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Estimation Carbon Rent in the Cement Industry of Iran: Abatement Advantage under Paris Agreement
(Experience-based on European Union Emissions Trading System)

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Abstract

The present study aims to determine how cement industry profit is affected by considering conditions of implementation of the Paris Agreement. It also aims to determine factors affecting pollution and reduced pollution caused by cement production. In order to achieve these goals, the case study of Iran has been investigated during 2011-2013 using logarithmic mean Divisia index (LMDI). By estimating experimental model, the results represented that environmental pollutions caused by the manufacturing industry can be reduced using new technologies, and alternative fuels. Results also indicate seven factors in the decomposition for pollution emission, including the activity effect, the clinker trade effect, the The clinker share effect, The fuel mix effect, The thermal and electrical energy efficiency effect, and the electricity carbon emission factor effect. We can make distinction between the first two effects that are options for non-technical pollution reduction and other effects that are options for technical pollution reduction. Additionally, results suggest that cement companies of Iran have not created surplus quota and they have not surplus production and profit. This indicate that, unlike European countries that have surplus quota and profit or carbon rent, Iran does not have it, since surplus production quota generated freely has not been generated to lead increased income and wealth creation.

Keywords: Cement Industry, Log Mean Divisia Index (LMDI), Pollution, Making Paris Agreement.

JEL Classification: L61, C49, Q53, F53.

1. Introduction

The cement entrperises of Iran form subclass of Iranian non-metal mineral industry. Iran began to produce cement officially with the inauguration of the first cement factory in 1934 with a capacity of 100 tons within a signle day. Henceforth, the level of production grew and became 58.7 million tons in 2015. TIranian metropolices (such as Tehran, Mashad, Tabriz or Isfahan etc.) are very polluted. Vast capacity of cement production has put Iran among the world's top

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fifteen countries for cement production (Portal of Iran's Cement I, May 2010). In fact, rise of production capacity has become a major concern in Iran's cement industry over the recent years (Ostad-Ahmad-Ghorabi & Attari, 2013).

Production of cement undergoes the following stages:

1. Providing raw materials (mixing/homogenizing, grinding and preheating)
2. Burning of them to shape cement clinker in the kiln,
3. Grinding of clinker and mixing with additives.

Global climate has changed and become warmer majorly because of greenhouse gas (GHG) emissions related to energy use. Industries are the cause of 28.3% of world final energy use and 38.5% of CO2 emissions in 2012. The non-metallic minerals industry is the third-largest industrial energy user, which is the reason of almost 12% of the world use of industrial energy, the majority of which can be because of the cement industry. In 2012, the cement enterprises used almost 8.5% of overall industrial energy and accounted for 34% of the industrial direct CO2 production (Huang, Chang, & Fleiter, 2016).

After 2005, cement emission in Europe has been covered by the European Union Emission Trading Scheme (EU ETS), known as Europe's flagship policy to deal with climate turnover (Branger et al, 2013)

The analysis of index decomposition starts with characterizing a governing function relating the overall to be broken down to a variety of previously defined reasons of interest. As the governing function is characterized, a variety of decomposition techniques may be generated to measure the effect of variation of these factors overall. An LMDI (Log Mean Divisia Index) decomposition (Ang, 2004) of emissions was carried out given cement Production in Iran. We estimate the effect of seven factors on emission changes, which is relevant to various mitigation levers: activity, clinker trade, clinker share, alternative fuel use, thermal and electricity efficacy , and decarbonisation of electricity. This investigation let us recognize the major forces behind variations in aggregated carbon emissions, in Iran's cements factories as a whole. A distinction can be made between the first two impacts (activity and clinker trade) which produce non-technological abatement and the rest that produce technological abatement.

2. Methodology

So far the emission abatement options have been set forth qualitatively or according to simple indices. Quantifying their relevant contribution in the growth of cement CO_2 emissions needs

A decomposition method that will be illustrated in the next part.

Decomposition of carbon emissions because of cement production From now on, C means emissions, Q is for quantities and E stands for energy use.

$Q_{Clinker,t}^{PROD}$ should be distinguished. It is the quantity of clinker generated at ear t and $NI_{Clinker.t}$that is the quantity of clinker employed in real for cement production.

International trade is the distinguishing point between the two (we ignore stock changes):

$$Q^{NET}_{Clinker,t} = Q^{PROD}_{Clinker} + NI_{Clinker.t} \tag{1}$$

$Q^{PROD}_{Clinker,t}$ Is the net imports of clinker. We divide emissions into 3 groups: emissions caused by combustion of fuels (subscript F), process emissions (subscript P) and indirect emissions caused by electricity
Use (subscript E):

$$C_t = C_{F,t} + C_{P,t} + C_{E,t} \tag{2}$$

First, emissions caused by fuel combustion, $C_{F,t}$, can be decomposed as follows:

$$C_{F,t} = Q_{Cement,t} \frac{Q^{NET}_{Clinker,t}}{Q_{Cement,t}} \frac{Q^{PROD}_{Clinker,t}}{Q^{NET}_{Clinker,t}} \frac{E_{T,Clinker,t}}{Q^{PROD}_{Clinker,t}} \frac{C_{F,t}}{E_{T,Clinker,t}}$$
$$= Q_{Cement,t} \times R_t \times H_t \times I_{T,t} \times CEF_{F,t} \tag{3}$$

Where $E_{T,clinker,t}$ is the employed thermal energy; R_t the clinker-to-cement ratio; H_t is the clinker home production ratio ($H_t > 1$ in case additional clinker is generated than used, or, in other words, if the aggregate imports are negative); I_T, is the intensity of thermal energy (in GJ per ton of clinker), and $CEF_{F,t}$ is the carbon intensity of the fuel mix (in tCO_2/GJ). The formula for process emissions $C_{P,t}$ is:

$$C_{P,t} = Q_{Cement,t} \frac{Q^{NET}_{Clinker,t}}{Q_{Cement,t}} \frac{Q^{PROD}_{Clinker,t}}{Q^{NET}_{Clinker,t}} \frac{C_{P.t}}{Q^{PROD}_{Clinker,t}}$$
$$= Q_{Cement,t} \times R_t \times H_t \times CEF_{pro} \tag{4}$$

Where CEF_{pro} is the CO_2 emission index for the calcination of limestone that is known as time invariant, no information on its change.
The formulation for $C_{E,t}$ is:

$$C_{E,t} = Q_{Cement,t} \frac{E_{E,t}}{Q_{Cement,t}} \frac{C_{E,t}}{E_{E,t}}$$
$$= Q_{Cement,t} \times I_{EI,t} \times CEF_{elec,t} \tag{5}$$

Where $E_{T,clinker,t}$ is the electricity employed; $I_{El,t}$ is the electricity intensity of production (in MWh per ton of cement) and $CEF_{elec,t}$ is the electrical energy emission index (in tCO2/MWh).

Overall emissions of cement production are then:

$$C_t = Q_{Cement,t} \times (R_t \times H_t \times \left(CEF_{pro} + I_{T,t} \times CEF_{F,t}\right) + I_{EI,t} \times CEF_{elec,t} \tag{6}$$

Abatement levers are more observable in this formula which is consisted only of positive terms: in addition to decreasing activity (reducing $Q_{\text{cement,t}}$) or outsourcing clinker (reducing H_t), technological abatement methods are decreasing R_t (clinker replacement), $CEF_{F,t}$ (alternative fuel use), $I_{T,t}$ and $I_{EI,t}$ (thermal energy and electricity efficacy), and decreasing $CEF_{elec,t}$ (decarbonisation of electrical energy) (Branger & Quirion, 2015).
H_t and $Q_{Cement,t}$ are produced indirectly by estimation.

$$Q_{Clinker,t}^{PROD} = \frac{C_{EUTL}}{CEF_{pro} + I_{E,t} \times CEF_{F,t}} = \frac{C_{EUTL,t}}{C_k CI_t} \tag{7}$$

Where $C_k CI_t$ is the clinker carbon intensity. Then H_t is given by:

$$H_t = \frac{Q_{Clinker,t}^{PROD}}{Q_{Clinker,t}^{PROD} + NI_{Clinker,t}} \tag{8}$$

Where $NI_{Clinker,t}$ and $Q_{Cement,t}$ are produced:

$$Q_{Cement,t} = \frac{Q_{Clinker,t}^{PROD} + NI_{Clinker,t}}{R_t} \tag{9}$$

The overall formula of LMDI (Ang, 2005) is as follows When emissions can be decomposed as $C_t = X^1 \times X^2 \times \ldots \times X^n$ the change of emissions $\Delta^{tot} = C_T - C_0$ can be decomposed as $\Delta^{tot} = \Delta^1 + \Delta^2 + \ldots + \Delta^n$, with

$$\Delta^k = \frac{C_T - C_0}{\ln C_T - \ln C_0} \times \ln \frac{X_t^k}{X_0^k} \tag{10}$$

$$\begin{aligned} \Delta^{tot} &= C_T - C_0 \\ &= \Delta^{act-F} + \Delta^{sha-F} + \Delta^{tra-F} + \Delta^{fmix} + \Delta^{eff-F} + \Delta^{act-P} + \Delta^{sha-P} + \Delta^{tra-P} \\ &\qquad + \Delta^{act-E} + \Delta^{eff-E} + \Delta^{elec} \\ &= \Delta^{act} + \Delta^{sha} + \Delta^{tra} + \Delta^{fmix} + \Delta^{eff-F} + \Delta^{eff-E} + \Delta^{elec} \end{aligned} \tag{11}$$

Carrying out the proper categorization:

$$\begin{aligned} \Delta^{act} &= \Delta^{act-F} + \Delta^{act-P} + \Delta^{act-E} \\ \Delta^{tra} &= \Delta^{tra-F} + \Delta^{tra-P} \\ \Delta^{sha} &= \Delta^{sha-F} + \Delta^{sha-P} \end{aligned} \tag{12}$$

Seven factors exist in the decomposition:

The activity impact (Δ^{act}): effect of overall cement production on Emission changes.

The clinker trade impact (Δ^{tra}): effect of the clinker trade on emission Changes.

The clinker share impact (Δ^{sha}): effect of clinker replacement on emission changes.

The fuel mix impact (Δ^{fmix}): effect of the employment of replacement fuel on Emission changes. •

The thermal energy and electricity efficacy impact (Δ^{eff-F} *and* Δ^{eff-E}):

Effect of thermal energy and electricity efficacy.

The electrical energy carbon emission factor impact (Δ^{elec}): carbon emission factor effect on emission changes (Branger & Quirion, 2015).

3. Results

The impact of electrical efficiency, the effect of clinker trade, the effect of clinker's share, the effect of the carbon emission factor, the impact of combined fuel are the same in the current situation and the implementation of the Paris agreement, and the only difference is its coefficients. The effect of the total changes on the implementation of the Paris agreement was negative in all three, but in the current situation, the effect of total changes in the period of 2012-2011 has been positive and in the other two periods negative. Furthermore, the effect of the activity is negative in the current situation (2012-2013), but positive in two other periods, with the difference that in the implementation of the Paris agreement, this effect is negative in the period of 2011-2012, and in the other two periods, it is positive. The positive effect of activity is due to increased cement production, which results in increased activity in the construction industry.

In all three periods, clinker outsourcing and underground activities that are obtained through the overall impact of the clinker business and activities are positive. They were 1051.32407 million tons during 2011-2012, and 1644.07521 during the period of 2012-2013, and 6550/02901 in the period of 2011-2013, which means an effective factor in reducing carbon pollution, and it consequently reduces the pollution. However, the impact of technology, which is the result of a combination of other effects, has been negative, and its values were 4158.46218 million tons for the period 2011-2012, -3233.95968 during the period 2012-2013, and -19782.08308 during the period 2011-2013.

Furthermore, sine when the quotas given to cement companies are higher than the emissions that are needed to produce a real amount of cement, a surplus of quota will be generated. However, the reverse has happened here and the resulted values are negative. This indicates that given the production of Iranian cement companies, no surplus has been created, and ultimately no production surplus and profit have been gained. This shows that, contrary to the cement industries of the European countries that have surplus Quotas and profits - in other words, carbon rent, in Iran there is no carbon rent because the free production surplus quota is not created, leading to more revenue and creation of wealth for the cement industry.

4. Conclusions and suggestions

This study aimed to evaluate the calculation of carbon rent in the cement industry of Iran, considering the reduction of pollution in terms of implementing the agreement of Paris in the period 2011-2013. The results indicate that the total cement production in this period increased and the rate of fossil fuel release increased as well, which contributed to environmental pollution. Indirect emissions from electricity consumed in cement production were also growing. In general, to compare the three emissions from which whole cement production is obtained, process emissions play a smaller role. The results of the research indicate that by comparing the actual cement production in the reference year, the amount of imports and the surplus of the quota will be determined. With the increase of these two values, it will be possible to find that more sales and profits are obtained. Because when the import is positive and there is a great sum of the quota, the sale of these products could increase profits and improve the prosperity of the economy, yet with the mere difference that the results of this study indicate that the comparison between these two values was negative and the numbers were 03107.13811, -1589.88446 and -13232.05407, which indicates that the production of Iranian cement companies with the existing technology had no quotas surplus, and ultimately there was no production and profit surplus. This has led more pollution, and the long-term goal of the Paris climate agreement is not met.

The factors that influence pollution are divided to 7 decomposition factors for emission, which are as follows: activity impact (the impact of producing cement on emission changes), clinker business impact (the impact of clinker business on emission changes), clinker share impact (the impact of replacing clinker on emission changes), combined fuel impact (the impact of alternative fuel on emission changes), electrical and thermal efficiency impact and the effect of carbon emission (the impact of electricity carbon emission on emission). Given the findings, it can be concluded that the impact of technology provides the surplus share ratio impact from technological performance, and the impact of clinker business and activity gives the surplus share ratio impact from clinker outsourcing and underground activity.

Excessive allocation is defined as the sum of the impact of the clinker business and activity. This allocation can be seen as the difference between the actual allocation and the output-oriented allocation based on current clinker production with a certain level of technology. It is selected based on current clinker production with a certain level of technology and the reference state. When production is less than the equivalent production of $Q_{Cement}^{A_t}$ limit, the net import is positive, which can be observed in light of the above tables, and the effect of clinker business and activity, which is a ratio of surplus quota due to outsourcing clinker and underground activity, is positive. Pollution reduction options, in addition to being technologic, are one of the solutions for use of alternative fuels, which reduces fossil fuel consumption and pollution. Furthermore, increasing the efficiency of electric and thermal energy and reducing the intensity of carbon electricity can reduce the emissions. Based on the results of the research, the following policies are recommended:

1. Based on the results, one way of reducing the pollution is the new technologies that reduce the consumption of fossil fuels and hence the

pollution. It is suggested that we make market incentives for investing in novel methods for reducing the emissions.

2. According to the results of the production of Iranian cement companies, no surplus has been created and, as a result, no production and profit surpluses existed. As a result, energy efficiency has not been increased. Therefore, it is suggested that, by encouraging the cement industry to use clean technologies, we can increase energy efficiency and create a surplus of quotas, which as a result leads to the reduction of pollution, more sales, and ultimately more benefit for the producers.

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