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Estimating Property Rights Expenditures in Iran

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Abstract

There are many indices for measuring property rights (PR) security. They may be classified into two groups: subjective proxies and objective proxies. Most of the proxies are subjective. One contribution of this paper is introducing a new approach for measuring government expenditures devoted to PR protection. Calculating physical capital within the introduced new approach is another contribution of this paper. Finally, the proposed approach is applied for measuring PR and physical capital in Iran.
Keywords: Genetic Algorithm, Iran, Physical Capital, Property Rights.
JEL Classification: O43, B52, E11

1. Introduction

Property rights (PR) and contracts may be violated by citizens or governments in different ways. Government violation can be via direct property expropriation of assets, defecting on public, debt money debasing, prohibition of informal transactions, failing in providing legal infrastructure, etc. (Clague et al., 1996, p. 254). Different indices are suggested for measuring the status of property rights in literature, but, focusing only on a specific aspect, none of them could consider all aspects of property rights and contracts.

Generally, proxies for PR protection can be divided into subjective and objective proxies. Subjective indices rely on the ideas of experts about institutional status of the country, but objective proxies are based on values of some economic variables.

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Some elements of the following indices are used in literature[1] as subjective proxies for protecting PR:

International Country Risk Guide (ICRG),
Business Environmental Risk Int. (BERI),
Business International (BI),
Hajji-Ibrahim Indices (HI),
Freedom House, Economic Freedom Index (FH),
Heritage Foundation, Economic Freedom Indices (HF),
Fraser Institute, Economic Freedom Index (FI),
Fedderke, Kadt, and Luize Indices (FKL),
Johnson, McMillan, and Woodruff Indices (JMW), and
Political Instability Indices (PI).

The following elements use the mentioned indices to measure the status of PR: expropriation risk, repudiation of contracts risk by government, rule of law (from ICRG[2]), contract enforceability, nationalization risk/potential (from BERI index), bureaucratic efficiency (from BI index), sum of political rights indices, type of economic system, measures of public policies and economic freedom (from HI index), subgroups of rule of law and personal independence and human rights in the section of civil liberty (from FH index), PR (from HF index), legal structure and PR protection or governance (in FH index), seven elements of FKL index[3], a combination of 3 indices from 7 suggested indices of JMW (extra-legal payment for getting licenses, extra-legal payment for services, and inability of courts for fulfilling contracts), revolutions and coup states in countries, and political assassinations and terrors in PI[4].

Although, majority of indices in previous studies are mental or subjective, Clague et al. (1996, 1999) were the first who offered an objective index for measuring PR protection status. Their index is called Contract-Intensive-Money (CIM). In some studies, other indices such as inflation rate, money debasing, black market premium of foreign exchange and its control, level and changes of tax, amount of public property, and credits devoted to private sector are used. But, in many studies, CIM index has been preferred.

CIM index has a number between 0 and 1. It only shows governance and violation status. In this study, using a recursive method, we suggest another

1. For more information, see Samadi, 2008, chap. 2, pp. 34-59.
2. Some studies such as Clague et al. (1996), Knack and Keffer (2002), and Law (2006) use a general index (combination of 5 elements of ICRG index).
3. This index has four different features with respect to FI and FH indexes. For further studies, see Federke et al. (2001, pp. 113-114).
4. For further studies of some shortcomings of this index, see Sango (2003, pp. 89-90), and Dincer (2007, p. 830).

measure. Then, the main contribution of this study is to calculate expenditures devoted to PR protection by the government. Another contribution is estimation of physical capital stock.

Some points should be considered:

1. There should be differentiation between measures which evaluate *attributes of institution* and measures which evaluate *performance of institutions* (Arron, 2000, p. 103).
2. There should be differentiation between measures of *protective rights* and *intrusive rights* (Norton, 2000, p. 322-323).
3. There should be differentiation between *contract institution* and *PR Institution* (Acemoglu and Johansson, 2005, p. 950-956).

The proposed index of this article relates to the performance of institutions, protective rights, and PR institutions, ignoring other aspects.

The rest of the article is organized as following. In section 2, we develop an endogenous growth model. In Section 3, we solve the proposed model. Section 4 presents the methodology of research. Section 5 reports some empirical results for Iranian economy using calibration. Finally, some general conclusions are presented in the final section.

2. Model

A myriad of studies have been devoted to explaining the role of incomplete PPRs in economic growth process. For example, you can see look at Tornell and Velasco (1992), Tornell and Lane (1999), Grossman and Kim (1996), Lindner and Stroulik (2004), Mino (2006), Gonzalez (2007), Rennani, Dallali and Samadi (2008), Sevensson (1998), Gradstein (2004), Dincer and Ellis (2005), Teng (2000), Sylwestre (2001), Palda (1999), Grossman and Kim (1996), and Anderson and Bandiera (2005). In Rennani, Dallali and Samadi, (2008), a complete model has been developed that shows the role of PPRs in economic growth process. In another study, Samadi and Ostadzad (2013) combined private-ordering and legal-centralist views of property rights and proposed an augmented endogenous growth model to calculate the optimum share of public and private sectors in property rights protection (PPRs). Also, the shares of government and private sectors in total production have been calculated.

The main aim of this study is to estimate time series of expenditures devoted to PR protection using a recursive method in the framework of an endogenous growth model. To this end, an endogenous growth model has been developed. It is extended regarding Figure 1.

Suppose that government devotes a part of its revenue to PR protection. Also, suppose that increasing PR affects social welfare, directly and indirectly. PR protection, on the one hand, increases production as well as household consumption. This effect is the indirect effect of increasing PR protection on social welfare. On the other hand, increasing PR protection increases safety in the society and social welfare (direct effect).

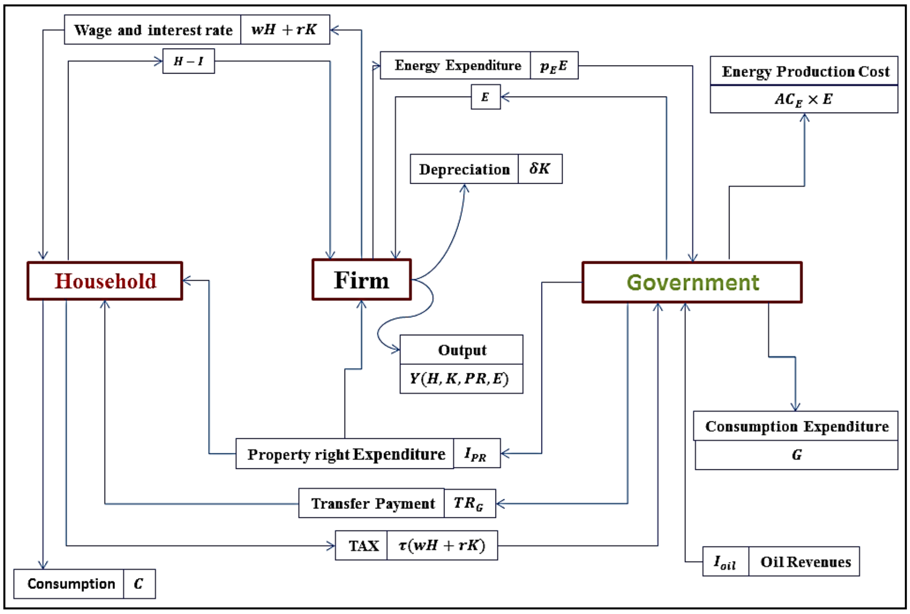

Fig. 1. Control box of income cycle of household, firm, and government

Source: Research findings

In legal-centralist view, it is assumed that PR should be defined and protected by the government. But, in private-ordering view, economic agents invest on PR without considering the government's role. Following Samadi and Ostadzad (2013), it is assumed that only the government invests on PR protection. Thus, the dominant view is legal-centralist view. Therefore, it is assumed that PR is public goods.

2.1. Welfare function

Attention to the concept of intertemporal preferences– selection between consumption in different times– clarifies the point that consumption is postponed when PR is protected. Thus, it is assumed that intertemporal utility is a function of consumption and expenditures of PR protection:

$$u(C_t, PR_t) = \frac{\left[C_t\, PR_t^{\nu}\right]^{1-\sigma}}{1-\sigma} \tag{1}$$

Therefore, discounted social welfare function is shown in Eq. (2).

$$W = Max\int_0^{\infty} e^{-\rho t}U(C_t, PR_t)\ dt = Max\int_0^{\infty} e^{-\rho t}\frac{\left[C_t\ PR_t^{\nu}\right]^{1-\sigma}}{1-\sigma}\ dt \qquad (2)$$

where C_t is consumption, σ is inverse of intertemporal elasticity of substitution, PR_t is expenditures devoted to protection of PR, ν is sensitivity of social welfare to PR protection, and ρ is discount rate.

2.2. Equations of Motion

Three equations of motion are regarded in this study: equation of motion for stock of physical capital, labor force, and PR protection[1]. Following Hadian and Ostadzad (2013), it is assumed that, equations of motion for labor force (H) and capital (K_t) take the forms of Eq. (3) and (4)[2].

$$\dot{H} = \xi H \qquad (3)$$

$$\dot{K} = I_t - \delta K_t \Rightarrow \dot{K} = (1-\tau)\left[wH_t + rK_t\right] + TR_G - C_t - \delta K_t \qquad (4)$$

where ξ is the growth rate of labor force, r is the rate of capital return, w is wage rate, δ is capital depreciation rate, TR_G is transfer payments, and δK_t shows capital depreciation. Also it is assumed that the household income is allocated to:

1. Consumption (c), 2. Tax ($\tau\left[wH_t + rK_t\right]$), and 3. Investment ($I_t$).

In Figure 1, it is assumed that government revenues are collected from three channels: 1. Tax ($\tau\left(wH + rK\right)$), 2. oil revenue (I_{oil}), and 3. sale of other energy products ($p_E E$). Government revenue is spent in 3 ways: 1. government consumption, 2. expenditures on PR protection (I_{PR}), and 3. Energy production expenditures ($AC_E \times \mathrm{E}$)[3].

Government investment in PR protection in every period increases PR protection capital stock and, therefore, production and social welfare increases. Thus, equation of motion for PR stock is:

$$\dot{PR} = I_{PR} - \delta' PR \qquad (5)$$

where δ' is depreciation (or destruction) rate of PR protection stock.

Suppose that production function takes the form of augmented Cobb-Douglas function as:

$$Y = AH^{\alpha}K^{\beta}PR^{\gamma}E^{\theta} \qquad (6)$$

1 This study assumes that PR is like a physical capital.

2 Regarding income cycle of private sector expenditure in Fig. 1, we have $I_t = (1-\tau)\left[wH_t + rK_t\right] + TR_G - C_t$.

3. where, AC_E is average expenditure of energy production

where A is transitional parameter of production function, α is elasticity of production with respect to labor, β is elasticity of production with respect to physical capital, γ is elasticity of production with respect to PR capital, and θ is elasticity of production with respect to energy.

It is assumed that government's budget deficit is:

$$BD = TR_G + AC_E \times \mathrm{E} + G + I_{PR} - \left[p_E E + \tau\left(wH + rK\right) + I_{oil} \right] \quad (7)$$

Assuming that energy prices equal to average energy costs in long-term ($AC_E = P_E$), and government follows the balance budget fiscal rule, and in steady state, government budget deficit is zero (BD=0), simplifying Eq. (7), transfer payments take the form:

$$TR_G = \left[\tau\left(wH + rK\right) + I_{oil} \right] - G - I_{PR} \quad (8)$$

3. Solving the model

The basic model presented in this paper can be summarized as follows:

$$\begin{aligned} W &= Max \int_0^{\infty} \frac{\left[C_t\, PR_t^{\nu}\right]^{1-\sigma}}{1-\sigma} e^{-\rho t}\, dt \\ \dot{H} &= \xi H \\ \dot{K} &= Y + I_{oil} - p_E E - G - I_{PR} - C_t - \delta K_t \\ \dot{PR} &= I_{PR} - \delta' PR \\ Y &= AH^{\alpha} K^{\beta} PR^{\gamma} E^{\theta} \end{aligned} \quad (9)$$

To solve the model, current Hamilton function is:

$$HA = \left\{ \frac{\left[C_t\, PR_t^{\nu}\right]^{1-\sigma}}{1-\sigma} + \lambda_1\left[\xi H\right] + \lambda_2\left[Y + I_{oil} - p_E E - G - I_{PR} - C_t - \delta K_t\right] + \lambda_3\left[I_{PR} - \delta' PR\right] \right\} e^{-\rho t}$$

where λ_1, λ_2, and λ_3 are shadow price of labor force, Physical capital, and PR capital, respectively. Since the control variables are C, E, I_{PR} and state variables are H, K, PR, first order conditions are shown in Eqs. (10)-(15).

$$\frac{\partial HA}{\partial C} = 0 \Rightarrow PR^{\nu}\left[C\, PR^{\nu}\right]^{-\sigma} - \lambda_2 = 0 \Rightarrow PR^{\nu}\left[C\, PR^{\nu}\right]^{-\sigma} = \lambda_2 \Rightarrow PR^{\nu-\nu\sigma} C^{-\sigma} = \lambda_2 \Rightarrow$$

$$PR^{\nu(1-\sigma)} C^{-\sigma} = \lambda_2 \quad (10)$$

$$\frac{\partial HA}{\partial E} = 0 \Rightarrow \lambda_2\left[\frac{\partial Y}{\partial E} - p_E\right] = 0 \Rightarrow \frac{\partial Y}{\partial E} = p_E \xrightarrow{\frac{\partial Y}{\partial E} = \theta\frac{Y}{E}} \theta\frac{Y}{E} = p_E \Rightarrow \theta Y = p_E E \quad (11)$$

$$\frac{\partial HA}{\partial I_{PR}} = 0 \Rightarrow +\lambda_2\left[-1\right] + \lambda_3\left[1\right] = 0 \Rightarrow \lambda_2 = \lambda_3 \quad (12)$$

(13)

$$\frac{\partial HA}{\partial H}=\rho\lambda_1-\dot{\lambda}_1\Rightarrow\lambda_1\left[\xi\right]+\lambda_2\left[\frac{\partial Y}{\partial H}\right]=\rho\lambda_1-\dot{\lambda}_1\xrightarrow{\frac{\partial Y}{\partial H}=\alpha\frac{Y}{H}}\lambda_1\left[\xi\right]+\lambda_2\left[\alpha\frac{Y}{H}\right]=\rho\lambda_1-\dot{\lambda}_1$$

(14)

$$\frac{\partial HA}{\partial K}=\rho\lambda_2-\dot{\lambda}_2\Rightarrow+\lambda_2\left[\frac{\partial Y}{\partial K}-\delta\right]=\rho\lambda_2-\dot{\lambda}_2\xrightarrow{\frac{\partial Y}{\partial K}=\beta\frac{Y}{K}}\lambda_2\left[\beta\frac{Y}{K}-\delta\right]=\rho\lambda_2-\dot{\lambda}_2$$

(15)

$$\frac{\partial HA}{\partial PR}=\rho\lambda_3-\dot{\lambda}_3\Rightarrow\nu C\,PR^{\nu-1}\left[C\,PR^{\nu}\right]^{-\sigma}+\lambda_2\left[\frac{\partial Y}{\partial PR}\right]+\lambda_3\left[-\delta'\right]=\rho\lambda_3-\dot{\lambda}_3\xrightarrow{\frac{\partial Y}{\partial PR}=\gamma\frac{Y}{PR}}$$

$$\nu C^{1-\sigma}\,PR^{\nu-1-\sigma\nu}+\lambda_2\left[\gamma\frac{Y}{PR}\right]+\lambda_3\left[-\delta'\right]=\rho\lambda_3-\dot{\lambda}_3$$

Solving Eqs. (10)-(15), growth rate of expenditures on PR protection (g_{PR}) is:[1]

$$g_{pr}=\left(\frac{1-\beta-\theta}{\gamma}\right)g^{*}\tag{16}$$

Simplifying Eqs. (10)-(16) gives the PR protection expenditures on production:

$$pr_t=\left[1+\left(\frac{1-\beta-\theta}{\gamma}\right)\left(\frac{y_t-y_{t-1}}{y_{t-1}}\right)\right]pr_{t-1}\tag{17}$$

Also, solving Eqs. (10)-(15), the amount of physical capital is:

$$k_t=p_E\left[\frac{1}{p_E}\left(\frac{r_t\theta}{1-\theta}\right)\left(\frac{p_E}{A\theta}\right)^{\frac{1}{\beta}}\right]^{\frac{\beta}{\beta+\theta-1}}\left[\frac{1-\theta}{r_t\theta}\right]pr_t^{\frac{\gamma}{1-\beta-\theta}}\tag{18}$$

It must be mentioned that, to solve models and for simplicity, variables were considered in per capita form.

4. Methodology

In this section, an algorithm will be developed to estimate time series of PR protection expenditure. Proposed algorithm is shown in Figure 2.

4.1. Proposed Algorithm

At first, expenditure for protection of PR is considered as a percentage of production in base year ($pr_0=\varpi y_0$). Thus, one parameter that should be estimated in the model is ϖ. We assumed that ϖ as random variable has a normal distribution with zero mean and variance 1 ($\varpi\approx N(0,1)$) and,

1. See appendix, Equation (a34)

therefore, a stochastic value is selected for it. Regarding Eq. (17), with initial value for PR protection ($pr_0 = \varpi y_0$), time series of GDP, and using Eq. (19), we can calculate PR protection expenditure in period 1 as:

$$pr_1 = \left[1 + \left(\frac{1-\beta-\theta}{\gamma}\right)\left(\frac{y_1 - y_0}{y_0}\right)\right] pr_0 \quad (19)$$

Using recursive Eq. (17), time series of PR are calculated based on β, θ, γ parameters. Thus, we have a time series of PR protection expenditure based on parameters ($PR_t = PR(\beta, \theta, \gamma)$). Next, with estimated PR_t and interest rate (r_t), we computed time series of physical capital stock based on Eq. (18) ($K_t = K(A, \beta, \theta, \gamma)$).

To estimate production function ($Y = AH^{\alpha} K^{\beta} PR^{\gamma} E^{\theta}$), first, *m*, stochastic value from a normal distribution function in a specific range, is allocated to parameters $(A, \alpha, \beta, \theta, \gamma)$. Having this *m* parameter, *m* time series of capital stock and expenditures of PR protection will be computed.

In the next step, *m* estimated time series are put in production function and m values are estimated for production using Eq. (20).

$$\hat{y} = A\hat{k}^{\beta}\, \hat{pr}^{\gamma} \hat{e}^{\theta} \quad (20)$$

where $\hat{k}$ and $\hat{pr}$ are time series of physical capital and PR protection capital stock, respectively, that can be calculated by Eqs. (17) and (18).

Using genetic algorithm, the best values for $(A, \alpha, \beta, \theta, \gamma)$ parameters are selected in a way that they yield minimal $RSS = \sum_{t=1}^{T} \left(Y_t - \hat{Y}_t\right)^2$ and/or least absolute deviation ($LAD = \sum_{t=1}^{T} \left|Y_t - \hat{Y}_t\right|$) from real values of GDP. Selecting the best parameters and assuming a given value of ϖ , time series of physical capital and PR protection expenditure are stored using LAD and LS methods. Then, another stochastic value is selected for ϖ and respect to m times for different ϖ 's. Now, among *m* calculated time series with different initial values, time series with the least errors in LS and LAD are selected. Since there are 5 parameters for each of which, *n* stochastic value is selected with *m* random initial values, estimated time series among $m \times n^5$ random time series using continuous genetic algorithm will be selected. For example, with n=100000 and m=8000, estimated time series selected among 8×10^{23} time series will be a huge number.

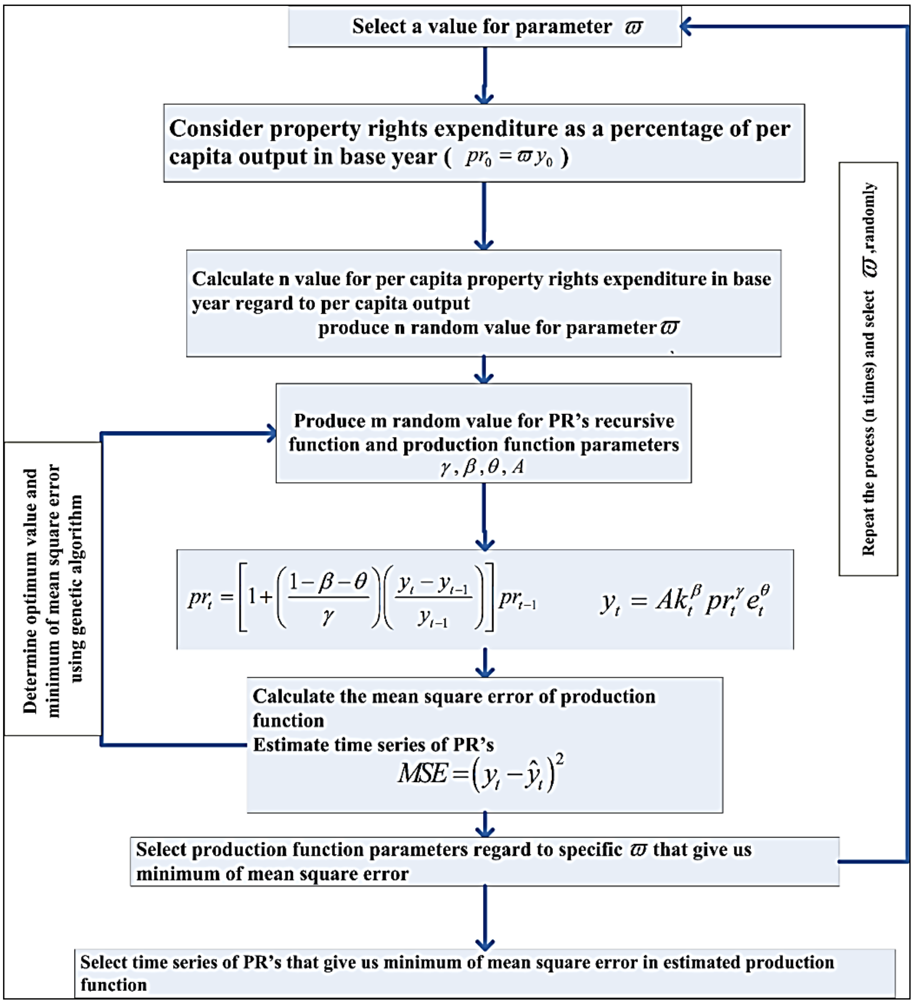

Fig. 2. Algorithm for estimating time series of PR protection

Source: Research findings

4.2. Continuous genetic algorithm

In this paper, genetic algorithm was used for minimizing RSS and LAD to estimate parameters of production function (Eq. 20). Besides gradient-based optimization methods, intelligent optimization methods are developed. Their advantage is finding optimum point without a need to derive objective function. Its susceptibility to fall in the trap of local minimum is very low compared with gradient-based optimization methods.

Genetic algorithm is a technique for finding an optimum solution. This algorithm is a specific type of evolutionary algorithms, using biological techniques such as heredity and mutation. These algorithms are good options for prediction techniques based on regression. Advantages of genetic algorithm are ability for optimization with continuous and discrete variables, the lack of need to derivation for optimization, ability to work with many variables, identifying optimum minimums, and ability to work with numerical and experimental data and analytic functions (Haupt and Haupt, 1996).

Steps of doing a continuous genetic algorithm, such as optimization algorithms, start from variables' definition and objective function and ends with convergence examination. To estimate parameters in solving optimization problem, the aim is minimizing RSS (Eq. 21) and then minimizing LAD (Eq. 22). To do so, data of t=1,2,…,k and t=k+1,…, n are used for prediction.

$$RSS = \sum_{t=1980}^{2012} \left(Y_t - \hat{Y}_t\right)^2 \tag{21}$$

$$LAD = \sum_{t=1980}^{2012} \left|Y_t - \hat{Y}_t\right| \tag{22}$$

In genetic algorithm, objective function is examined for different parameters $(A, \alpha, \beta, \theta, \gamma)$ and the algorithm follows in cyclical order to estimate minimum value of objective function. To start the process of setting variables by genetic algorithm, we define a chromosome in an array of variables' values (which are parameters of Eq. 20) based on which optimum objective function should be provided. Thus, chromosomes of this study are as follows:

$$Chromosome = \left[A, \alpha, \beta, \theta, \gamma\right]$$

Determination coefficient (R^2) can be calculated from Eq. (23).

$$R^2 = 1 - \sum_{t=1980}^{2012} \frac{\left(Y_t - \hat{Y}_t\right)^2}{\left(Y_t - \bar{Y}\right)^2} \tag{23}$$

In Eq. (23), $\bar{Y}$ is the mean of GDP in different periods and $\hat{Y}$ can be calculated by Eq. (20. Also, in Eq. (20), time series of physical capital and PR protection capital can be estimated by Eqs. (17) and (18).

Since genetic algorithm is a grid-search method, it must be limited to the search in a specific range. The more limited the space of variable, the more exact the solution. Since we do not know anything about initial area of parameters, first generation should be considered diverse enough. In that way, the model can search in a variable space with a reasonable size before focusing on the most promising areas. Here, a big population of chromosomes (n=100000) is considered. First, all variables are normalized to have a value between 0 and 1 and create a random matrix of normal distribution with mean of 0 and variance 1. Chromosomes of initial population which are good enough for survival are selected in natural selection stage. These chromosomes reproduce children of next generations. In this paper, generation change rate equals to 0.5; it means that 50% of low chromosome population is removed and high chromosome population is selected.

The proper number of chromosomes for cross over in mating results from multiplying generation change rate by initial population. In this study, S=5000 chromosomes that are more suitable than the others create reproduction pool.

In reproduction pool, two pairs of parents are coupled by a random method. Thus, there are 2500 pairs for mating. Each pair breeds 2 children with characteristics of each parent. Parents survive to form a part of next generation. For mating, value-based weighting method was used (Haupt and Haupt, 1996). Next, two parents, selected in mating steps were coupled and produced children. There are different methods for reproduction. In this study, a heuristic combination method of Michelvige (1994) was used.

Genetic algorithm may converge into an area of objective function's surface. If this area is close to global optimum, convergence is to the benefit of algorithm. But for the functions with many local optimums, algorithm may converge towards a local optimum. In these functions, if we do nothing and the algorithm goes, it will converge towards a local optimum. Then, a local optimum, instead of a global optimum, will be reported. To avoid this problem with creating random changes (mutation) in variables, we make algorithm trigger other areas of objective function's surface. Mutation rate is considered 0.2 to move towards the other section of the surface (i.e. among 100000 extant chromosomes, we mutate 2000 chromosomes). In this way, genetic algorithm is repeated to find parameters of production function that give us minimum RSS and LAD values.

5. Calibration and Estimation

Here, we estimate time series of PR protection expenditures in Iran regarding the developed algorithm. First, the model is estimated using LS and LAD methods during 1980-2007. Then, the data of 2008-2012 is used for forecasting and testing its reliability. To estimate Eq. (6), real GDP per capita (from WDI and energy balance sheet) in US dollar and real prices of 2005, energy data (from energy balance sheets), the total production of energy (fossil and renewable energies based on per ton of petroleum), and interest rate (Central Bank of Iran) are utilized.

Extending recursive Eq. (17), PR protection amount in period t takes the form:

$$pr_t = \varpi y_0 \prod_{i=1}^{t}\left[1+\left(\frac{1-\beta-\theta}{\gamma}\right)\left(\frac{y_i - y_{i-1}}{y_{i-1}}\right)\right] \quad (24)$$

Replacing in Eq. (18), per capita physical capital in every period is:

$$k_t = \left[\left(\frac{r_t\theta}{1-\theta}\right)\left(\frac{1}{A\theta}\right)^{\frac{1}{\beta}}\right]^{\frac{\beta}{\beta+\theta-1}}\left[\frac{1-\theta}{r_t\theta}\right]\left(\varpi y_0 \prod_{i=1}^{t}\left[1+\left(\frac{1-\beta-\theta}{\gamma}\right)\left(\frac{y_i - y_{i-1}}{y_{i-1}}\right)\right]\right)^{\frac{\gamma}{1-\beta-\theta}} \quad (25)$$

Thus, regarding Eqs. (20)-(25), Eqs. (26) and (27) for calculating LS and LAD for different chromosomes and specific value of ϖ will be achieved:

$$RSS_j = \sum_{t=1980}^{1997}\left(Y_t - A_j\left[\phi_j\left(A_j,\theta_j,\beta_j\right)\right]^{\beta_j}\left(\varpi y_{1980}\right)^{\frac{\gamma_j(1-\theta_j)}{1-\beta_j-\theta_j}}\left(\prod_{i=1981}^{t}\left[1+\left(\frac{1-\beta_j-\theta_j}{\gamma_j}\right)\left(\frac{y_i-y_{i-1}}{y_{i-1}}\right)\right]\right)^{\frac{\gamma_j(1-\theta_j)}{1-\beta_j-\theta_j}} E_t^{\theta_j} r_t^{\frac{\beta_j(1-\theta_j)}{\beta_j+\theta_j-1}}\right)^2 \quad (26)$$

$$LAD_j = \sum_{t=1980}^{1997}\left|Y_t - A_j\left[\phi_j\left(A_j,\theta_j,\beta_j\right)\right]^{\beta_j}\left(\varpi y_{1980}\right)^{\frac{\gamma_j(1-\theta_j)}{1-\beta_j-\theta_j}}\left(\prod_{i=1981}^{t}\left[1+\left(\frac{1-\beta_j-\theta_j}{\gamma_j}\right)\left(\frac{y_i-y_{i-1}}{y_{i-1}}\right)\right]\right)^{\frac{\gamma_j(1-\theta_j)}{1-\beta_j-\theta_j}} E_t^{\theta_j} r_t^{\frac{\beta_j(1-\theta_j)}{\beta_j+\theta_j-1}}\right| \quad (27)$$

where $\phi\left(A,\theta,\beta\right) = \left[\left(\frac{\theta}{1-\theta}\right)\left(\frac{1}{A\theta}\right)^{\frac{1}{\beta}}\right]^{\frac{\beta}{\beta+\theta-1}}\left[\frac{1-\theta}{\theta}\right]$.

We need to minimize RSS_j and LAD_j using different values of $\left[A_j,\alpha_j,\beta_j,\theta_j,\gamma_j\right]$ with specific ϖ. In Eqs. (26) and (27), we want to minimize the difference of estimated value by the model and realized value of GDP. The aim is to find parameters for minimizing this difference. Observable and independent variables are y_t, E_t, r_t. Minimizing objective functions of genetic algorithm (Eqs. 26 and 27), parameters will be estimated for Iran. After estimating parameters using recursive Eqs. (24) and (25), time series of unobservable variables, physical capital (k_t), and PR protection capital (pr_t) will be estimated. Regarding the studies of Alimoradi (2003), Vafi Najar (2005), Dallali Esfahani, et al. (2008), Moshiri and Nikpour (2007), Pazhuyan and Fagihnasiri (2008), Mahmoodzadeh (2010), Deliri et al. (2010), and Azarbaijani et al. (2011), the range of parameters are shown in Table 1.

Results of estimating parameters using genetic algorithm (values of parameters that minimize objective functions (Eqs. 26 and 27)) are shown in Table 2.

Table 1. The range of parameters for searching the best value

Parameter	Min	Max
A	0	10
α	0.1	0.6
β	0.1	0.5
θ	0.1	0.5
γ	0	0.6

Table 2. Estimated parameters using LS and RSS methods

Parameter	LAD	LS
A	7.260 (3.123)	7.394 (3.203)
α	0.174 (3.234)	0.174 (3.236)
β	0.297 (2.586)	0.298 (2.587)
θ	0.223 (2.908)	0.190 (1.652)
γ	0.450 (3.906)	0.433 (3.829)
ϖ	0.043 (2.505)	0.039 (1.359)
R^2	0.992	0.991
RSS	19274.602	64612.850
$LAD_{\text{Prediction}}$	31943.922	46691.279

Source: Research findings

Note: Values in the parenthesis are t statistics

Regarding the statistics of Table 2 at 95% significance level, coefficients of θ and ϖ are not significant in LS method; while in LAD, all coefficients are significant at 95% significance level. Figure 3 shows simulated values of GDP per capita by LAD and LS methods and actual values of GDP per capita in 2007-2012. According to Figure 3, LAD and LS methods have high predictability power.

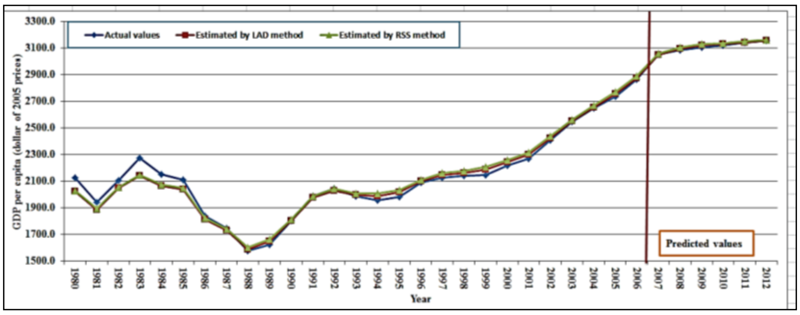

Fig. 3. Simulated and actual values of GDP per capita by LAD and LS methods
Source: research findings

Thus, based on the conducted tests and their predictability, the model has enough validity for calculating time series of per capita PR protection capital. The results of time series of per capita PR protection capital and physical capital are shown in Table 3.

Table 3. Per capita PR protection capital and physical capital (In 2005 prices)

year	Per capita PR capital		Per capita physical capital	
Method	**LAD**	**LS**	**LAD**	**LS**
1980	98.43	90.7	6514.87	8557.9
1981	88.93	81.6	5936.94	7797.3
1982	97.19	89.4	6439.76	8456.5
1983	105.81	97.7	6960.02	9138.6
1984	99.45	91.6	6576.58	8634.6
1985	97.36	89.6	6449.68	8467.9
1986	83.87	76.7	5626.93	7384.7
1987	79.17	72.3	5338.05	7005.2
1988	70.87	64.4	4823.54	6328.6
1989	73.13	66.5	4964	6512.8
1990	81.77	74.7	5498.32	7212.3
1991	91.09	83.5	6068.52	7958.8
1992	93.83	86.1	6235.67	8177.8
1993	91.06	83.5	6066.96	7956.5
1994	89.58	82.1	5976.66	7838
1995	90.84	83.3	6053.45	7938.7
1996	96.2	88.4	6379.86	8366.3
1997	97.85	89.9	6479.56	8497
1998	98.76	90.8	6534.77	8569.4
1999	98.91	90.9	6543.51	8580.8
2000	102.65	94.5	6769.85	8877.4
2001	105.12	96.9	6918.77	9072.6
2002	112.17	103.6	7342.06	9627
2003	119.33	110.5	7769.67	10187
2004	124.38	115.3	8070.08	10580.6
2005	129.02	119.8	8345.24	10941.1
2006	135.6	126.1	8733.65	11449.9
2007	145.34	135.5	9306.14	12199.4
2008	147.09	137.2	9408.54	12333.6
2009	148.02	138.1	9463	12405
2010	148.96	139	9517.47	12476.4
2011	149.89	139.9	9571.93	12547.8
2012	150.82	140.8	9626.39	12619.2

Source: research findings

Simulated time series of Per capita PR protection capital using LAD and LS methods are shown in Figure 4.

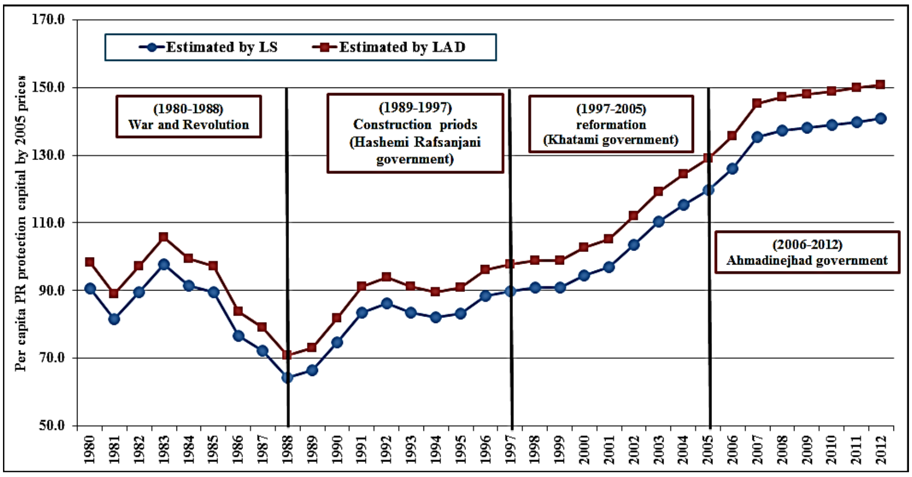

Fig. 4. Per capita PR protection capital by using LAD and LS methods
Source: Research findings

Figure 4 is consisted of 4 periods:

1980-1988: war and revolution era

1988-1997: construction era (Hashemi Rafsanjani's government)

1997-2005: reformation era (Khatami's government)

2005-2012. fundamentalism era (Ahmadinejhad's government).

Regarding Figure 4, per capita PR protection capital from 1980-1988 is decreasing because of war. It has a high growth from 1988-2007. It shows that after war, there have been more investments on PR protection. But, from 2007-2012, this trend has stopped and growth of PR protection capital has been decreasing. This result is consistent with stylized facts of Islamic Republic of Iran.

6. Concluding remarks

Although many criteria used for PR protection are mental and subjective indexes, CIM index is a quantitative and objective index with a number between 0 and 1. Using recursive method in this paper, another measure was suggested. One contribution of this paper is that time series of expenditures devoted to protecting PR by the government is calculated in Islamic Republic of Iran. Another contribution of this study is estimating the amount of physical capital in Iran.

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