Iranian Economic Review, Vol.12, No.19, spring 2007

The Sources of Cost Advantage in Selected INDIAN Manufacturing Industries

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Abstract

The study demonstrates the fact that the majority of the Indian manufacturing industries have decreased their real unit cost by the benefits of economies of learning and economies of scale during 1991 – 2001. The study also shows that high and low concentrated industries are equally enjoying benefits of economies of scale but high concentrated industries are enjoying more of the benefits of economies of learning as compared to low concentrated industries. The results support the hypothesis that high concentrated industries enjoy more cost advantage than low concentrated industries. The results also indicate that Indian firms must pay more attention to the benefits of economies of learning (dynamic economies of scale) to promote their competitiveness in domestic and international markets otherwise they may lose their market share in the markets.

Key words: Cost advantage, economies of scale, economies of learning, concentrated industries.

1- Introduction

Most of empirical studies focus on only one of dimensions (static or dynamic) of cost advantage. The contribution of the study is the examination of both dimensions simultaneously. Some of studies on dynamic economies of

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scale are examined here. The concept of learning by doing (which is known as dynamic economies of scale) was introduced by Wright (1936). He studied labor productivity in the U.S. airframe industry. He could show that the number of man hours needed to produce an aero plane body declines with the cumulative number of aero planes produced. A theoretical contribution to the concept was given by Arrow (1962). He incorporated learning effects associated with cumulative investments into a macroeconomic growth model. Some other economists like Lucas (1988, 1993), Stokey (1988) and Young (1991, 1993) continued the Arrow tradition of including learning by doing in macroeconomics growth model. Another theoretical contribution was given by Dasgupta and Stiglitz (1988). They investigated the implications of learning by doing on the market structure. Economies of scale also have been examined by many empirical studies. Massimo Filippini and Marika Zola (2004) estimated a Cobb-Douglas cost frontier function for a sample of 47 Swiss postal offices for the year 2001. They found economies of scale in the industries and the results implied that merger would generate cost advantages. The study focused on static economies of scale and failed to examine dynamic dimension. Tor Jakob Klette (1998) studied economies of scale and price – cost – margin in the in Norwegian manufacturing. He found that increasing returns to scale is not a widespread phenomenon in Norwegian manufacturing. The study also failed to examine dynamic effects.

In the study attempt has been made to examine the nature of cost advantage of Indian manufacturing industries originated by economies of scale and economies of learning in Indian manufacturing industries. In fact the study focuses on cost advantage in static (economies of scale) and dynamic (economies of learning) dimensions.

2- A Brief Survey and Specification of the Model

Economies of learning and the economies of scale respectively can assess the dynamic and static dimensions of cost advantage. The difference between the reduction in average cost due to economies of learning and economies of scale is that economies of learning cause a downward shift in the long run average cost

(LAC) curve, while economies of scale causes movement from point to another point on the same long run average cost (LAC) curve[1].

Each dimension (static and dynamic) of cost advantage has been examined separately in many empirical studies. The study attempts to integrate these two dimensions into a single model. In fact this integration gives the opportunity to assess and compare static and dynamic dimensions of cost advantage simultaneously. The most common model of learning by doing[2] (dynamic dimension) may be written as:

$$c_t = c_0 Q_t^{\lambda} \qquad (1$$

Where c_t is (real) unit cost of production at time t, c_0 (real) unit cost of production in initial production period and Q_t is cumulative number of units that have been produced (proxy for experience). The above equation implies that labor learns through experience and that experience is obtained during the production process and finally it reduces unit cost.

Almost all empirical works on learning by doing have used linear form of the equation to estimate learning effects. Therefore the linear form of equation (1) (with a disturbance term added) will be:

$$\ln c_t = \ln c_0 + \lambda \ln Q_t + \varepsilon_t \qquad (2$$

Where λ is the elasticity of learning (i.e. percentage change in unit cost for a given percentage change in cumulative output). And ε_t is a random error term to allow for unobservable or immeasurable shocks. And it is assumed that $E(\varepsilon) = \cdot$.

On the other hand to assess static dimension of cost advantage the most common model used empirically is Cobb Douglas cost function which may be written for each industry as follows:

$$\ln Y = \ln A + \beta \ln K + \alpha \ln L \qquad (3$$

1- For more details refer to Dominick Salvatore, 2003, "Microeconomics theory and application"
2- For more details refer to Guido Fioretti 2007: The organizational learning curve, European Journal of Operational Research, 177, 1375-1384.

Where Y is output, K is capital and L is labor force. And the rate of return to scale (σ) will be β plus α . Or $\beta + \alpha = \sigma$.

To derive cost function from the Cobb-Douglas production function, we have the following equation,

$$C = (\alpha + \beta)\left[A\alpha^{\alpha}\beta^{\beta}\right]^{-1/\sigma} Y^{1/\sigma} r^{\beta/\sigma} W^{\alpha/\sigma} \qquad (4$$

Where C is nominal total cost, r is the capital price and W is labor price.

The above equation can be rewritten by equation (5) where h is equal to $(\alpha + \beta)\left[A\alpha^{\alpha}\beta^{\beta}\right]^{-1/\sigma}$.

$$C = hY^{1/\sigma} r^{\beta/\sigma} W^{\alpha/\sigma} \qquad (5$$

To get a linear form of equation (5) we convert the equation into logarithm form. The form of logarithm (with a disturbance term added) will be:

$$\ln C = \ln h + 1/\sigma \ln Y + \beta/\sigma \ln r + \alpha/\sigma \ln W + \varepsilon_t \qquad (6$$

To convert the nominal cost function into real cost function we assume that the weights in price deflator of Gross National Product (GNPD) reflect the input use (L, K) by firms (Berndt 1996). Therefore we will have:

$$\ln GNPD_t = \frac{\beta}{\sigma}\ln r_t + \frac{\alpha}{\sigma}\ln W_t \qquad (7$$

And also we define total costs in constant money value (C'), in terms of total costs in current money value (C_t) and price deflator of Gross National Product (GNPD). Therefore we will have:

$$C'_t = \frac{C_t}{GNPD_t} \quad \Rightarrow \quad \ln C'_t = \ln C_t - \ln GNPD_t \qquad (8$$

By substituting the right side of equation (6) for $\ln C_t$ and the right side of equation (7) for $\ln GNPD_t$ in the above equation we get the following equation.

$$\ln C' = \ln h + 1/\sigma \ln Y + \varepsilon_t \qquad (9$$

There are two major differences between learning by doing model (equation 2) and Cobb Douglas cost function (equation 8). Firstly there is no Q_t in Cobb-Douglas cost function where as A is not there in learning by doing model. Secondly Cobb-Douglas cost function model has total cost as dependent variable while learning by doing model has average cost. In order to equate these two equations the following modifications has been carried out.

To eliminate the first difference, experience can be related to technology (Berndt 1996). We assume identity between (Q_t) and (A) because it is not hard to believe that experience (Q_t) and technology (A) are related, as advances in knowledge should be related to learning. Therefore we can assume that

$$A_t \equiv Q_t^{(-\lambda)} \qquad (10$$

The above identity expresses the level of knowledge in time t as cumulative production in time t rose to the $(-\lambda)$ power.

We substitute $Q_t^{(-\lambda)}$ instead of A in equation (8). Therefore the linear Cobb Douglas cost function will be:

$$\ln C_t' = \ln h' + \frac{\lambda}{\sigma}\ln Q_t + \frac{1}{\sigma}\ln Y_t + \varepsilon_t \qquad (11$$

Where $h' = \sigma\left[\alpha^{\alpha}\beta^{\beta}\right]^{-1/\sigma}$

h' is just h which the effects of A has removed.

The second difference, between Cobb Douglas cost function (equation 10) and learning by doing (equation 2) is the concept of cost, which have been used in these two models. The cost in learning by doing model is average cost while the cost in Cobb Douglas cost function is total cost. In order to eliminate the second difference between these two models, we convert the total cost of Cobb Douglas cost function into average cost. Therefore we define average cost as $c = C'/Y \Rightarrow \ln c = \ln C' - \ln Y$ where c is average cost, C' total cost and Y output.

By substituting $\ln h' + \frac{\lambda}{\sigma}\ln Q_t + \frac{1}{\sigma}\ln Y_t$ for $\ln C_t'$ in the above definition of average cost we will obtain the following equation.

$$\ln c_t = \ln h' + \frac{\lambda}{\sigma}\ln Q_t + \frac{1-\sigma}{\sigma}\ln Y_t + \varepsilon_t \qquad (12$$

For estimating the coefficients the following linear equation can be used

$$\ln c_t = \beta_0 + \beta_1 \ln Q_t + \beta_2 \ln Y_t + \varepsilon_t \qquad (13$$

Where c_t is real unit cost of production at time t, Q_t is cumulative number of units produced up to and including period t (proxy for experience) and Y_t is output at time t. the expected sign of β_1 is negative and β_2 is positive.

As mentioned before λ and σ are respectively estimations of dynamic and static dimensions of cost advantage. Therefore in order to recover these parameters the following formula can be used.

$$\sigma = \frac{1}{1+\beta_2} \ \& \ \lambda = \frac{\beta_1}{1+\beta_2} \qquad (14$$

3- Empirical Results

The model developed in the methodology is used in order to measure dynamic and static dimensions of cost advantage empirically in Indian manufacturing industries. Twenty industries have been selected for the empirical investigation because there is different industrial classification in the available Indian data sources. The different industrial classification imposed limitations to examine more industries. Therefore only twenty industries have been examined. Out of these, ten industries belong to high concentrated industries and the remaining ten belong to low concentrated industries. High concentrated industry is defined as industry, which its average number of incumbent firms during the period is twenty or less than twenty and low concentrated industry is defined as industry, which its average number of incumbent firms during the period is more than twenty. The sample of industries is presented in table (1). The selected period for the study is 1991-2001.

Table1: Selected industries for empirical examination

	Industry
1	Bicycles
2	Chemical Machinery
3	Paints & Varnishes
4	Passenger cars & Multi Utility Vehicles
5	Silk Textile

6	Sponge Iron
7	Steel Wire
8	Textile Machinery
9	Tobacco Products
10	Woolen Textile
11	Cement
12	Computer Software & Hardware
13	Drugs & Pharmaceuticals
14	Glass & Glassware
15	Plastic Products
16	Soya bean Products
17	Steel
18	Steel tubes & Pipes
19	Tea & Coffee
20	Textile Processing

With respect to the classification and time period, we estimate the dynamic and static dimensions of cost advantage in high and low concentrated industries and also compare the importance of each dimension in the two groups of industries. As the study examines twenty industries and it is expected that these industries experience contemporaneous shocks (e.g., business cycles), the Seemingly Unrelated Regression method[1] (SUR) has been used for estimation during 1991 – 2001. In fact this estimation method improves upon precision of the traditional "ordinary-least squares" method by taking advantage of the likely presence of contemporaneous inter-correlation between the unmeasured error terms of the equations. The method of estimation applies to a system where each equation has an endogenous variable on the left side and only exogenous variables on the right side. As in the standard regression case, the disturbances are assumed to be uncorrelated with the exogenous variables. Each equation of this kind of a system could be estimated by regression, equation by equation.

1- The Seemingly Unrelated Regression method also is called multivariate regression or Zellner's method.

However, if the disturbances of the equations are correlated, the SUR estimator is more efficient, because it takes account of the entire matrix of correlations of all of the equations. In fact the Seemingly Unrelated Regression estimator minimizes the determinant of the covariance matrix of the disturbances[1].

The estimated coefficients are presented in tables (2) and (3).

Table 2: Estimated Coefficients in High Concentrated Industries

Industry	β_0	β_1	β_2
Bicycle	6.64*	-	-0.55*
Chemical Machinery	3.96*	-0.21*	-0.07*
Paints & Varnishes	6.06*	-0.13*	-0.34*
Passenger cars & Multi Utility Vehicles	7.07*	-0.14*	-0.15*
Silk Textile	0.38*	-0.32*	0.35*
Sponge Iron	2.96*	-0.25*	0.17*
Steel Wire	3.27*	-0.21*	0.11*
Textile Machinery	3.13*	-0.27*	0.14*
Tobacco Products	-	-	-0.78**
Woolen Textile	4.50*	-0.19*	-0.18*

Note: * denotes significant at one percent, **significant at five percent, ***significant at ten percent and insignificant coefficients have not been reported.

1- For further information, see Arnold Zellner, 1962: "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias" *Journal of the American Statistical Association*, 57, 348-368.

Table 3: Estimated Coefficients in Low Concentrated Industries

Industry	β_0	β_1	β_2
Cement	8.72*	0.15*	-0.42*
Computer Software & Hardware	6.84*	0.20*	-0.60
Drugs & Pharmaceuticals	10.77*	0.10*	-0.78*
Glass & Glassware	5.08*	-0.06*	-0.43*
Plastic products	4.86*	-0.31*	0.21*
Soya bean Products	3.65*	-0.30*	0.27*
Steel	9.80*	-0.14*	-0.26*
Steel tube & Pipes	3.52*	-0.41*	0.43*
Tea & Coffee	1.70*	-0.33*	0.49*
Textile processing	3.96*	-0.28*	0.21*

Note: * denotes significant at one percent, **significant at five percent, ***significant at ten percent and insignificant coefficients have not been reported.

Based on the estimated coefficients, Rate of Return to Scale (RRS) and Economies of scale (ES) has been calculated to measure the static dimension and is given in the table (4).

Table 4: Rate of return to scale and economies of scale in high and low concentrated industries

Industry	RRS $(\alpha + \beta)$	ES
High Concentrated Industries		
Bicycles	2.21	121%
Chemical Machinery	1.08	8%
Paint & Varnishes	1.51	51%
Passenger cars & Multi Utility Vehicles	1.18	18%
Silk Textile	0.74	-26%
Sponge Iron	0.85	-15%
Steel Wire	0.90	-10%
Textile Machinery	0.88	-12%

Tobacco Products	4.63	363%
Woolen Textile	1.23	23%
Average	1.52	52%
Low Concentrated Industries		
Cement	1.74	74%
Computer Software & Hardware	2.51	151%
Drugs & Pharmaceuticals	4.52	352%
Glass & Glassware	1.77	77%
Plastic Products	0.83	-17%
Soya bean Products	0.78	-22%
Steel	1.35	35%
Steel tubes & Pipes	0.70	-30%
Tea & Coffee	0.67	-33%
Textile Processing	0.83	-17%
Average	1.57	57%

RRS: Rate of Return to Scale

ES: Economies of Scale (RRS – 1)

From the above table it is observed that in high concentrated industries more than half of the industries enjoy increasing rate of return to scale and the average rate is 1.52. It indicates that static economies of scale have played a significant role to enhance cost advantage in this group of industries. In other words the majority of the industries could decrease the unit cost by expansion of production during the period of time. In low concentrated industries also half of the industries enjoy economies of scale and the average rate of return to scale is 1.57, which indicate increasing rate of return for this group of industries. Therefore it can be said that both groups more or less are enjoying economies of scale.

On the other hand another dimension of cost advantage, which is called “dynamic economies of scale”, has been assessed by the elasticity of learning by doing (λ). Based on the values of learning elasticity, learning rates are calculated. Learning rate expresses the relative decline in production cost with a doubling of the cumulative production and it is calculated by $1-2^{\lambda}$. These two measures of dynamic economies of scale are presented in table (5). The majority of industries in these two groups have enjoyed dynamic economies of scale. But the level of utilization of dynamic economies of scale is not equal in these two groups of industries. In high concentrated industries the average learning rate is 14% while the average learning rate in low concentrated industries is only 4%. It indicates that high concentrated industries enjoy more benefits from dynamic economies of scale compared to low concentrated industries.

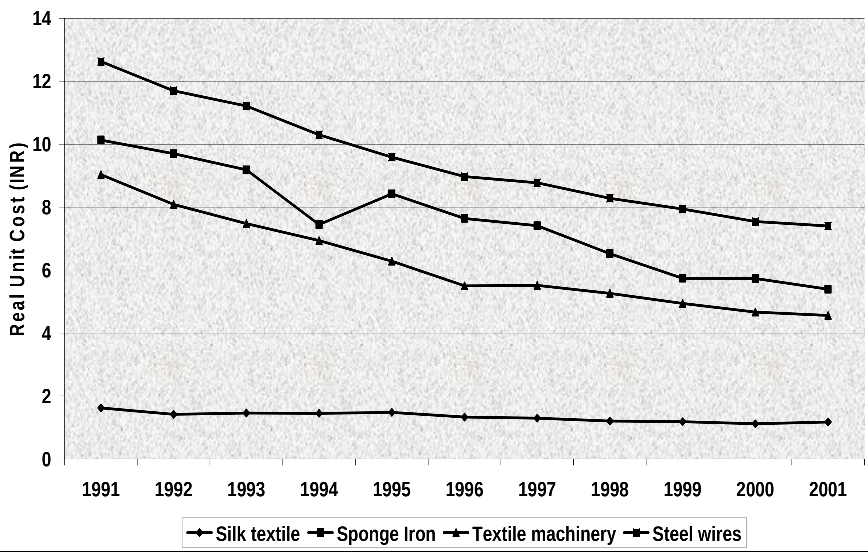
Table 5: Elasticity of learning and learning rate in high and low concentrated industries

Industry	Elasticity of Learning (λ)	Learning Rate
High Concentrated Industries		
Bicycles		
Chemical Machinery	-0.23	15%
Paint & Varnishes	-0.20	13%
Passenger cars & Multi Utility Vehicles	-0.16	11%
Silk Textile	-0.23	15%
Sponge Iron	-0.21	14%
Steel Wire	-0.19	12%
Textile Machinery	-0.24	15%
Tobacco Products		
Woolen Textile	-0.23	15%
Average	-0.21	14%
Low Concentrated Industries		
Cement	-0.25	16%
Computer Software & Hardware	0.50	-41%
Drugs & Pharmaceuticals	0.44	-36%
Glass & Glassware	-0.11	7%
Plastic Products	-0.26	16%
Soya bean Products	-0.24	15%
Steel	-0.19	12%
Steel tubes & Pipes	-0.29	18%
Tea & Coffee	-0.22	14%
Textile Processing	-0.23	15%
Average	-0.09	4%

Significant estimations are reported

The impact of static economies of scale on the reduction of unit cost is approximately equal in these two groups of industries. The significant difference between the impacts of dynamic economies of scale between these two groups of industries indicates that the high concentrated industries enjoy more cost advantage mainly because of dynamic impacts (not static impacts). In other words, the cost advantage that has kept the firms in high concentrated industries in a better position than firms in low concentrated industries is originated by experience and learning (dynamic impacts).

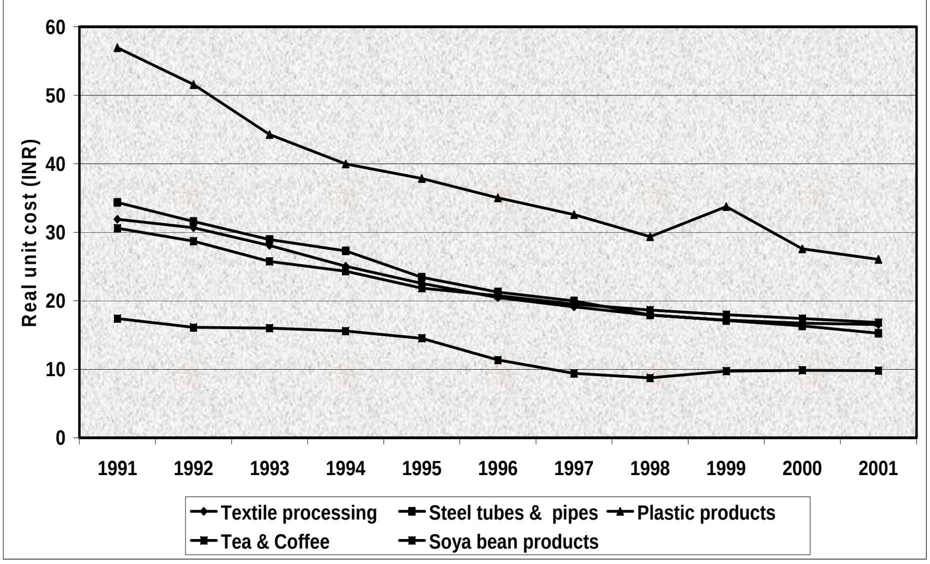
Figure (1)
The trend of real unit cost in four selected industries



This result demonstrates the fact that incumbent firms responded to the new industrial policy by focusing on improving their technology and streamlining production process. However, we observed that four industries like silk textile, sponge iron, steel wire and textile machinery suffer from decreasing rate of return to scale. Even though as figure (1) shows, these industries were in a position to decrease their unit cost due to strong impact of dynamic over static economies of scale. Therefore the figure shows a decreasing trend for unit cost in these industries. In other words, the reduction of unit cost in the industries can be justified by the impacts of learning which were so strong that could offset the impacts of decreasing rate of return in these industries. It implies the importance of dynamic economies of scale for the industries to keep and enhance their cost advantage and competitiveness.

As table (4) shows, five industries in low concentrated industries including plastic products, Soya bean products, steel tubes and pipes, tea and coffee and textile processing industries suffer from diminishing return to scale. It indicates that the expansion of production scale has not decreasing effect on unit cost in these industries. But as the figure (2) shows, these industries also could successfully decrease unit cost during the period of time due to strong effect of dynamic economies of scale.

Figure (2)
The trend of real unit cost in five selected industries



All the estimations for learning effects on unit cost in the industries are significant. The strong significant impact of learning in the industries can be attributed to the age of the industries. Almost all the industries are among old Indian industries. Therefore their learning (experience) on production and management has decreased the unit cost. In low concentrated industries two industries like Computer software and hardware and drugs and pharmaceutical are not enjoying dynamic economies of scale. It may due to dynamic economies of scale usually exist in old industries and Computer software and hardware is not an old industry in India. This phenomenon for computer software and hardware industry can be justified by the low age of the industry. Drugs and pharmaceuticals industry also is not enjoying dynamic economies of scale. The main reason is that the majority of firms in the industry are young (most of the firms have entered to the market during 1990s) and therefore they do not have enough experience to enjoy significant of dynamic economies of scale.

4- Concluding Remarks

The empirical results demonstrated that the majority of the selected industries could decrease their real unit cost by the benefits of economies of learning and economies of scale. The real unit cost for almost all of the industries has been declined during the period under review. The findings of the study show that high and low concentrated industries are equally (approximately) enjoying benefits of economies of scale but high concentrated industries are enjoying more of the benefits of economies of learning as compared to low concentrated industries. It seems that high concentrated industries are enjoying more cost advantage in India. In other words the empirical results of the study do not reject the hypothesis that high concentrated industries enjoy more cost advantage than low concentrated industries. There are nine industries, which are suffering from diseconomies of scale in terms of static dimension. However due to benefits of economies of learning these industries could keep and even promote their cost advantage by focusing on the benefits of economies of learning. In view of this they should focus their efforts on dynamic economies of scale to enhance their competitiveness. Otherwise they may lose their market share.

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