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AN INQUIRY INTO THE SOURCES OF GROWTH AND STAGNATION IN IRANIAN ECONOMY

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An Inquiry into the Sources of Growth and Stagnation in Iranian Economy

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Abstract.

Iran was a textbook example of economic success in the two decades prior to the advent of the Islamic Revolution in 1979. But she has turned into an example of economic failure ever since. This study finds that nearly half of the 11 percent difference in economic growth in the two periods can be attributed to productivity. The study confirms the presents of significant productivity differentials in the two periods in the manufacturing sub-sectors and tries to explain it. To explain manufacturing productivity differentials in the two periods a Tonrquist measure of TFP, corrected for market imperfection and non-constant returns to scale technology, is constructed. On the issue of market imperfection it is found that Iranian manufacturing sectors suffers from a decreasing return to scale technology and mark-up pricing since 1979. In the cross section of 23 manufacturing sectors it is found the degree of market participation of the private sector versus public sector has the highest explanatory power in explaining sectoral productivity differentials.

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1. Introduction

Iran was a textbook example of successful economic development in the 60's and the early 70's. From 1959 to 1977 Iran's real non-oil GDP per capita grew on average by 6.8 percent, a rate that was truly exceptional before the rise of Asian tigers. By early seventies her GDP per capita exceeded that of Singapore and it was almost twice that of Turkey or South Korea. But the picture is very different today. In 1999, GDP per capita in Iran was equal or less than what it was some 27 years earlier in 1972 and 30 percent lower than its peak in 1976. Iran's GDP per capita is now 85 percent of Turkey's, 35 percent of South Korea's and 26 percent of Singapore's (World Development Indicator 2001 and Summers and Heston 1992).

Being a major oil exporter, changes in oil prices explain part of the sharp variation in GDP per capita in Iran. The rise of oil prices following the Arab oil embargo of 1973-74 dramatically increased the income of oil exporting countries, including that of Iran. This helped the Iranian GDP to reach heights that had never been experienced before. The Iranian economy however, was enjoying a solid and continuous economic growth well before the rise in oil prices or the expansion of her extraction capacities in the late 60's and the early 70's. Iranian non-oil GDP per capita from 1955 to 1970 on average grew by 4 percent a year. If this growth had continued Iranian GDP per capita would be close to that of England today.

Some of the declines in per capita income can be attributed to the 1979 revolution and the eight-year Iran-Iraq war. Iranian economy took a dive in 1978 with the outbreak of unrest that led to the Islamic revolution and it took another dive in the final years of the war in1986 and 1987, when Iraq targeted Iranian cities and its economic infrastructure. From 1977 to 1988, on average non-oil income per capita in Iran declined by 3.3 percent per annum. Iranian economy started to grow again once the war was ended in the mid 1988. The growth of GDP per capita averaged 5.3 percent for the first four years after the war; the period in which most of the war damaged infrastructure was reconstructed. But hopes for regaining the pre-1978 growth rates soon faded away as the economic growth slowed down in 1992. From 1992 to 1999, on average non-oil income per capita in Iran grew by less than half a percent per annum.

The extent of economic failure since the 1978-79 revolution in general and its meager achievements in the 90's when the state was not faced with any external or internal threat and the oil prices were in general favorable is puzzling. The failure is puzzling because despite the war, vast amounts of investment were made in physical and human capital since the 1978-9 revolution (thanks to the oil revenue). Investment share of GDP, in the post 1979 era on average, was not less that the 1959-77 years. Investment share of GDP on average was 0.21 in both periods of 1959-77 and 1979-99. Massive investment was made in human capital since the 1978-79-revolution as it is evident by the achievements made in literacy and school enrolment rates. Literacy rate rose from 43 percent in 1975 to 72 percent in 1996. In the same period the number of student enrolled in the primary, secondary and the tertiary education increased from 93, 45 and 5 percent to 98, 77 and 18 percent respectively[1] (WDI 2002).

The primary goal of this paper is to find the sources of economic stagnation in Iran. In section 2, we identify the sources of the Iranian economic growth at the sectoral level. That is, we estimate the contribution of factor inputs and productivity by four major economic sectors to the overall GDP growth in Iran before and after the 1978-79 Islamic revolution. The results of this section show that lower capital formation and lower productivity growth in the non-agricultural sectors of the economy are the main sources of economic stagnation in the years after the 1978-79 revolution. To get a better a better understanding of the productivity slow down in the industry, we focus on the manufacturing sector where a more detailed and reliable data set for analysis is available. First we measure the sources of productivity slow down in the manufacturing sector, and then we investigate the factors that affect productivity in the manufacturing sector. However we find that depending on the method of estimation and the assumptions the TFP results can be different. In section 3 we present a discussion of estimation methodology. In this section we present a methodology for estimating manufacturing TFP growth rates at sub-sectoral levels under the standard assumptions of perfect competition and constant returns to scale (CRS). Then we present a methodology for testing the impacts of various macroeconomics and institutional as well and industry specific variables on manufacturing TFP growth. Finally, we present a methodology for estimating TFP growth rates under market imperfection and non-CRS. Data sources are discussed in section 4. The results are presented in section 5. First the standard Tornquist measures of TFP growth rates are presented then by relaxing the standard assumptions of perfect competition and constant returns to scale technology

[1] On the investment on the educational system in Iran during the 1990's, see the World Bank Report No. 13233-IRN: Islamic Republic of Iran: Education, Training and the Labor Market, 26 July 1996, pp. 23-56.

the mark up and scale parameters are estimated and used to construct the "true" TFP growth rates. And finally using a set of macroeconomic and sector specific variables an attempt is made to explain variations in manufacturing standard and "true" TFP growth rates. And finally the paper is concluded in section 6.

2. Sources of growth: a gross approximation at broad sectoral level

If productivity growth is in fact the main source of high GDP growth rates before the 1978-79 revolution and low growth rates afterward then we should be able to confirm and illustrate this at the sectoral level. Once the lagging industry is identified we can look for the sources of economic malfunctioning at a more micro level and then generalize the main conclusions to the rest of the economy. We employ the standard growth accounting method to calculate TFP growth rates in various sectors. To start, consider the following Cobb-Douglas production function:

$$Y_{it} = A_{it} K_{it}^{a} (H_{it} L_{it})^{(1-\alpha)} \quad 1 > \alpha > 0 \qquad (1)$$

where Y_{it}, K_{it}, H_{it} and L_{it} respectively denote output, physical capital stock, human capital and labor of sector i at time t. A_{it} denotes Hicks-neutral technological change or TFP.

Log differentiation and then re-arrangement of equation (1) gives the following equation for TFP growth.

$$dTFP_{it} = (dA/A)_{it} = (dY/Y)_{it} - \alpha(dK/K)_{it} - (1-\alpha)[(dH/H)_{it} + (dL/L)_{it}] \qquad (2)$$

The sectors considered here are agriculture, oil and gas, industry and services. Relative importance of these sectors in terms of their contribution to GDP can be studied

Table 1. Sectoral value added shares*

	1966-76	1976-86	1986-96	2000
All economy				
Agriculture	0.17	0.19	0.24	0.23
Oil and gas	0.37	0.24	0.14	0.14
Industries	0.14	0.18	0.20	0.20
Manufacturing and Mining	0.07	0.10	0.13	0.16
Services	0.32	0.39	0.40	0.43
Non-oil economy				
Agriculture	0.28	0.24	0.28	0.28
Industries	0.22	0.24	0.24	0.27
Manufacturing and Mining	0.11	0.13	0.15	0.18
Services	0.50	0.52	0.48	0.45

* Constant 1982 prices are used for calculating average shares

from Table 1 where GDP share of each sector is given for three time periods of 1966-75, 1976-85, and 1986-95 and also 2000. As it can be seen from the table oil and gas used to be the largest sector in terms of value added in the 1960's and the 1970's but its importance has declined continuously in the last two decades. The relative share of non-oil sectors have increased as the share of oil sector has gone down. However, sectoral shares seem to be relatively stable in the non-oil par of the economy in the last 30 years. Industry seems to be an exception. Industry share of non-oil GDP has increased from 11 percent in 1966 to 18 percent in 2000.

Table 2. Growth decomposition in the non-oil economy

Average annual growth rate (percent)

	1966-76	1976-86	1986-96	1976-96
Growth rate of				
Value added	13.1	0.7	3.9	2.3
Employment	3.1	1.7	3.1	2.4
Physical capital	15.1	5.6	2.6	4.1
Index of human capital	0.8	0.9	1.1	1.0
Contribution of				
Employment	2.1	1.2	2.1	1.6
Physical Capital Stock	5.0	1.8	0.9	1.3
Human Capital	0.5	0.6	0.7	0.7
Growth rate of total factor productivity*with and without human capital in the formula				
Including human capital	5.6	-2.9	0.3	-1.3
Excluding human capital	6.1	-2.3	1.0	-0.7

*Alpha is assumed to be 0.33

Table 2 presents the growth rates of value added, employment, physical capital, the index of human capital and the calculated measure of TFP in the non-oil part of Iranian economy. These figures are calculated for 1966-76, 1976-86, and 1976-96 periods for which data on employment by sector is available (from the census data).

Capital stock is estimated using perpetual inventory method. The estimates are based on some crude assumptions on the capital output ratios in 1956 when our data on investment series begins. Allowance was made for the destructive effects of the 8-year Iran-Iraq on capital stock. Based on the estimates of the Plan and Budget Organization, higher depreciation rates were assumed for the war period. The index of human capital is from Collins and Bosworth (1996). In the calculation of total productivity, labor elasticity of output is set equal to 0.67. This estimate is based on the share of labor compensation to value added in the 1984 input-output table of Iran (after adjusting for proprietors, income).

There is a sharp contrast between the performance of Iranian economy before and after 1976. From 1966 to 1976 the non-oil part of Iranian economy grew at a staggering rate of 13.1% per annum. In the following two decades this figure fell to 0.7% and 3.9% respectively. From 1976 to 1996 the non-oil part of Iranian economy grew at an average annual rate of 2.3 percent. This is 10.8-percentage points less than the growth rate achieved in the previous period. What are the sources of this difference? Capital accumulation rates in the 1966-76 period are indeed very high compared to the 1976-96 rates or any international standards for that matter. However only 7.2-percentage point of 13.2% growth in the 1966-76 period can be attributed to factor inputs and the remaining 5.6 points should be credited to productivity growth. In fact 64 percent of the difference in economic performance in the two periods can be attributed to differential productivity performance and 33 percent to physical capital accumulation. This illustrates the significance of productivity in the current economic stagnation in Iran.

In search for the sources of growth it would be interesting to know how various economic sectors have contributed to total economic growth and what their sources are. Table 3 presents GDP growth by sector and factor components. The labor elasticity of output is set equal to 0.74 in the agricultural sector, 0.07 in the oil and gas, 0.65 in the industry and 0.64 the service sectors. These estimates are based on labor compensation to value added ratios in the Iranian input-output table in 1984 (after adjusting for proprietors' income).

Table 3. Average annual growth rate of value added, labor, capital and productivity by sector (percent)

	1966-76	1976-86	1986-96	1976-96
Value added				
Agriculture	6.5	4.5	3.7	4.1
Oil and gas	11.6	-11.5	6.2	-3.1
Industry	18.4	-1.4	5.7	2.1
Services	14.5	0	3.1	1.6
Weighted avg. of all sectors	12.6	-2.2	4.2	1.2
Weighted avg. of non-oil sectors	13.2	0.7	3.9	2.3
Employment				
Agriculture	-0.5	0.6	0.5	0.6
Oil and gas	3.4	2.1	4.6	3.3
Industry	6.2	-1.6	5.1	1.7
Services	4.8	5.3	3.3	4.3
Capital Stock				
Agriculture	14.9	2.5	1.4	2.0
Oil and gas	12.8	2.5	-0.2	1.1
Industries	23.2	3.3	4.7	4.0
Services	14.3	6.5	2.3	4.4
Total Factor Productivity*				
Agriculture	3.1	3.4	3.0	3.2
Oil and gas	-0.5	-14.0	6.1	-4.3
Industry	6.3	-1.5	0.7	-0.4
Services	6.3	-5.7	0.2	-2.8
Weighted avg. of all sectors	3.2	-5.3	1.8	-1.4
Weighted avg. of non-oil sectors	5.4	-2.3	1.1	-0.6

*Labor elasticity is 0.74 for agriculture, 0.07 for oil, 0.65 for industry and 0.64 for services.

The significance of the oil sector in the Iranian economy is evident from the table. In general growth rates are higher in periods in which oil income is higher (i.e., 1966-1976 and 986-1996 periods), and lower in other periods (i.e., 1976-86 years). However, as it is evident from the weighted averages of the non-oil sectors of the economy this impact does not override other economic forces. The value added and productivity growth rates before 1976 are much larger than the ones after 1976. In addition, as the economy grows larger the importance of oil sector becomes smaller. In the 1966-76 years, value added share of the oil and gas sector was 43%. This figure dropped to 17% in the 1976-96 years and 14% in 2000.

Productivity growth rates are generally high for the 1966-1976 years and low for the 1976-96 years (see Table 4 for an international comparison). Value added weighted average of sectoral productivity is 3.2% in the 1966-76 period compared to –1.4% in the two the following two decades. This is a massive 4.6-percentage point difference!

Table 4. Comparative productivity growth statistics

Country	Period	Sector	TFP growth rate (% per year)
South Korea (1)	1963-79	Mfg.	6.1
South Korea (2)	1971-89	Mfg.	3.7
	1971-89	Service	1.7
Taiwan (3)	1966-90	Mfg.	1.4
	1966-90	Service	2.6
Singapore (4)	1986-95	Mfg.	4.0
Malaysia (5)	1985-96	Mfg.	3.4

1- Dollar and Sokoloff (1990)
2- Moon, Jo Whong and Kim (1991)
3- Alwyn Young (1995)
4-Maison Abdullah el. al (2001)
5-Ower and Abdullah (2000)

The presence of the oil sector makes the application of our simple growth accounting exercise somewhat complicated. Much of the value added in the oil sector cannot be attributed to labor and capital input. But in the absence of a "resource factor", growth in the value added is attributed to the growth rate of labor, capital or productivity[2]. One way to get around this problem is to exclude the oil and gas sector from our growth calculations[3]. Using this measure we see that the productivity growth differences in the two periods of before and after the 1978-79 revolution is even higher. The growth rate of non-oil economy in the 1966-76 years was 5.42% compared to –0.6% in the 1976-96 years, a massive decline of more than 6% per annum!

In the 1966-76 period the industry and the service sectors have the same extraordinary productivity growth rate of 6.3 percent. Productivity in the agriculture sector is about half of this figure and yet very high by any standard. In the 1976-86 period productivity growth rates are over 7.7 -percentage points lower in the non-oil sector of the economy. This period contains a revolution and 6 years of an eight-year destructive war with Iraq.

Agriculture however seems to be an exception to the general trend of falling productivity in this period. Productivity improvement in agriculture seems to be

[2] Labor compensation was only 3% of value added in the oil sector in 1984 and 7% in 1996.
[3] Contribution of the oil sector to the overall growth rate of the economy is obviously beyond its value contribution to GDP. Oil revenue comprises near 60 percent of total government revenue in Iran, a fact that has not changed much over the last 30 years. With the decline in the oil revenue, primarily the development share of government expenditure (call it public investment) has decreased. Public oil income elasticity of public development expenditure is estimated to be 0.68. That is for every $10 increase in public oil revenue, public development expenditure increases by nearly $7. Therefore lower oil revenue (or even lower growth rate of oil revenue) leads to lower total investment and thus lower growth.

continuing and even increasing in this period. Unlike the other sectors agriculture was not very much affected by the revolution and the war. Following the 1978-79 revolution all the commercial banks, insurance companies and almost all of the large manufacturing firms (and some medium sized firms) were nationalized or simply confiscated in Iran. Some land confiscation also took place but by the time of the revolution there were not many large scale private farming around any way. Large scale land ownership in agriculture came to an end in Iran following the land reform in the early 1960's. In fact, aside from a few public agro-business units, agriculture is the only sector that is truly private in Iran.

The 1986-96 period covers the final two years of the Iran-Iraq war and eight years of post war period. In this period the negative productivity growth rates of the previous decade are turned into positive numbers and the high productivity improvements in agriculture is more or less sustained. The productivity gains in the non-oil and non-agricultural part of the economy are quite disappointing. In the industry and the services productivity growth rates are 5.5 and 6.1 percentage point lower than their respective growth rates in 1966-76. In sum the growth rate of non-oil economy after the revolution is about 11 percentage points lower than the earlier period where more than half of which (6.2 percentage point) can be attributed to the loss productivity.

Table 5 shows the decomposition of sectoral growth and its contribution to the overall growth. It can be seen from the table that the growth rate of the non-oil economy in the 1976-96 period is 6.5 percentage points less than the 1966-76 period of which almost 4 percentage points can be attributed the reduction of productivity growth and 2.4 points can be attributed to the lower growth rate of capital accumulation. At the sectoral level, two-third of the 6.5 percentage point difference in growth performance in the two periods comes from sluggish growth rate of services and the remaining one-third comes from sluggish growth rate in the industry. Of the 2.2 percentage point of the reduction in non-oil economic growth performance that can be attributed to the industrial sector about half comes from lower capital accumulation and half from lower productivity growth. In other words although industry comprise only 20 percent of Iranian GDP in 2000 and its share of output was even smaller in the past few decades, its contribution to growth or demise of Iranian economy is about 30 percent, half of which can be attributed to the productivity performance in that sector.

Table 5. Decomposition of growth contribution to GDP by sector

Average annual growth rate (percent)

	1966-76	1976-86	1986-96	1976-96
Value added				
Agriculture	1.1	0.8	0.9	0.8
Oil and gas	4.3	-2.8	0.9	-0.7
Industry	2.6	-0.3	1.2	0.4
Services	4.6	0.0	1.3	0.6
Total	12.6	-2.2	4.2	1.2
Non-oil sum	8.3	0.6	3.3	1.9
Employment				
Agriculture	-0.1	0.1	0.1	0.1
Oil and gas	0.1	0.0	0.0	0.0
Industry	0.6	-0.2	0.7	0.2
Services	1.0	1.3	0.8	1.0
Total	1.5	1.2	1.7	1.4
Non-oil sum	1.4	1.2	1.6	1.4
Capital Stock				
Agriculture	0.7	0.1	0.1	0.1
Oil and gas	4.4	0.6	0.0	0.2
Industry	1.1	0.2	0.3	0.3
Services	1.6	0.9	0.3	0.6
Total	7.8	1.8	0.7	1.2
Non-oil sum	3.4	1.2	0.8	1.0
Total Factor Productivity				
Agriculture	0.5	0.6	0.7	0.6
Oil and gas	-0.2	-3.4	0.9	-0.9
Industry	0.9	-0.3	0.2	-0.1
Services	2.0	-2.2	0.1	-1.1
Total	3.2	-5.3	1.8	-1.4
Non-oil sum	3.4	-1.9	1.0	-0.5

Service and industry are clearly the lagging sectors in the Iranian economy responsible for almost the entire decline in the performance of the non-oil economy. And productivity explains two-third of that. In the quest for the sources of economic growth in Iran it would have been informative if we could pursue the question of productivity in a more detailed level in the service sector. Data at sub-sectoral level is not available for the service sector in Iran. In addition measurement of output in service sector is quite murky particularly in an economy such as Iran that public sector is large. Sensitivity of government expenditure (hence the measured TFP figures) to oil revenues from oil exports makes the TFP growth measures for the service sector less reliable. In contrast a continuum of manufacturing surveys is available in Iran that allows us to study the manufacturing sector in 3 or 4-digit ISIC level. We pursue the question of falling GDP per capita and productivity in the manufacturing sector in the next two sections.

3. Methodology

3.1 TFP measurements under CRS and perfect competition

First we must establish a methodology for calculating TFP across sectors in discrete time. Consider the following production function:

$$Q_{it} = A_{it}F_i(K_{it}, L_{it}, M_{it}) \qquad \text{where } i=1, 2, 3,...,n \tag{3}$$

Output, Q_{it}, in sector i is produced with labor, L_{it}, capital K_{it}, and materials M_{it} as inputs. A_{it} is an industry specific index of Hicks-neutral technical change. Totally differentiating (3), and dividing through by Q_{it}, we have:

$$dQ/Q_{it} = (\partial Q/\partial L)(dL/Q)_{it} + (\partial Q/\partial K)(dK/Q)_{it} + (\partial Q/\partial M)(dM/Q)_{it} + (dA/A)_{it} \tag{4}$$

Under perfect competition the value of marginal product is equal to the factor price. Therefore, the elasticity of output with respect to input can be replaced by factor income share in the value of sectoral output. That is,

$$(wL/pQ)_{it} = (\partial Q/\partial L)(L/Q)_{it} \tag{5a}$$
$$(rK/pQ)_{it} = (\partial Q/\partial K)(K/Q)_{it} \tag{5b}$$
$$(nM/pQ)_{it} = (\partial Q/\partial M)(M/Q)_{it} \tag{5c}$$

where p is output price and w, r and n are factor prices of labor, capital and materials respectively. Substituting (5a)-(5c) into 4 and rearranging terms, we have

$$dQ/Q_{it} = (wL/pQ)(dL/L)_{it} + (rK/pQ)(dK/K)_{it} + (nM/pQ)(dM/M)_{it} + (dA/A)_{it} \tag{6}$$

We shall denote the labor and materials shares of output as θ_L and θ_M. Under constant returns to scale the factor shares would sum to 1, hence capital share is simply equal to one minus the sum of labor and material share of output (i.e., $\theta_K = 1- \theta_L - \theta_M$). Using the new notations we can rewrite (6) as the following,

$$dTFP_{it} = (dA/A)_{it} = dQ/Q_{it} - \theta_{Lit}(dL/L)_{it} - \theta_{Mit}(dM/M)_{it}$$
$$- (1- \theta_{Lit} - \theta_{Mit})(dK/K)_{it} \quad (7)$$

To make this operational we replace dZ/Z_t by $\ln Z_t$-$\ln Z_{t-1}$and θ_{zt} with average factor share $(1/2)(\theta_{zt} + \theta_{zt-1})$ which is denote it by $\bar{\theta}_z$. Finally we arrive at the Tornquist index number formula for TFP growth as the following:

$$dTFP_{it} = [\ln Q_{it} - \ln Q_{it-1}] – [\bar{\theta}_{Li} (\ln L_{it} - \ln L_{it-1}) + \bar{\theta}_{Mi} (\ln K_{it} - \ln K_{it-1})$$
$$+ (1- \bar{\theta}_{Li} - \bar{\theta}_{Mi})(\ln K_{it} - \ln K_{it-1})] \quad (8)$$

Now, given the Tornquist index of TFP growth we test for the significance of factors deemed to be influential on growth rate of productivity. Conceptually, the factors than can influence sectoral productivity growth are either common to all sectors or sector-specific. Therefore, we can specify the following general equation in testing for
the determinants of TFP growth rates:

$$dTFP_{it} = \alpha_i + \mathbf{b}\mathbf{S}_t + \mathbf{c}\mathbf{Z}_{it} + u_{it} \quad (9)$$

$\mathbf{S}_t$ is a vector of macroeconomic or institutional variables that can affect productivity in all sectors. $\mathbf{Z}_{it}$ is a vector of certain characteristics of each industry i at time t that can influence TFP growth, variables such as share of R&D expenditures or share of skilled labor in each industry i at time t. α_i captures sector-specific productivity changes that vary over sectors but not over time. Bold-faced characters **b** and **c** are vectors of parameters and u_{it} is an independently and identically distributed random component term.

However, as we will see in the description of the data, time series data on industrial characteristics are not available. Therefore, instead of time-series cross section equation (9) the following two equations, where one is time series and the other cross sections will be employed.

$$dTFP_t = \alpha 1 + \mathbf{b}\mathbf{S}_t + u_t \quad (10)$$

$$dTFP_i = \alpha 2 + \mathbf{cZ}_i + u_i \quad (11)$$

Variables on the left hand side of the two above equations are Tornquist measures of TFP growth rate. $dTFP_t$ measures productivity growth rate of total manufacturing in time t and $dTFP_i$ measures average of productivity growth rate in sector i for a given time period.

3.2 TFP Measurement under non-CRS and imperfect competition

Hall (1988) shows that when the assumptions of perfect competition and constant returns to scale are relaxed, the standard measure of TFP no longer reflects the true productivity growth any more. Following Harrison (1994) extension of the Hall model, in this section first we provide a framework in which imperfect competition and non-CRS behavior can be tested for. Then we present a new formulation for Tornquist index of TFP growth corrected for imperfect competition and non-CRS behavior. This adjusted TFP measure will subsequently be used to test for the determinants of manufacturing TFP growth.

When there is imperfect competition, firms with market power do not set the value of marginal product equal to the factor price. In that case the output elasticity of factor exceeds factor share by a multiple of markup price factor μ. Then equation (6) must be replaced by the following equation

$$dQ/Q_{it} = \mu_i\,[(wL/pQ)(dL/L)_{it} + (rK/pQ)(dK/K)_{it} + (nM/pQ)(dM/M)_{it}] + (dA/A)_{it} \quad (12)$$

Under CRS, the factor shares would sum to $1/\mu$ but when we allow for non-CRS the sum of factor shares would equal to β/μ, where β may be less than, equal to or greater than one. Rewriting (12):

$$dQ/Q_{it} = \mu_i x_{it} + \beta_i (dK/K)_{it} + (dA/A)_{it} \quad (13)$$

with $x_{it} = [\theta_L dl + \theta_M dm]_{it}$.

Lower case variables l and m are equal to ln(L/K) and ln(M/K). Then the true TFP growth (dTFP*) is,

$$dTFP_{it}^* = dQ/Q_{it} - \mu_i x_{it} - \beta_i (dK/K)_{it} \quad (14)$$

The extend of the bias is equal to

$$dTFP_i - dTFP_i^* = (\mu_i - 1)x_i + (\beta_i - 1)(dK/K)_{it} \quad (15)$$

Therefore, when x is negative (e.g., capital grows at a faster rate compared to labor and material inputs) and the mark up prices are positive, then productivity gains are understated if there is constant or decreasing return to scale.

Thus equation (13) can be used to determine the degree of economy of scale and competitiveness of an industry. However, this equation suffers from an endogeneity problem since inputs and output are determined simultaneously. In order to control for at least part of this the endogeneity problem, we assume that the Hicks neutral technological change parameter is a random variable of the following form:

$$A_{it} = A_{i0} \exp(\phi_{it} t)$$
$$dA/A_{it} = \phi_{it} = a_i + \lambda_t + u_{it} \quad (16)$$

where A_{i0} is the technological level of industry i at the beginning, period 0, and ϕ_{it} is the growth rate of technological change. Thus the growth rate of the technological change of industry in i period t consists of an industry-specific growth rate, a_i, and a period specific growth rate, λ_t, which captures the macroeconomic shock which is common across industries in the same period, plus a white noise, error term u_{it}. Substituting equation (16) into equation (13) we will get

$$dQ/Q_{it} = a_i + \lambda_t + \mu_i x_{it} + \beta_i (dK/K)_{it} + u_{it} \quad (17)$$

The sum of the estimated industry-specific effects and period specific effects can be interpreted as the expected value of the growth rate of productivity of the industry i in the period t relative to the base year.

Now we can incorporate the mark-up factor, μ, and the returns to scale parameter, β, in the definition equation (8) and rewrite an equation for the "true" Tornquist index number of TFP growth, dTFP*, as the following:

$$dTFP_{it}^{*} = [\ln Q_{it} - \ln Q_{it-1}] - \mu_i\, [\theta_{Li}\, (\ln L_{it} - \ln L_{it-1}) + \theta_{Mi}\, (\ln M_{it} - \ln M_{it-1}) + (\mu_i / \beta_i - \theta_{Li} - \theta_{Mi})(\ln K_{it} - \ln K_{it-1})] \qquad (18)$$

Subsequently we can substitute the new estimate of TFP growth for the standard TFP figures in equations (10) and (11) to test for the determinants of manufacturing productivity growth.

4. Data and sources

Measurements of sectoral productivity growth rates require data on output, labor input, capital input, intermediate input, and factor shares. I obtained manufacturing data from Statistical Center of Iran (SCI). Data on output, intermediate input, labor input and factor shares were obtained from SCI. I have used data on manufacturing industries with ten employees or more. Firms with less than 10 workers although comprise 75 percent of total firms in Iran but they produce only 16 percent of manufacturing value added (based on 1995 data).

There was no estimate of manufacturing capital stock available at the sectoral level. I constructed capital stock by type (machinery and equipment, building, and the other) and by sector using a standard perpetual inventory model. The data on manufacturing investment is obtained from CSI and the totals are reconciled with Central Bank's data on the purchase of investment goods by type. Data on price deflators are from Central Bank of Iran (CBI).

I obtained annual data for 9 two-digit industry groups (ISIC Rev. 2) for the years 1971-76 and 27 three-digit industry groups for the years 1979-98 (ISIC Rev. 2 for years 1979-93 and ISIC Rev. 3 for years 1994-98). For the two missing years I used data from CBI and rescaled them to reconcile with CSI data. Data in 2 digit ISIC data on manufacturing is available from 1971 onward. Since 1980, SCI has conducted census survey on manufacturing products. At the time of the study however, I had access only to the 1995 census report, which is one of the most comprehensive industrial surveys conducted by SCI.

In the absence of producer price indexes (PPI) I have deflated manufacturing and output and value added data using wholesale price indexes (WPI). The items on WPI are limited and the definitions do not quite match with those of industrial classification. To match the two definitions, a new index using 1986 Input-Output table was constructed. Then the constructed price index was amended with the PPI series from1990 onward with proper scaling[4].

5. TFP growth estimation

5.1 The "standard" measure of TFP growth

Table 6 presents factor productivity growth estimates for Iran's 7 major manufacturing industries for four sub-periods during 1972-1998 years. Annual sectoral TFP growth rates are given in the appendix. Relative importance of these sectors in terms of value added generated and employment is given in Table 7. Value added weighted average of all manufacturing is given at the bottom of the table. It seems that the TFP measure of chemicals is strongly influenced by oil prices and war destructions. The weighted average is also reported for manufacturing exclusive of chemicals. According to Table 6, sectoral TFP growth rates in the 1972-98 period averaged 0.5% per annum under the standard assumption of perfect competition and constant returns to scale.

The manufacturing TFP growth rates in the 1972-98 can be divided into three distinct periods of pre revolution 1972-77, revolution and war 1978-88 and the post war period 1989-98. Total manufacturing TFP growth rate in the pre-revolution period averaged 3.3% per annum (4.7% exclusive of chemicals). This is quite impressive by any standard. The productivity growth rate of machinery and non-metallic mineral products in particular are astounding. The TFP of these sectors grew by 8.1% and 5.8% per annum in

the 1972-77 years. Productivity growth rates fell sharply in the 1978-88 period. In this period total manufacturing TFP growth rate averaged –1.7% per annum (-3.3% exclusive of chemicals). The fastest growing sectors in the 1972-77 period, i.e., the

[4] A two-tier approach was also tried for deflating value added via creating yet another set of price indexes for intermediate inputs. But the results were disappointing.

machinery and the non-metallic mineral products, experienced the worst TFP growth rates in 1978-88 years. TFP growth rates of machinery and non-metallic minerals fell to -6.9% per annum. It is not surprising that much of the productivity loss in machinery occurred in the year of the revolution (over 60% in 1978) when almost all of the large firms were confiscated by the new government.

Table 6. Standard TFP growth rates (percent)

Industry (2 digit ISIC rev.2)	1972-77	1978-88	1989-98	1972-98
Food and beverages	2.7	-3.1	1.2	-0.2
Textiles and clothing	1.3	-0.5	-0.7	-0.2
Chemicals	-4.1	-0.5	0.7	-0.9
Non-metallic minerals prod.	5.8	-6.9	0.8	-1.2
Basic metals	1.0	1.1	-2.8	-0.4
Machinery	8.1	-6.9	2.6	0.0
Manufacturing n.c.e**	-0.5	-1.6	2.2	0.1
All Mfg.*	3.3	-1.7	1.1	0.5
Mfg. excluding chemicals*	4.7	-3.3	1.1	0.1

*Value added weighted average
**not elsewhere classified

Table 7. Three-year average share of sectoral value added and employment

	Value added		Employment	
Sectors	1971-73	1996-98	1971-73	1996-98
Food and beverages.	0.27	0.13	0.18	0.15
Textiles and clothing	0.19	0.09	0.35	0.20
Chemicals	0.16	0.21	0.08	0.13
Non-metallic minerals prod.	0.08	0.10	0.11	0.15
Basic metals	0.05	0.16	0.02	0.08
Machinery	0.21	0.26	0.18	0.24
Mfg. n.c.e.*	0.05	0.04	0.06	0.06

*Including ISIC 33, 34 and 39

With the war ending in the summer of 1988, productivity growth picked up again after 11 years of decline. Total manufacturing TFP growth rate averaged 1.1% per annum in the post-war period of 1989-98. However most of this productivity gain was achieved in the early post war period, 1998-91, where the reconstruction of some of the damaged infrastructure during the war allowed for a better utilization of the existing excess capacities in manufacturing sector. The total manufacturing TFP growth rate for the 1991-98 is only 0.1%. In this period, non-metallic minerals and food are the only two sectors that show some modest productivity improvement (1% and 0.8% respectively). At the same time, basic metals, textiles and machinery, the three thriving sectors in the 1972-77 years, experienced sizable productivity deteriorations (-2.6%, -1.2 and –0.4 respectively). These sectors are in fact amongst some of the most dynamic manufacturing industries in South Korea and Malaysia (see footnotes of Table 3 for some references). That means in the machinery sector for example while South Korea has achieved 50% to 140% productivity improvement in the last 20 years Iran has experienced about –50% productivity deterioration, a trend that seems to be continuing to date.

Table 8. Standard TFP growth rates (percent)

Industry (3 digit ISIC rev.2)	1982-88	1989-98	1982-98	1992-98
Food products	-0.8	1.3	0.4	0.2
Food n.c.e	-2.6	0.1	-1.0	-1.0
Beverages	-2.9	2.5	0.3	1.4
Tobacco products	-5.2	4.7	0.6	4.6
Textiles	-1.2	-0.4	-0.7	-0.1
Clothing	0.9	-4.2	-2.1	-3.4
Leather products	0.3	-1.4	-0.7	-0.8
Footwear	1.4	-1.6	-0.4	0.0
Wood products, except furniture	-4.4	-0.7	-2.2	0.7
Furniture	-8.4	2.2	-2.2	-0.5
Paper and products	-5.3	1.0	-1.6	-0.3
Printing and publishing	-3.5	1.5	-0.6	2.5
Industrial Chemicals	0.0	0.9	0.5	-3.8
Other Chemicals	0.8	0.7	0.7	-0.5
Refineries & misc. pet. Prod.	-29.1	-1.6	-12.9	-1.5
Rubber products	-1.4	-0.3	-0.7	-2.1
Plastic products	-1.3	-2.2	-1.8	-3.1
Pottery & Glass	-3.7	-4.0	-3.9	-0.8
Non-metallic minerals prod. n.c.e	-9.9	1.9	-3.0	1.9
Iron and Steel	4.9	-3.1	0.2	-2.5
Non-ferrous metals	3.4	-2.4	0.0	-1.6
Fabricated Metal products	-7.8	-1.1	-3.8	-2.9
Machinery, except electrical	-2.8	1.9	0.0	-0.9
Electrical goods	-4.0	1.6	-0.7	0.1
Transport equipment	-6.4	5.9	0.8	-5.2
Professional and scientific equip.	-7.2	6.5	0.8	5.8
Manufacturing n.c.e	-3.0	0.8	-0.7	-1.7
All Mfg.*	-1.9	1.3	0.0	-0.2
Mfg. excluding chemicals*	-1.7	1.3	0.1	-0.2

*Value added weighted average

Table 8 presents total factor productivity growth for Iran's 27 manufacturing industries for four time periods of 1982-88, 1989-1998, 1982-98 and 1992-98. Detailed annual TFP growth rates for the 1980-1998 period in presented in the appendix. Estimated TFP measures in some sectors show unusually large variation in 1980 and 1981. This could be related to the way the capital stock series is constructed for the 27 industries. This table conveys the same information as of Table 7 in more details. The 1.3% average TFP growth rate in 1989-1998 seems to be mostly due to growth in the years immediately after the Iran-Iraq war. If we exclude the 3 years between 1989 and 1991, the average declines to –0.02%. This latter figure is more likely to represent the current trend in Iranian manufacturing industry.

5.2 Estimation under imperfect competition and non-CRS

5.2.1 Production technology and market structure

Now we examine the validity of perfect competition and constant returns to scale assumption made in the estimation of the "standard" TFP in section 3. This can be established by estimating equation (17). First we apply equation (17) to the time series cross-section data on 7 Iranian manufacturing sectors in the 1972-98 period. The results are reported in Table 9.

The sum of the time dummy variables measures total manufacturing average annual total factor productivity growth. Coefficients of x and dK/K respectively measure returns to scale and markup pricing. The dummy variable for 1978 picks up the negative productivity shock of the revolution. The dummy variables for 1986 and 1987 pick up the destructive effects of the last two years of the Iran-Iraq war. In these two years alone Iranian manufacturing suffered 29 percent productivity loss. The war ended in the summer of 1988. Some of the productivity loss in the last two years was recovered in the second half of 1988.

The expected TFP growth rate of total manufacturing is equal to the sum of the dummy variables which is nearly zero percent (0.04%). Note that manufacturing TFP growth rate prior to the revolution averaged 4% per annum. Manufacturing TFP growth rate since the end of Iran-Iraq war has averaged only 1%. The coefficients of x and dK/K indicate the presence of slight markup pricing and decreasing returns to scale. However the null hypothesis of perfect competition or constant returns to scale cannot be rejected at 95% significance level. But once the panel data is divided into two sub-periods of pre and post 1978 revolution we can see significant market imperfection and diseconomies of scale in the 1979-98 period. The results of these regressions are reported in Table 10.

Table 9. Estimations of Mfg. TFP growth, markup and returns to scale

Period: 1971-1998		
Estimation Method: GLS		
Total Panel Obs'n: 189		
Variables	**Coefficient**	**T-statistics**
X	**1.03**	18.34
dK/K	**0.84**	8.81
Dummy 1972	0.05	1.66
Dummy 1973	0.02	0.82
Dummy 1974	0.06	1.93
Dummy 1975	0.01	0.27
Dummy 1976	0.05	1.85
Dummy 1977	0.05	1.70
Dummy 1978	-0.11	-4.10
Dummy 1979	0.02	0.69
Dummy 1980	0.02	0.55
Dummy 1981	0.02	0.79
Dummy 1982	0.00	-0.10
Dummy 1983	0.03	0.95
Dummy 1984	-0.01	-0.27
Dummy 1985	0.00	-0.05
Dummy 1986	-0.08	-2.98
Dummy 1987	-0.21	-7.76
Dummy 1988	0.13	4.71
Dummy 1989	-0.03	-0.93
Dummy 1990	0.08	2.79
Dummy 1991	-0.02	-0.66
Dummy 1992	-0.01	-0.29
Dummy 1993	0.01	0.40
Dummy 1994	0.04	1.07
Dummy 1995	-0.01	-0.31
Dummy 1996	-0.01	-0.27
Dummy 1997	0.04	1.41
Dummy 1998	-0.02	-0.86
R-squared	0.83	
Adjusted R-squared	0.81	
S.E. of regression	0.10	
F-statistic	28.87	
Durbin-Watson stat	2.28	

Table 10. Estimations of Mfg. TFP growth, markup and returns to scale

Period	1972-78	1979-98
Estimation	GLS*	GLS*
Total panel observations	49	140
Variables	Coefficient/Std error (in parenthesis)	
X	0.88	1.11
	(0.09)	*(0.09)*
dK/K	0.92	0.80
	(0.10)	*(0.12)*
R-squared	0.89	0.86
Adjusted R-squared	0.87	0.83
Durbin-Watson stat	2.02	2.24

*Statistics of the dummy variables are not reported

A joint null hypothesis of perfect competition and constant return to scale cannot be rejected for the 1972-78 period but the hull hypothesis is rejected at more than 95% confidence level. A single hypothesis of perfect competition and constant return to scale is rejected at more than 90% confidence level for the 1979-98 period.

Given the large share of public firms in manufacturing and the extent of support they receive the presents of mark up pricing and decreasing returns to scale in Iran is understandable. While 90% of firms with more than 10 employees are private in Iran over 50% of manufacturing value added is produced in public firms (65% in 1989 and 53% in 1998). These firms are typically large with more than 50 workers (92% in 1989 and 61% in 1998). The restrictive trade policies practiced in the 80's and most of the 90's provided a virtual monopoly position to a number of large scale public firms in Iran. In this period while imports of nearly all of consumer goods were severely restricted or outright forbidden imports of intermediate and investment goods were heavily subsidized via multiple foreign exchange policies. The foreign exchange rate designated for intermediate and capital goods imports was less than 95% of its market value for a number of years. In this situation public firms specially, the large ones with strong influential patrons would receive larger foreign exchange rations.

Management of nearly all of the large-scale manufacturing firms in Iran changed after 1979. Properties of many prominent industrialists were confiscated following the revolution and new managers were appointed by the state. It is estimated that there are over 2500 public firms in Iran. But only 600-700 are listed in the general budget. The status of the remaining two third is not quite clear. A large number of these firms are organized into a few semi-public foundations called "bonyad" (foundation in Farsi). Bonyads were originally created to preserve the Islamic principles and help the poor. But now they are semi-independent semi-public conglomerates that are involved in various economic and charitable activities. Not much is known about bonyads. The president of a bonyad is directly appointed by the supreme leader and is answerable only to him. They get some funding from Management and Plan Organization (without presenting any balance sheet of their operations). The bonyads have easy access to cheap foreign exchange allocation and low-cost nationalized bank credits.[5]

Much of public investment in Iran is made by public firms. It is only natural that public firms, especially those in bonyads get the most lucrative contracts. In fact, the investment decisions themselves (or industrial and public policy for that matter) are often made under the strong influence of the patrons of these firms. Thus the presents of decreasing returns to scale in Iranian manufacturing sector might in fact be a reflection of inefficient public management often subject to intense rent seeking activities.

Table 11 presents estimates of sectoral markup and scale economies for 7 manufacturing sectors for two sub-periods of 1972-98 and 1978-98. In the 1972-98 period 5 out of 7 industries have estimated mark-ups greater then one**.** But none of them are significantly different from one at more than 95% significance level. In this period 5 out of 7 have estimated increasing and 2 have estimated decreasing return to scale.
However only one of these industries (basic metals) has a scale economy that is significantly lower than one. A joint hypothesis of perfect competition and CRS is can be rejected at more than 90% significance level in the 1978-98 period. At the sectoral level, two industries (food and Mfg n.c.e.) have mark-ups greater than one at more than 95% significance level and two sectors (food and basic metals) have returns to scale less than one at more than 95% significance level.

[5] One of these, Bonyad Mosfazan va Janbazan (BMJ) is the largest conglomerate in Iran. According to its own Web page (www.iran-bonyad.org), "[BMJ is] presently the largest economic section in Iran, second only to government…[BMJ is] active in most outstanding industrial and business sectors: food and beverages, chemicals, cellulose items, metals, petrochemicals, construction materials, dams, towers, civil development, farming, horticulture, animal husbandry, tourism, transportation, five-star hotels, commercial services, financing, joint ventures, etc. Added to these, is the special legal status of bonyad which is considered to be the most unchallenged private enterprise in Iran." BMJ alone is believed to own over 25 percent of the non-oil economy.

Table 11. Estimations of Mfg. TFP growth, markup and returns to scale

Period	1972-1998		1978-1998	
Estimation Method	GLS		GLS*	
Total panel observation	189		140	
Variables	Coefficient/Std error (in parenthesis)			
Markup in				
Food	1.10	*(0.11)*	1.12	*(0.09)*
Textiles	1.02	*(0.11)*	1.05	*(0.15)*
Chemicals	1.26	*(0.16)*	1.29	*(0.21)*
Non-metallic mineral prod.	1.06	*(0.17)*	0.99	*(0.20)*
Basic metals	0.79	*(0.15)*	0.67	*(0.18)*
Machinery	0.89	*(0.15)*	1.02	*(0.14)*
Mfg. N.c.e.	1.05	*(0.15)*	1.40	*(0.15)*
Returns to scale in				
Food	0.69	*(0.26)*	0.51	*(0.34)*
Textiles	0.65	*(0.24)*	0.09	*(0.49)*
Chemicals	0.75	*(0.15)*	0.73	*(0.35)*
Non-metallic mineral prod.	0.96	*(0.19)*	0.53	*(0.38)*
Basic metals	0.71	*(0.14)*	0.64	*(0.15)*
Machinery	0.98	*(0.29)*	0.92	*(0.37)*
Mfg. n.c.e.	0.93	*(0.26)*	0.45	*(0.38)*
R-squared	0.84		0.87	
Adjusted R-squared	0.80		0.84	
Durbin-Watson stat	2.21		2.14	

*Statistics for the dummy variables are not reported

Application of equation (17) to 27 Iranian manufacturing sectors for the 1980-1998 period is presented below (standard errors in parentheses):.

$$dQ/Q = \underset{(0.005)}{-0.02} + \underset{(0.023)}{1.14}\, x + \underset{(0.056)}{0.96}\, dK/K \qquad (19)$$

N=513 R-squared= 80, DW=2.4

The results of this regression shows that mark-up pricing has become a common practice in Iranian manufacturing sector in the post revolution period. The detailed sectoral analysis of mark-up pricing and returns to scale technology is presented in Table 12.

Table 12. Estimations of Mfg. TFP growth, markup and returns to scale

Estimation Method: Pooled GLS
Dependent variables: growth rates of output
Total panel observations: 513
Period: 1980-1998

Sector	Markup (μ)	Std-error	Returns to scale	Std-error
Food products	1.26	0.13	0.87	0.38
Food n.c.e	1.00	0.07	0.38	0.34
Beverages	1.42	0.25	0.95	0.31
Tobacco products	0.43	0.59	-0.27	1.07
Textiles	1.11	0.14	0.63	0.33
Clothing	1.16	0.10	0.73	0.53
Leather products	1.26	0.08	1.03	0.64
Footwear	0.85	0.29	1.82	1.21
Wood products, except furniture	1.22	0.11	0.71	0.44
Furniture	1.19	0.12	1.00	0.36
Paper and products	1.28	0.19	1.41	0.39
Printing and publishing	0.95	0.20	0.89	0.55
Industrial Chemicals	1.04	0.09	0.85	0.10
Other Chemicals	1.24	0.09	0.63	0.52
Refineries & misc. pet. Prod.	1.59	0.33	1.79	0.69
Rubber products	1.07	0.08	1.04	0.11
Plastic products	1.23	0.08	-0.48	0.40
Pottery & Glass	1.23	0.47	0.12	0.71
Non-metallic Minerals prod. n.c.e	1.15	0.18	0.81	0.49
Iron and Steel	0.76	0.21	0.78	0.15
Non-ferrous Metals	1.09	0.12	0.92	0.14
Fabricated Metal Products	1.08	0.15	1.09	0.36
Machinery, except electrical	1.22	0.13	1.57	0.38
Electrical Goods	0.82	0.13	0.77	0.28
Transport Equipment	1.38	0.17	1.06	0.44
Professional and Scientific Equipment.	0.66	0.19	0.97	0.63
Manufacturing n.c.e	0.51	0.28	0.71	0.39
R-squared	0.86			
Adjusted R-squared	0.84			
Durbin-Watson stat	2.42			

According to the results in Table 12 out of 27 manufacturing industries 16 have estimated mark up greater than one and 18 have decreasing returns to scale. To test for the significance of non-CRS technology and imperfect competition Wald test was conducted. The null hypothesis perfect competition (PC) and the joint hypothesis of PC and CRS are both rejected at more than 99% confidence. At the sectoral level the null hypothesis of constant returns to scale is rejected for 4 industries at more than 95% significance level. The null hypothesis of perfect competition is 6 industries at more than 95% significance level and that of 10 industries at more than 90% significance level.

5.2.2 Measure of TFP growth adjusted for imperfect competition and non-CRS

The result of application of equation (18) to standard TFP growth rate of Table 6 is presented in Table 13. This table presents TFP growth estimates for Iran's 7 major manufacturing industries adjusted for market imperfections and non-constant return to scale technology for four sub-periods during the 1972-1998 period. Annual sectoral adjusted TFP growth rates are given in the appendix.

Table 13. TFP growth rates adjusted for market imperfections (percent)

Industry (2 digit ISIC rev.2)	1972-77	1978-88	1989-98	1972-98
Food and beverages	4.3	-2.2	1.4	0.6
Textiles and clothing	2.4	-1.7	-0.1	-0.2
Chemicals	2.1	-0.2	1.7	1.0
Non-metallic minerals prod.	2.8	-6.5	0.8	-1.7
Basic metals	1.8	1.9	-0.8	0.9
Machinery	5.8	-5.6	1.8	-0.3
Manufacturing n.c.e	-2.0	-1.4	3.9	0.5
All Mfg.*	4.1	-1.4	1.6	0.9
Mfg. excluding chemicals*	4.2	-2.9	1.5	0.3

*Value added weighted average

Two observations can be made when comparing Table 13 with Table 6. First, the adjusted TFP growth rates are generally higher than the standard ones, especially in the periods that capital accumulation grew faster relative to material and labor inputs such as the 1972-77 and the 1989-98. Second, while there are large differences between the adjusted and the standard TFP growth rates in the sectoral level, at the aggregate level the differences are relatively very small (in the magnitude of a few tenth of percentage points).

Table 14 presents the adjusted total factor productivity growth for Iran's 27 manufacturing industries for four sub-periods of 1982-88, 1989-1998, 1982-98 and 1992-98. The detailed annual TFP growth rates in the 1980-1998 years are presented in the appendix. The adjusted TFP growth rates of the 1992-98 years represent the current

Table 14. TFP Growth Rates adjusted for market imperfections (percent)

Industry (3 digit ISIC rev.2)	1982-88	1989-98	1982-98	1992-98
Food products	-0.3	1.1	0.5	0.4
Food n.c.e	-2.4	4.2	1.5	3.8
Beverages	-2.5	2.8	0.6	1.9
Tobacco products	-5.0	4.1	0.3	4.2
Textiles	-1.4	1.2	0.1	1.5
Clothing	0.5	-3.3	-1.8	-3.2
Leather products	-0.8	0.1	-0.3	-0.4
Footwear	2.1	-1.8	-0.2	-0.4
Wood products, except furniture	-2.8	1.7	-0.1	2.3
Furniture	-5.3	2.4	-0.8	-0.4
Paper and products	-3.7	-0.5	-1.8	-1.9
Printing and publishing	-3.7	1.3	-0.7	2.4
Industrial Chemicals	0.3	4.6	2.8	1.5
Other Chemicals	-0.6	-0.7	-0.7	-1.3
Refineries & misc. pet. Prod.	-19.7	0.6	-7.8	1.5
Rubber products	-2.0	0.0	-0.8	-1.8
Plastic products	-1.4	-2.0	-1.8	-2.0
Pottery & Glass	-2.8	-3.3	-3.1	-0.8
Non-metallic minerals prod. n.c.e	-8.4	0.6	-3.1	-0.2
Iron and Steel	5.9	0.8	2.9	0.2
Non-ferrous metals	3.6	-0.8	1.0	-0.4
Fabricated Metal products	-7.3	-1.4	-3.8	-3.2
Machinery, except electrical	-3.3	-0.3	-1.5	-2.5
Electrical goods	-4.0	2.2	-0.4	0.5
Transport equipment	-0.9	0.2	-0.2	-7.7
Professional and scientific equip.	-6.3	8.7	2.5	8.0
Manufacturing n.c.e	0.7	2.5	1.8	1.3
All Mfg.*	-1.4	1.3	0.2	0.2
Mfg. excluding chemicals*	-1.3	1.3	0.3	0.2

* Value added weighted average

productivity trend in Iranian manufacturing. The performance of the economy in this period can be viewed as the steady state condition of the post revolution policies in Iran. This is a period that the state is politically stabilized and is not faced with any significant internal or external threat. This is also a period in the economy has recovered from much of the war damages (i.e., the 3 immediate post-war are excluded). A comparison of the adjusted TFP growth rates (Tables 13 and 14) with the standard ones (Tables 7 and 8) shows that while there is not much difference between the two measures of TFP growth rates in the aggregate (i.e., -0.2% versus 0.2% annual growth rate for the whole manufacturing). There is a significant improvement in TFP growth measurements at sectoral levels. However, the gist of the message is still the same:

Iranian manufacturing continues to have a serious productivity slow down since the 1978 revolution.

The six sectors of food, industrial chemical, non-metallic mineral products, iron and steel and transport equipment roughly have equal size in terms of sectoral share of value added (10% each). Amongst these sectors only industrial chemicals has experienced a sizable productivity growth. The productivity growth rates of the remaining sectors are either very small (such as food 0.4% and iron and steel 0.2%) or negative (i.e. transport equipment –7.7%[6] and iron and steel –0.2).

5.3 Explaining standard TFP growth slow down

5.3.1 Time series study of 7 manufacturing sectors in 1972-98

To explain TFP growth first we use weighted average of "standard" sectoral TFP growth rates in the 1972-1998 period (STFP) and regress it against a number of macroeconomic variables that are thought to have an influence on productivity growth. The least square estimate of the manufacturing TFP growth yielded the following result (t-statistics in parentheses):

$$\underset{}{dSTFP} = \underset{(-2.1)}{-0.08} + \underset{(2.4)}{0.17}\, PVTINVS - \underset{(-2.0)}{0.05}\, EXPG \qquad (20)$$

Number of observations = 27, $R^2 = 0.27$, Durbin-Watson = 2.3

Where PVTINVS is the private share of aggregate investment in machinery (i.e, purchases of machinery and equipment for investment purposes in the whole economy) and EXPG is the growth rate of manufacturing exports. The regression above suggests that 10% increase in PVTINVS would increase the growth rate of manufacturing total factor productivity by 1.7%, which is quite a lot. This is of course expected. The private share of aggregate investment in machinery was 0.72 in 1972. But as the state took a more active role in the economy with the increase in its oil revenues this share began to decrease. In 1977 private share of aggregate investment in machinery was down to 0.45.

[6] . It is interesting to note that the Iranian and the Korean auto manufacturing industries began production about the same time in the mid 1960's. Some politicians now in Iran pride themselves by calling Paykan, the oldest brand of automobile made in Iran, a completely national car that almost all its parts are made domestically. However it is doubtful that this product can compete in the international market.

Private investment continued to decline down as a share of total investment in machinery and it reached its lowest point of merely 0.13 in 1987 (at the pick of the Iran-Iraq war). Private investment after the war increased to 56 percent of total. This share has continued to increase in the 90's to the extent that in 1998 the PVTINS is equal to what it was in 1972 that is 0.72. However there is much more to the explanation of TFP growth than what private investment share can reveal (apparent from the regression's low R^2), in fact private investment shares in the 90's was on average higher than those in the 1971-77 years while TFP growth rates were much lower in the 90's.

The negative effect of export growth on manufacturing TFP growth is not in lines with conventional wisdom. Manufacturing exports in Iran has never been an important source of foreign exchange earning. At most they could finance 1/60 to 1/70 of imports in the mid 1970's. With the rise of oil revenues manufacturing exports decreased due to strong domestic demand in the 70's. They decreased further following the 1978 revolution and became nearly negligible in early 1980's. For most of the period under study foreign exchange policies were strongly against manufacturing exports. Manufacturing exports have often been limited to very large public firms. Based on 1995 manufacturing survey data 70% of manufacturing exports are made by firms with more than 1000 employees of which nearly 90% are public. This is when manufacturing exports had already been quadrupled from their low figure in mid 80's. In the 80's exports were even more concentrated in large public firms. When we divided our sample into two sub-period of before and after 1989 then while the coefficient of exports remained negative for the first period it became positive for the second period. This might be interpreted a regime change in trade policy in the 90's. However because of our very small sample size nothing definite can be said about this. The effects of change in inflation rate, exchange rate stability were also tested in the above regression but none of them had any significant effect of the manufacturing TFP growth rates.

Now we use the "adjusted" TFP growth rates in equation (10) to explain manufacturing total factor productivity growth. The least square estimate of the manufacturing TFP growth yielded the following result (t-statistics in parentheses):

$$\underset{}{dTFP} = \underset{(-1.8)}{-0.07} + \underset{(2.3)}{0.17}\, PVTINVS - \underset{(-1.9)}{0.05}\, EXPG \qquad (21)$$

$N = 27$, $R^2 = 0.25$, Durbin-Watson = 2.5

This regression is not any better than the one reported above. This is expected since there are not large appreciable differences between the standard and the adjusted TFP growth rates at the manufacturing aggregate level.

5.3.2 Cross-section study of 27 manufacturing industries

Now we use industry specific characteristics to explain productivity growth in the manufacturing sector. As mentioned earlier at the time of the study only the 1995 manufacturing survey data was available to the authors. Thus in explaining the productivity dynamics we are limited to some data for the 1989-98 period and more detailed data for 1995. To explain the dynamics of TFP growth we construct a series of ten-year average growth rates of a number of variables such as TFP, export share of value added in 1995, capital-labor ratio in 1989, number of firms (in thousands) in 1989, percentage change in the number of firms in 1989-1998, private share of output in 1989 and the share of employees with at least a high school diploma in 1995 for 27 manufacturing industries.

We start with the “standard” 10-year average TFP growth rate (dSTFP), and regress it private share of output in 1995 (PVTQS), export share in 1995 (EXPS95), capital-labor ratio in 1989 (KLR89) and percentage change (in absolute terms) in the number of firms in the industry from 1989 to 1998 (PCNF) in 27 manufacturing industries. The PCNF signifies the ease in which the firms can enter and leave the industry and hence an indicator of competitiveness. We employed weighted cross-section least squares method using sectoral value added shares as weighting series. The results of the regression are as the following (t-statistics in parentheses):

$$\underset{(-3.1)}{dSTFP = -6.62} + \underset{(1.0)}{2.51}\ PVTQS - \underset{(-0.5)}{2.17}\ EXPs + \underset{(3.7)}{3.47}\ KLR89 + \underset{(2.3)}{3.32}\ PCNF \quad (22)$$

$$N = 27, \quad Adj\text{-}R^2 = 0.44$$

Now we use 10-year average of the adjusted TFP growth rates (dATFP) as our dependent variable in the above equation and get the following result:

$$dATFP = -2.25 + 5.78\ PVTQS + 12.96\ EXPs - 1.69\ KLR89 + 3.55\ PCNF \quad (23)$$
$$(-2.1) \quad (4.7) \qquad (6.4) \qquad (3.7) \qquad (5.0)$$
$$N = 27, \quad Adj\text{-}R^2 = 0.73$$

A comparison of the two equations indicate that the regression equation that employs adjusted TFP growth rates is superior to the one that uses the standard TFP growth rates. For the later not only yields inferior explanatory power but more importantly it yields results that are potentially misleading.

The regression in equation (23) implies that private firms experience higher productivity growth rates. For every one percent increase in the private share of industrial out put TFP growth increases by 5.78%. Export oriented industries experience much higher productivity growth. That is for every one percent increase in the export share of value added TFP growth rate increases by 13%. Equation (23) indicates that capital intensive industries experience lower productivity growth rates. This result is somewhat peculiar. If anything one might expect the opposite. One might expect that the process of learning by doing in high-tech industries which are often very capital intensive result in a larger productivity growth. Perhaps a similar argument has persuaded the government to subsidize capital to the extent that it has in the last two decades. Industrial investment has been subsidized in Iran mainly through foreign exchange policies and credit rationing. Imports of capital goods were subsidized in the 80's and much of the 90's. The subsidy rate was often more than 70 percent of market values of foreign exchange rate. In addition large scale public firms enjoyed sizable investment credit from public banks with negative real interest rates. And finally positive coefficient of PCNF indicates that industries with higher entry and exit rates experience higher productivity growth. That is industries that are in a more competitive environment experience higher productivity growth.

A number of sector specific characteristics such as the educational level of employees, research and development expenditure, years of employees experience and such were tried in regression equations (22) and (23) but non of them provided satisfactory result. One variable, the share of employees with at least a high school diploma seemed to be promising. However this variable is highly correlated with the private share of sectoral output. Public firms in general employ more educated labor force nevertheless their productivity growth is smaller than private firms.

6. Conclusion

We found that nearly half of near 11 percent difference in the performance of Iranian economy before and after the 1978-79 revolution can be explained by the productivity differential in the two periods. Manufacturing is one of the sectors that is hit the hardest. The productivity growth rate of this sector for the five years before the revolution was more than 4 percent which fell to less than negative one percent in the years after the revolution. Some of these productivity differentials can be explained by the chaos of 1978 and the destructions of the Iran-Iraq war. But highly restrictive trade policies and the industrial policies in support of large scale public firms have also played an important role in creating a non competitive environment. In this paper we explained part of this change in productivity by using a measure of Tornquist index of TFP corrected for market imperfection and non-constant returns to scale technology. We found that private participation is the most significant explanator for the time-series and cross section variation in TFP.

Yet, a significant part of the variations in productivity remain unexplained. The change in economic environment after the Islamic revolution is more profound that the mere change public/private share of economic activity. Enforcing discipline in the work place especially that of larger private manufacturing firms became very difficult or even dangerous. In addition to the constant threat of confiscation private manufacturers had to deal with a work force that felt that the time of labor “exploitation” and “capitalistic mastery” is gone. In larger firms the interference of workers in managerial decisions were given a legal status in the form of participation of Islamic worker committees.

One crucial element of change in the economic environment of Iran after the revolution is the prevalence of predatory attitude of public sector toward private sector. With the establishment and the spread of semi-public conglomerates (Bonyad), the state practically exploited any lucrative business opportunity that it could. Thus private business was viewed as a rival to public business and subject to formal or more often informal pressure to withdraw or share the pie with government officials. Business activities were not limited to large conglomerates. In early 1990’s various branches of the armed forces and even the intelligence service joined the crowed. As a result the budget of public firms as a share GDP increased from 16.8% in 1989 to 42% in 1998[7].

[7] Budget laws and Economic Reports of Central Bank various years.

While the share of their debt to total public dept to central bank increased from 7.9% to 39.7% in the same period. And yet this is only the tip of the iceberg as these figures reflect only the public firms and not the semi-public ones of Bonyad. Hence Iranian economy of at least 1990's can be characterized as one of monopolistic with decreasing return to scale as our results indicate.

Uncertainties about property laws, arbitrariness in their enforcement, changes of laws regarding foreign direct investment, recurrent turmoil in foreign policy and the U.S trade embargo against Iran are just a few examples of issues that potentially have great impact on productivity but I have not taken these issues into account. Our incomplete success in explanation of the sources of economic growth and stagnation in the last three or four decades resonates Stiglitz (1996) findings when he looks for the sources of East Asian growth miracle that

> "The engine metaphor has some important limitations: it encourages a search for particular factors that account for growth, although it may in fact be the system as a whole, including the interactions among the parts, that account for growth., …., The real miracle of East Asia may be political more than economic: why did government undertake these policies? Why did politicians or bureaucrats not subvert them for their own self-interest? Even here, the East Asian experience has many lessons, particularly the use of incentives and organizational design within the public sector to enhance and reduce the likelihood of corruption."

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