FEMISE network

FORUM EURO-MEDITERRANÉEN DES INSTITUTS ÉCONOMIQUES

EURO-MEDITERRANEAN FORUM OF ECONOMIC INSTITUTES

Etudes financées ou co-financées par le Femise

Tendances actuelles et impact des accords d'association euro-méditerranéens sur les flux internationaux de capitaux, de biens et services

International Flows of Capital, Goods and Services : Current Trends and the Impact of the Eu-Med Association

SESSION #8 — 18 Février 2000

ESTIMATES OF CAPITAL STOCK FOR 3-DIGIT ISIC MANUFACTURING SECTOR IN IRAN: 1982-1997

Hamid Mohtadi
University of Minnesota-ERF, Egypt

Février 2000

With the financial support of the European Commission — External Relations DG

ESTIMATES OF CAPITAL STOCK FOR 3-DIGIT ISIC MANUFACTURING SECTOR IN IRAN: 1982-1997*.

Hamid Mohtadi

University of Minnesota and Wisconsin-Milwaukee

Ahmad R. Jalali-Naini

Center for research on Economic Development and Planning, Iran

Pei-Chien Lin

University of Minnesota

February 2000

Draft

***This is a research report on an ERF-FEMISE Sponsored Research project on Capital Stock and TFP measure for Iran and Egypt, directed by Hamid Mohtadi**

Estimates of Capital Stock for 3-digit ISIC Manufacturing Sector in Iran: 1982-1993.

1. Background

This paper, which is the first part of a two-stage project, deals with developing a databank for capital stock at 3-digit ISIC levels for the manufacturing industries in select countries of the Middle East and North Africa (MENA) for the period 1982-93, based upon UNIDO and local (in-country) data. The original proposal was granted for the two countries, Egypt and Iran, which have been the focus of present work, but upon the successful completion of the project more countries may be added in the future. Stage II, which is the subject of the second paper, involves utilizing this databank to construct systematic estimates of Total Factor Productivity (TFP) in these countries and industries for the same period.

Creation of such a databank will enable both countries to address key policy issues that cannot be adequately answered now. For example, capital stock data are needed for estimation purposes in EU-MENA trade policy (e.g., role of trade in factor intensity and identifying sectors with comparative advantage), or the impact of EU expansion on the MENA's industrial and labor policies (e.g., skill and capital substitutability) and its macro policies (e.g., economic growth and convergence hypothesis). Similarly, TFP is key to understanding sources of economic growth and is especially relevant to technology and knowledge-based policies, such as the impact of technology on economic growth, education and training of the workforce, role of trade with EU on technology diffusion to the MENA region, export promotion policies and their sectoral productivity impact, the productivity effects of Intellectual Property in different sectors.

Growth in the MENA region has been sensitive to trends in TFP. A sharp decline in the rate of growth of total factor productivity (TFP) and lower rates of physical capital accumulation are the most important factors explaining a marked slow-down of GDP growth rate in the MENA region after mid-1980s (Senhadji,1999). Both capital accumulation and increased employment have contributed significantly to economic growth in MENA. For the 1960-94 period as a whole, capital accumulation is estimated to be the most significant source of growth, followed by increased employment and human capital formation, respectively. Even though MENA's rate of TFP growth declined precipitously after 1974, and its growth rate during 1987-1994 was estimated to be negative, TFP has contributed *comparatively* more to economic growth in MENA than in Africa and Latin America, but less than that in South and East Asia. Compared to Latin America, Sub-Saharan Africa, and to a lesser extent South Asia, human capital has been a relatively more important source of growth in MENA. Growth policies should search for the type of economic and institutional reforms capable of inducing a higher rate of increase in TFP.

This paper begins with a detailed description of the methodology, followed by a description of capital stock estimation. The actual results are presented in Annex 1.

2. Methodology

UNIDO and in-country are used to convert capital stock data from gross investment data. The method used is the PIM (Perpetual Inventory Method), outlined in OECD (1992) with distribution function for life of machinary from Ball and Witzke (1993). Because more information from in-country sources are needed to supplant the UNIDO data, the present project deals with an initial set of two countries, Iran and Egypt for which the UNIDO data exists *and* contacts with regional ERF fellows have been made. In Iran, Dr. Ahmad Jalali-Naini and in Egypt, Drs. Lobna Abdel-Latif and Elia El-Mahdi are contributing to the calculation of capital stock.

The PIM Method: PIM is known as the Perpetual Inventory Method (PIM) and is thoroughly described by OECD (1992) as well as detailed in Statistics Canada (1979). The first step involves adding up *weighted* sums of investments (Gross Capital Formation) over time, as follows:

$$K_t = \sum_{i=0}^{L} w_{t-i} I_{t-i} \qquad (L \le t)$$

where K_t is the real Gross stock of capital, L is service life of capital (discussed below), I_t is the real Gross Capital Formation in time t, and w_i is the weight associated with the contribution of investments during the period t-L to t.

Measuring w_i: This weight is estimated differently by different OECD countries, based on varying assumptions regarding the survival of machinery after initial installation. One common assumption made by some OECD members is that the machinery of the same kind are withdrawn from service *simultaneously* when their service life L is reaches. This approach, known as "Simultaneous Exit", assumes a mortality function that is in the form of step function:
$w_i = 1$ *for* $i < L$, *and* $w_i = 0$ *for* $i \ge L$.

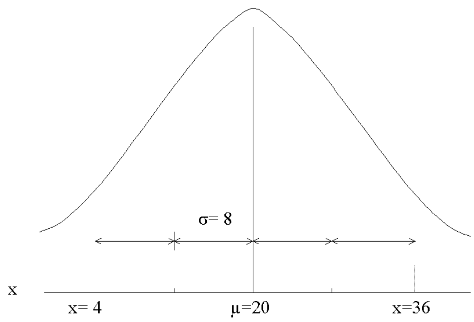
Yet, the assumption of simultaneously discarding machines seems unrealistic. Thus, some OECD members assume a "Delayed Linear" function where discarding begins sometime *after* initial installation but occurs at a constant rate. Then w_i will be uniformly distributed around L. Still, other OECD countries assume a normal distribution of w_i over time. Comparing the resulting figures for Gross Capital Stock from these varying assumptions, Statistics Canada (Koumanakos, 1980) and the Norwegian Bureau of Statistics (Biorn, et. al., 1985) find the results to be sensitive to the choice of mortality functions. Still, OECD analysts conclude, "…the bell-shaped function is really the only plausible candidate," (OECD, 1992) and most OECD members use this function.

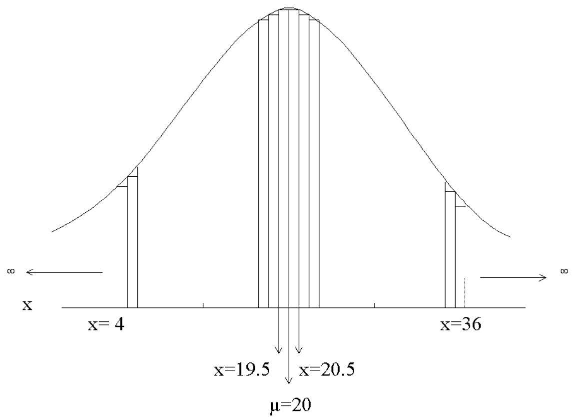
Given the prevalence of the bell shaped distribution, we adopt this approach as well. However, since capital's life is finite, we modify this by estimating a truncated normal distribution, following Ball and Witzke (1993) around some mean value of L, as discussed below.

Measuring L: This measure has two aspects, the mean value of L and the distribution around this mean value. Methods to estimate the mean value of L has ranged from estimates based on capital assets' lives from tax authorities, with many inconsistencies (see OECD, 1992) to estimates based on company accounts (e.g., estimates used for France by Atkinson & Mairesse (1978) and Cette & Szpiro (1978), for Italy by Barca & Magnani (1989) and for Canada by Tarasofsky et. al. (1982)), to estimates based on survey methods (e.g, Japan). However, many OECD countries use other countries estimates for this purpose. For this reason, OECD (1992) provides a rather detailed table providing for estimates of mean value of L across a large number of detailed sectors. Yet it is not uncommon to see researchers use a single value for this number, ranging from 15 to 20 years, since most values do fall in this range. For the purpose of this work, we have assumed an average service life of 20 years[1] .

For the distribution of L around this mean value we use a truncated normal density function, truncated at 2 SD of the mean with mean of μ=20 years, representing $\overline{L}$ for mean life of machinery and standard deviation of σ=8 years representing one SD around $\overline{L}$. The distribution was truncated at points of two standard deviations before and after the mean. The area under the truncated normal curve was then adjusted upward within the allowed range of asset lives as shown below.

[1] This is an average of the mean life of forms of capital, mechinary and buildings. See the section on measurement of investment flow.





This density function then assigns weights π_i to each value of L_i where π_i is the probability of occurrence of a machine with life of L_i obtained from the truncated normal distribution. The index i runs from 1 to 199, indicating the number of segments used to calculate the truncated normal distribution. A SAS program was written to generate this distribution.

We then calculate the *efficiency function* for that service life by using assuming a value for the decay rate of capital stock (see Ball 1993 for details). For this purpose β=.5, the decay rate of capital, repeating the process for all possible service lives. This decay rate of capital was chosen by comparing these rates for several different countries, and also by local expert interviews. This efficiency function is given by:

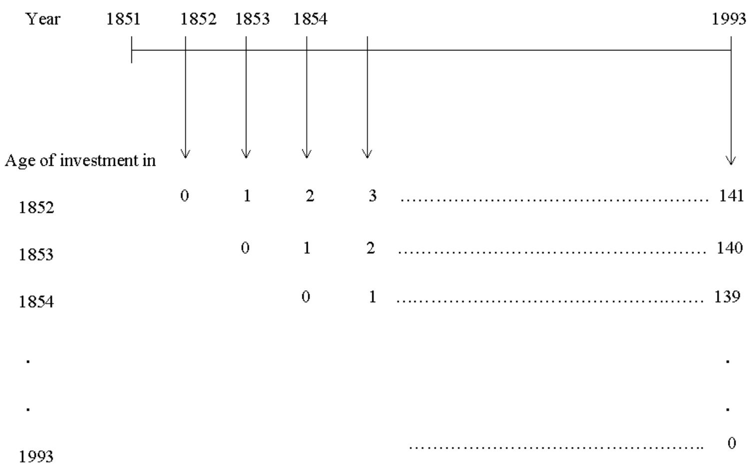
$$w_{it} = \frac{L_i - t}{L_i - \beta t}, \qquad 0 \le t \le L, \qquad d_t = 0 \qquad if \qquad t > L$$

An aggregate efficiency index was then constructed as a weighted sum of the individual efficiency functions using the frequency of occurrence as weights.

$$w_t = \sum_{i=1}^{199} \pi_i . w_{i,\tau}$$

Measuring Initial Capital Stock: There are several approaches to the measure of initial capital stock, including the ICOR (incremental capital-output ratio). However, for the purposes of parsimony and consistency we extend the PIM method backwards following Ball and Witzke (1993) and Behrens (1981) until the investments flow levels of to zero. (For Ball this point is reached in the year 1850 in the case of France. For our analysis this level is reached in the year 1914, implying that investments grew from zero in 1914 to the initial year of observation in our sample, 1982. This approach has a distinct advantage in that it makes any assumptions regarding the initial choice of capital stock unnecessary.

The diagram below illustrates this point. Although the diagram starts from 1850 we have actually chosen 1914 as our initial year of I=0, as mentioned. Further, note that since the service lives of assets are deviated two standard errors from their mean (20 years), if age t exceeds the maximum expected service lives L , then the efficiency index would be wit=0.



The procedure involves the following steps: The first step involves forecasting backward, as discussed above, to expand the real investment data. This involves first running the following regressions

$log(y) = a+b(year)$

$log(I/y)=c+d(year)$

where y=real sectoral output, I=real sectoral investment and year=1914-1997. We then calculate the real investment series, for 1914-1982, predicted from above equations, by:

$$\hat{I} = \exp[\log \hat{y} + c + d(year)]$$

Capital Stock Calculation: Finally, the capital stock of period t was constructed as the weighted sum of all past real investment, with the weights (w) obtained from above:

$$K_t = \sum_{i=0}^{L} w_{t-i} I_{t-i} \quad (L \leq t)$$

Annex 2 provides the SAS output of the 3-digit capital stock for Iran based on the above procedure (Annex 1 gives the sector definitions).

Measurement Issues: Due to the paucity of data at 4-digit, an initial goal of this project, only 3-digit data is reported here. Data are reported for the 1983 to 1997 period. Since the raw data on fixed investment are in nominal terms we had to choose an appropriate deflator. We began with several deflators and a weighted-average of several indices, to reflect the weighted- average cost of the bundle of investment goods. For each industry (e.g. food, textiles, glass) annual fixed investment is the sum of expenditures on machinery, tools, transportation vehicles, construction, electrical generators, etc. Therefore, a wholesale price deflator for each of the above items had to be obtained and weighted with their share in total investment expenditures to calculate a deflator for each ISIC number. For a number of years and a number of industries the breakdown of total investment expenditures were not available, and therefore we had to find an alternative deflator. Since fixed investments (capital goods, electric generators, and construction) are considerably less heterogeneous than industrial output, the manufacturing sector's fixed investment deflator was found to be a good representative index for deflating nominal investment when data on the components of investment expenditures were not available. The deflated investment series, or real investment flows, was used to estimate real capital stock series.

Real investment flows were initially estimated for 3 and 4-digit ISIC code. For comparative purposes, and due to the fact that time series 4-digit data are much more limited, three digit data were finally chosen. Different rates of depreciation were calculated for construction and machinery. For depreciation, or more technically, decay rate of machinery both international data and a small survey of local expert opinion was considered. The decay rate for construction is usually lower than that for machinery. A use-life of between 16 to 20 is usually considered for machinery. Factors such as the availability of exchange rate and the black market exchange rate premium influence the decision to buy and install new machinery in those countries that import capital goods. Usually when foreign currency becomes significantly more expensive and/or its availability is limited new capital equipment purchases are delayed and older machinery stay in use for a longer period of time. In the case of Iran, official exchange rate depreciated very massively in the early 1990s, and black market premia was very high during the 1985-1991 period. Considering all these factors, an average use-life of about twenty years was assumed.

References

Atkinson, M. and J. Mairesse, 1978. “Length of Life of Equipment in French Manufacturing Industries.” *Annales de l’INSEE*. No. 30-31/1978. INSEE, Paris.

Ball, E. and H. Witzke 1993 “The Stock of Capital in European Community Agriculture.” *European Review of Agricultural Economics*. pp. 437-450.

Barca F. and M. Magnani, 1989. L’industrie fra Capitale e Lavoro. Il Mulino, Bologna.

Biorn, E., E. Holmoy and O.Olsen, 1985. “Gross and Net Capital Productivity and the Form of the Survival Function – Some Norwegian Evidence.” *Discussion Paper no. 11*. Central Bureau of statistics, Oslo.

Cette G. and D. Szpiro, 1978. “La Duree de Vie des Equipments Industriels sur la Periode 1972-1984.” Cahiers Economiques et Monetaires. No. 28. Paris.

Koumanakos, P., 1980. *Alternative Estimates of Non-residential Capital in Canada, 1926-1980*. Statistics Canada, Ottawa.

OECD, 1992. *Methods Used by OECD Countries to Measure Stocks of Fixed Capital*. Paris.

Senhadji, A. 1999. “Sources of Economic Growth: An Extensive Growth Accounting Exercise.” *IMF Working Papers*, WP/99/77.

Statistics Canada, 1979. *Fixed Capital Flows and Stocks*. Ottawa.

Tarasofsky, A. T. Roseman and H. Waslander, 1982. “Ex Post Aggregate Real Rates of Return in Canada, 1947-76.” *A Study for the Economic Council of Canada.* Ottawa.

UNIDO, 1981-96. *UNIDO Industrial Statistics Database 3-Digit Level of ISIC Code*. (Available on diskette).

3-digit ISIC Definition

Series Code	Series Name
311	FOOD PRODUCTS
314	TOBACCO
321	TEXTILES
322	WEARING APPAREL,EXCEPT FOOTWEAR
323	LEATHER PRODUCTS
324	FOOTWEAR,EXCEPT RUBBER OR PLASTIC
331	WOOD PRODUCTS,EXCEPT FURNITURE
332	FURNITURE,EXCEPT METAL
341	PAPER AND PRODUCTS
342	PRINTING AND PUBLISHING
351	INDUSTRIAL CHEMICALS
352	OTHER CHEMICALS
353	PETROLEUM REFINERIES
354	MISC. PETROLEUM AND COAL PRODUCTS
355	RUBBER PRODUCTS
356	PLASTIC PRODUCTS
361	POTTERY,CHINA,EARTHENWARE
362	GLASS AND PRODUCTS
369	OTHER NON-METALLIC MINERAL PROD.
371	IRON AND STEEL
372	NON-FERROUS METALS
381	FABRICATED METAL PRODUCTS
382	MACHINERY,EXCEPT ELECTRICAL
383	MACHINERY ELECTRIC
384	TRANSPORT EQUIPMENT
385	PROFESSIONAL & SCIENTIFIC EQUIPM.
390	OTHER MANUFACTURED PRODUCTS

Capital Stock (in real local currency) for 3-Digit ISIC Code (Iran)

Year	311	314	321	322	323	324	331	332	341
1982	103326018	9864255.2	125125794	2593420.6	11995999	11059048	16643325	5183994.9	9305945.5
1983	102624809	9914742.9	130179602	2580091.3	11197925	10457052	16576961	5075776.6	9621994.4
1984	108765556	9840018.3	137731838	2627221.3	10886664	10244112	16947521	5056454.9	11039719
1985	112136499	10079237	140897750	2792310.7	10613648	10079521	16621951	5073952.7	13093152
1986	115407549	9857184	146193835	2955041.8	10240700	9941912.3	16229396	5485617.3	14339015
1987	117274415	10247716	150450562	3077530.9	9800901.7	9492520.1	15731076	5556884.4	14411567
1988	126575631	9691894	153684341	9708746.2	10285864	9671714.2	17376871	6980463.9	14990297
1989	126929406	9091813.6	152620150	9901470.5	9958400.4	9284945.2	17088662	7786569.7	15413322
1990	125431386	8483649.8	153297674	9666537.5	9471636.4	8742176.5	17091615	7788986.5	16584930
1991	123410618	7767199.7	156274644	9957547.3	9370284.8	8285796	17146515	7477345.1	16535794
1992	123653014	7217317.6	162096904	9894022.7	8955566.3	7964644	17439792	7645776.9	17793259
1993	127007641	8681785	171387311	9772343.8	8576268.8	8026811.5	16822559	8016723.8	18477801
1994	127950385	11948959	176614370	9602578.6	8032677.9	7647216.6	17123422	7770914.8	19614184
1995	133534070	11291835	192548318	9912997.5	8085036.6	6967143.7	17282214	7221115.6	23976197
1996	139778997	11089132	194668131	9689332.5	7682156.6	6322381.7	16889658	6679069.1	25845212
1997	145459004	10973873	195789273	9520233	7318332.2	5712227.5	17384656	6145753.2	26753046

Year	342	351	352	353	354	355	356	361	362
1982	3130061.8	3921553.3	30776500	2199301.6	164929171	7931106.5	47162650	1807643.5	24308152
1983	3293241	5583964.9	31785643	2778001.8	134219614	8242575.4	45217827	2002305.6	23434408
1984	3959382.6	6551348.8	33063038	3433407.7	109183952	9012775.7	45479033	2370035	22701751
1985	4300711.9	8109015.1	35280400	3909185.5	88842631	10950432	45182628	2749958.3	23407827
1986	4652121.8	9194816.4	38048717	4151255.5	72185434	12558350	45012616	2881504	23450574
1987	4841246.7	9681768	39198485	4210333.6	58782230	14071185	43843726	3105889.1	23257644
1988	6167275.1	13152988	43050077	4141891.7	48143757	14666123	43814741	3366862.4	23105308
1989	6756437.1	15912501	46218047	4060094.1	39336598	15154353	43506952	3539470.8	22959854
1990	7872162.5	18490302	47341263	4072849.6	32060814	16565674	44358171	3630084.9	22607795
1991	8994423.4	21703608	49484099	3979937.2	26693301	16209066	42341734	3707457	23106932
1992	9529053.5	24202908	50776034	3788141.1	22164716	16454728	41380754	3907823.6	22631923
1993	10848565	24953501	53174597	3737929.5	18426578	18035111	42303905	4505696.5	25179701
1994	11556556	26255910	54061671	4121359.6	15376674	18766491	40836061	5361059.4	23811880
1995	14436430	114803990	59288905	9762568.6	12646615	19502643	40961966	6677289.6	23054172
1996	14508607	124708560	62089868	13582023	10418973	30725520	39780620	7294554.8	22958110
1997	15396994	135287172	63682046	25896160	8588146.2	65621426	39972123	7883336.4	23918745

CONTINUED

year	369	371	372	381	382	383	384	385	390
1982	241748664	6822791.6	7225389.1	35575485	48301097	53722396	41526979	3918315.1	1105037
1983	231751490	24687214	7415289.8	36622740	48197255	52970718	41519228	4181555.1	1156318.8
1984	230099728	25081310	8974159.8	39180385	50629174	54175297	43331495	4667968.3	1275235.7
1985	228657392	26487008	10213120	42782161	55385480	53358036	48570702	5092096.4	1460713.6
1986	226413222	28431404	11267789	45311776	59884826	53495924	60049304	5313375.1	1718551.6
1987	224487655	29639863	11720810	47014324	59978322	54491179	59151999	5414525.3	1896208.4
1988	226552692	30918452	21447009	52528294	70415016	55375693	60112151	5513512.1	2907095.1
1989	224353925	31566742	30429724	52950842	75054047	55905581	60775843	5542085	2966003.3
1990	219097702	31628237	29911966	59612310	77188936	53521087	59361954	5337036.5	2880674
1991	211866715	33231060	30897807	60867082	79006260	51594639	58015921	5472611.2	3265490.2
1992	205917842	36624172	47023866	62752106	87344029	50467581	62135404	5559026	3359365.3
1993	205916980	51593654	56128100	64892413	94364923	50793895	65939850	5966182.8	3695339.2
1994	200185779	70560155	57727428	77314235	97109610	49815859	68479461	6658675.3	4072760.3
1995	196272467	135958469	59228495	80775251	99566345	50296959	71335655	8072862.9	4371891.1
1996	194382442	155033659	58426010	82309976	99737178	52110736	74242382	8292784.3	4742426
1997	204772105	191244715	57884794	85345007	99677008	52683982	80500084	8953871.5	5290288.2