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Investment and Adjustment Costs in the Iranian Agriculture

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Abstract: The general objective of this study is to develop an appropriate dynamic model of third generation for analyzing investment and adjustment costs in agriculture sector of Iran. In this study, input demand functions are estimated for agriculture sector during 1979-2004 using 3SLS method. An improved dynamic model was built on the basis of the cost of adjustment theory to estimate the impacts of production inputs on agricultural investment. The results indicate that the energy price has positive and significant impacts on agricultural investment while war and the ratio of investment to production in previous period have negative impacts. Furthermore, the results indicate that technology is labor intensive. Based on the results, the estimated coefficient for is the adjustment costs is equal to 315 for Iranian agriculture. It means that increasing investment to reach the equilibrium after a shock needs adjustment costs where the amount of this cost is at a rate of 157.54 which is high and so in case of a shock to the sector, farmers have to pay high costs to reach the previous position. The results also indicate that material input is complement with investment, energy and labor.

Key words: Investment, agriculture, dynamic model, 3SLS, adjustment cost

INTRODUCTION

Agricultural investment is an important determinant of future productivity. The inherently dynamic nature of investment decisions has challenged both theoretical and empirical modeling. The study of investment behavior holds an important place in economic literature.

Although econometric studies of investment behavior are widely developed in economic literature, there are few published studies of agricultural investment. In the past three decades, empirical studies based on flexible functional forms have been published that characterized the behavior and technology of farms. The vast majority of these flexible functional forms are based on the translog form, developed by Christensen *et al.* (1973). Dynamic factor demand models have been built on the basis of the theory of cost of adjustment developed in several papers by Lucas (1967), Treadway (1974) and recently by Skjerpen (2005) and Morana (2007). They propose a general investment framework in which a capital dynamic is endogenously determined because farms cannot move instantaneously to a new optimal position, when factor prices change.

The adjustment cost hypothesis provides an appealing rationalization for the divergence of actual from desired values of a production input (Watkins, 1993). Based on this hypothesis, it is costly for farmers to rapidly adjust production inputs to their long-run equilibrium values. Slow adjustment cost hypothesis provides the required bridge between short-run and long-run economic analysis (Vasavada and Ball, 1988). In this study, we develop dynamic cost of adjustment factor demand models introduced by earlier studies (Berndt *et al*., 1981). Recently a few studies are done on agricultural investment and adjustment costs (Pietola and Myers, 2000; Gardebroek and Lansink, 2004; Hennessy and Moschini, 2006). They found that adjustment costs create inertia concerning intermediate signals such that earlier decisions are not overturned and also a bias against imposing an early ban. Besides, instantaneous adjustment may be impossible or imply (high) costs of adjustment. In the long run, quantities of these quasi-fixed factors can be adjusted at lower costs of adjustment.

Agriculture sector of Iran has a main role in the economy where, 25% of employment and 20% of GNP are related to this sector. On the other hand, there are many industries that are related to the agriculture sector of Iran. Hence, the investment behavior may have an important impact on the production, employment and sustainable development on agriculture sector of Iran. The general objective of this study is to estimate the variables have impacts on the investment in the Iranian agriculture. At

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this study, for the first time, we will estimate the adjustment cost rate and also study the impacts of variables which have effects on Iranian agriculture to make appropriate policies for a better future of this sector.

MATERIALS AND METHODS

The theoretical concept: The dynamic input demand model developed in this paper is built on the basis of the cost of adjustment theory (Lucas, 1967). Eisner and Strotz (1963) developed the theory of adjustment in a dynamic optimization framework. Based on their theory, resources are used in adjusting capital stock and the present value maximized by the firm depends on the optimal level of inputs selected by the firm and on the paths of the current capital stock to the optimal level. In all models, in spite of differences in their complexity, an objective function, incorporating factor adjustment costs and a production function, is specified. In these models, the costs vary with the speed of capital adjustments. It is assumed that the values of the expected input and output prices do not change. This stationary expectation assumption is required if the dynamic optimization is to be well defined (Nerlove, 1972).

Following Berndt *et al.* (1979, 1980) and Berndt *et al.* (1981) and Moschini (2001), the optimal adjustment paths for the quasi-fixed inputs are derived by incorporating a short-run cost/profit restricted function into a long-run dynamic optimization framework. As the rate of change of each quasi-fixed input increases in a given period, the amount of foregone output rises. In the single-product case, the effect is measured in terms of decreases in physical units of the product (Rezitis *et al*., 1998). Thus, the final system of behavioral equations to make a dynamic model includes the short-run input demand equations for energy, material, labor and the investment demand equation that will be explained at the next section. The empirical model for Iranian agriculture is estimated using annual aggregated data for the period 1979-2004 obtained from various Statistics Iran publications. Using dynamic model includes the short-run input demand equations, for the first time, we will estimate the variables affect the investment on Iranian agriculture. Besides, will find the adjustment cost for Iranian agriculture. The adjustment cost hypothesis is used to explain input adjustment, in terms of low marginal resource returns and considers input and output adjustments made by changing relative prices in agriculture. These costs vary with the speed of capital adjustment (Thijssen, 1996). Knowledge about adjustment costs helps policy makers in the design of stabilization policy. Model estimates suggest that it may take a few years before the output supply and input demand levels stabilize to their new long-run equilibrium values.

The empirical model: In order to illustrate empirically the dynamic model, which was theoretically developed in section 2, a functional form must be specified for the restricted normalized cost function G and the continuity assumptions incorporated in the theoretical model must be modified to conform to the data constraints. It is assumed that the net changes in quasi-fixed inputs ($\dot{K} = \partial K / \partial t$) can be represented by discrete net changes ($\Delta K = K_t - K_{t-1}$) and that output in period t is produced by quasi-fixed input in place at the beginning of that period. In terms of functional form, the quadratic normalized restricted cost function of Berndt *et al*. (1979, 1980) is modified so that coefficients of the demand equations represent effects of price changes on input-output ratios rather than on input levels (Morrison and Berndt, 1981).

An important assumption is that expectations of the relevant price variables are fixed at the current level for all future periods; that is, static price expectations are assumed. This assumption allows for the existence of a fixed long-run equilibrium position toward which the firm is striving; that is, the assumption of static expectations implies that the firm's target is not moving during time unless actual prices change.

To illustrate a tractable model, consider a production function $\bar{Q}$ as a function of three variable inputs: labor (L), energy (E) and material (M) and also capital (K) as a quasi-fixed input. So the production function can be written as:

$$\bar{Q} = f(K, L, E, M, I, T) \tag{1}$$

where, I is net investment and T is the technology level (as a time trend). Given exogenous prices and fixed capital in short-run, the theory of duality between cost and production functions implies that, given short-run cost-minimizing behavior, the underlying production function can be represented uniquely by a normalized restricted cost function:

$$G = G(P_E, P_L, P_M, K_{-1}, \Delta K, Q, T) = L + P_E E + P_M M \tag{2}$$

Where:

P_E = Normalized price of energy, $P_E = P_E/P_L$

P_M = Normalized price of material, $P_M = P_M/P_L$

P_L = Price of labor

K = Capital stock
ΔK = Change in capital stock
Q = Output
T = Time (intended to represent technological change)

The functional form chosen to approximate normalized restricted cost function is quadratic because of a few desirable properties (Treadway, 1971). Following Treadway, we consider the normalized variable cost function in quadratic form, so it can be specified as:

$$\begin{aligned} G = L + P_E E + P_M M = \bar{Q}[&\alpha_0 + \alpha_{0T}T + \alpha_E P_E + \alpha_M P_M + \alpha_{MT}P_M T + \alpha_{ET}P_E T \\ &+ \tfrac{1}{2}\left(\alpha_{EE}P_E^2 + \alpha_{MM}P_M^2\right) + \alpha_{EM}P_E P_M] + \tfrac{1}{2}\alpha_{KK}\, K_{-1}^2/Q \\ &+ \alpha_K K_{-1} + \alpha_{KT}K_{-1}T + \alpha_{EK}P_E K_{-1} + \alpha_{MK}P_M K_{-1} \\ &+ \alpha_{KT}\Delta K\cdot T + \alpha_K \Delta K + \alpha_{EK}P_E \Delta K + \alpha_{MK}P_M \Delta K \\ &+ \alpha_{KK}K_{-1}\,\Delta K/Q + \tfrac{1}{2}\alpha_{KK}\,(\Delta K)^2/Q \end{aligned} \quad (3)$$

Internal costs of adjustment, $C(\Delta K)$, consists of all terms of the variable cost function G given by Eq. 3 involving ΔK and can be shown as:

$$\begin{aligned} C(\Delta K) = &\alpha_{KT}\Delta K\cdot T + \alpha_K \Delta K + \alpha_{EK}P_E \Delta K + \alpha_{MK}P_M \Delta K \\ &+ \alpha_{KK}K_{-1}\,\Delta K/Q + \tfrac{1}{2}\alpha_{KK}\,(\Delta K)^2/Q \end{aligned} \quad (4)$$

This expression can be simplified somewhat by restricting the nature of quadratic adjustment cost such that when the rate of capital adjustment, ΔK is equal zero, the marginal adjustment costs at that point must also be equal to zero. This implies that:

$$\frac{\partial C(\Delta K)}{\partial \Delta K} = C'(\Delta K)\Big|_{\Delta K=0,\, K=K^*} = \alpha_K + \alpha_{Kt}T + \alpha_{EK}P_E + \alpha_{MK}P_M + \alpha_{KK}\,K^*/Q = 0 \quad (5)$$

Which implies that the parameters $\alpha_K, \alpha_{KT}, \alpha_{EK}, \alpha_{MK}, \alpha_{KK}$ a must also be equal to zero. When these restrictions are imposed, the normalized restricted cost function imposing the expected output $\bar{Q}$ will be reduced to:

$$\begin{aligned} G = L + P_E E + P_M M = \bar{Q}[&\alpha_0 + \alpha_{0T}T + \alpha_E P_E + \alpha_M P_M + \alpha_{MT}P_M T + \alpha_{ET}P_E T \\ &+ \tfrac{1}{2}\left(\alpha_{EE}P_E^2 + \alpha_{MM}P_M^2\right) + \alpha_{EM}P_E P_M] + \tfrac{1}{2}\alpha_{KK}\, K_{-1}^2/Q \\ &+ \alpha_K K_{-1} + \alpha_{KT}K_{-1}\cdot T + \alpha_{EK}P_E K_{-1} + \alpha_{MK}P_M K_{-1} \\ &+ \tfrac{1}{2}\alpha_{KK}\,(\Delta K)^2/Q \end{aligned} \quad (6)$$

The adjustment costs are reduced to:

$$C(\Delta K) = \tfrac{1}{2}\alpha_{KK}\,(\Delta K)^2/Q \quad (7)$$

Using the Shepard-Uzawa-McFadden lemma, the short-run optimal demand equations for energy and material would be derived from the Eq. 6 as:

$$E/Q = \alpha_E + \alpha_{ET}T + \alpha_{EE}P_E + \alpha_{EM}P_M + \alpha_{EK}\,K_{-1}/Q \quad (8)$$

$$M/Q = \alpha_M + \alpha_{MT}T + \alpha_{MM}P_M + \alpha_{EM}P_E + \alpha_{MK}\,K_{-1}/Q \quad (9)$$

The short-run demand function for labor is determined from:

$$\frac{L}{\bar{Q}} = \frac{G}{\bar{Q}} - P_E\frac{E}{\bar{Q}} - P_M\frac{M}{\bar{Q}} \quad (10)$$

Therefore, the demand function for labor would be defined as:

$$\begin{aligned} L/Q = &\alpha_0 + \alpha_{0T}T - \tfrac{1}{2}\left(\alpha_{EE}P_E^2 + 2\alpha_{EM}P_M P_E + \alpha_{MM}P_M^2\right) + \alpha_K\,K_{-1}/Q \\ &+ \alpha_{KT}K_{-1}\,T/Q + \tfrac{1}{2}\alpha_{KK}\,K_{-1}^2/Q^2 + \tfrac{1}{2}\alpha_{KK}\,(\Delta K)^2/Q^2 \end{aligned} \quad (11)$$

The adjustment cost related term only directly affects the labor equation. The demand equation for investment can be derived as:

$$\Delta K/Q = a_K + a_{Kt}t + a_{EK}P_E + a_{MK}P_M + \alpha_u u_K + \alpha_k \frac{K_{-1}}{\bar{Q}} \quad (12)$$

Thus, the final system of behavioral equations to make a dynamic model includes the short-run input demand equations for energy (8), material (9), labor (11) and the investment demand Eq. 12. The system is a simultaneous dynamic model and therefore must be estimated though a three stage least square regression process (3SLS).

The empirical model for Iranian agriculture is estimated using annual aggregated data for the period 1979-2004 obtained from various Statistics Iran publications. Aggregate material input was compiled from data on the use of agricultural feed, seed, pesticides and fertilizer. The main part of energy in agriculture sector of Iran comes from fuel and electricity and so the aggregate stock of energy was compiled from total expenditures of fuel and electricity. Energy is considered from important activities such as seeding, tillage, harvest, pest control, fertilizer applications etc. The value of labor is calculated as the value of payments to hired workers plus an estimation for the value of unpaid family labor using the mean wage rate of hired workers and the number of farms. Interest rates were obtained from Central Bank of Iran reports.

The aggregate stock of capital was compiled using the stocks of agricultural machinery and buildings. The net investment data were computed as the annual changes in the corresponding stocks of the quasi-fixed input. Aggregate output was compiled using the output of livestock and crops. All price indices are aggregated and were normalized by the price of labor. Each variable was examined for its time series properties using the ADF test and found to be stationary. Land was not explicitly included in the model, because it is almost constant at the Iranian agriculture.

RESULTS AND DISCUSSION

The parameters for the model were estimated using the 3SLS (three stage least squares) in Eviews 3.0 for Iranian Agriculture during 1979-2004. The results for Stationary are shown in Table 1 and the estimated value for each parameter, t-statistics and p-values, Durbin-Watson test and heteroscedasticity white test results for Iranian agriculture are shown in Table 2. The results indicate no specific problem at the estimated model. The own-price coefficients for each equation have the expected sign.

Based on the results in Table 2, considering the estimated demand equation for energy, the technology uses less energy in production. On the other hand, the unexpected sign of normalized price of energy indicates labor intensity for Iranian agriculture. In fact, the normalized price of energy has an inverse relation with wage rates. Hence, decreasing wage rates, result more labor and so more energy using in agricultural sector. The results also show that material and energy are complement.

Besides, the negative sign of C (5) indicates that the agriculture sector is labor intensive. It is because increasing capital use more labor force in the sector and so value-added increases at a rate more than energy consumption and therefore the average of energy consumption will decrease. In the estimated demand equation for material, similar to the demand equation for energy, the technology used in agricultural sector use less material in production. Besides, the positive sign of C (15) indicates that capital and material are complement. The estimated dummy variable of war shows that the war has negative impacts on capital and material consumption and also technology in agricultural sector.

In the estimated demand equation for labor, similar to the demand equations for energy and material, the technology uses less labor force in production. This indicates that improving technology, average of force labor needed in production will be reduced. The estimated parameters show an inverse relation between wage rate and demand for labor force. Besides, energy and material are complement for labor force. It means that consumption more energy or material in the Iranian agriculture needs

Table 1: Results of stationary test for time-series variables

	ADF	
Residuals	Without trend	With trend
Rised (EQ)	-5.82	-5.66
Rised (MQ)	-3.83	-3.66
Rised (LQ)	-5.01	-4.81
Rised (IQ)	-4.81	-4.66

Table 2: Parameter estimates for the dynamic investment model for Iranian agriculture

Equation	Variable	Parameters estimated	t-statistics	p-value
Energy demand	A_E	0.032982	3.656628	0.0005
equation	T	-2.31E-05	-3.521679	0.0008
F=.09	PEL	0.177151	2.641209	0.0102
D.W.=2.07	PML(-1)	-0.234747	-3.331466	0.0014
R^2 = 0.91	K1Q	-0.000751	-3.022888	0.0035
	AR(1)	0.595601	4.278819	0.0001
Material demand	A_M	0.005942	3.378752	0.0012
equation	T	-4.30E-06	-3.327311	0.0014
F=1.05	PEL	0.016621	2.372033	0.0205
D.W.= 1.88	PML	0.003559	0.347568	0.7292
R^2 = 0.77	K1Q(-1)	0.000103	2.487034	0.0153
	D_{59}	-0.016894	-4.490979	0.0000
	T×D_{59}	1.24E-05	4.496773	0.0000
Labor demand	A_L	15425.39	5.945366	0.0000
equation	T	-11.13446	-5.920667	0.0000
F=.74	PEL^2	53503605	3.338789	0.0014
D.W.= 1.92	PEL×PML	-32303602	-2.015333	0.0478
R^2 = 0.99	PML^2	16139383	2.567138	0.0125
	K1Q	-29331.06	-3.665836	0.0005
	KTQ	20.982180	3.647875	0.0005
	K1Q^2	894.128600	4.338789	0.0000
	IQ^2	-315.082300	-1.463855	0.1478
	PEL×PEM×D_5	-1.07E+10	-4.456504	0.0000
Investment	A_K	10.679730	2.859826	0.0056
demand	T	-0.007741	-2.859405	0.0056
equation	PEL	59.532130	3.217463	0.0020
F=1.08	PML	6.987134	0.250522	0.8029
D.W.=2.05	PKL(-1)	-10.146180	-0.455316	0.6503
R^2 = 0.73	K1Q(-1)	-0.036486	-0.590990	0.5565
	T×D_{59}	-3.61E-05	-6.534460	0.0000
	AR(1)	-0.422886	-2.517458	0.0142

using more labor force. The estimated results also indicate that increasing capital uses more labor in agriculture sector where this is another reason for labor intensity of Iranian agriculture sector. In the estimated demand equation for investment, similar to the demand equations for energy and material and labor, the technology used in agricultural sector use less investment in production. The estimated parameters show that increasing investment is affected by less wage rates related to energy price which again indicates that agriculture sector is labor intensive. The estimated results also show the negative impact of war on agricultural sector of Iran.

Estimated adjustment costs: As we already mentioned, the adjustment costs can be calculated from the Eq. 7 as:

$$C(\Delta K) = 1/2a_{kk} \, {(\Delta K)^2}\big/{\bar{Q}}$$

Based on the estimated a_{kk}, the amount of this parameter is equal to 315.08. In other words, at a long-run period, the adjustment costs would be equal to 157.54 times $(\Delta K)^2/Q^2$. It means that increasing investment to reach the equilibrium after a shock needs adjustment costs where the amount of this cost at a rate of 157.54. We can also conclude that because of adjustment costs, agriculture of Iran is decreasing return to scale.

Model validation: Figure 1-4 show the validity of the model for material, energy, labor and investment demand equations by corresponding real and simulated values.

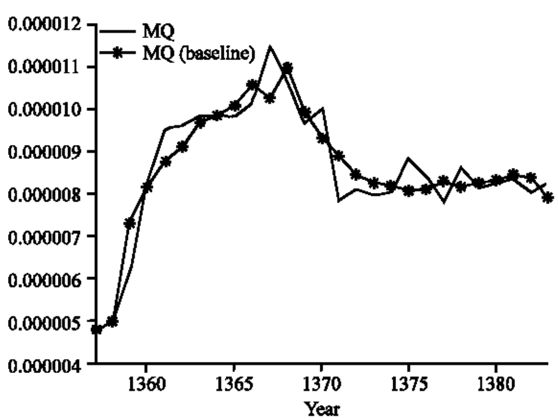

Fig. 1: Validity for material demand equation. The x-axis shows the time trend and the y-axis indicates the trend of inputs

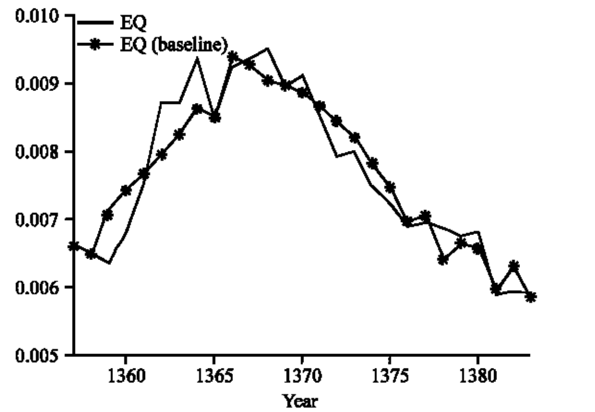

Fig. 2: Validity for energy demand equation. The x-axis shows the time trend and the y-axis indicates the trend of inputs

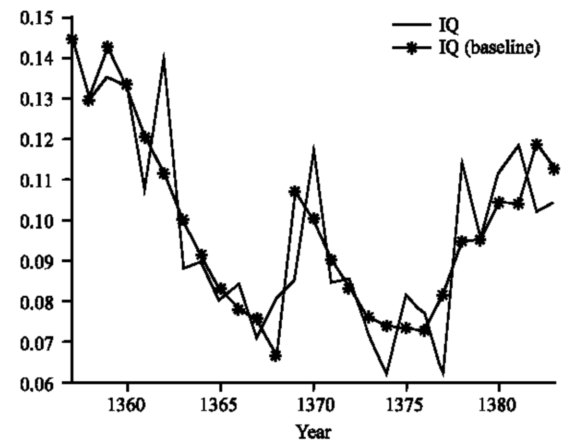

Fig. 3: Validity for investment demand equation. The x-axis shows the time trend and the y-axis indicates the trend of inputs

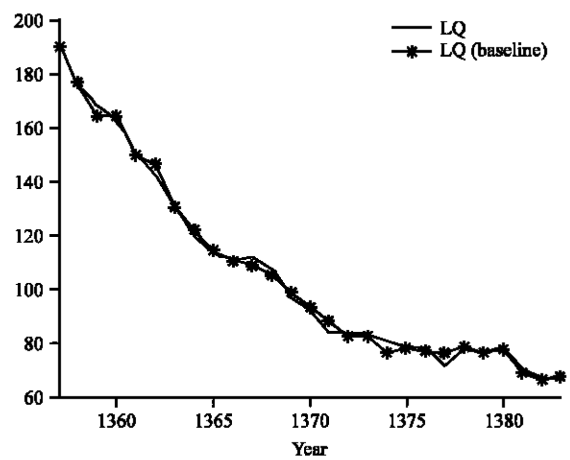

Fig. 4: Validity for Labor Demand Equation. The x-axis shows the time trend and the y-axis indicates the trend of inputs

Model stability: Figure 5-8 show the stability of the model for material, energy, labor and investment demand equations in case of imposing a shock to the model using a change in exogenous variables. A 50% change has made on normalized energy price in 1990. The Fig. 5-8 show a stability situation for all equations.

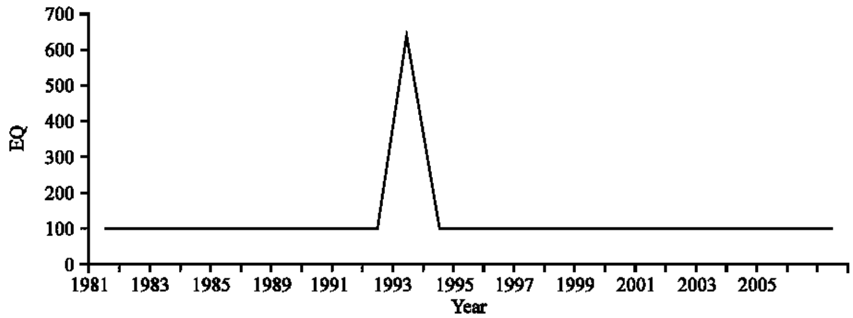

Fig. 5: Impacts of energy price shock on (EQ)

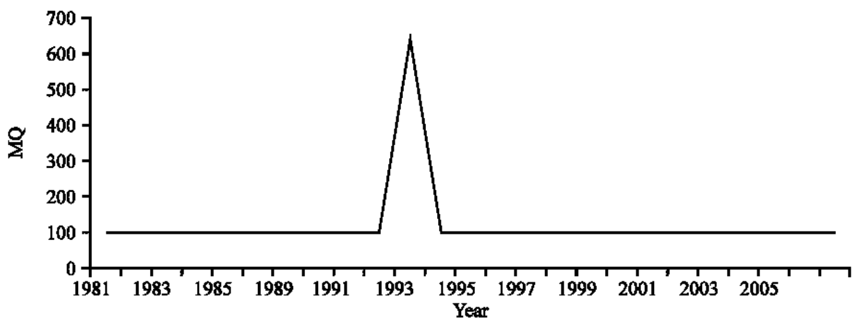

Fig. 6: Impacts of energy price shock on (MQ)

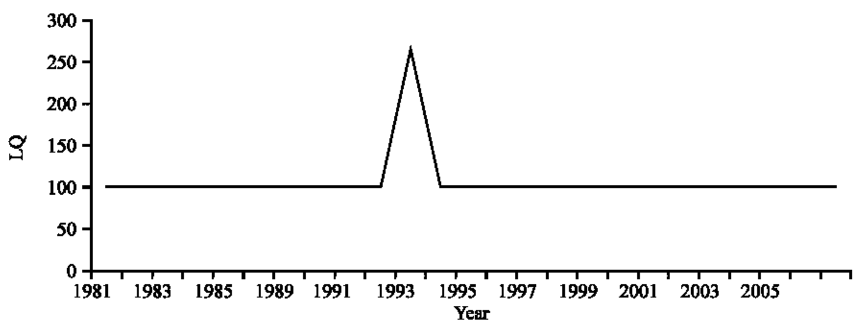

Fig. 7: Impacts of energy price shock on (LQ)

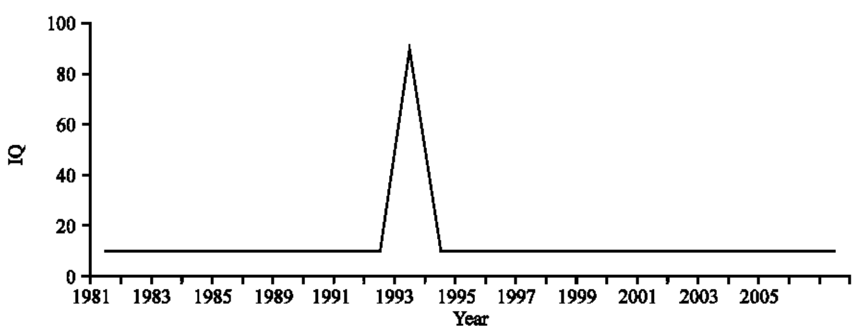

Fig. 8: Impacts of a shock on (IQ)

CONCLUSIONS

The dynamic input demand model combines the cost of capital adjustment and output choice to create a dynamic model that is theoretically and empirically appealing. The four input empirical model provided a tractable means of estimating input demand system. The application to Iranian agriculture resulted in model that was dynamically stable and consistent with profit maximization. The results show that capital is a quasi-fixed input, with significant adjustment costs and a slow rate of adjustment. Similarly, Vasavada and Chambers (1986), Boetel *et al.* (2007) and Halvorsen (1991) also showed that capital is a quasi fixed factor for US Agriculture. Based on the results, the estimated coefficient for is the adjustment costs is equal to 315 for Iranian Agriculture. It means that increasing investment to reach the equilibrium after a shock needs adjustment costs where the amount of this cost is at a rate of 157.54 which is high and so in case of a shock to the sector, farmers have to pay high costs to reach the previous position. Based on our expectation, technological change and machinery investment are labor-using for Iranian agriculture and so the policy makers may try to decrease the rate of employment at this sector. In fact policy makers by increasing farm size will improve labor productivity and lead to a more efficient utilization of farm capital, resulting in lower average cost of production. Similar to the study of Rezitis *et al.* (1998), all short run input demands are inelastic and increase slightly in the long-run. Capital and energy as well as capital and material and also energy and material are complementary. There is some indication that technology within the sector has a positive effect on Iranian agricultural input productivity. Besides, agricultural value added has positive impacts on next period investment. Hence, increasing productivity in the agriculture sector will have positive impacts on the investment at this sector.

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