# Combination of Econometric Methods and System Dynamics Approach to Improve the Iranian Agricultural Policies

**Mohammad Hashem Moosavi Haghighi**

Researcher in “Fars Research Centre for Agriculture and Natural Resources”
PhD in Agricultural Economics and Lecturer in Azad Univercity, Shiraz Branch

P.O.Box 71555-617 Shiraz, Iran, Dr. M. Hashem Moosavi H.

H/P 0098-9173102356 , Home 0098-7116251499 ,
Office 0098-7117204959 , Fax 0098-7117205107

musavee@gmail.com & mosavi@farsagres.ir

## Abstract

*Agriculture is an important economic sector and a strategic component for the rural development in Iran. However, the sector has been beset by a labour surplus situation as indicated by the high labour/land ratio. This situation, together with inappropriate combination of labour with other factors of production, has caused a low growth rate in the agricultural production. The main objective of this study was to determine the optimal employment and production policies in the Iranian agricultural sector. Econometric methods provide representations of the system in equations. Production, export-import, demand for labour and agricultural products, as well as the wage functions were estimated using the data collected during 35 years, and substituted in the economic component of the System Dynamics (SD) model to simulate the outcomes. The results indicate that a downward turn for the labour surplus problem will happen in 2008. After wards, the agricultural employment will gradually decline. Consequently, the cityward migration will increase, and the unemployment problem shifts from the rural to the urban areas. The average annual production growth rate in the 2007-2021 period is estimated at 1.8%. Furthermore, higher production is commensurate needed with substantial investment and adoption of appropriate technology. This study further demonstrates that combination of the SD approach and econometrics methods is highly effective in arriving at logical answer.*



***Keywords:*** *System Dynamics Simulation, Econometrics Methods, Socio-Economic Model, Agricultural Labour, Agricultural Sector Policies,*


## Introduction

The Iranian agricultural sector contributed about 15% of the country's value added in 2005, and created 23% of the total employment in 2004. The main issue in this sector is the low labour productivity and its negative effect on the production process (Khakbazan and Gray, 1993; Khalilian and Yari, 2001; Akbari and Ranjkesh, 2003, Moosavi and Mad Nasir, 2007). National policies during the past two decades have sought to strengthen the agricultural activities in order to achieve a higher level of self-sufficiency in food producing and a more diversified source of foreign exchange, thus reducing the vulnerability to fluctuations in oil prices. These same objectives, which were included in the past development plans, are also reported in the Third Plan and at of the 25-year strategy, a roadmap for the economic restructuring of the I. R. of Iran. A central stated goal of this plan is achieving food security by 2021 [Iranian Islamic Year (Solar-Hejri), 1400].

Over-employment in the agricultural sector and its resultant diminishing return, along with an inappropriate combination of other production factors, has caused a serious problem in the rate of output in recent years. Therefore, it can be stated that one of main challenges of the agricultural sector is reducing its labour surplus in order to increase productivity and output. However, it is not possible for this sector to release its surplus labour in due time. Moreover, the Adjustment Cost (AC) is probably higher than the Disequilibrium Cost (DC), (Al-Jalaly, 1992; Benjamin, 1992; Amini, 2002; Moosavi and Mad Nasir, 2008) for the agricultural labour in Iran. Hence, the adjustment

coefficient[1] is also small in the Iranian agricultural sector in order to adjust itself to the optimal level of employment (Moosavi and Mad Nasir, 2008).
The cityward migration has been on the rise during the past 30 years. Therefore, the rural areas are losing their manpower. The main reasons for this movement are job vacancy, higher paying and enjoying the urban facilities. Moreover, chaotic migration has increased urban unemployment, and in turn has adversely affected both urban and rural communities. The advancement in the country's capital-intensive technology has also increased the cityward migration of the labour force, thus decreasing the demand for labour in the agricultural sector. During the 1978/79 to 2000/01 period, employment in the agricultural sector decreased by 2.5%, whereas the value added increased by 135.2% (SCI, Various Issues). This was mainly due to increased utilization of capital-intensive methods in the production process in the agricultural sector of Iran. Thus, an important fundamental issue in this sector is whether the agricultural labour, as a factor of production, contributes significantly to the economy.
According to statistics (SCI, Various Issues), the unemployment rate in the urban area was increasing and it stands presently at more than 10%. Thus, the society has been adversely affected by this increased, double-digit unemployment rate; therefore, the policy-makers have to control this rate at an acceptable range in order to avoid tension build up in the society.
Fei and Gustav (1964) theorized that of the fundamental features of the basic model of surplus economy, the supply of land in the underdeveloped countries is sharply limited, and more importantly, labour is redundant in the agricultural sector. Thus, there exist a number of workers in this sector with zero marginal productivity. The prime location for such surplus labour has traditionally been in the developing countries, the agricultural sector, concentrated specifically in the subsistence agriculture, characterized by the family farms, in contrast to commercialized plantation agriculture, that strives for profit maximization entities, which able it to hire and fire workers following well-known neoclassical principles.
As development over the past half century has proceeded apace, some initially labour surplus countries, including Taiwan, South Korea and Thailand, have graduated from their initial labour surplus condition, as evidenced by the gently rising unskilled wages in both sectors, finally giving way to rapid and sustained increases, as secular labour shortage make their appearance. Such a turning point was reached around 1968 in Taiwan, around 1973 in South Korea and around 1993 in Thailand (Gustav, 2004). While in some developing countries, the labour shortage has happened in the agricultural sector in the process of development (Mad Nasir and Ghazali, 1998), the labour surplus problem has persisted for a long time in the agricultural sector of Iran. As the other economy sectors in Iran had not experienced a dynamic change in their performance, they were unable to absorb agricultural labour during the past three decades. Not only did the Islamic Revolution and the 8-year war with Iraq influence this process, the inappropriate policy and political instability had also worsen this situation. On the other hand, the trend has changed towards the capital using methods in other sectors. The capital had increased from 1972 to 2002; 221, 165, 360, 403% in the agricultural, oil and gas, industry and mining and service sectors, respectively (SCI, various Issues). Since 1966, the capital had been flowing into the industrial and service

[1] For example, if the adjustment coefficient for the agricultural sector was 20% (0.2), it suggests that it would take about five (1/0.2) years before the actual employment adjusts itself to the optimal level of employment. In Iranian agriculture, the adjustment coefficient is equal to 0.044.

sectors in Iran; therefore, the industrial and service sectors had expanded. This process known as industrialization, has resulted in an increase in population, specifically in the urban areas[2]. Thus, the added population had to seek livelihood in sectors not related to agriculture. Moreover, all available land in the rural areas had already been cultivated by the labour intensive techniques, and the marginal productivity of labour had fallen below zero with most available labour intensive techniques. With continuing population growth, the more hidden unemployment began to appear in the rural and urban areas alike.

### Issues and Challenges in Perspective

The agricultural employment was relatively stable during 1966-2001. Moreover, the share of agricultural Value Added (VA) in the whole economy had also been relatively stable, i.e. from 15.1% in 1970 to 15.5% in 2003 (SCI, Various Issues). This situation is in direct contradiction to the level of development in many countries, where it is expected that the agricultural employment trend and share of agriculture in whole economy to considerably decline as a country is developing. Consequently, the whole mentioned problems in the agricultural sector are systematically related to each other, with a complex feedback. Therefore, a systematic overview concerning the issues and challenges in the agricultural sector is needed to discuss. The most important characteristics of the SD model in this study are the dynamic change of the socio-economic variables during the time. The static models can also be used in studying the role of labour in the production process, but they have no adequate efficiency where different assumptions are considered. Therefore, the dynamic models are more suitable to define the realities of the world.

Thus, the general objective of this study is to determine the optimal employment and production policies in the agricultural sector of Iran. Whereas, the specific objectives are to estimate the econometric models of the Iranian agricultural sector to determine the production and other relationship in the SD model; to develop a SD model and identify the relationship among the socio-economic variables in the agricultural sector of Iran for simulating the future trend of employment and production; and to simulate the SD model pertaining to different scenarios.

## Methodology

The framework developed in this study was drawn from the SD model, which was strictly combined with the econometric methods based on the economics theory. Thus, this section discuses the theoretical framework, and the different mathematical formulations such as the production function, export and import functions, demand for labour, and social model, which were used in the SD model. Hence, the used methodologies were separated into various sections.

[2] The annual average growth rate of the total population increased at 2.71% in the past 44 years (from 1959/60 to 2002/3); while the urban population increased at 4.33%, the rural population increased at 1.17% (SCI various Issues).

## Translog with Technological Change (TWTC)

To avoid strong prior restrictions on technology, a flexible functional form (Caves and Christensen, 1980), Translog production function was chosen (Moosavi and Mad Nasir, 2007 and Moosavi et al., 2008). Since the Cobb-Douglas (CD) function (Cobb, and Douglas, 1928) is nested within the Translog, the Translog specifications were tested (Christensen et al., 1973) to consider an extension of the CD production function to be more general and flexible form for describing the relationships between the output and input levels. Christensen and Greene (1976) and others like Heshmati (1994), Moosavi et al., (2008), have applied technological terms into the Translog form. Thus, the production function for the Iranian agricultural sector is represented by:

$$Ln(Y) = \alpha + \sum_{i=1}^{n} \beta_i LnX_i + \beta_t T + (1/2)[\sum_{i=1}^{n} \delta_{ii}(LnX_i)^2 + \beta_{tt}(T)^2]$$

$$+ \sum_{\substack{i=1 \\ (i \neq j)}}^{n} \sum_{j=2}^{n} \delta_{ij}((LnX_i)*(LnX_j)) + \sum_{i=1}^{n} \delta_{it}(LnX_i) * T \qquad (1)$$

where Y is the output and $X_i$'s are the inputs (capital, labour and land), the T is included as one of the explanatory variables representing the rate of the exogenous technical changes. The three share equations (for capital, labour and land) are obtained based on the mathematical derivatives of the Translog form as follows:

$$E_i = \frac{\partial Ln(Y)}{\partial Ln(X_i)} = \beta_i + \delta_{ii}(LnX_i) + \sum_{\substack{j=1 \\ (i \neq j)}}^{n} \delta_{ij}(LnX_j) + \delta_{it}\,\mathrm{T} \qquad (2)$$

The equation for technology is also expressed as follows:

$$E_t = \frac{\partial Ln(Y)}{\partial (T)} = \beta_t + \beta_{tt} T + \sum_{i=1}^{n} \delta_{it}(LnX_i) \qquad (3)$$

To avoid near singular matrix, one of the share equations was deleted and the system was estimated according to the ISUR[3] method. Hence, the Translog had been estimated with three share equations to increase the efficiency of estimation (Berndt and Christensen, 1973 & 1974). The Seemingly Unrelated Regression (SUR) method, also known as the multivariate regression or Zellner's method, estimates the parameters of the system, accounting for the heteroskedasticity and contemporaneous correlation in the errors across the equations. Figure (1) shows the substituted production function into SD model according to Stock and Flow Diagram (S&FD) for the agricultural production model.

[3] Iterative Seemingly Unrelated Regression (ISUR)

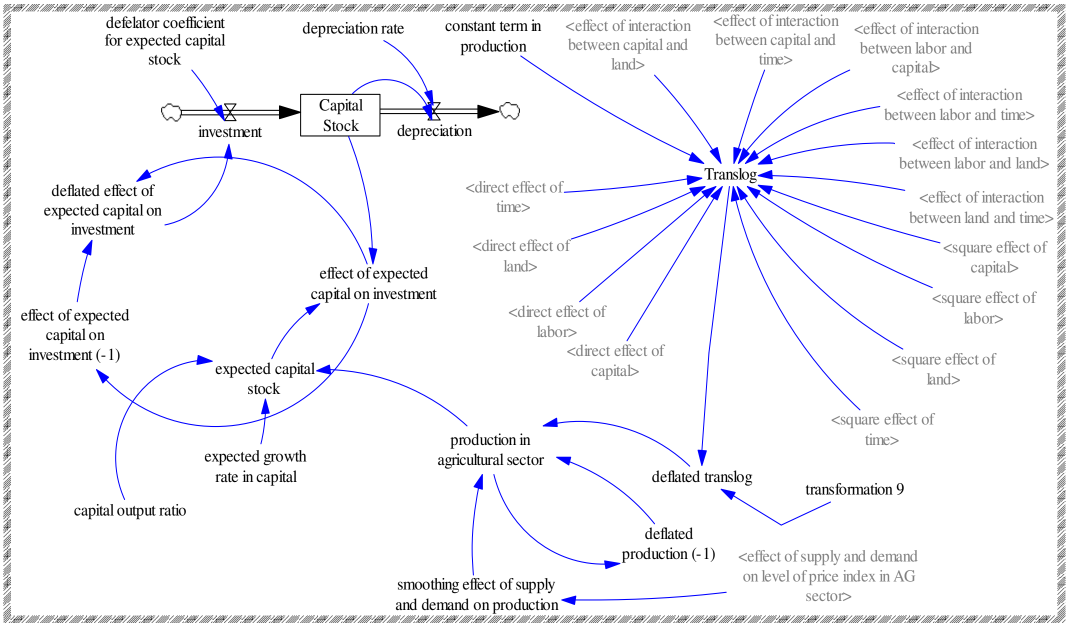


**Figure 1: S&FD for the Agricultural Production**

## Dynamic Demand for Labour

The objective of this section is to examine a dynamic model of labour demand with consideration of DC and AC based on partial adjustment method (Nerlove's 1958). Therefore, Equation (4) is a dynamic labour demand based on partial adjustment process and it can be estimated by the econometric methods (Amini, 2002; Moosavi and Mad Nasir, 2008).

$$LnN_t = \alpha_0 + \alpha_1 \ln(N_{t-1}) + \alpha_2 Ln(y_t)$$
$$+ \alpha_3 Ln(w_t) + \alpha_4 Ln(r_t) \qquad (4)$$

Where $N_t$ is the agricultural employment, 1-$\alpha_1$ is the adjustment coefficient for lagged agricultural employment, $\alpha_2$ is the employment production elasticity ($y_t$ is agricultural production), $\alpha_3$ is the wage elasticity ($w_t$ is wage price) and $\alpha_4$ is the cross-price elasticity ($r_t$ is capital price). It is expected that the estimated parameter would place in these ranges $0<\alpha_1<1$, $\alpha_2>0$ and $\alpha_3<0$.

When the relationship between the capital and labour in the production process is substitution or complement, the relevant estimated parameter will therefore be negative or positive ($\alpha_4<0$ and $\alpha_4>0$). When the price of capital is increased, two effects will occur, the substitution and output effects. With the increase in the capital price, a relative price of labour decrease after that demand for labour is increased. In this case, labour substitute for capital in the process of production. This is called the substitution effect. Whereas, when the price of capital increases, the total cost of production increases. Then, the results decline in demand for all the inputs. This is called output effect (Borjas, 1996). If the output effect is greater than the substitution effect, the relationships between the labour and capital are complement and vice versa. Figure (2) shows the S&FD for the agricultural dynamic demand for labour.

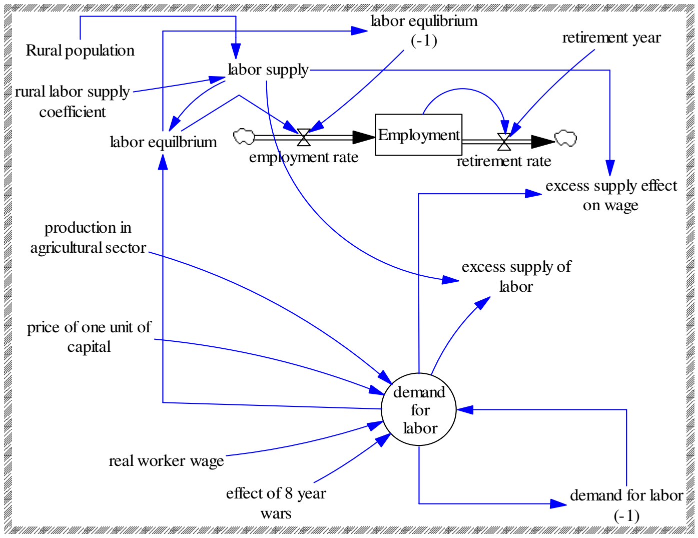


**Figure 2: S&FD for the Agricultural Dynamic Demand for Labour**

## Export and Import Functions

In Iran, exports can be divided into two main categories; the oil export and non-oil export. The main portion of the non-oil export is agricultural export. Based on the theoretical concept (Arize and Afifi, 1987; Kohli, 1991; Wilkinson, 1992; Marquez, 1994; and Clarida, 1994), the agricultural export function (X) is the function of the real exchange rate (er), and the GDP per capita in the OECD countries (Io), the price index for the agricultural products (Pag), the total production (TP), the dummy variable for the 8 years' war (DWAR), the dummy variable for the Islamic Revolution (DR), and the export in the last period ($X_{t-1}$).

$$X_t = f(er_t, Io_t, Pag_t, TP_t, DWAR_t, DR_t, X_{t-1}) \qquad (5)$$

It is expected that the first derivatives from (5) indicate these signs:

$$\frac{\partial X}{\partial e} = \overset{\circ}{X}_{er} > 0, \qquad \overset{\circ}{X}_{Io} > 0, \qquad \overset{\circ}{X}_{t-1} > 0 \qquad (6)$$
$$\overset{\circ}{X}_{Pag} < 0, \qquad \overset{\circ}{X}_{TP} > 0$$
$$\overset{\circ}{X}_{DWAR} < 0, \qquad \overset{\circ}{X}_{DR} < 0$$

The demand for agricultural export can be expressed based on (Arize and Afifi, 1987; and Khan and Knight, 1988) as follows:

$$\begin{aligned} Ln(X_t / OECDind_t) &= \alpha_0 + \alpha_1 Ln(Io_t / OECDind_t) \qquad (7) \\ &+ \alpha_2 Ln(er_t) + \alpha_3 Ln(X_{t-1} / OECDind_{t-1}) \\ &+ \alpha_4 Ln(TP_t / er_t) + \alpha_5 Ln(Pag_{t-1}) + \alpha_6 DWAR_t + \alpha_7 DR_t \end{aligned}$$

where $OECDind_t$ is the price index in the OECD countries, the real exchange rate is used instead of the official exchange rate as it is expected that when the real exchange rate increases, the export also increases and vice versa. Therefore, the export should have positive response to the real exchange rate. The $X_{t-1}$ can be declared as the adjustment co-efficient factor between the optimal and actual export. In other words, $X_{t-1}$ states the restriction on the non-oil export, market share, and export capacity.

In the economic literature , import (M) can be stated as a function of the real exchange rate (er), real national income per capita (I), price index for imported goods (Pi), price index for the agricultural products (Pag), and import in last period ($M_{t-1}$).

$$M_t = f(er_t, I_t, Pi_t, Pag_t, M_{t-1}) \qquad (8)$$

It is expected that the first derivatives from the demand for the agricultural import indicate these signs:

$$\frac{\partial M}{\partial e} = M^{\circ}_{er} < 0, \qquad M^{\circ}_{I} > 0 \qquad (9)$$

$$M^{\circ}_{P_I} < 0, \qquad M^{\circ}_{M_{t-1}} > 0$$

$$M^{\circ}_{P_{AG}} > 0,$$

Equation **(**9) elaborates that when the real national income, import in the last period and the agricultural price increase, the agricultural import also increases; while the real exchange rate and imported price index have negative relation with the agricultural import. In fact, in the economic literature, the real exchange rate has a key factor in the demands for both the export and import functions. The demand for the agricultural import can be expressed as follows (Arize and Afifi, 1987; and Khan and Knight, 1988):

$$Ln(M_t / OECDind_t) = \beta_0 + \beta_1 Ln(I_t) + \beta_2 Ln(er_t) \qquad (10)$$
$$+ \beta_3 Ln(M_{t-1} / OECDind_t) + \beta_4 Ln(Pi_t) + \beta_5 Ln(Pag_t)$$

Figure (3) presents the SD diagram for the international trade (export-import) for the agricultural sector of Iran. When both the export and import are estimated, these functions will substitute the export-import segment in the S&FD.

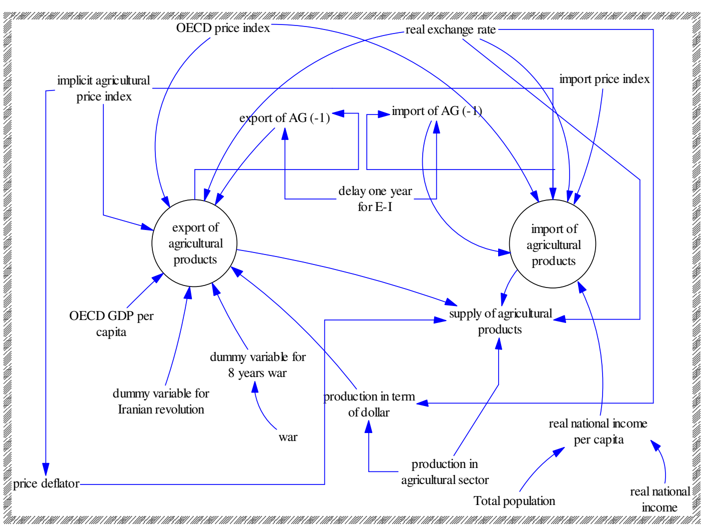


**Figure 3: S&FD for the Agricultural Export-Import**

**Demand for Agricultural Products**

The consumption of agricultural products is a good representative of the demand for its products, indicating a function of the consumption per capita and its total population. The consumption per capita is a function of the real income, own prices, prices of other goods, taste, and climate. For simplicity, taste, prices of other goods and climate can be assumed as constant. Therefore, the demand per capita for the agricultural products ($Xd_t$) is defined as the function of the real national income per capita ($I_t$), agricultural price index ($Pag_t$) and demand, in last period ($Xd_{t-1}$).

$$Xd_t = \alpha (I_t)^{\beta} * (Pag_t)^{\delta} * (Xd_{t-1})^{\lambda} \tag{11}$$

In economic literature, different functional forms (such as linear, logarithmic and parabolic) for estimation were modified. A number of the non-linear forms can be transformed into linear models. In statistical studies, considering all prices in the demand function is impossible. On the other hand, there are no good substitution and complement products for all agricultural products. Therefore, all excluded variables such as taste, substitution price, climate etc., which can be accumulated in the residual term. Equation (11) with simple logarithm from both sides can be transformed to a linear form, and Equation (12) is therefore obtained.

$$Ln(Xd_t) = \alpha + \beta Ln(I_t) + \delta Ln(Pag_t) + \lambda Ln(Xd_{t-1}) \tag{12}$$

The parameters estimated from Equation (12) can be substituted into a S&FD as in Figure (4). It is noted that the "real national income per capita" is calculated by the real national income divided by the total population, and these have effects on the demand for agricultural products. The price elasticity and income elasticity show that the price and income have effects on the agricultural demand products.

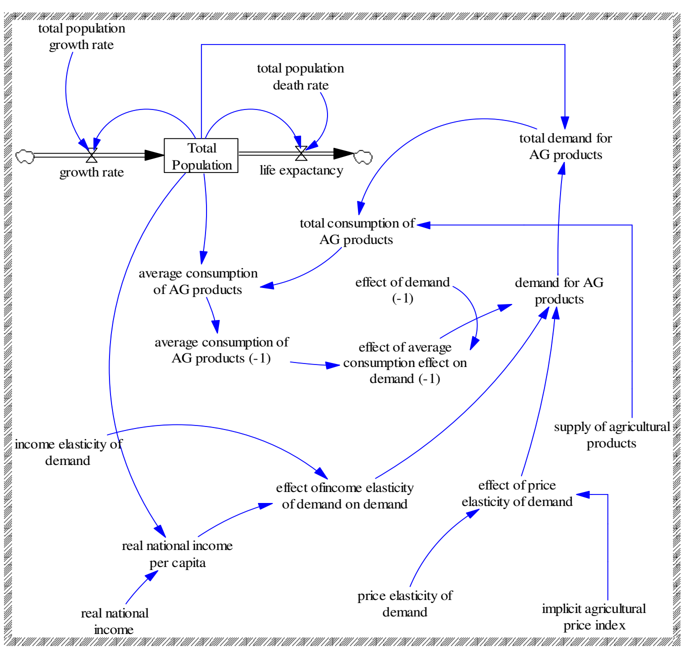


**Figure 4: S&FD for the Agricultural Products Demand**

## Wage Function

The other estimation assisting to build some parts of ths SD model is the agricultural wage function. It is supposed that the agricultural wage level is a function of the inflation rate, wage level in the last period, and excess supply of labour in the agricultural sector.

$$WL_t = \alpha_0 + \alpha_1 INF_t + \alpha_2 WL_{t-1} + \alpha_3 ESI_t \qquad (13)$$

$$Where \quad \mathrm{ESI}_t = \frac{\mathrm{LS}_t}{\min(\mathrm{LS}_t, \mathrm{EM}_t)}$$

where WL is the nominal agricultural wage (dependent variable), INF is the inflation rate, LS is equal to agricultural labour supply, EM is the total agricultural employment, $WL_{t-1}$ is lagged variable of $WL_t$, and ESI is an indicator that shows the excess supply in the agricultural sector. Employment is obtained in two forms: firstly, from the equivalent of supply and demand ($S_L$=$D_L$); secondly, the minimum of supply or demand (Min $S_L$ or $D_L$) when we have excess supply or excess demand in the labour market.

$$\text{If } \mathrm{LS} > EM \longrightarrow ESI \text{ (Excess Supply Indicator)} \uparrow \longrightarrow WL \downarrow$$

$$\text{If } \mathrm{LS} < EM \longrightarrow ESI \text{ (Excess Supply Indicator)} \downarrow \longrightarrow WL \uparrow$$

Figure (5) presents a segment of the SD model that uses this estimation.

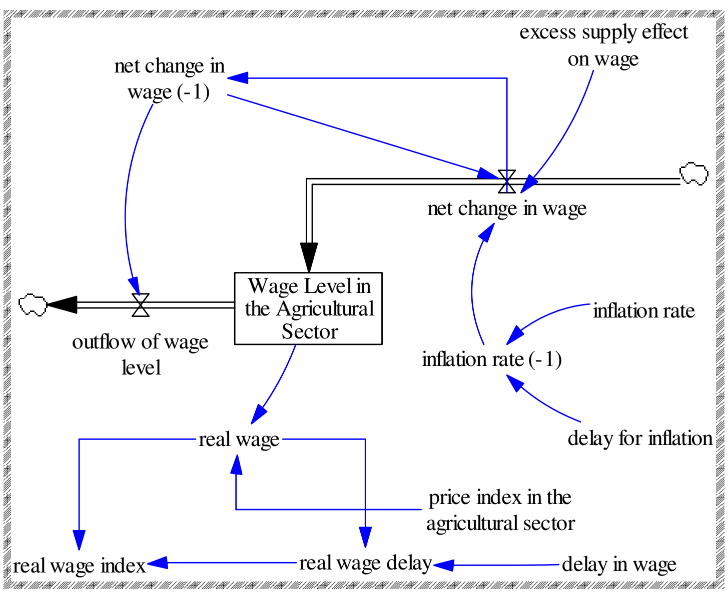


**Figure 5: S&FD for the Agricultural Wage**

## Social Model

In the social model, social variables related to the boundaries of the model are considered. Social researchers, in their research pertaining to emigration, would consider a lot of social variables and interrelationships in the rural area. However, the segment of social variables in the present study related to the supply of labour in the agricultural sector is emphasized. When the boundaries of the SD model are expanded, the accuracy

of the model will decrease extremely, and the researcher will get astray from the objectives.
The population in the rural areas is a level variable; and it is calculated based on the increase in the birth rate and the decrease in the death rate plus the net flow of emigration from the rural to the urban areas. The increase in the rural income per capita with delay has a positive effect on the rural population. The net flow of the emigration is affected by three factors; namely unemployment, real wage index, and the rate of emigration with a delay. In turn, the rate of emigration based on the Todaro model (Todaro and Smith, 2003) is affected by the differences in the income between the rural and urban areas by subtracting the cost of emigration from the rural to urban areas. The probability of finding jobs in the urban areas is also included to the model. All the mentioned variables affect the emigration with a delay.
Emigration is also affected by the increase in job opportunities in the urban areas. The job opportunities in urban area have been affected by the sectors such as industrial, construction and service. Figure (7) shows the social model used in this study.

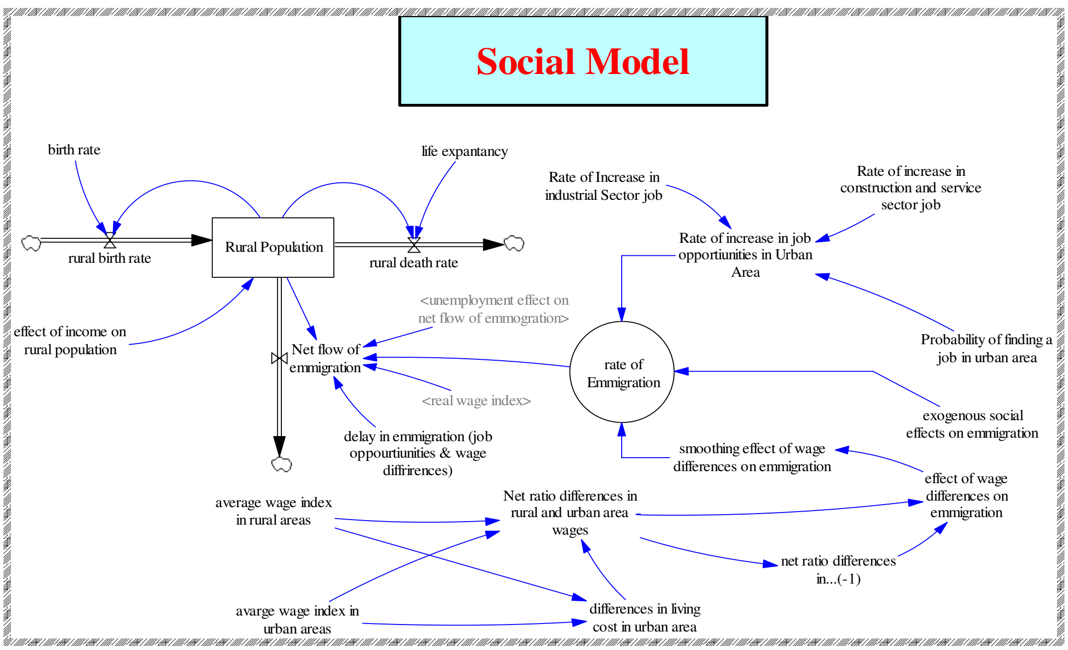

**Figure 7: S&FD for the Social Model in the Iranian Rural Areas**

Both the social and economic models have many interlinks (*See* complete model in the Appendix E, Figures E-1 to E-10). This interlink includes the effect of the social model on the economic model and vice versa. For example, the population in rural areas has effect on the supply of labour in the economic model. The income per capita in the rural area has an effect on the emigration, leading to the effect on the rural population, unemployment rate, etc.

Finally, the SD simulation uses the econometrics results from the preceding sections to drive key variables such as production, demand for labour, demand for agricultural products, agricultural export, agricultural import, and worker wage in the socio-economic model relationships. Kummerow (1997: 7-1) emphasized that "Econometric

modelling is positivist empiricist science - the researcher takes the role of objective-observe seeking to understand and predict the system behaviour"[4].
System Dynamics means the "application of the attitude of mind of a control engineer to the improvement of dynamic behaviour in a managed system" (Coyle, 1996: 5). However, the agricultural sector of Iran is designed and managed collectively as a system; by multiple individuals, institutions and organizations such as farmers, cooperative companies and governmental organizations, respectively.
In spite of the wide range of applications using the SD, most SD models are created in four stages based on Forrester's approach (Randers, 1980). The four stages of model building[5] are outlined below (Figure 6) based on Forrester's approach (Forrester, 1997), showing the essential step of each stage or phase. Each sub-stage is shown in Figure (6) and each phase is explained in related boxes.

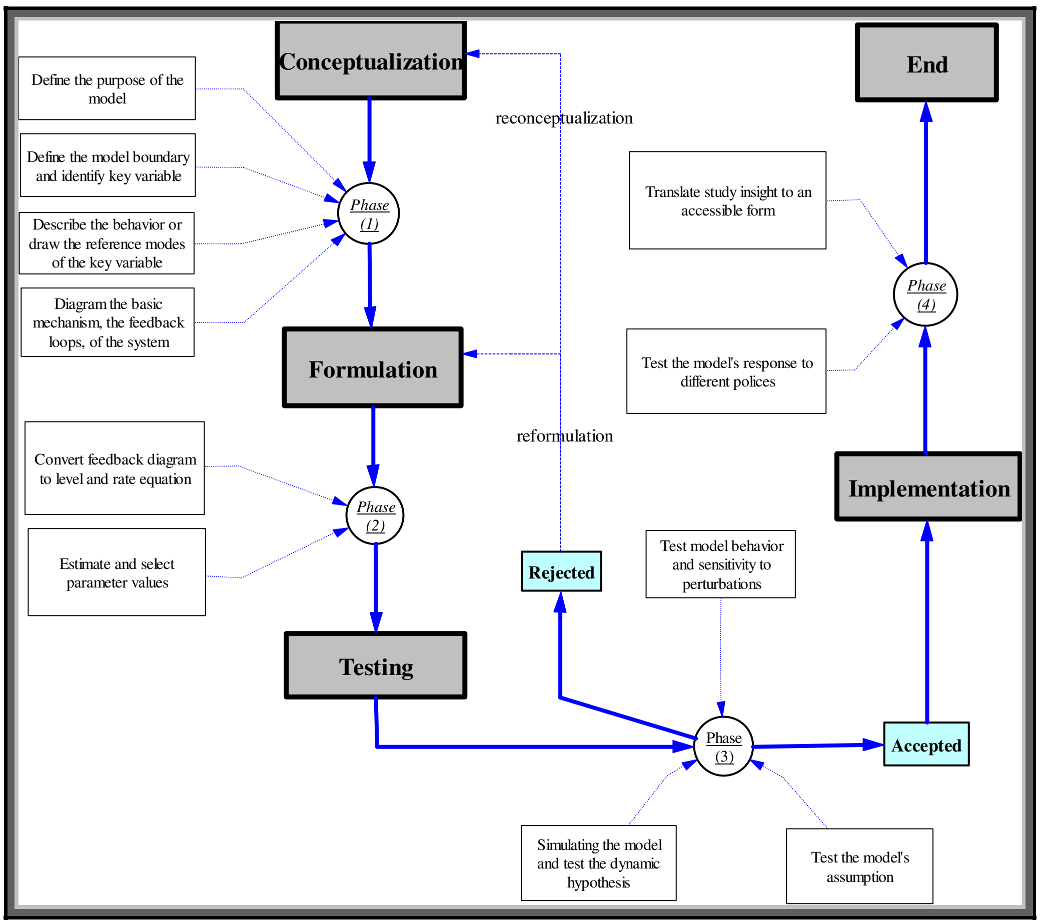


**Figure 6: Forrester's Phase Approach for Building a System Dynamics Model**
**Source: Forrester, (1997)**

---

[4] Kummerow also says "Having a possibly biased parameter estimate, estimated by an unambiguous and replicable statistical procedure is probably better than having no parameter estimate at all, or making one up out of whole cloth" (Kummerow, 1997: 7-60).
[5] Conceptualization, Formulation, Testing and Implementation

## Analysis of Results

This section presents the empirical results obtained from the econometric estimations and socio-economic model. Therefore, it is divided into two sub-sections; the first presents the results of the econometric estimations and in the second, the SD simulation results are discussed. The SD simulation sub-section, also is separated into two parts; the Policy-Makers Optimization, and the Payoff Optimization.

### Econometric Estimations

A production function is well behaved if it has positive marginal products for all inputs, and is quasi-concave. Obviously, the results of Figure (8) illustrated that the production technology of the Iranian agriculture did not have a well-behaved quality. This confirms the hypothesis that the marginal productivity of labour falls below zero for Iran, as indicated in Figure (8). On the other hand, the production surface of labour is in phase three, where the Marginal product of labour ($MP_L$) has a negative value. Marginal Product of Land ($MP_Z$) and Marginal Product of Capital ($MP_K$), according to the different functional form for the all years, are positive. It can be concluded that on the production surface of land and capital, we are on phases one or two, where the slopes of the $MP_Z$ and $MP_K$ are both positive.

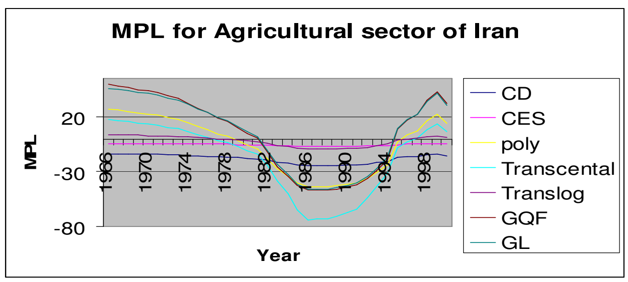


**Figure 8: Marginal Products of the Labour ($MP_L$) in the Agricultural Sector of Iran Based on the Different Functional Forms (1966/67 to 2000/01); Cobb-Douglus (CD), Constant Elasticity of Substitution (CES), Generalized Quadratic Form (GQF), Generalized Leontief (GL) Source Moosavi and Mad Nasir, (2007)**

The best of seven estimated production functions was selected based on different statistical tests. All of the estimated production functions checked with relevant statistical tests[6] were found acceptable. Model specification tests such as *Jarque-Bera* normality test on the residual of the model, and *Ramsey's RESET* test (Ramsey, 1969), for selecting the best shape of the functional forms, were also conducted. The translog had the best functional shape and showed better production relationships in the agricultural sector of Iran. The translog form is flexible (VRTS)[7] and consistent with the agricultural production of Iran (Moosavi and Mad Nasir, 2007 & Moosavi et al., 2008).Therefore the estimated result for the TWTC function is as follows:

[6] Include stationary test for all variables in the econometrics function for avoiding spurious regression (Intriligator, et al., 1996)
[7] Variable Return to Scale (VRTS)

$$
\begin{aligned}
Ln(Y) = {} & \underset{(2.4^*)}{1616.052} + \underset{(3.12^*)}{35.45082}{*}Ln(K) - \underset{(-2.6^*)}{386.7835}{*}Ln(L) - \underset{(-2.05^*)}{47.11784}{*}Ln(Z) + \underset{(0.35)}{0.268648}{*}(T) \\
& + \underset{(0.65)}{0.113635}{*}(LnK)^2 + \underset{(2.7^*)}{46.6178}{*}(LnL)^2 + \underset{(0.42)}{0.49996}{*}(LnZ)^2 + \underset{(2.77^*)}{0.005313}{*}(T)^2 - \underset{(-3.15^*)}{4.2224}{*}(LnK){*}(lnL) \\
& - \underset{(-0.18)}{0.060297}{*}(LnK){*}(LnZ) - \underset{(-3.7^*)}{0.055241}{*}(LnK){*}(T) + \underset{(2.19^*)}{5.3495}{*}(LnL){*}(LnZ) + \underset{(0.28)}{0.02664}{*}(LnL){*}(T) \\
& - \underset{(-0.2)}{0.005644}{*}(LnZ){*}(T) \qquad (R^2=0.98)
\end{aligned}
$$

where Y, K, L, Z and T represent the agricultural production, capital, labour, land and technological change, the numbers in parentheses are t-statistics. The results of autocorrelation tests on the residuals of TWTC do not indicate any autocorrelation problem.

Table (1) shows the results of the nested test for the three functional forms between 'CD' with 'Normal Translog[8]', 'CD' with 'TWTC' and 'Normal Translog' with 'TWTC'. The results suggested that the best form was the 'TWTC'.

**Table 1: Likelihood Ratio Test**

| Functional Form | No. of coefficients | F-Statistics | Probability | Likelihood Ratio | Probability |
|---|---|---|---|---|---|
| CD | 4 | -- | -- | -- | -- |
| TWTC | 15 | 34.03 | 0.0000 | 104.35 | 0.0000 |
| Normal Translog | 10 | -- | -- | -- | -- |
| TWTC | 15 | 14.10 | 0.0000 | 52.85 | 0.0000 |

The sign of elasticity for technology ($E_T$) is negative during the Before Revolution (BR) and War Period (WP) periods. The $E_K$ (K for capital), $E_Z$ (Z for land) and $E_T$ increase over the time in comparison to the $E_L$ (L for Labour). In the study period, $E_K$=0.63, $E_Z$=0.25, and $E_T$=0.06 are relatively large in magnitude.

The $E_T$ can be further decomposed additively into the PTC ($B_t + B_{tt}T$) and the NNTC ($\Sigma_i \delta_{it} X_i$) components (Forsund and Hjalmarsson, 1987). The technical change is defined as non-neutral if the passage of time affects the marginal rate of the technical substitution between the inputs. The use of the flexible functional form and interaction of time with the inputs allows for the non-neutral technical change whereas, the PTC is presented by a simple time trend in the production function. The calculation of the rate of the technical change based on estimation results, are presented in Table (2).

The overall results showed that the PTC had progressed during the period of study, as well as during the war and the Islamic Revolution periods. The NNTC had a slight decrease, i.e., from 0.01 to 0.02 in each period. However, the overall technical change had increased over the different periods because of the greater magnitude of the PTC.

[8] Translog without technological change

**Table 2: Decomposition Rate of Technical Change into the PTC and NNTC in the Agricultural Sector of Iran**

| Time | PTC | NNTC | Overall Technical Change |
|---|---|---|---|
| B R | 0.30 | -0.35 | -0.046 |
| A R | 0.40 | -0.38 | 0.021 |
| W P | 0.37 | -0.37 | -0.004 |
| A W P | 0.42 | -0.38 | 0.042 |
| O T | 0.36 | -0.37 | -0.004 |

BR =Before the Islamic Revolution (1966/67 to 1977/78), AR = After the Islamic Revolution (1978/79 to 2000/01), WP = War Period (1980/81 to 1987/88), AWP = After War Period (1988/89 to 2000/01), OT = Overall Time (1966/67 to 2000/01)

The results of the estimated regression cooperate for the dynamic demand model for the agricultural labour is reported in Table (3), as follows:

**Table 3: Results of the Estimation Dynamic Demand Function for the Agricultural Labour**

| Variable | Coefficients | Estimated Parameters | T-test Statistics | Accepted at Level |
|---|---|---|---|---|
| Constant | $\alpha_0$ | 0.225 | 0.45 | -- |
| Ln(L(-1)) | $\alpha_1$ | 0.956 | 14.27 | 1% |
| Ln(TP) | $\alpha_2$ | 0.0565 | 2.44 | 5% |
| Ln(w) | $\alpha_3$ | -0.0323 | -1.23 | -- |
| Ln(r) | $\alpha_4$ | 0.002 | 3.68 | 1% |
| DWAR | $\alpha_5$ | -0.0116 | -2.55 | 5% |
| $R^2$ | 0.98 | | | |
| Adj-$R^2$ | 0.98 | | | |
| DW | 1.76 | | | |
| F-Statistics | 247.7 | | | |

where; $\alpha_1$=0.956 is the employment lag coefficient, 1-$\alpha_1$=0.0.044 is the deflator coefficient, $\alpha_2$=0.056 the employment production elasticity, $\alpha_3$=-0.032 wage elasticity, $\alpha_4$=0.002 the cross price elasticity and $\alpha_5$=-0.011 is the dummy variable for 8 years war (between Iran and Iraq). The labour demand was estimated using the Least Square method. The results show that only the wage elasticity is not significant. All coefficients have the right sign, and no auto-correlation problem was detected.

The adjustment coefficient is equal to 0.044 (1- $\alpha_1$=$\lambda$), suggesting that the speed of adjustment is too slow. It would take 22.7 (1/$\lambda$=22.7) years of the actual employment to adjust to the optimal level of employment (Moosavi and Mad Nasir, 2008). The cross price elasticity indicates that the relation between the capital and labour in the agricultural sector is substituted.

Tables (4) and (5) report the results of the agricultural export and import functions. The exchange rate has positive sign in the export function, while the sign changes to negative in the import function. The income per capita in the OECD countries deflated by the OECD price index demonstrates a positive effect on the export due to time. For example, an increase of 1 dollar in the income per capita in the OECD country causes the agricultural export to increase to 0.413 dollar in average. The agricultural price index and total production had respectively negative and positive effects on the agricultural export. The outcomes of the war and Islamic Revolution on the agricultural export were negative.

The national income per capita, agricultural price index and import in last period had positive effects on the agricultural import, while the real exchange rate and price index for the agricultural import had negative effect on the agricultural import.

**Table 4: Results of the Estimation Agricultural Export Function**

| Variable | Coefficients | Estimated Parameters | T-test Statistics | Accepted at Level |
|---|---|---|---|---|
| Constant | $\alpha_0$ | -5.507 | -0.72 | -- |
| Ln(er) | $\alpha_1$ | 1.805 | 2.45 | 5% |
| Ln($I_o$/OECD) | $\alpha_2$ | 0.413 | 0.93 | -- |
| Ln(X(-1)/OECD(-1)) | $\alpha_3$ | 0.383 | 2.68 | 5% |
| Ln($P_{ag}$(-1)) | $\alpha_4$ | -0.257 | -1.32 | -- |
| Ln(TP/er) | $\alpha_5$ | 0.924 | 2.46 | 5% |
| DWAR | $\alpha_6$ | - 0.304 | -2.41 | 5% |
| DR | $\alpha_7$ | - 0.361 | -1.97 | 10% |
| $R^2$ | 0.81 | | | |
| Adj-$R^2$ | 0.77 | | | |
| DW | 1.89 | | | |
| F-Statistics | 20.84 | | | |

**Table 5: Results of the Estimation Agricultural Import Function**

| Variable | Coefficients | Estimated Parameters | T-test Statistics | Accepted at Level |
|---|---|---|---|---|
| Ln(IN) | $\beta_1$ | 0.595 | 5.02 | 1% |
| Ln($P_i$) | $\beta_2$ | -0.448 | -2.63 | 5% |
| Ln(M(-1)/OECD(-1)) | $\beta_3$ | 0.405 | 3.38 | 1% |
| Ln(er) | $\beta_4$ | -0.321 | -2.25 | 5% |
| Ln($P_{ag}$) | $\beta_5$ | 0.925 | 3.18 | 1% |
| $R^2$ | 0.85 | | | |
| Adj-$R^2$ | 0.83 | | | |
| DW | 1.69 | | | |
| F-Statistics | 38.08 | | | |

Table (6) shows the results of demand for agricultural products, all variables are significant at level 1%. Based on the expectation, both the income and consumption in the last period had positive effect on the demand for the agricultural products, and the price of the agricultural products has negative effect on the demand for these agricultural products.

**Table 6: Results of the Estimation Demand for Agricultural Products**

| Variable | Coefficients | Estimated Parameter | T-test Statistics | Accepted at Level |
|---|---|---|---|---|
| Constant | $\alpha_0$ | -1.214 | -3.16 | 1% |
| Ln(IN) | $\alpha_1$ | 0.123 | 3.42 | 1% |
| Ln($P_{ag}$) | $\alpha_2$ | -0.0154 | -2.42 | 1% |
| Ln(XD(-1)) | $\alpha_3$ | 0.723 | 10.38 | 1% |
| $R^2$ | 0.91 | | | |
| Adj-$R^2$ | 0.90 | | | |
| DW | 1.98 | | | |
| F-Statistics | 104.55 | | | |

Referring to Table (7), all coefficients for agricultural wage function are significant at 1% level, and all statistics show a good fitness of workers' wage in the agricultural sector. The worker wage lag and inflation rate had positive effect on the workers' wage, while the excess supply indicator (ESI) had negative effect. When the labour supply is bigger than its employment in the same period, it causes the workers' wage (WL) to decline, and vice versa.

**Table 7: Results of the Estimation Agricultural Wage Function**

| Variable | Coefficients | Estimated Parameter | T-test Statistics | Accepted at Level |
|---|---|---|---|---|
| WL(-1) | $\alpha_0$ | 1.2583 | 112.94 | 1% |
| ESI | $\alpha_1$ | -0.3499 | -6.94 | 1% |
| INF(-1) | $\alpha_2$ | 0.0682 | 7.06 | 1% |
| $R^2$ | 0.99 | | | |
| Adj-$R^2$ | 0.98 | | | |
| DW | 1.51 | | | |

**System Dynamics Simulation Results**

Since the model has been formed, the validity of the model was done based on several tests such as error checking, dimensional consistency, behaviour reproduction, sensitivity analysis, extreme condition and parameter assessment tests. The results of different tests (Sterman, 2000: 859-891) indicated that the ability of the SD model to simulate agricultural sector was acceptable (*see* Appendix “C” for results of different tests). When the confidence in the structure and the behaviour of the model had been developed, it was ready to design and evaluate the policies for improvement.

The policy design is much more than changing the values of parameters, as it includes the creation of the entire new strategies, structures, and decision rules. Therefore, three fact are important to designing the optimal Policies include manageability, influential, and possibility. Manageability refers to the variables (parameters) which can be controlled by the policy makers, some variables such as income elasticity, price elasticity, the OECD income per capita, war, import price index, revolution, and international prices are not under control of policy makers. On the other hand, there are also parameters which are under policy maker’s control, or some of variables they have minimal control over them. The term ‘influential’ explains the effect of these variables (parameters) on the system to achieve the goals should be considerable. The results of the sensitivity analysis determine which parameter is influential; for instance, employment is insensitive to the increase in the use of land. Possibility means that changing these variables should be possible over the simulation period. For example, increasing the investment in the agricultural sector by 50% per year or decreasing the exchange rate by 20% per year, is not possible for policy makers because of the tremendous side effects that may be imposed onto other sectors or intervention of other policies (policy dilemma). Similarly, the life expectancy may have possible effects on the population in the rural area in the long-run, but this may not be the case in the short-run. Therefore, manageability (variables are under control), influential (variables are effective), and possibility (availability) are important factors that should be taken into consideration when designing a policy package.

Optimization means to achieve the best. Hence, we should return to our problem statement and objectives. The main purposes of this study are to build a socio-economic model structure for policy makers, to find the optimal policies concerning employment and production. The interaction of the different policies must also be considered because the real systems are non-linear, and the impact of combining these policies is usually not the sum of their impacts alone. Often, Policies interfere with one another; and sometimes they reinforce one another by generating substantial synergies.

In this section, two types of optimization processes were conducted: first, Policy-Maker (manual) and second, Payoff (automatic) optimization. The first process was done by entering the complementary function into the SD model such as ramp; step, etc. in order to improve the system behaviour; while in the second process, the optimization was done by defining a payoff function. There is an important difference between Policy-Maker and Payoff optimization methods. In the first method, the researchers ‘determine’ how much and when constants or parameters should change over the simulation time to reach the goals. Whereas, in the Payoff Method, the researchers need to only determine which constants or parameters in confident domain (based on the sensitivity analysis) should change to reach the goals, but the value of constants or parameters were automatically found by the package. In other word, in the Policy-Maker method, researchers select the changes in values of constants or parameters.

**A-Policy-Makers Optimization**

Based on the problem statements, in order to increase the production and employment, the effects of increase in the factors of production (land and capital) were first analyzed.
**Scenario (I) -** The AEIS[9] with the pressurized and surface (Gravity) irrigation system in Iran is 38%. The AEIS in the world is 55% and the maximum 70% is observed. Based on the estimations, 53 Billion cubic metres of water is waste (Mansoori, 2001). Hence, if the AEIS will be increased consequently, therefore the arable land will increase in its area. In this, the government has planned to increase this arable land (irrigated land) in about 5% for 15 years from 2007 to 2021, by developing water resources management (providing more water) and improving its irrigation systems.
Figures (9) and (10) indicate the effect of this policy on the agricultural production and employment, respectively. The production will increase, whereas there is no considerable change in employment. The agricultural employment could not increase because of the high labour/land ratio in the agricultural sector.

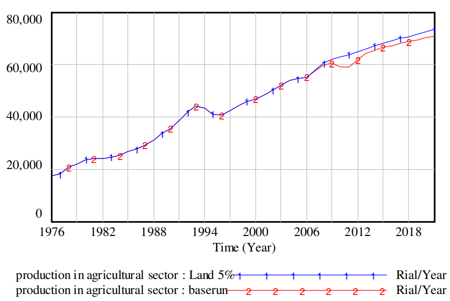


**Figure 9: Agricultural Production**

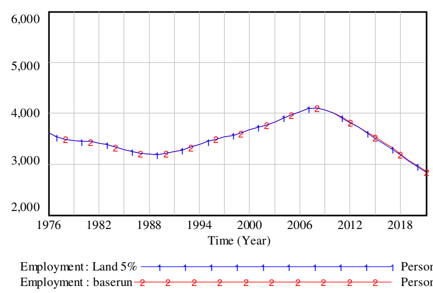


**Figure 10: Agricultural Employment**

**Scenario (II) -** The government will increase the agricultural capital by increasing the agricultural investment at about 5%, for 15 years from 2007 to 2021. Figures (11) and 12 illustrate the impacts of investment increases on the production and employment. When the investment increases, it causes the capital to increase in the process of production, and employment will consequently increase (complementary relation between capital and labour). Figure (11) shows a deviation from the theoretical expectation (from 2007 to 2016). When the investment increased, it was also expected that the production would subsequently increase. On the other hand, the agricultural production was expected to increase (based on the theory) during the specified periods, i.e., from 2017 to 2021. From the econometric paradigm, when the signs of coefficient did not agree with the theory, the model is therefore not good. In this situation, an appropriate response to these unexpected signs is to change the lag structure or re-specify the model. From the SD perspective, the wrong signs or unexpected behaviour could mean the system had been designed because the people were unable to make the right decisions. For instance, Forrester (1991) "overruled the econometrically estimated results, in favour of choosing a model structure that 'makes sense'". In the current SD model, the production therefore involves many feedback loop (FBL); and it cannot be interpreted using a simple econometric equation. In the same vein, the behaviour of the production simulations covers a wide range of complex feedbacks with hundreds of equations, as compared to the simple models with a single loop. Therefore, it can be

[9] Applied Efficiency of Irrigation System

predicted that the production would increase when all inputs have increased with the improvement in the overall technological change over the time.

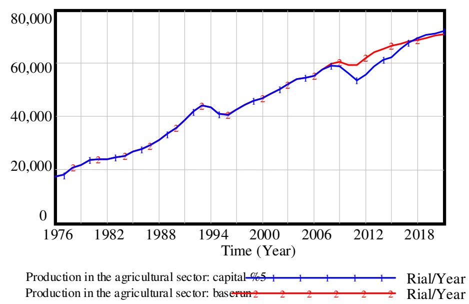


**Figure 11: Agricultural Production**

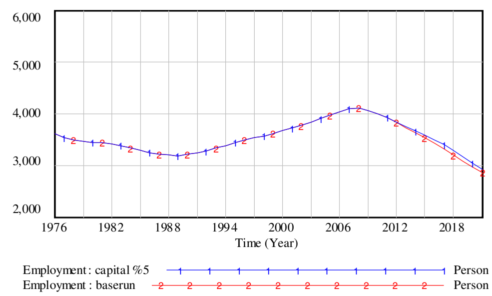


**Figure 12: Agricultural Employment**

**Scenario (III) -** In the agricultural sector, where there were more agricultural imports the domestic production was reduced. In fact, an inverse relationship was obtained between the domestic agricultural product and the agricultural import. The agricultural import was expected to decline in the current scenario by the government policy. Therefore, Scenario (III) can be implemented by imposing some restrictions on the amount, type, and tariff of the agricultural import. The outcome of current scenario would cause the agricultural import to reduce by 40% during the 2007-2021 period, based on the primary model (baserun) used.

Figures (13) and (14) indicate that the effect of this policy will cause the agricultural production to increase considerably. In other words, a production response to import is effective while the employment response is just a little.

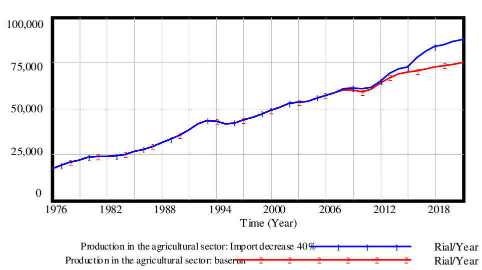


**Figure 13: Agricultural Production**

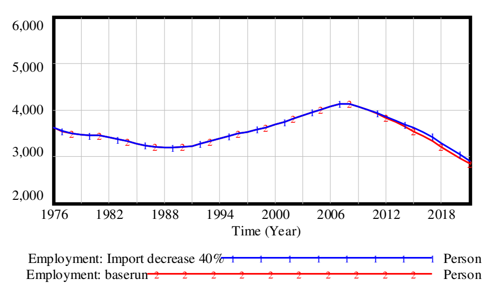


**Figure 14: Agricultural Employment**

**Scenario (IV) -** Some constants and inputs (control variable) will change in the social model. These constants and inputs are used in the social model, but they are not necessarily of the social variables type. The objective of this scenario is to observe the effect of the exogenous variables in the social model on the agricultural sector of Iran. These changes will occur during the 2007-2021 period in order to regulate the excess supply of workers in both the urban and rural areas by the government, as well as to improve the trend of agricultural rural income per capita. In fact, these changes have redistribution effects on the society and will decrease dualism between the rural and urban areas. These constants and inputs are as follows:

[1]- Job opportunities in the industrial, construction and service sectors will increase 5% per year.

[2]- The "wage differences" between the rural and urban areas will decrease 75% between the 2007 and 2021 periods.
[3]- Delay in decision-making taken by the rural people to immigrate to the urban areas decreases (the development in communication and facilities) from 1.5 year to 1 year during the 2007-2021 period.
[4]- The probability of finding job for the rural workers increases about 60% during the 2007-2021 period.

All the above constants and inputs are changed simultaneously in the form of a policy package. The important point in Figures (17) to (19) is that the two behaviours will be observed: firstly, in the short-term, and secondly, in the mid-term period. Both the agricultural employment and rural population, during the 2007-2014 periods, are more than the baserun line; whereas during the 2015-2021 period, they are lesser than the baserun line, and as for the rural income.

Figure (15) shows the “effect of wage differences on emigration”. It fluctuated and would then become stable during the 2006-2008 periods. The outcome of the current scenario (social scenario) on the production is small (Figure 16), while this outcome on the employment is considerable (Figure 18). It is remarkable to note that the consequence of the different forces in the SD model cause a complicated behaviour in trend of the variables.

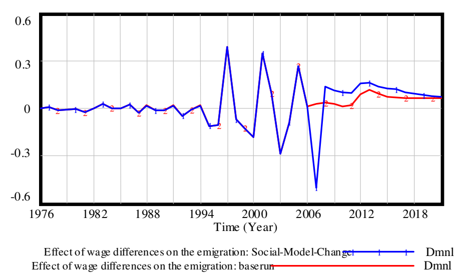


**Figure 15: Effect of Wage Differences on the Emigration**

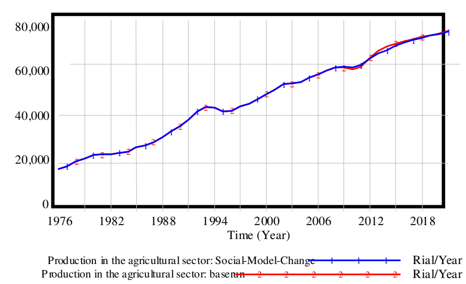


**Figure 16: Agricultural Production**

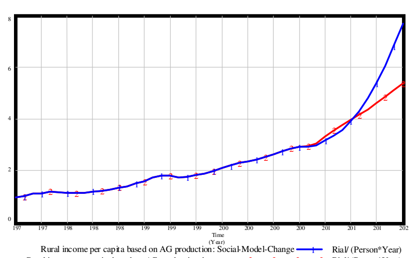


**Figure 17: Agricultural rural Income per capita**

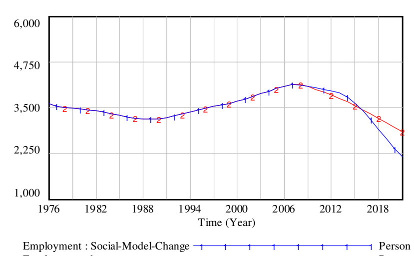


**Figure 18: Agricultural Employment**

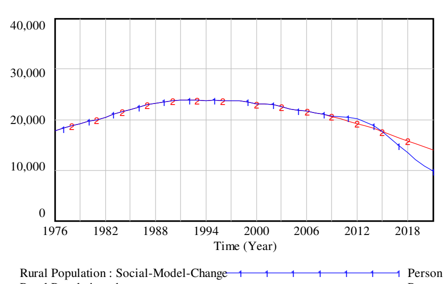


**Figure 19: Rural Population**

**B-Payoff Optimization**

In order to use the Payoff optimization method, it is necessary to define what is good and what is bad. To start a Payoff optimization, it is necessary to select the parameters (under control) to be changed in confident domain (by using the results from the sensitivity analysis) to achieve the goals. Hence, it is crucial to select the constants to vary in order to maximize or minimize the payoff function.

Based on the general objective, to increase the employment and production, four scenarios are selected. Each scenario is divided into two parts: first, when the market factors[10] are not included; and second, when they are included. These scenarios are considered as follows:

[1]- Policy makers plan to increase production, the employment is not considered to increase or decrease.

[2]- Policy makers plan to increase employment, the production is not considered to increase or decrease.

[3]- Policy makers plan to increase production and employment simultaneously as one set.

[4]- Policy makers plan to increase production, employment, export, income; and decrease emigration and unemployment simultaneously as one set. It is remarkable to mention that Scenario (4) is not related to the objective of this study, and is therefore selected as optional. It is selected to show how the model acts in different situations and circumstances.

**Scenario (1) -** The production is increased with the specific parameters change such as retirement year, job opportunities in other sectors, rural labour participation rate in the agricultural sector, investment rate, probability of finding job in the urban areas, delay in emigration, import tariff, PTC and NNTC technological change. In all scenarios, the Vensim Package reports for before and after policy the parameter changes.

As mentioned before, all scenarios were divided into two parts: when market factors are not involved, and when all market factors are involved in the SD model. In other words, the market factor is allowed to change by the government to achieve the optimal policy, which is defined by the policy makers[11]. For example, the exchange rate and real worker wage should be decreased and increased by 10% and 20%, respectively, when production would like to reach the maximum level in the SD model during the 2007-2021 period.

Based on the results of tables reported in Appendix D, the production and employment will change during 2007-2021, 15.22% and -4.18%. Nevertheless, when the market factors are included in the SD model, the production and employment will change 16.2% and -2.09%, respectively. Then, it could therefore be stated that these changes would happen in the SD model once the parameters were changed.

Figures (20) and (21) illustrate the agricultural production and employment in three different situations. First, it indicates (line marked with number 3, ‘baserun’) when SD model simulated the agricultural production and employment in the current situation without any policy. Second, it indicates (line marked with number 2, ‘scenario I’) the agricultural production and employment in the situation of Scenario (I) without involving any market factors. Third, it indicates (line marked with number 1, ‘scenario

[10] The market factors are; the agricultural price index, the decrease in the wage differences between the rural and urban areas, real exchange rate, and the real worker wage

[11] In this condition the government does interfere in the market by using of these variables.

I-Market') Scenario (I), but with the involvement of the market factors. Results shown in Figures (20) and (21) indicate that the market factor has minimal effect on the production; whereas, when the parameters are changed without any market factors, they have a considerable effect on the trend of production during the policy simulation (2007-2021).

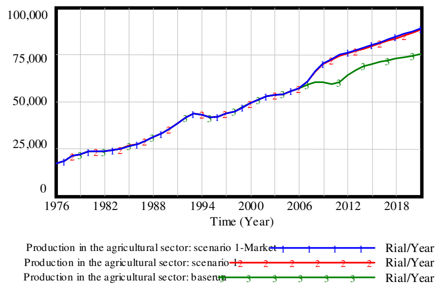


**Figure 20: Simulated Agricultural Production Based on Scenario (1) [Payoff Method]**

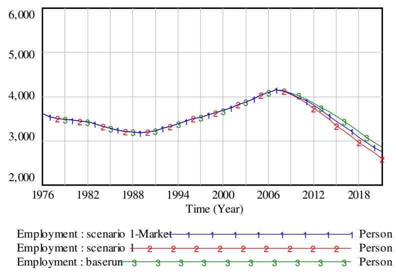


**Figure 21: Simulated Agricultural Employment Based on Scenario (1) [Payoff Method]**

**Scenario (2) -** It is crucial to note that Scenario (2) is the reverse of Scenario (1). That is, when the policy makers want to increase the employment alone, the production is therefore set free. The important point in the results is, when we want the agricultural employment to increase, it will lead to increment in land around 32.6% in the period of 2007-2021. Obviously, this shows that the combination of land and labour in the process of production is not appropriate, and that more land is needed to increase agricultural employment.

The other important point is that the PTC and NNTC should be changed in order to develop the labour using method (capital and land saving). The agricultural labour demand then increases, which consequently leads to an increase in the agricultural employment. Results in related Tables (*see* Tables in Appendix D) report the changes of the two states (percentage), when the agricultural employment increases. In the first state, when the market factors were not included, the employment and production were changed to 12.5% and -14.7%, respectively; whereas in the second state, when the government employed the market tools, the employment and production were changed to 23.5% and 4.5%, respectively in 2007-2021 period. These results from the previous and current scenarios indicate that the market factors have great effects on the agricultural employment and it shows the situation improves than earlier. Figures (22) and (23) show the agricultural production and employment in different situations.

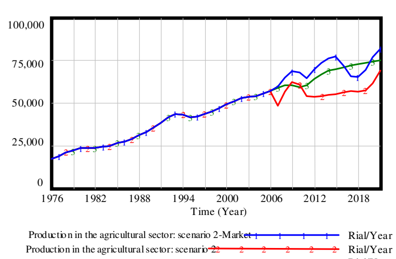


**Figure 22: Simulated Agricultural Production Based on Scenario (2) [Payoff Method]**

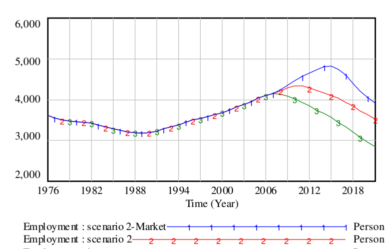


**Figure 23: Simulated Agricultural Employment Based on Scenario (2) [Payoff Method]**

**Scenario (3) -** Employment and production are two key variables in the SD model, as mentioned in the problem statement and the general objective of the study. Hence, the policy makers plan to increase agricultural employment and production simultaneously in the SD model as one set, in Scenario (3). The results indicate that the production increased by 15.2%; whereas, the employment was increased by 8.6%. However, the results confirms this fact, i.e., when the government involved the market factors to improve the policy variables (employment and production), the production increased from 15.2% to 16%; whereas, the employment increased from 8.6% to 21.1%.

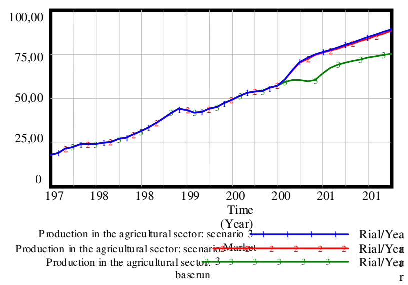


**Figure 24: Simulated Agricultural Production Based on Scenario (3) [Payoff Method]**

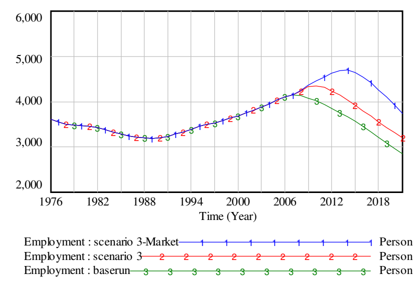


**Figure 25: Simulated Agricultural Employment Based on Scenario (3) [Payoff Method]**

**Scenario (4) -** In the final scenario, a number of important variables are considered to change over the simulation time (2007-2021), alongside the employment and production. The agricultural production, employment, export and income are considered to increase; whereas, the unemployment rate and emigration are expected to decrease. The results derived when the market factors were not taken into consideration are given in Appendix D (Tables D-7 to D-12). The increase in production, employment, export and income were found to vary from 15.2%, 3.5%, 22.2%, 14.5% to 14.5%, 16.3%, 24.1%, and -1%, respectively when the market factors were included. On the other hand, the unemployment rate and emigration rates decrease from -0.61%, -5.6% to -12.8%, and -39.3%, respectively. Obviously, these results have indicated some important point, as listed below:

[1]- When more variables were considered as the policy variables in the SD optimization method, the magnitude change of each variable was decreased (comparing the results of other scenarios with the current scenario).

[2]- Due to the SD feedback loops and interactions among the variables, some changes might be unwanted, including the reduction in the income per capita, i.e., from 14.5% to -1% (*see* Tables D-9 and D-10 in Appendix D).

[3]- The effect of the market factors on the rates of unemployment and emigration in the social model was seen as considerable.

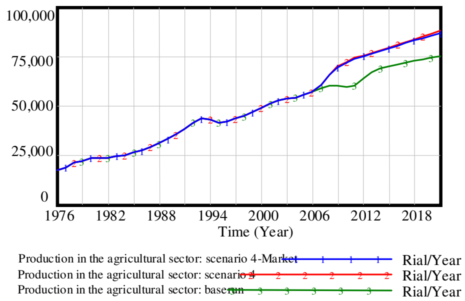


**Figure 26: Simulated Agricultural Production based on Scenario (4) [Payoff Method]**

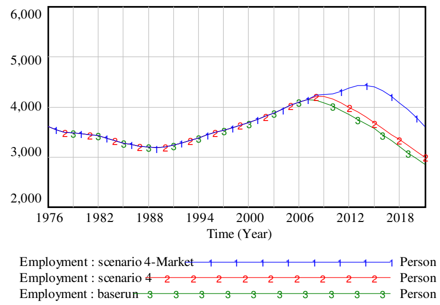


**Figure 27: Simulated Agricultural Employment based on Scenario (4) [Payoff Method]**

# Conclusions

## Summary of Finding

System Dynamics (SD) method is chosen to simulate the agricultural sector of Iran as an integrated system. In order to simulate system for better accuracy, some econometrics functions were estimated and substituted in the SD formulations.
The important results of the SD model simulation after carrying out the model validity are as follows:

- The rural population has shown a ‘overshoot and collapse’ behaviour type during the simulation period (1976-2021). The “rural population” will decline because the “cityward migration" plus the “death rate in the rural areas" are more than the “birth rate” in the rural areas.
- According to the development plan of the country, the real growth rate in the whole economy should increase about 8% annually, whereas the results of the SD simulation showed that the agricultural production would increase 1.8% per year in future year. Obviously, this finding shows that the agricultural production growth rate would not be match to the governmental development plan over the future time, and the production in the period (2007-2021) needs more considerations.
- The results of the SD model simulation indicate that a turn for the labour surplus problem will happen in 2008. After that period, the employment will gradually decline per year. The employment in the agricultural sector from 2007 to 2021 will also decrease from 4136 to 2839 thousand people (a total decrease of 30% for whole period and 2% annually).
- The results of the simulated data for export indicate that the trend is damped oscillatory with the decreasing rate. After large fluctuations from 1976 to 2000, the results show that the agricultural export will decrease from 2001 to 2021 (total of 31.3% and 1.49% annually). However, the agricultural import has a different story. It increases due to the increase in population and income. After some fluctuations, the trend of the agricultural import is increasing over the time of simulation.
- Agricultural land is a one of the important factors in the production process based on the results of the production functions. When the total arable land is increasing 5% per year from 2007 to 2021, the production and income will also increase, but the

employment cannot be increased because of the high labour/land ratio in the agricultural sector.

- When government will decrease the agricultural import, the results indicated that the agricultural production would increase considerably but the agricultural employment increased slightly.

**Policy Implications**

The combination of two methodologies (SD and econometric) showed more effective policy implication. For example in production functions model when inputs are changed, only the effect of change on the total production is investigated, while in the current SD model other effects such as the effect on the employment, rural population, immigration, unemployment, export, import, and etc. along with multiple FBL are investigated. In other words, the effect of increasing in one factor of production can be seen on the wide range of socio-economic variables. This is one of the important advantages as compared with other methodologies particularly when multiple assumptions can be examined therefore further policy implications can be extracted. Based on the analysis of the results from SD model, several policy implications emerged as follows:

Based on the results of dynamic demand function, the relationship between capital and labour were substitution (Table 3). Hence, the econometrics results suggested that the policy makers can reduce the price of capital to substitute the capital instead of the labour in production process. Whereas, based on the SD results when the coefficients of labour demand join to other parts of SD model, the relationship would convert to complement. The reason of this occurrence is the interaction among different socio-economic factors and many FBL forces. Therefore, in this situation the use of more capital in the agricultural sector can increase labour slightly in the production process in certain period.

The migration of the villagers to the metropolitan cities, to find jobs and efficient incomes as well as utilize the available facilities, is an increasingly rising occurrence. Obviously, the rate of unemployment in the urban area is increasing over the time because of the high cityward migration. Unfortunately, this means that the problems from the rural will also be moved to the urban areas. The results of the SD simulation confirm this hypothesis, while the cityward migration during 2006-2021 will increase to 115%. Hence, creating jobs in both the rural and urban areas, as well as decreasing the "wage differences" between these two areas, are recommended.

The increase in the capital alone cannot increase the agricultural production; hence, it needs to be increased with the improvement in the technological change and other inputs as one package.

The increase of the under-cultivated land by a development in the irrigation system and water resource management has influential policies to increase production, but it not a successful policy to increase employment.

**Recommendations**

As an integrated system, the rural and urban sectors are interactive. Thought there has been a major ‘out of plan migration’ from the rural to the urban areas possibly due market forces; the resultant outcome has been both the areas were plagued by high unemployment. Both areas apparently are unable to absorb the manpower resource efficiently. The lagged adjustments were noted to be very low too, while population growth in the rural areas was relatively too high. Here, in both areas employment creation activities were not there to match up with the available manpower and/or the needed skill or knowledge were not made available to the manpower hence it is caused mismatching in labour market in the rural and urban areas in Iran. Therefore, these policies are recommended as package to the policy makers. It is remarkable to mention that all recommendation policies should be done simultaneously as one package:

[1]- Improved physical linkage and provide more facilities between rural and urban areas such as road, rail, infrastructural affaires, and others in order to decrease duality.

[2]- Employment creation activities in rural areas in non-agricultural production [Small and Medium Enterprise (SME) activities aim at urban demand) and development of the services sector to include tourism, and financial support services such as the banking and insurances.

[3]- The agricultural sector needs to focus on two clusters of crops, one for industrial crops that is oriented for export and the other crops needed for domestic consumption especially with the growing domestic demand. Activities at the farm need to be extent to include storage, packaging, post harvest, semi processing, central collection, hubbing and transportation

[4]- New arable lands that are made into cultivation need to planted high value crop and cost of production is expected to be high.

[5]- Commercial vertical integration (either forward or backward) should be encouraged as to ensure farm operation would also benefits from the high value from post harvest and processing operations. Products development, need also to be focused as additional high value income.

[6]- Technological development should focus more on the biotechnology to improve yield and should avoid labour reduction technologies but rather labour-assisted technologies at the present situation of excess labour. It is also important to mind by reducing the agricultural labour the rural income may decrease and consequently human level index.

[7]- It is very crucial that agricultural products are accessed to relatively large market especially the external markets. Obviously, the relatively high growth in the agricultural price index would be more due to the structural inflation rate instead of external and internal demand. If demand were much confined to the local market, the price index is pressure to fall.

Focus of implication from the study would be on the manpower planning and development as the issue of labour has been made central in relation to production capacity and management in the sector. Hence, market factors that influence employment are important to be addressed by policy makers to stabilize the inter-regional disparities; to include concern on productivity of labour, the unemployment, wage rates, skilled and unskilled labour, labour movement etc as noted. With surplus labour in the rural areas that has adversely affect production efficiency, hence excess labour needs to be mobilized out of the rural system. Hence preparing this labour cluster for appropriate training and education for non-agricultural employment are relevant. At the same time, expertises in modern agricultural production are also needed to match technologies.

Employment creation at the urban sectors is also vital for the planned development of the sectors to further absorb the excess labour in the rural areas. However, the skills of those labours of the rural areas need to be adjusted to match the relativity modern urban sector requirement. At the same time, skill development and upgrading for non-agricultural tasks/jobs in the rural areas settings can be planned given diversification economics activities in the rural settings training an education for the targeted pool of labour is crucial. Hence, intersectional development plan (rural and urban development) and linkages need to be addressed by policy makers.

Finally, policy makers should decide based on the cost and benefit of each policy package; and then, simulate many policy alternatives based on the government abilities, international facts, country development plans and other policy priorities.

Choosing the best Policies is needed to define the government abilities, objectives, and available instruments. These depend on the data and information gathered on the above themes. The best and efficient policies will only be found based on the full information gauged.

## References


Akbari, N. and Ranjkesh, M. (2003). Total Factor Productivity in the Iranian Agricultural Sector. Agricultural Economics and Development, 11, Vol. 43 & 44 (In Persian).

AL-Jalaly, S. (1992). Agricultural Sector Employment and Need for off-farm Employment. Pakistan Development Review: 817-828

Amini, A. (2002). Analysis of Main Factor on Labour Demand and Employment Forecasting in the Third Iranian Development Plan. Journal of Budget and Planning, 74, 53-86 (In Persian).

Arize, A. and Afifi, R. (1987). An Econometric Examination of Import Demand Function in Thirty Developing Countries. Journal of Post Keynesian Economic, IX (4): 604 -16.

Benjamin, D. (1992). Household Composition, Labour Market, and Labour Demand: Testing for Separation in Agricultural Household Models. Econometrica, 282-322

Berndt, E. and Christensen, L. (1973). The Translog Function and the Substitution of Equipment, Structures, and Labour in U.S. Manufacturing 1929-1968. Journal of Econometrics 1, 81-114.

Berndt, E. R. and Christensen, L. (1974). Testing for the Existence of a Consistent Aggregate Index of Labour Inputs. American Economic Review. June, pp. 391-404.

Borjas, G. J. (1996). Labour Economics. McGraw-Hill International Editions. Economic Series.

Caves, D. W. and Christensen, L. (1980). Global Properties of Flexible Functional Forms. American Economic Review 70, 422- 432.

Christensen, L. and Greene, W. (1976). Economies of Scales in US Electronic Power Generation. Journal of Political Economy 84, 655-676.

Christensen, L. R., Jorgenson, D. and Lau, L. (1973). Transcendental Logarithmic Production Frontiers. Review of Economics and Statistics 55, 28–45.

Clarida, R. (1994). Co-integration, Aggregate Consumption, and the Demand for Imports: A Structural Econometric Investigation. American Economic Review, 84 (1), 298-308.

Cobb, C. W. and Douglas, P.H. (1928). A Theory of Production. American Economic Review 18 (Supplement), 139-165.

Coyle, R. G. (1996). System Dynamics Modelling: A Practical Approach. London: Chapman and Hall.

Fei, J. C. H. and Gustav, R. (1964). Development of Labour Surplus Economy: Theory and Policy. Homewood, I11.

Forrester, J. W. (1991). System Dynamics and the Lessons of 35 Years. A Chapter for the System Basis Policy Making in 1990, April 29.

Forrester, J. W. (1997). Building a System Dynamic Model. Prepared for the MIT System Dynamic in Education Project Under the Supervision of Dr. Jay W. Forrester, Copyright © 1997 by the Massachusetts Institute of Technology.

Forsund, F.R. and Hjalmarsson, L. (1987). Analysis of Industrial Structure: A Putty-Clay Approach. IUI, Almqvist & Wiksell International, Stockholm.

Gustav, R. (2004). Labour Surplus Problem. Yale University, This paper can be downloaded from: http://ssrn.com/abstract=631206

Heshmati, A. (1994). Estimating Random Effects Production Function Models with Selectivity Bias: an Application to Swedish Crop Producers. Agricultural Economics 11, 171-189.

Intriligator, M. D., Bodkin, R.G. and Hsiao, C. (1996). Econometric Models: Techniques and Applications. Second Edition, Prentice Hall.

Iranian Islamic Year (Solar-Hejri) 1400, Third Plan and 25-year Strategy (2002), Management and Planning Organization, (In Persian).

Khakbazan, M. and Gray, R. (1993). The Role of Labour in Iranian Agriculture. Second Congress of Agricultural Economics, Fars Province, Shiraz University.

Khalilian, S. and Yari, A. (2001). Investigation about Effective Factors on Productivity and Value Added of Economic Sector in Iran. Third Agricultural Congress, Mashad, Vol. 2, 1379, (In Persian).

Khan, M. and Knight, M.D. (1988). Important Compression and Export Performance in Developing Countries. Review of Economics and Statistics, Vol. 70, No. 2, pp. 315-321.

Kohli, U. (1991). Technology, Duality, and Foreign Trade: The GNP Function Approach to Modelling Imports and Exports. The University of Michigan Press, Ann Arbor.

Kummerow, M. F. (1997). A Paradigm of Inquiry for Applied Real Estate Research: Integrating Econometric and Simulation Methods in Time and Space Specific Forecasting Models Australian Office Market Case Study. PhD Thesis, School of Economics and Finance, Curtin University of Technology, Australia.

Mad Nasir, S. and Ghazali, M. (1998). Agriculture and Agribusiness in Malaysia under Structural Economic Transformation. Journal of ISSAAS (International Society for Southeast Asian Agricultural Science), 4(2): 1-22.

Mansoori, J. (2001). Ministry of Energy, Research Department, (In Persian).

Marquez, J. (1994). "The Constancy of Illusions or the Illusion of Constancies: Income and Price Elasticises for U.S. Imports, 1890-1992", International Finance Discussion Papers, 475.

Moosavi-Haghighi, M. H., and Mad Nasir, S. (2008). Dynamic Demand Function for the Iranian Agricultural Labour. American-Eurasian J. of Agricultural & Environ. Sci., 2 (supple 1): 80-85, IDOSI Publication.

Moosavi-Haghighi, M. H., and Mad Nasir S. (2007). A Unique Agricultural Situation in Iran, USM-UPM-PETA Conferences, Penang, Malaysia, 28th to 29th November 2007.

Moosavi-Haghighi, M. H., Kowsar, S. A. and Mad Nasir S. (2008). Production Technology in the Iranian Agricultural Sector. American-Eurasian J. of Agricultural & Environm. Sci., 2 (supple 1): 86-90, IDOSI Publication.

Nerlove, M. (1958). Distributed Lags and Demand Analysis for Agricultural and Other Commodities. Washington, U.S. Department of Agriculture, Agricultural Handbook No. 141, June 1958.

Ramsey, J. B. (1969). Tests for Specification Errors in Classical Linear Least-squares Regression Analysis. Journal of the Royal Statistical Society, B, 31, 350-371.

Randers, J. (1980). Element of the System Dynamics Method. Portland, OR: Productivity Press, 344, pp.117-139.

SCI, "Statistical Centre of Iran", http://www.sci.org.ir

Sterman, J. (2000). Business Dynamics: Systems Thinking and Modelling for a Complex World. McGraw, Tokyo.

Todaro, M.P. and Smith S.C. (2003). , Economic Development, Harlow, England: Pearson/Addison Wesley, 9th Edition.

Vensim, User's Guide, (1988-2005), Ventana, System, Inc.

Vensim, Reference Manual, (Copyright 1998-2003, Revision Date April 7, 2003), Ventana, System, Inc.

Wilkinson, J. (1992). Explaining Australia's Imports: 1974-1989, Economic Record, 68(201), pp.151-164.