. k_j is the number of units of capital (actually proportional to) needed per unit produced of product j and K_j is the total capital (actually proportional to) available to sector j. m_f is the number of units of imported crude oil needed per unit of output of the refining sector and M_f is the total import allowed.

When the data and parameters prevailing in 1975 are introduced into problem (1) the economic activity that took place in that year is reconstructed. Given that at the prevailing oil prices in 1975 there were no constraints on imports of oil, the outcome of problem (1) is the maximum.

Any constraint on import of oil or in the pattern of usage of the products, would, given that all other constraints and parameters are constant, render lower values for the objective function. The purpose of this study is to evaluate the effects on the economy of constraints on the import of oil given various scenarios. The effects are summarized either into the total returns to the domestic factors of production or into the price the economy would be willing to pay per additional unit of imported oil which is the increment of the total returns. This marginal increment is the value of one unit of the constraint, i.e. is the implicit price (shadow price) of the constraint. Note that the price is in the same units as the objective function is measured by.

The common feature to all scenarios is the constraint of importing oil. The level of the constraint is lowered parametrically in order to trace out its effects upon the value of the objective function and upon the value of marginal product of oil in the economy (in terms of value added). The scenarios that are examined are:

a) The economy is forced to supply 90% of the final uses of all goods and services except products of the refinery sector of which only 80% has to be supplied.

b) The economy has to supply 100% of the final uses of all goods and services except those of refineries of which only 90% has to be supplied. Capital stock increased by 10 percent.

c) Technological progress was energy saving. The refinery products and electricity coefficients of all sectors have declined by 10%, while capital stock increased by 10%.

d) There is an upper limit constraint on the value of imports of inputs*.

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* This is already a second order constraint. One might start from a constraint on the deficit in the current account. Then assuming maximum levels of exports and minimum levels of imports of directly used consumption goods the constraints upon the imports of inputs is figured out.

Meanwhile the price of crude oil is increasing.

The four scenarios can be viewed as belonging to two categories. The first and the last are short-run scenarios. In particular the quantity of capital at each sector, and the technology (input/output coefficients) are constant. In the second and third scenarios the capital constraint is increased implying that investment took place. In the third also technological progress takes place. Obviously additional scenarios and combinations of those already tested can be designed. However, we suggest that those presented are the imported ones.

DATA and ANALYSIS

In this study the 1975 input-output table servesas the basis upon which all the tests are conducted. Appendix 1 contains data on the total value of output, on final uses, on the import of inputs and on the returns to labor and capital of each of the 38 sectors the economy is divided into.* As noted above the returns to labor are proportional to the quantity of labor used as are the returns to capital.

In the base run the 1975 economy was reconstructed through the maximization of the objective function of problem (1) while varying the value of M_f. Table 1 contains the results. As can be seen the implicit price of the import constraint stays constant up to a level of less than three fourths of the actual imports. How can we explain thie "strange" result. The explanation is rather simple. As long as the lowering of imports does not affect the level of production of the other sectors but only the quantity of refined products for final uses the loss to the system is the value added generated per unit of imports which is .062 (.0487/.7844). The

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* The original table contains 40 sectors. We aggregated the Services, Trade and General Repairs into one sector.

quantity of final uses of refinery products is 1762. Hence 1381 (1762 x 0.7844) units of imported oil are directed to that usage and they can be cut off with only a minor effect of IL.85.6 million (.062 X 1380) on the level of the objective function, which is less than one percent. This solution, while being feasible on theoretic grounds does not stand a chance in real life. It seems to us that cuts to levels of below 90% of final uses of all goods and services except refinery products and of below 80% of refinery products are politically not feasible.

Model A describes this case. Now the level of imports at which their implicit price levels off to .062 is 3800, i.e. by more than 1000 above the basic model. It starts after the supply constraint of refined products is fulfilled. The margin up to 4053 is the 20% of final uses of refinery products (353 units which require 276 units of imports of crude oil). Note that all the supply constraints are already fulfilled at the level of imports of 3550 (at 3500 there is no feasible solution). Given these supply constraints when the imports are cut by less than 10 percent (from 4053 to 3650) the implicit price of a unit of import is already 12.5, implying it is 12.5 times the value it is ascribed in reality (by definition a value of 1.0). This value is increasing very steaply, reaching the value of 33.0 at the border of feasibility. Experimeting with other levels of constraints of supplying either final uses or just private consumption clearly indicates that the more stringent is the constraint (the closer it is to the actual final uses of 1975/6) the higher are the implicit prices at each level of imports of oil.

As noted, the constraints and parameters used above were relevant for 1975/6. Meanwhile the population has grown, investments in capital were made, income per capita has increased and the import of crude oil was on an upward trend. Unfortunately we do not have sectorial data of later years. Thus, we assumed the following:

capital stock has increased by 10 percent in each sector. The input-output coefficients stayed the same (Model B) or those of the inputs of refinery products and electricity declined by 10 percent (Model C). The economic system has to supply for final uses amounts that at least equal those supplied in 1975/6.

The increase in capital stocks realise constraints that were previously binding. Thus it is expected that the implicit price of imports of oil will increase. Here as before we also get the implicit price of capital telling in which sector to invest given the level of the oil import constraint. The interesting results are that at the imports of 4100 the implicit price of a unit of imports is 28.4, but it drops rapidly to .062 (already at 4400), because the capital constraints again become the binding ones. This procedure is repeated when the capital stocks were increased by 20% relative to the base stock. Now, at the level of imports of 4400 the implicit price of oil imports is still 5.91, since capital is not yet binding all over.

The next trial with the input-output model was to lower the refinery products and electricity input coefficients which resembles energy saving technology. The coefficients were lowered by 10 percent. None of the other coefficients were changed. Given such technological change, the constraint of oil imports is expected to be less binding, while the constraints of capital more binding. In particular, the system can produce the same amount of goods and services as before with only 90% of the energy previously imported. The experiment reported here allowed an increase in capital stocks by 10 percent and required the system to supply the same amounts for final uses as in 1975/6. Now at a level of imports of crude which is 5% below the 1975/6 imports, the shadow price of the import constraint is already about IL.13.8 (Model C).

The last trial with the input-output model was to impose a constraint on the value of imports of all inputs while letting the price of imported crude oil to rise. The constraint upon the expenditures of imported inputs substitute for the import of oil constraint. Yet, the interpretation is quite different. The implicit price of the expenditure constraint is of the lack of foreign exchange (measured in units of domestic currency). This constraint at periods of increasing oil prices is the situation faced currently by many of the developed countries (deficit in the balance of payment) and practically by all developing countries. We found that at the level of imports of 1975/6 when oil prices increase by about 34%, the implicit price of the foreign exchange constraint (actually measured in IL) is about 1:0, i.e. increasing the constraint by one unit would increase the returns to domestic factors by 1.0 IL. The increase of oil prices by OPEC between 1975/6 to 1978/9 was about at that level. Note that the solution becomes non-feasible when the increase in oil prices exceeds 70% (recall that 90% of the final uses is forced to be supplied).* The outlet is to increase the allowance for imports which in many countries means the increase of the deficit of the balance of payment.

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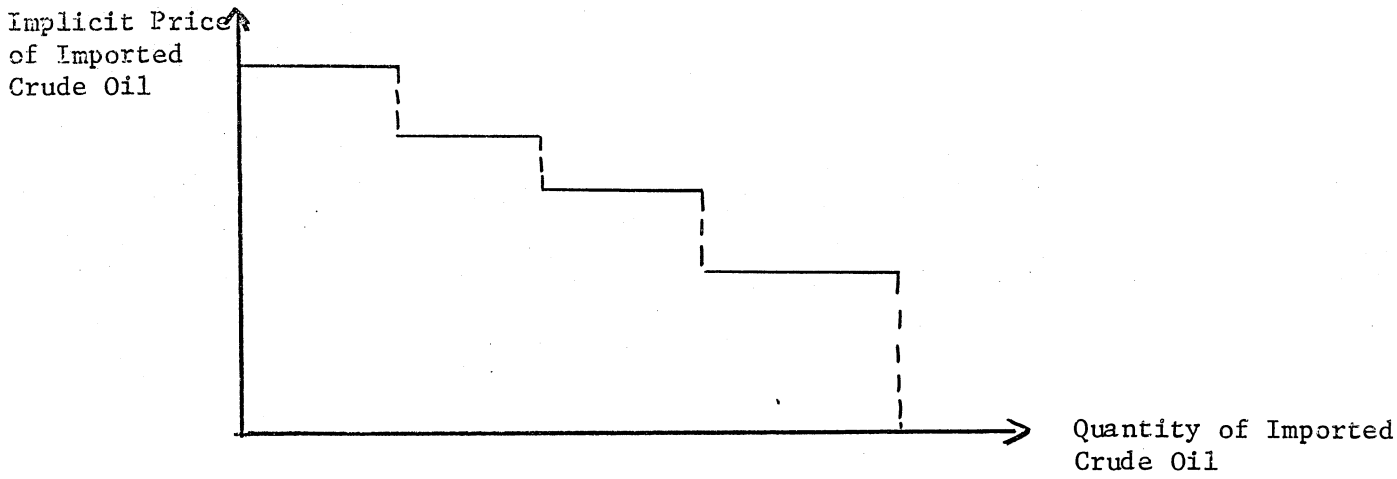
* Interesting results are obtained when the value of allowed imports of inputs changes or the percent of final uses that has to be supplied changes.

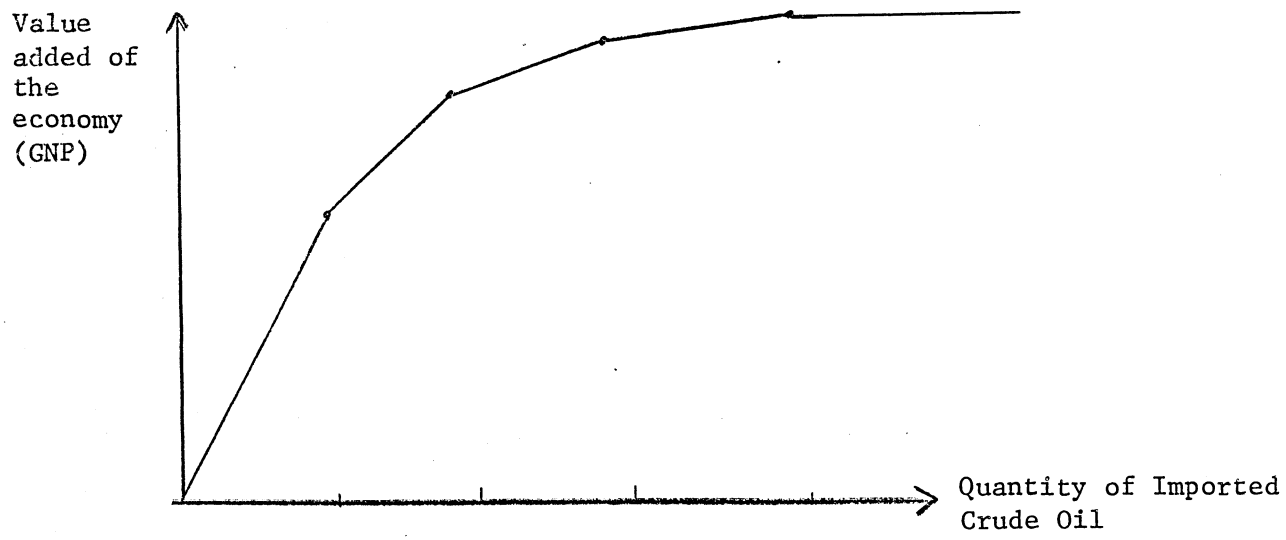
Hence, oil prices, the value of imports of inputs and the level of supply of final uses form with the shadow price of the import constraint a four dimensional space. The Iso implicit price surface can be drawn in order to find the marginal rate of substitution between constraints (work in progress). This trade-off between constraints is relevant also to Models B and C.

FURTHER ECONOMIC INTERPRETATIONS

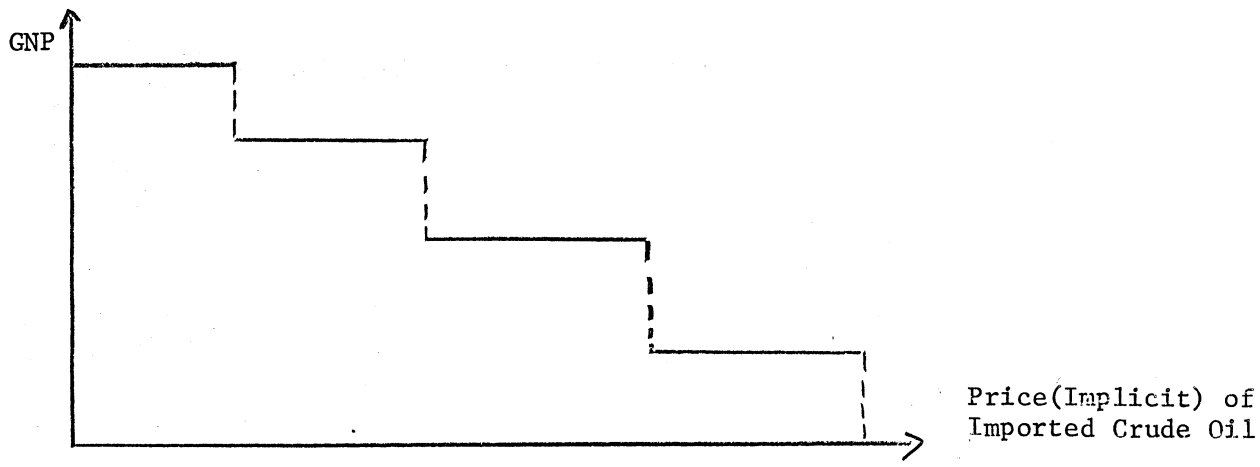
The information rendered by various scenarios enables the calculation of other measures of sensitivity to import constraints. As noted by changing the level of the constraint, we trace out the demand for imported oil. Given the overall linearity and the point estimation we employed, the general nature of the curve is of steps.



The complementing figure to the demand for an input is the production function from which it is derived. This function in our case is composed of linear segments.



From these two a third curve can be drawn which relates the GNP to the price of the imported oil,



A good measure of the curvature of each of the curves is their elasticity. The elasticity of the first is the conventional demand elasticity(calculated at the right-hand column of Table 1). The second is the conventional partial elasticity of production and the third (not yet coined by a specific name) is the internal rewards w.r.t. imported input prices. The mathematical expressions for the corresponding arc elasticities are:

1) $$\frac{IE_{i+1} - IE_i}{IE_{i+1} + IE_i} \Big/ \frac{IP_{i+1} - IP_i}{IP_{i+1} + IP_i}$$

2) $$\frac{GNP_{i+1} - GNP_i}{GNP_{i+1} + GNP_i} \Big/ \frac{IE_{i+1} - IE_i}{IE_{i+1} + IE_i}$$

3) $$\frac{GNP_{i+1} - GNP_i}{GNP_{i+1} + GNP_i} \Big/ \frac{IP_{i+1} - IP_i}{IP_{i+1} + IP_i}$$

where i is the level of the constraint (e.g. downward the column of IE where for the highest i = 1). Note that the third elasticity is just the product of the first two.

The demand elasticities except for the basic model are very small implying a rather steep demand curve or a very narrow range of quantities over which prices might matter. Even for the basic model the elasticities are all below unity. The partial elasticities of production of the basic model are small and far below unity (the highest is about .45). In Model A they start at a level of about 1.5 but decline rapidly to below unity. Similar results are found for Models B and C. Given these patterns of behavior of the first two elasticities, the behavior of their product is obvious. It is never above unity and relatively very small implying that the third figure is rather flat within the boundaries of existence.

Model C is somewhat exceptional within the framework of import constraints. Yet it might be the most experienced one by many countries. The elasticity we calculated is that of the returns to the domestic factors w.r.t. the price of imported oil. As the price of oil rises the elasticity approaches the factor share of oil in total returns (to domestic factor and oil (4050 out of 58500)).

CONCLUSIONS

Instead of summarizing the detailed results of this study we compare them with the relevant ones found in Fishelson [1979]. Recall that the last year which was analyzed was 1972 which was before the earthquake in the energy markets (the end of 1973). Hence, the price structure of inputs in 1975/6 was quite different from that in 1972 with energy scoring the largest increase. By 1975/6 more than two years had passed since the first jump of prices and further increases were already expected. Thus one should expect that the production sector would consider these facts and information when optimizing its behavior.There are, however, arguments that the

Israeli producers were rather reluctant towards such changes given the "cost plus" pricing policy used by many (price controls are highly responsible for this).

We found that the demand elasticities in 1975/6 were considerably lower than in 1972, i.e. the demand became steeper. The behavioral implication is that given the technology reached in 1975/6 there is very little room to play with quantities of imported oil. There is a very wide range which is the final uses of refinery products which can be lowered without affecting the structure of production. Yet the social welfare losses might be much higher than those implied by disturbances in production.

TABLE 1 - LEVELS OF IMPORTS OF CRUDE OIL VALUE ADDED OF THE ECONOMY AND THE IMPLICIT PRICE OF A UNIT OF IMPORTED OIL

Level of Imports (IE)	Value Added (GNP)	Implicit Price (IP)	Demand Elasticity
	BASE CASE		
4053	54635	.062	
3500	54600	.062	
3000	54569	.062	-.13
2500	54419	.79	-.18
2000	53135	5.17	-.35
1500	48830	12.51	-.95
1000	40902	19.18	
	MODEL A		
4053	54635	.062	
3800	54619	.062	-0.07
3750	54597	.79	-.010
3700	54435	5.17	-.018
3650	53985	12.51	-.030
3600	53182	19.67	
3550	51951	33.08	-0.28
3500	Not Feasible		

MODEL B

Level of Imports (IE)	Valued Added (GNP)	Implicit Price (IP)	Demand Elasticity
4500	60098	0	
4400	60094	.062	-.013
4300	60074	.785	-.015
4200	59531	12.51	-.032
4100	57605	28.42	
4000	Not Feasible		

MODEL C

4100	60074	0	
4000	60069	.062	-.015
3900	60010	.87	-.017
3800	59541	13.78	-.027
3700	57056	49.35	
3600	Not Feasible		

MODEL D

Relative Change in Price of Import of oil			Elasticity of Returns to Domestic Factors w.r.t. oil prices
80%	Not Feasible		
70%	50330	9.75	
60%	52230	2.93	-.0620
50%	53165	1.89	-.0250
40%	53793	1.53	-.0160
30%	54196	.59	-.0100
20%	54392	.50	-.0044
10%	54572	.45	-.0038
0%	54635	.062	-.0011

APPENDIX I, ACTIVITY LEVEL, FINAL USES, IMPORTS OF INPUTS AND RETURNS TO DOMESTIC FACTORS PER UNIT OF ACTIVITY,

Israel 1975/6 (current prices)

	Activity None	Activity Level (Million IL)	Final Uses (Million IL)	Imports (million IL)	Returns to Domestic Factors (IL/IL)
1.	Field Crops	1496	322	47	0.593
2.	Livestock	4160	1293	60	0.303
3.	Citrus	1626	1465	104	0.573
4.	Other Agr.	2376	2049	46	0.781
5.	Mining & Quarrying	1358	689	196	0.539
6.	Meat Fish & Milk Products	4939	4024	949	0.143
7.	Other Food	7565	4487	2554	0.178
8.	Textile	2930	1060	495	0.320
9.	Clothing	3466	3413	404	0.294
10.	Leather & Products	607	471	100	0.319
11.	Wood & Carpentery	2168	831	398	0.339
12.	Paper & Products	1244	278	426	0.229
13.	Printing & Publishing	1275	572	139	0.407
14.	Rubber & Products	799	487	184	0.311
15.	Plastic Products	1160	375	230	0.311
16.	Chemicals	2589	1482	561	0.332
17.	Drugs	489	424	169	0.339
18.	Other Chemicals	1219	600	245	0.335
19.	Petroleum	5167	1762	4053	0.049
20.	Glass,Ceramic Cement	2243	260	280	0.351
21.	Basic Metals & Pipes	1559	586	543	0.250
22.	Metal Products	5756	2786	1243	0.378
23.	Machinery	2149	1294	409	0.417
24.	Electrical Equip.	1509	813	314	0.341

Activity None		Activity Level (Million IL)	Final Uses (Million IL)	Imports (Million IL)	Returns to Domestic Factors (IL/IL)
25.	Electronic Equip.	2728	2386	583	0.428
26.	Ships & Planes	2641	2384	810	0.464
27.	Other Vehicles	1135	900	374	0.174
28.	Diamonds	4553	4521	2723	0.268
29.	Optic.Equipment	332	269	58	0.358
30.	Other Industrial Products	598	537	164	0.371
31.	Residential Constr.	7786	7786	413	0.455
32.	Other Construction	9345	8820	751	0.418
33.	Electricity	2214	883	37	0.355
34.	Water	946	142	21	0.490
35.	Road Transportation	5357	3435	79	0.502
36.	Shipping & Air Trans.	5136	5101	2990	0.304
37.	Other Transportation	2992	1828	151	0.723
38.	Services & Trade	31711	17202	915	0.533

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