# Economic growth and environmental pollution in Iran: evidence from manufacturing and services sectors

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2015

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Reception of originals: 08/25/2014
Release for publication: 04/29/2015

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## Abstract

This article aims to answer the question of whether the manufacturing (and mining) and services sectors in Iran should be reconstructed or grown as before, in order to improve the environmental quality. The global warming, if not global burning, is a dire warning about environmental pollution dangers to everyone, living on the Earth. In this field, Iran is a good candidate due to its significantly high share of CO2 emissions in proportion to the low share of economic growth in the world which can be remedied by economic growth, based on Environmental Kuznets Hypothesis (EKH). We employ the Auto-Regressive Distributed Model (ARDL) to examine the long run equilibrium relationship between CO2 emission and economic growth. The results show that, regarding EKC, the nexus of CO2 emissions and economic growth in either sector is in a sharply ascending phase. It implies that if manufacturing (and mining) and services sectors inflate, the quality of environment will decline owing to the intensive and pollutant energy-using structures. Thus, rather than growing, they should be reconstructed by importing cleaner and more efficient technologies and developing internal inventions.

**Keywords:** Environment. Manufacturing. Services.

## 1. Introduction

The global warming, if not global burning, is a dire warning about environmental pollution dangers to everyone, living on the Earth. “Nobody on the planet is going to be untouched by the impacts of climate change” said the chairman of the Intergovernmental Panel on Climate Change (IPCC) in Yokohama, Japan, in 2014 where and when a meeting was held on IPCC report of that year. With regard to the report, the scientific proofs’ level of the warming effects has approximately doubled since 2007. In the report, there are many reasons for the concern, for example declining the amount of fresh water and food, threats to unique systems like Arctic sea ice Coral Reefs, and the changes of animal and plant settlements. Carbon Dioxide ($CO_2$) is one of the most important contributors, if not the most important one, to air pollution. Therefore, studying the trade-offs between $CO_2$ emissions and economic growth is at the top of the environmental and economical agenda.

In this field, Iran is a good candidate due to its significantly high share of $CO_2$ emissions in proportion to the low share of economic growth in the world which can be remedied by economic growth, based on Environmental Kuznets Hypothesis (EKH) (Grossman an Kruger 1991). In 2000s, the Gross Domestic Product (GDP) of Iran made up averagely less than 0.005 per cent of that of the world, while this share is more than thirty times higher for $CO_2$ emissions, accounted for more than 0.15 per cent (World Development Indicator). This large share is due to many facts including the low price of subsidized fossil fuels like gasoline (Taghvaee and Hjiani, 2014), poor environmental standards (Jafari and Baratimalayeri, 2008), and inefficient energy generators (Camara and Filho, 2007). So this country pollutes the environment thirty times more than which it produces.

Reaching to the descending phase of the Environmental Kuznets Curve (EKC) can be a simple remedy for the issue, as the more economic growth the less environmental pollution. Since the more pollutant economic-sectors, such as manufacturing (and mining) and services, play an important role in the nexus of economic growth and environmental pollution, the main objective of the study is to investigate EKH about the two distinct sectors. If the relationship between economic growth in either sector and environmental pollution is established in the descending phase of EKC, the sector growth would turn down the environmental pollution rate. Otherwise, their infrastructures are environmentally-unfriendly which should be innovated, reconstructed, and developed, rather than growth. Hence, in order to reduce the pace of environmental degradation, this article aims to answer the question of whether the manufacturing (and mining) and services sectors in Iran should be reconstructed or grown as before.

With regard to the Kuznets Environmental Hypothesis, there is an inverted U-shaped relationship between environmental pollution and economic growth. . The environmental pollution increases as the economic growth surges in the early stages for the simple reason that the higher income, the higher energy consumption (Taghvaee and Hajiani, 2014). However, it starts decreasing after hitting a peak, so-called turning point. A large number of studies have shown that the nexus of economic growth and environment degradation follows an inverted U-shaped curve, accepting the EKH (Selden, T.M., Song, D., 1993; Ang, 2008;

Taghvaee and Shirazi 2014). However, many researchers rejected the hypothesis (Hettige et al., 2000).

Many studies have examined the hypothesis with various indices and models, employing a vast variety of environmental indices. In order to test EKH, many income indices have been used such as Gross Domestic Product (GDP), agriculture share in GDP, and industry share in GDP (Kebede et al., 2010). Moreover, there are some environmental indices, applied in this kind of research, including air pollution, such as CO2 (He and Richard 2010; Saboori et al., 2012; Taghvaee and Shirazi 2014), NO2 emissions (Roca et al., 2001), water pollution, such as Biological Oxygen Demand (BOD) (Taghvaee and Shirazi 2014), and deforestation (koop and tole, 1999; Taghvaee and Shirazi 2014). All the above-mentioned indices are examined in various models, including panel models (Farhani et al., 2014), pooled models (Iwata et al., 2011), simultaneous equation models (Junyi Shen, 2006) and time series models (Fodha and Zaghdoud, 2010; Taghvaee and Shirazi 2014). There are numerous researchers who employ time series models to avoid heterogeneous effects of heterogenic countries.

## 2. The model and Data

Following Qi et al. (2011), Ahmed and Long (2012), Boluk and Mert (2014), Katz (2014), Onafowora and Owoye (2014), Taghvaee and Shirazi (2014), CO2 emission can depend on economic growth and population structure. In contrast with the previous studies, in this study, economic growth splits into two various sectors: 1. Value added in manufacturing and mining 2. Value added in services. In order to test the none-linear relationship between environmental pollution and economic growth (EKC hypothesis) square and cubic value added in the sectors are applied in the specification as follows:

$$CO_t = f(x_t, x_t^2, x_t^3, ru), \qquad x = m, s \qquad (1)$$

where CO is per capita Carbon Dioxide emission, x per capita value added in various economic sectors in Rial of Iran, ru rural population percentage, t the year, m the value added in manufacturing and mining, and s the value added in services.

We transform the linear model into a log-linear one because it allows us to check EKC hypothesis. In addition, log-linear models produce more consistent and efficient results, compared with linear ones. Thus the log-linear model is as follows:

$$LCO_t = \alpha_0 + \alpha_1 Lx_t + \alpha_2 Lx_t^2 + \alpha_3 Lx_t^3 + \alpha_4 Lru_t + dr + u_t \quad (2)$$

where L refers to natural logarithm, dr dummy variable for the years before the Iran revolution in 1979, u error term, and $\alpha$ parameter.

In this study, per capita CO emission (metric tons) is derived from World Development Indicator (WDI). Per capita value added in an economic sector is the total value added in the corresponding sector divided by the total population. Value added in manufacture (and mining) and services (Rial of Iran), total population and rural population percentage are obtained from the economic time series database of the Economic Research and Policy Department of Iran. The dummy variable, dr, is one for the years before 1979, when the Iran revolution occurred, and is zero for the later years.

## 2.1. Bounds tests

We employ the Auto-Regressive Distributed Model (ARDL) proposed by Pesaran et al. (2001) to examine the long run equilibrium relationship between CO2 emission and economic growth because it has several advantages. Regardless of the stationary degree of the variables, ARDL estimates the long run parameters (Pesaran and Shin, 1999; Pesaran et al., 2001). Moreover, the long run estimators of the model are super-consistent in small samples.

In order for investigating cointegration by the above-mentioned bounds test, the equation 2 is reformed as follows:

$$\Delta LCO_t = \delta_1 + \beta_1 LCO_{t-1} + \beta_2 Lx_{t-1} + \beta_3 Lx^2{}_{t-1} + \beta_4 Lx^3{}_{t-1} + \beta_5 ru_{t-1} + \sum_{i=1}^{n} \theta_{1i} \Delta CO_{t-i} + \sum_{i=1}^{n} \theta_{2i} \Delta x_{t-i} + \sum_{i=1}^{n} \theta_{3i} \Delta x^2{}_{t-i} + \sum_{i=1}^{n} \theta_{4i} \Delta x^3{}_{t-i} + \sum_{i=1}^{n} \theta_{5i} \Delta ru_{t-i} + \epsilon_t \quad (3)$$

where Δ is the first difference operator and ε is the white noise error term which satisfy the classical properties. It is the estimated F-statistics which shows whether the null hypothesis below, implying the existence of long-run relationship, can be accepted or not.

$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$

$H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$

where i=1,2,…,5

With regard to the critical F-statistics values in Pesaran (2001), there are two critical bounds, lower and higher. The null hypothesis can be accepted if the F-statistic is under the lower critical bound (no cointegration, irrespective of whether the variable is I(0) or I(1)); and it can be rejected if it is over the upper one (cointegration, irrespective of whether the variable is I(0) or I(1)). In case it hovers within the bounds, the results are decisive. Before the bounds test, a unit root test should be carried out owing to the fact that the variables are assumed to be either I(0) or I(1). If the integration order of any variable is 2 or more, the F-statistic is invalid.

**2.2. Long-run relationship**

So as to display the long-run relationship between the CO2 emissions and the value added in the two economic sectors, the equation 2 is scattered on a plot, using the estimated coefficients. Firstly, the equation is run and the coefficients are estimated. Then, their stability is checked by cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). Subsequently, the equation 2 is scattered on a plot, using the estimated and stable coefficients. It shows the relationship between environmental pollution and growth in the economic sector. It is the relationship which reveals how intensive the environmental pollution of the economic sector is. The steeper is the slope of the relationship; the more pollutant is the economic sector, implying lower insufficiency and higher investment in more energy-wasting parts.

**3. Results**

Table 1 shows the Augmented Dickey Fuller and Dickey Fuller statistics. According to the figures, the integration orders of the variables were less than two, implying the reliability of the F-statistic prepared by Pesaran et al. (2001) for the bounds testing approach. This approach was employed to test the existence of long run relationship. To examine the null hypothesis of no-cointegration, the equation 1 was run via Ordinary Least Squares (OLS) method. Then the F-statistic for the joint significance of the lagged levels of variables was estimated to compare with the critical values prepared by Pesaran et al. (2001). The bounds test results are presented in table 2, implying the acceptance of long run relationship.

**Table 1: Unit root tests**

| **Variable** | **ADF** | | | |
|---|---|---|---|---|
| | **Level** | **Optimal Lag** | **First difference** | **Optimal Lag** |
| LCO | -1.7484 | 0 | -5.5907* | 0 |
| Lm | -1.4980 | 0 | -5.8138* | 0 |
| Lm2 | -1.2182 | 2 | -3.3001* | 2 |
| Lm3 | -1.0514 | 2 | -3.3333* | 2 |
| Ls | -2.1923 | 1 | -3.8438* | 0 |
| Ls2 | -2.1408 | 0 | -2.9349* | 2 |
| Ls3 | -2.0414 | 0 | -2.9542* | 2 |
| Lru | -0.9506 | 1 | -2.0031** | 2 |

Notes: The optimal lag is based on Schwartz-Bayesian Criteria (SBC).
* Rejection of the null hypothesis at the 5% significance levels.
** Rejection of the null hypothesis at the 10% significance levels.

**Table 2: Bounds tests co-integration test results**

| **Dependent variable DLCO** | | | |
|---|---|---|---|
| **Models** | **F-statistic** | **Critical bounds at 1%** | |
| | | **Lower bound I(0)** | **Upper bound I(1)** |
| Manufacturing and mining | 14.03*** | 3.516 | 4.781 |
| Services | 13.34*** | 3.516 | 4.781 |

*** Statistical significance at 1% level.

With regard to the table 3, Fig 1, Fig 2, Fig 3, and Fig4, both the models are satisfactory. The diagnostic tests results in the table 3 show that they passed the Breusch-Godfrey LM test (serial correlation), the ARCH test (heteroskedasticity), and the Jarque-Bra test (normality). Besides, all the plots, either CUSUM or CUSUMSQ, depict that the estimated regressions maintained the stability of the coefficients through the sample course. Therefore, the long run model is statistically reliable.

**Table 3: Diagnostic tests statistics**

| | **Manufacturing and mining** | **Services** |
|---|---|---|
| Serial correlation | 0.91906<br>(0.338) | 0.012313<br>(0.912) |
| Functional form | 0.13115<br>(0.717) | 1.4773<br>(0.224) |
| Normality | 0.057788<br>(0.972) | 1.2159<br>(0.544) |
| Heteroscedasticity | 0.19660<br>(0.657) | 0.7822E-4<br>(0.993) |

**Table 4: Long run relationship in manufacturing and mining model.**

| Variables | Coefficient | t-statistic | Prob. |
|---|---|---|---|
| Lm | 65.9399 | 3.8897 | 0.000 |
| Lm2 | -4.7807 | -3.7608 | 0.000 |
| Lm3 | 0.11580 | 3.6504 | 0.001 |
| Lru | -1.6420 | -11.7069 | 0.000 |
| Constant | -296.2893 | -3.9395 | 0.000 |
| Dr | 0.4964 | 13.4281 | 0.000 |

**Table 5: Long run relationship in services model.**

| Variables | Coefficient | t-statistic | Prob. |
|---|---|---|---|
| Ls | 298.4774 | 3.3021 | 0.002 |
| Ls2 | -20.2755 | -3.2356 | 0.002 |
| Ls3 | 0.45932 | 3.1736 | 0.003 |
| Lru | -1.8288 | -21.5339 | 0.000 |
| Constant | -1457.1 | -3.3534 | 0.002 |
| Dr | 0.46041 | 10.9466 | 0.000 |

Table 4 and 5 present the long run estimated coefficients for both sectors. They accept the EKC since, in either sector, are the signs of coefficients not only in accordance with the hypothesis but also they are statistically significant. Moreover, rural population coefficients were negative and statistically significant, implying an opposite nexus between that and CO2 emissions.

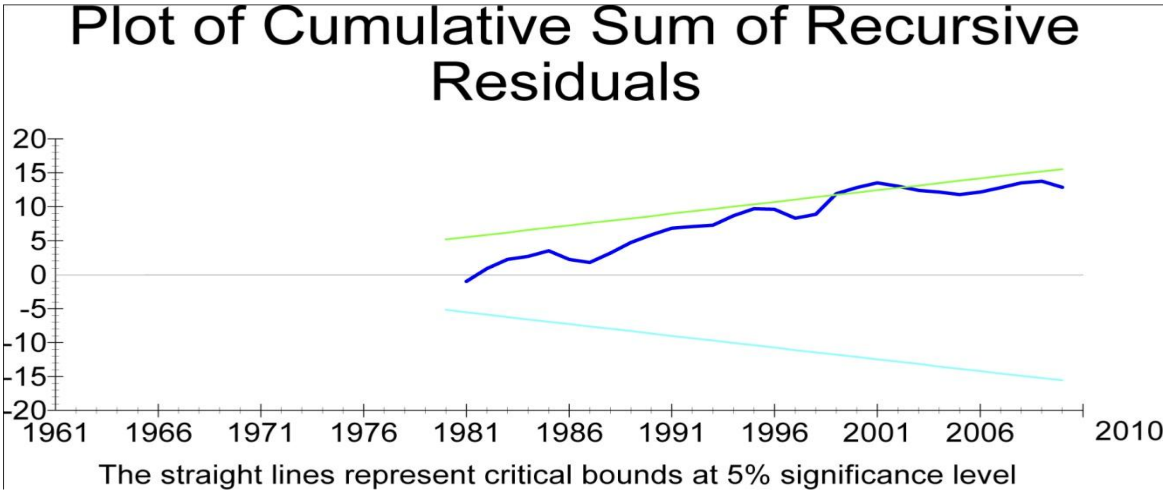


**Fig. 1: Plot of CUSUM test for the manufacturing and mining equation.**

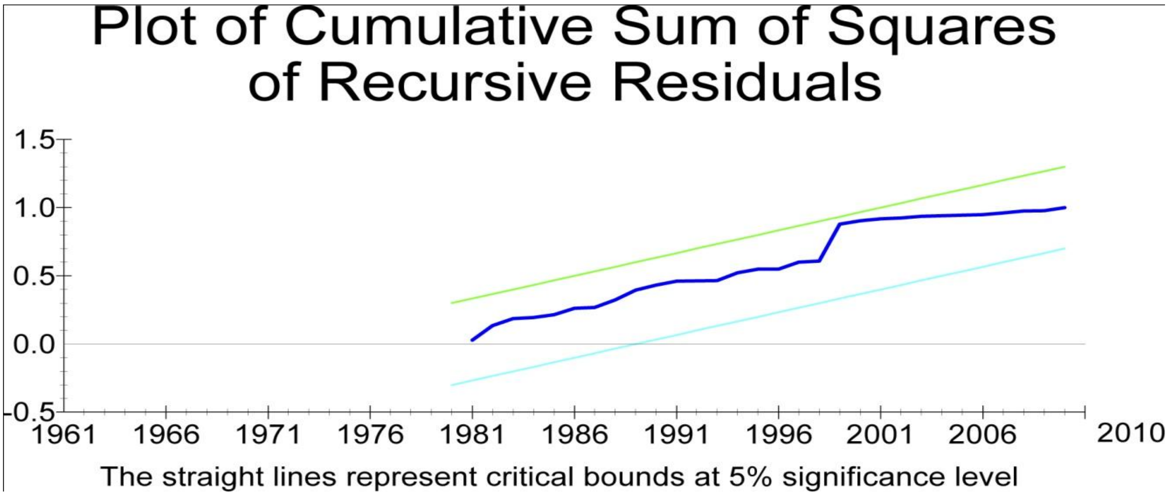


**Fig. 2: Plot of CUSUM of squares test for the manufacturing and mining equation.**

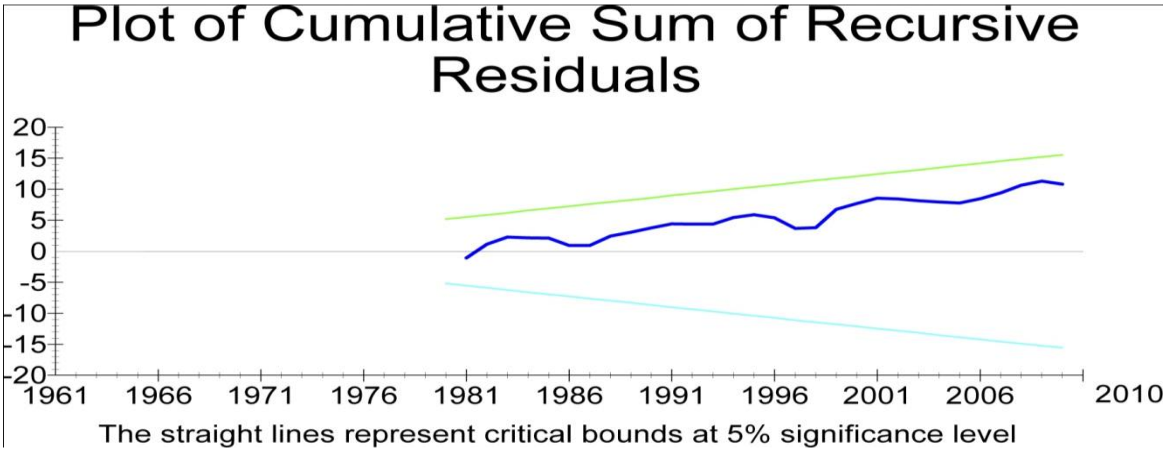


**Fig. 3. plot of CUSUM test for the services equation.**

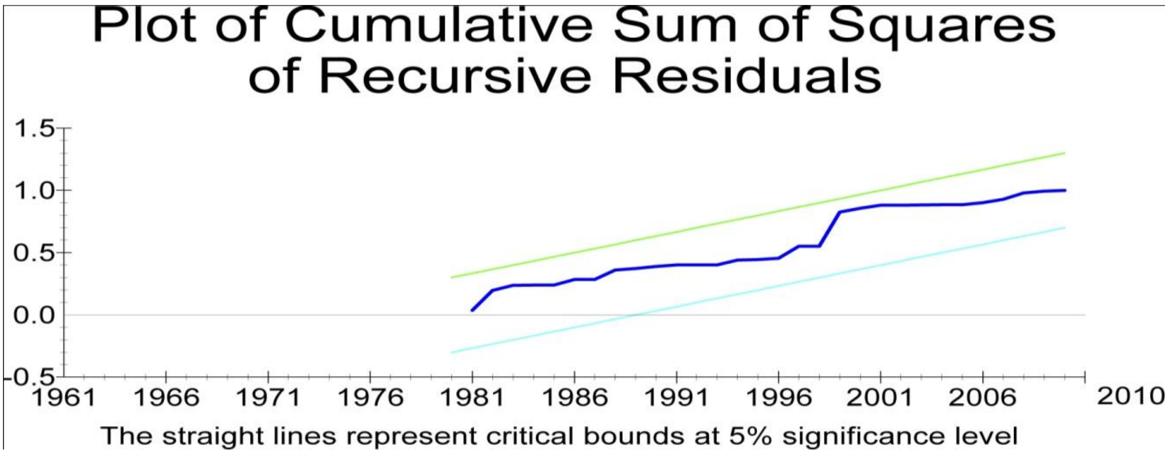


**Fig. 4: Plot of CUSUM of squares test for the services equation.**

Fig 5 and 6 present the scatter plot of the estimated CO2 emissions on the value added in both economic sectors, revealing N-shaped relationships. Clearly, a N-shaped relationship involves three phases: two phases with positive relationships at the start and the end; one negative relationship in the middle. As it can be seen in the right-end of the scatters, more increment of economic growth in each sector raises the slope of the spotted lines. The sharper is the slope, the more positively-intensive is the relationship between CO2 emissions and economic growth. So expanding the economic growth in each sector increases not only the value of CO2 emissions but also the acceleration rate, implying inefficiency in the infrastructure of manufacturing (and mining) and services.

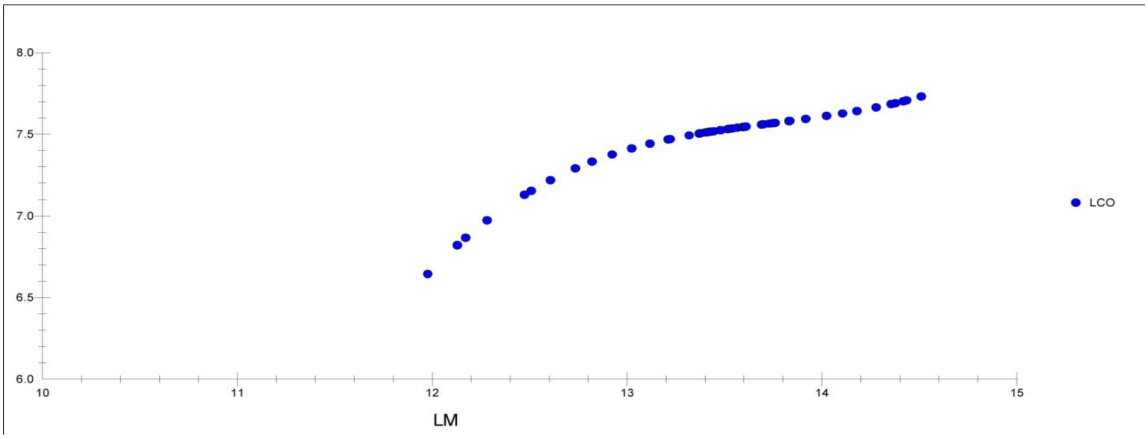


**Fig. 5: Scatter plot of the estimated CO2 emissions on manufacturing and mining value added.**

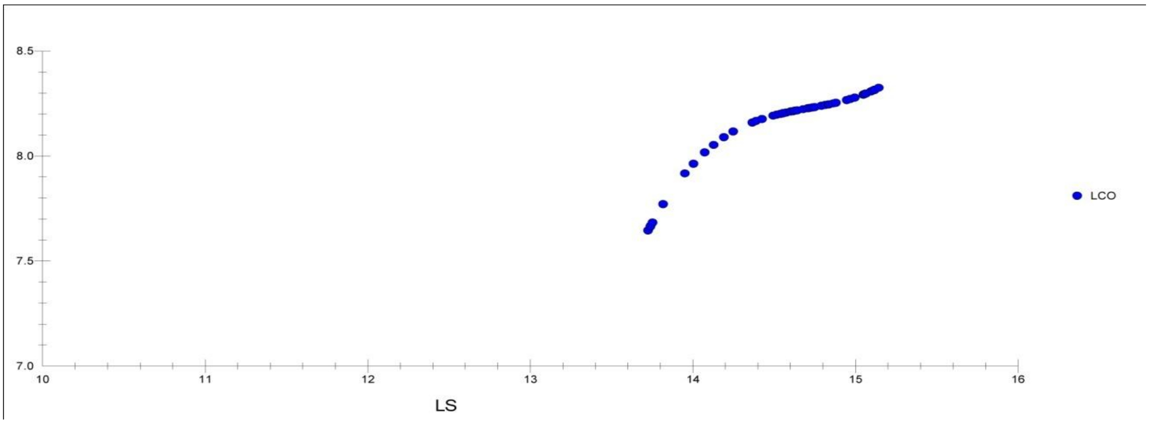


**Fig. 6: Scatter plot of the estimated CO2 emissions on services value added.**

## 4. Conclusion

Manufacturing (and mining) and services infrastructures in Iran should be reconstructed, rather than the growth of the available pollutant and intensive-energy-using frameworks. Regarding EKC, the nexus of CO2 emissions and economic growth in either side is in a sharply ascending phase. It implies that not only cannot the economic growth in the sectors slow down the air pollution but also it speeds up that. This positive relationship is for two main culprits. The first one is the intensive-energy-using framework and the second one is the negligible share of clean energies. Both the causes are discussed below.

Manufacturing (and mining) and services systems are extremely energy-consuming. The more growth in the sectors, the more polluted the environment. The manufacturing and mining sector, on the one hand, includes many factories with old and inefficient plants. Compared with more advanced technologies, they require considerably more amount of energy to provide a certain volume of goods. In other words, these manufacturers are wasting assets. Services sector, on the other hand, entails transportation system which, in turn, goes hand in hand with pollutant kinds of energies especially fossil fuels. Undeniably, transportation system burns more fuel to make a growth in the mentioned sector. It escalates the pollution. To tackle this problem, more energy-saving machines should be utilized by importing more efficient technologies and developing domestic innovation. Thus, environment will degrade, if either sector inflates because both of them are energy-inefficient.

Both the sectors consume the sorts of energy which are more pollutant. Take fossil fuels for example, it is used more than the other kinds of energy due to the huge stock in Iran, despite the fact that they are more pollutant. Clearly, transition from pollutant to clean economic activities is another approach to save the environment. Each sector includes many subsectors with various degree of pollution among which the cleaner ones should be grown. Unbalanced distribution of growth in minor subsectors may enlarge the pollutant activities, compared with the cleaner ones. The policy makers can redistribute it to expand the environmentally-friendly activities. For instance, the growth of banking and tourism, as subsectors of services, is an economic policy to reverse the pollutant economic section into a clean one. Moreover, importing cleaner technologies and evolving home creations of green–energy-using plants are the other solutions for the predicament in manufacturing and mining section.

With regard to the above-mentioned facts, if manufacturing (and mining) and services sectors inflate, the quality of environment will decline owing to the intensive and pollutant energy-using structures. They should be reconstructed by importing new technologies and developing internal inventions. For the future studies, the relationship between environmental pollution, on the one hand, and trade and R&D expenditure, on the other hand, should be analyzed to find the most effective solution.

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