How productive countries must become to achieve their goals INDCs on climate change?

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1. Introduction

As signed in Paris on December 2015, the agreement on climate change aims to hold the increase in the global average temperature to well below 2°C above the pre-industrial levels and to enhance efforts to limit the temperature increase to 1.5°C above pre-industrial levels both mainly through the reduction of CO2 emissions. In parallel, one of the targets of Sustainable Development Goals (SDGs) is to integrate climate change measures into national policies, strategies and planning.

One of the ways to achieve these goals is by promoting and following the submissions of the Intended Nationally Determined Contributions (INDCs) where each country determine CO2 emission reductions in the context of their national priorities, circumstances and capabilities in a global framework that drives to collective actions towards a low carbon future.

On the other hand, INDCs imply meaningful economic challenges for countries, especially for middle income countries that are facing their goals through a reduction of their emissions and are looking to increase their production. In this context, the measurement of productive performance is a key tool to design future economic and public policies in order to achieve both objectives: the reduction in emissions and the well economic performance for the wellness of their citizens.

The objective of this paper is to generate novel data on total factor productivity (TFP) related to energy-emissions and the accomplishment of INDCs countries. To accomplish this purpose, I am planning to follow three steps: First, using the framework of growth accounting methodology, a panel data model will be estimated showing the statistical significance of energy-emissions contribution to the output growth. Second, I two TFP indicators will be developed. a) Traditional TFP indicator and b) the total factor productivity with energy-emissions (TFP-E) indicator in order to measure productivity associate with CO2 emissions by country. Third, I will estimate the required rate of growth of TFP-E for the accomplishments of INDCs goals until 2030 year stablished by Paris agreement like the peak of emissions.

These novel indicators were estimated using the following databases in the range of 1960 to 2014: i) for INDCs goals we used the repository of United Nations; ii) total emissions of CO2 were obtained from World Bank statistics and iii) economic statistics like output, labor and capital would be obtained from the Penn World Table database version 9.0.

Results show two groups of countries in the sample: 1) countries with historical rates of productivity below from the required rate to achieve their own INDCs-targets and 2) Countries that based in its historical rate of productivity will achieve their INDC-goals. In average for the first group, growth rate of productivity is 1.53% per year until 2030, these means yearly 1.02 percent points greater than the historical average growth (0.51%). These is a significant effort to introduce new technology and innovation for those countries at the same time of limiting or reducing emissions.

This research contributes data through indicators for monitoring the implementation of SDGs in the public policy agenda of the countries in the context of social inclusive economic growth. Furthermore, an application of economic theory and empirical evidence regarding the INDCs commitment of the countries and productivity performance would constitute a key input for public policy design.

The following sections present a discussion about the relevance of Paris Agreement. Section 3 links the climate change agreements and the INDCs targets to the economic challenges that each country must to face. Section 4 presents the econometric strategy of estimating shares of energy on the aggregate function plus the results of the measure of TFP-E and the gap with historical performance by country. The importance and relevance of SDG indicators are presented with the proposed measure and finally we present some conclusion and possible extensions.

2. Paris Agreement and INDCs

The evidence on climate international agreements shows complexities and difficulties without significant results. The latest Conference of the Parties (COP) in Paris broke in a long story of failed attempts to find an agreement for action in climate change discussion for three main reasons: i) it changed the scope of Kyoto Protocol agreement, ii) through the Intended Nationally Determined Contributions (INDCs) established universal targets for the countries and iii) revealed and required environmental, social and economic actions for its implementation in a determined range of time.

Primarily, Kyoto Protocol in 1997 was the first international agreement to reduce the greenhouse-gas emissions (GHG) that contribute to the climate change in the world. It recognized the first stablished distinction between developed and developing countries previously defined in COP 1 in Berlin 1995 based in the principle "common but differentiated responsabilities and respective capabilities" (UNFCCC, 1992). Paris Agreement (PA) changed significantly that distinction taking into account previous efforts like the COP in Durban, establishing that the new commitment would be *applicable to all Parties (Countries).* In order to materialize this new approach, countries were required[1] to present their INDCs until the end of COP 21 in Paris.

Secondly, another achievement of PA was the delivery of 162 INDCs submissions[2] covering 161 countries plus a single submission of European Union representing 28 members. Emissions of this group were estimated around 95% emissions, excluding land use, in 2010; this represents 98% of global population. The commitments of INDCs

[1] http://unfccc.int/focus/indc_portal/items/8766.php

[2] In http://www4.unfccc.int/submissions/INDC/Submission%20Pages/submissions.aspx until 07/26/2016 was registered 189 countries considering that European Union conformed by 28 countries including yet United Kingdom

in terms of CO2 equivalent emissions reductions until 2030 were classified in four groups as follows: 1) 41 countries do not have an emissions reduction target; 2) 28 countries that compromise a target only under conditional support[3]; 3) 60 countries compromise targets of emissions reductions unconditionally and 4) 60 countries present both targets (conditional or unconditional) according the materialization of additional international support like shows figure N°1. According to Article 4 of PA each country shall update its INDC every 5 years.

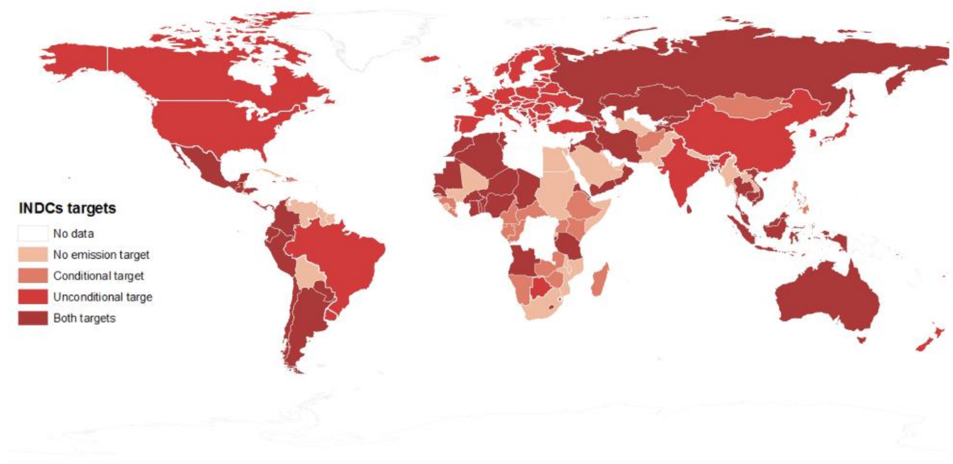

Figure 1: type of emissions reductions target in INDCs around the World

Thirdly, PA also inserted their objectives in the sense of sustainable development mainly because of the challenges in environmental, social and economic perspective. An example of this is the requirement to hold the increase of global average temperature recognizing that this would significantly reduce the risks and impacts of Climate Change. Furthermore, social and economic challenges are also implied in the agreement, looking to increase the ability to adapt and foster climate resilience, making finance flows consistent with pathways towards low GHG emissions.

In sum, we can infer that this agreement is an important landmark for the future climate change policy. Nevertheless, it incites policymakers to work on continuity and transparency values in their liabilities expressed in INDCs for the future and even more significantly, the need to take into account broad and specific economic challenges in the global economy and each country..

3. Economic challenges

Sustainable development, following the discussion presented in (Anand and Sen 2000), represents broad economic challenges. One of those challenges is to identify in the global commons problem and its relation with the own country targets declared in INDCs. On the top of that, macroeconomic impacts and fiscal policy actions, globally and for each country, would be demanded to accomplish those commitments. Consequently, the role of total factor productivity (PTF) in each country is crucial in order to have a

[3] The Conditional target is defined in function of international financial cooperation

measure in the assessment of the evolution of technology progress looking forward those goals.

Following Harrison and Lagunoff (2016), the global commons problem, in the case of GHG emissions, impose costs in country´s economy through its effects on climate. Hence, a global agreement requires the participations of most of the countries in order to set a global target of reductions with individual contributions or quota. The INDCs represents a case when those targets that each country assumes to achieve looking forward a global target. In this paper we are interested to determine if that quota is achievable in function of historical and projected macroeconomic analysis of each country.

In Farid et al (2016), under a scenario of 3°C increase of temperature the macroeconomic impacts to the global economy would be around 2% of GDP. The increase of temperatures would impact market sectors like agriculture, forestry, coastal real state and tourism; while non market impacts are also expected like ecosystem disruption, health damages and water stress. The authors identify also risks for developing countries and their ability to adapt to a new climate. It could be inferred that under assumptions of economic growth in the following decades capital, employment and consumption of energy (with CO2 eq. emissions) would determine the macroeconomic policy agenda in each country.

As well as macroeconomic impacts, INDCs would promote the main action from fiscal policy. Pricing carbon through taxes, fixing prices or even fixing quantities, have a broad range of combinations and implications as stated in Kaplow (2010). Furthermore, Farid et al (2016) considerer that the environmentally effective and the significant raising of revenues are two advantages that fiscal policies have over regulatory approaches. From a mitigation perspective, the practical issue is choosing and designing the policy instrument that best suited for implementing countries INDCs. Nonetheless, regulatory or fiscal policies must be conceived in the framework of an efficient and productive context for the countries; in this regard the natural link is founded whit the role of TFP.

4. Productivity and Empirical Approach

Following the discussion presented above, the role of TFP in the accomplishment of INDCs is the main purpose of this paper. Total factor productivity or technical change following the seminal paper Solow (1957) is defined like the difference between output and the contributions of productive factor like capital and labor. In other words TFP could be understood like the “measure of our ignorance” Abramovitz (1956).

The theory framework presented in Barro and Sala i Martin (2004) allows us to present a traditional Solow’s residual estimating like:

$$Y = AF(K, L) \tag{1}$$

Where Y is the aggregate output, K is physical capital, L is labor and A es the technological progress. Then, growth of TFP is defined as:

$$\frac{\dot{A}}{A} = \left(\frac{\dot{Y}}{Y}\right) - s_K\left(\frac{\dot{K}}{K}\right) - s_L\left(\frac{\dot{L}}{L}\right) \tag{2}$$

Furthermore, s_K and s_L are the shares of capital and labor in output. Both aggregated equals to 1 denoting constant returns of scale under competitive conditions. In order to achieve our goal linking the emission targets with economic growth through a measure of productivity, we will introduce another productive factor defined as energy-emissions consumption.

Following the theoretical framework of Xapapadeas (2005) and the empirical strategy of Tzouvelekas, Vouvaki and Xapapadeas (2007), this paper will contribute an additional approach bringing evidence for a larger sample of countries and a new econometric strategy for three measures of energy-emissions variables.

Aware of the discussion in Hassler, Krusell and Olovsson (2016), the aggregate output in presence of a third factor is:

$$Y_t \equiv F(A_t K_t^{\alpha} L_t^{1-\alpha}, A_t^X X_t) \quad (3)$$

Where X is defined like the effective input of energy-emissions; α is equal to s_K in equation (2); A_t^X is the input augmenting technical change related to energy-emissions variable. Then, a flexible functional form could be defined as:

$$y_t = \left[(1-\varphi)(A_t k_t^{\alpha})^{\frac{\theta-1}{\theta}} + \varphi(A_t^X x_t)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \quad (4)$$

In (4)[4] all variables are presented in terms of employment: aggregate output $y = Y/L$, capital $k = K/L$ and energy-emissions $x = X/L$. φ is a share parameter, θ is the elasticity of substitution between capital/labor and energy-emission. These approaches facilitate the differentiation between a perfect substitutes Cobb-Douglas composite and energy-emissions when $\theta = \infty$ and perfects complements, when $\theta = 0$ implying a Leontief function. For this paper we will assume that $\theta = 1$ in that sense our function is a Cobb Douglas for all input arguments.

If we express (4) in terms of (2) technical progress now would be expressed as:

$$\omega = \frac{\dot{y}}{y} - \alpha\frac{\dot{k}}{k} - s_x\frac{\dot{x}}{x} \quad (5)$$

Where $\omega = A_t + A_t^X$ denotes the total factor productivity with energy-emission (TFP-E) and $s_x$is the share of the energy-emission participation in the output. At this point our main objective is to estimate equation (5) with data for the 162 INDCs submissions obtaining shares of the productive factor and explaining the productive with energy-emissions productivity. For this propose it is necessary to implement an econometric strategy taking advantage of the heterogeneity of countries during the time to obtain a robust coefficients for TFP-E measure.

[4] If we want to see directly the interaction of employment as another productive factor of output, the equation is: $Y_t = \left[(1-\varphi)(A_t K_t^{\alpha} L_t^{1-\alpha})^{\frac{\theta-1}{\theta}} + \varphi(A_t^X X_t)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$

Econometric strategy

The best econometric method in order to estimate the coefficients related to our previous discussion is using cross section information and time series together, this method is known as panel data or longitudinal data. Regressions using this method can capture variations over countries and variations over time.

Rewriting equation (4) we obtain:

$$Y_{it} = A_{it}K_{it}^{a_1}L_{it}^{a_2}\left(A_{it}^{X}X_{it}\right)^{a_3} \quad (6)$$

Moreover, the function to be estimated taking (6) is:

$$\ln(Y_{it}) = \beta + \Lambda t + a_1 ln(K_{it}) + a_2 ln(L_{it}) + a_3 \ln(X_{it}) + \delta_i + \gamma_t + \mu_{it} \quad (7)$$

In the previous equation, $\Lambda t = \left[ln(A_{it}) + a_3 ln\left(A_{it}^{X}\right)\right]t$ that represents our interest variables of technical progress defined before like TFP-E. Then, $\ln(Y_{it})$ is the logarithm of real GDP for countries $i = 1, \dots, n$ and time periods$t = 1, \dots, T$. Likewise, $ln(K_{it})$ and $ln(L_{it})$ are logarithm of real stock of capital and labor that is measured by number of employees respectively. Variables $\ln(X_{it})$ is the energy-emissions variable and will change in three specifications as follows: Firstly, we will work with CO2 equivalent (kt) emissions following Tzouvelekas, Vouvaki and Xapapadeas (2007); secondly, we will estimate a second model using the Energy Use (kg of oil equivalent) and thirdly, we replace the energy use by only Fossil Fuel energy consumption (kg of oil equivalent) over the same countries and time periods, with δ_i denoting country specific fixed effects and γ_t representing heterogeneous country specific deterministic trends. Is important to mention that slope coefficients $\{a_1, a_2, a_3\}$ represents directly the shares of each input in the output function. Finally, term $\mu_{it} = \delta z_{it} + e_{it}$, where δz_{it} is a vector of unobserved common shocks and e_{it} is the individual specific normal distributed error.

Data

The dataset is an unbalanced panel containing 163 from 189 countries with INDCs compromises covering 50 years since 1964 to 2014. Macroeconomic variables like GDP, stock of capital and employment comes from Penn World Table version 9.0 dataset, CO2 emissions and the two types of energy consumption (Fossil fuel and Energy use) comes from World Bank Indicator dataset.

Table 1: Countries by region and income

	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan africa	**Countries by Income**
High income: nonOECD	2	5	8	7			2	**24**
High income: OECD	4	24	1	1	2			**32**
Low income	1		1			1	22	**25**
Lower middle income	4	6	4	4		5	13	**36**
Upper middle income	5	12	16	6		1	6	**46**
Countries by Region	**16**	**47**	**30**	**18**	**2**	**7**	**43**	**163**

In table 1 is represented the distribution of countries around the globe. Practically, all the continents are represented. Regarding the distributional income level we use the

World Bank criteria finding in average 32 countries by income category. Remaining 26 countries[5] from the complete list of INDC's were omitted because of lack of information in one of the two datasets used to build this sample.

Table 2: Variables description

Variable	Variation	Mean	Std. Dev.	Min	Max	Observations
t	overall	1989	17.09	1964	2014	N = 8313
Years	between		0.00	1989	1989	n = 163
	within		17.09	1964	2014	T = 51
t_average10	overall	4	1.71	1	6	N = 978
Average 10 years	between		0.00	3.5	3.5	n = 163
	within		1.71	1	6	T = 6
i	overall	82	47.08	1	163	N = 978
Countries	between		47.20	1	163	n = 163
	within		0.00	82	82	T = 6
Population	overall	33.33	121.77	0.04	1369.4	N = 877
Millons	between		111.89	0.05	1082.3	n = 163
	within		32.61	0.05	458.5	T-bar = 5
ln(GDP)	overall	10.39	2.25	5.19	16.6	N = 877
Millons od real US$ PPP	between		2.13	5.70	15.8	n = 163
	within		0.64	8.23	13.2	T-bar = 5
ln(K)	overall	11.43	2.31	5.62	17.7	N = 876
Millons od real US$ PPP	between		2.16	6.92	17.0	n = 163
	within		0.75	8.72	14.8	T-bar = 5
ln(L)	overall	0.86	1.83	-3.69	6.2	N = 790
Thousands	between		1.84	-3.67	5.6	n = 161
	within		0.38	-0.94	2.6	T-bar = 5
ln(CO2)	overall	8.75	2.72	1.30	15.8	N = 892
CO2 emissions (kt)	between		2.56	3.47	15.3	n = 163
	within		0.86	2.25	12.1	T-bar = 5
ln(Fossil Fuel)	overall	8.93	2.00	4.48	14.5	N = 603
Millones de Kg of oil eq	between		1.90	5.24	14.3	n = 126
	within		0.59	5.95	11.2	T-bar = 5
ln(Energy Use)	overall	9.01	2.17	2.88	14.7	N = 674
Millones de Kg of oil eq	between		2.26	3.23	14.4	n = 150
	within		0.51	5.98	11.2	T-bar = 4
INDCs targets	overall	2.83	1.08	1	4	N = 978
Target categories	between		1.08	1	4	n = 163
	within		0.00	3	3	T = 6
INDCs submissions	overall	67.25	48.23	1	162	N = 978
Number of submissions	between		48.35	1	162	n = 163
	within		0.00	67	67	T = 6
WB Regional	overall	3.83	2.18	1	7	N = 978
Number of regions	between		2.19	1	7	n = 163
	within		0.00	4	4	T = 6
WB Income	overall	3.29	1.43	1	5	N = 978
Number of categories	between		1.44	1	5	n = 163
	within		0.00	3	3	T = 6

Table 2 presents descriptive statistics of the dataset, variation over time and countries captured with statistics of within and between variance respectively. Analyzing the data, most of the variation around the macroeconomic and energy-emissions data

[5] The 26 countries omitted from the sample because of lack of information are: Afghanistan, Andorra, Congo, Cook Islands, Cuba, Eritrea, Federated States of Micronesia, Guinea, Guyana, Ivory Coast, Kiribati, Laos, Liechtenstein, Marshall Islands, Monaco, Nauru, Niue, Palau, Samoa, San Marino, Solomon Islands, Somalia, South Sudan, Tonga, Tuvalu and Vanatu.

comes from between effects justifying at first a sight fixed effects (FE) by countries in the econometric estimation. Now we are interested to see the statistical distribution characteristics of the variables.

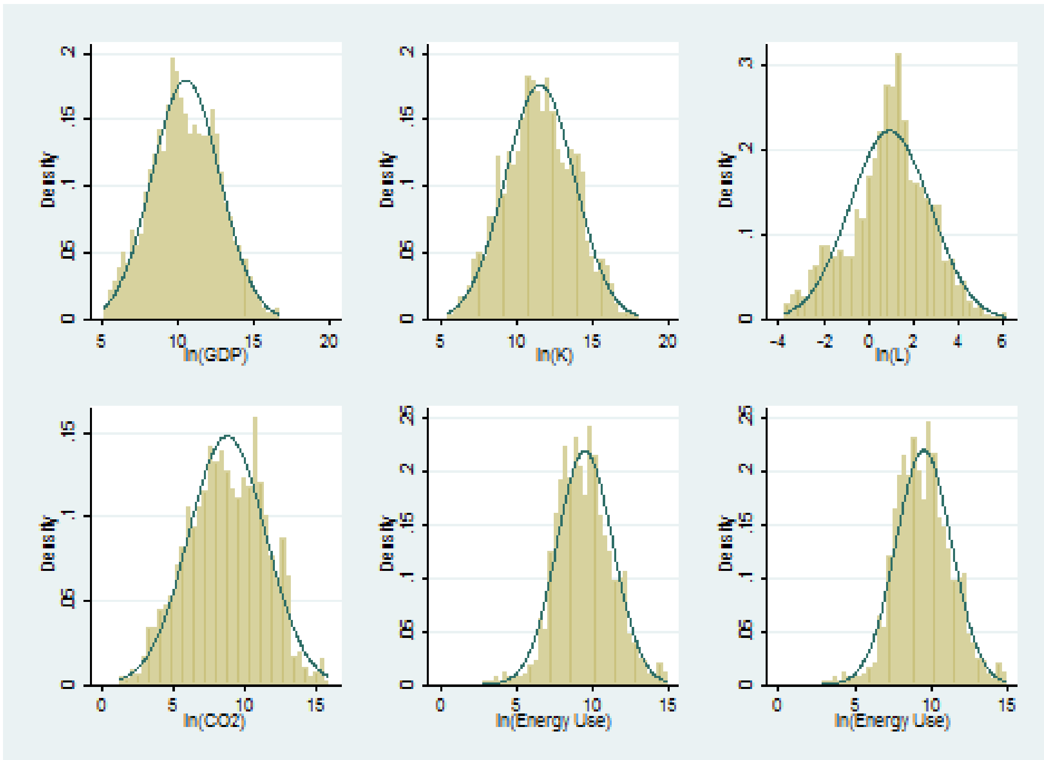

Figure 2: Normal distribution of variables in the model

In figure 2 all variables has a normal distribution verifying desirable characteristics for the model. Now we are interested to see the correlation between explanatory variables and the depended variable. In macroeconomics is well known the direct relations between GDP and macroeconomic variables like capital and labor moreover we are interested to prove the empirical relation between the output and CO2 emissions, Fossil Fuel energy and Use of Energy.

A first approach to significance and empiric relation of the model is obtained looking to the correlation coefficient. In figure 3, we present the linear correlation between output with macroeconomic and energy-emissions variables. As we expected before, output with capital and labor has a direct relation 95% and 77%. Apart from that, output with energy variables are positive correlated too, 94% with Use of energy and 93% with Fossil Fuel energy. The correlation between output and CO2 emission is 93%. Additionally, we present re relation between Fossil Fuel energy and CO2 emission, the intuition for this is the introduction of Fossil Fuel energy as part of the output production function with CO2 emissions like an instrumental variable in order to correct for endogeneity. The correlation between both variables is 99%

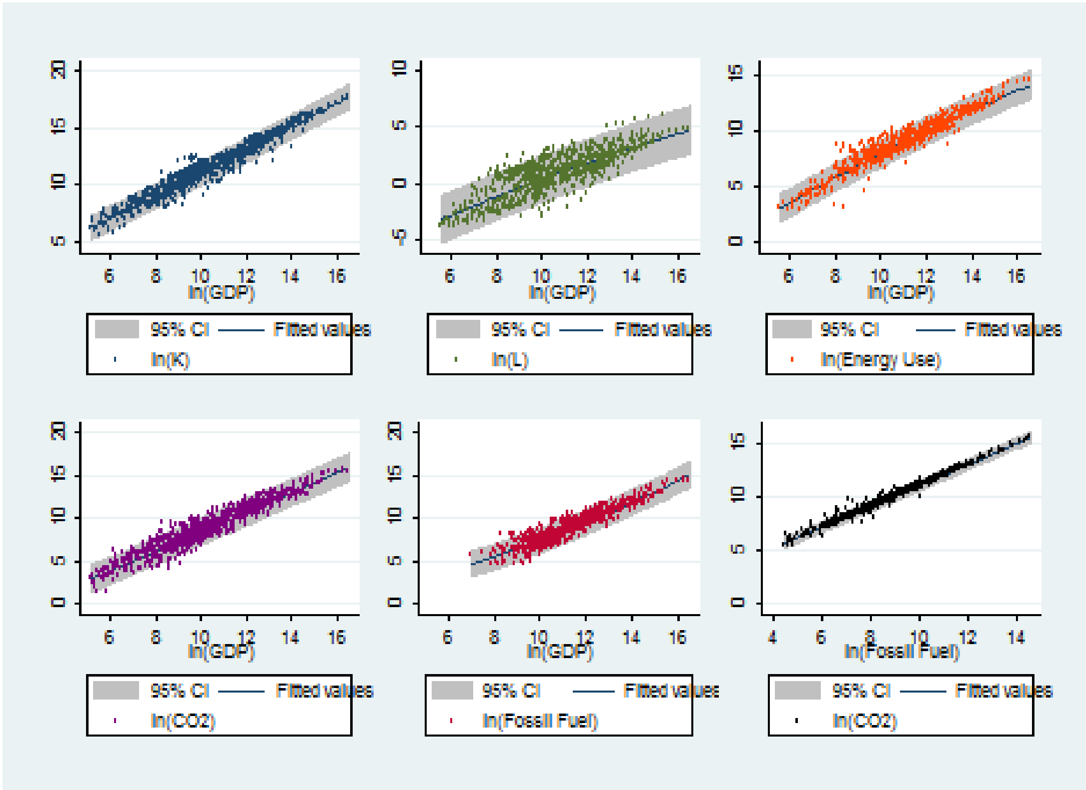

Figure 3: Lineal correlations of variables

Determining shares factors input in the production function

In order to estimate the TFP-E in (5), we present our results in Table 3 and Table 4. The main idea of these exercises is to estimate robust and consistent shares for factor productivity inputs and then calculate TFP-E using growth accounting. First, Table 3 presents a lineal regression panel data with fixed effects of logarithm of output and input factors.

Column (1) in Table 3, presents the traditional two factors capital and employment presenting the expected sing and are statistically significant at 99% with robust standard errors. The functional form of our equation allows us the direct interpretation of the coefficients as the shares in the production function. In the case of capital, its share is 66.8% and labor is 34.3%. Furthermore we cannot reject the null hypothesis of constant returns of scale testing it with a F-test (p-value) at 95.4%

Columns (2), (3) and (4) of Table 3 show results of the introduction of a third productive factor input defined above like the energy-emission variable. Firstly column (2), additionally to capital and labor, Fossil Fuel energy is statistically significant at 90% with the expected sign. Similarly to results in column (1) we cannot reject the null hypothesis of constant returns of scale testing the sum of the three inputs with a F-test (p-value) at 22.4%.

It is important to remember that the intuition to introduce Fossil Fuel energy consumption in the production function allow us to establish a link between aggregate production and share that represent in the final output. Results indicate that the growth of consumption of Fossil Fuel represents 8.6% of the GDP in average in our sample.

Table 3: Fixed Effects Panel Data regression 1964 to 2014 (ten years averages)

Variables	(1) Ln(Y)	(2) Ln(Y)	(3) Ln(Y)	(4) Ln(Y)
Ln(K)	0.668***	0.641***	0.628***	0.607***
	(0.0353)	(0.0480)	(0.0481)	(0.0388)
Ln(L)	0.343***	0.224***	0.211***	0.250***
	(0.0599)	(0.0743)	(0.0696)	(0.0620)
Ln(F)		0.0862*		
		(0.0442)		
Ln(U)			0.119**	
			(0.0469)	
Ln(CO2)				0.129***
				(0.0324)
Constant	2.542***	2.349***	2.145***	2.162***
	(0.372)	(0.463)	(0.444)	(0.360)
Observations	790	581	646	777
R-squared	0.923	0.918	0.958	0.927
Number of Countries	161	125	148	161
Heteroskedasticity	Robust	Robust	Robust	Robust
F test (p-value)	0.000	0.000	0.000	0.000
F test (p-value) (Ho: Constant returns)	0.754	0.224	0.278	0.700
FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results in columns (3) and (4) show the importance of the consumption of use energy in the balances of energies of the countries and the significance of the CO2 emissions in the production function. Regarding the Use of Energy it presents the expected sign and is statistically significant at 95%, its share in the production function is 11.9% higher than the share of Fossil fuels consumption. At first sight, it is an expected result because it includes the contribution of hydropower energy, nuclear energy and biomass energy. Besides, CO2 emission share in column (4) represents 12.9% of the output and is statistically significant at 99%. This result is comparable to the result obtained in Tzouvelekas, Vouvaki and Xapapadeas (2007). Both columns (3) and (4) cannot reject the null hypothesis of constant returns of scale testing the sum of the three inputs with a F-test (p-value) at 27.4% and 70% respectively.

Like another exercise of robustness of our first results, we present in Table 4, the dynamic approach of the previous output function estimation. For this purpose and trying to correct for time autocorrelation and endogeneity we estimate a general method of moments (GMM) system. Taking this strategy our main goal is to obtain a consistent relation between output and our inputs in the long term.

Econometric models presented in Table 4 shows that in the short term, variables expressed in differences, all the specifications have the expected direction and are statistically significant.

Table 4: Output determinants. Estimation Panel Data regression system GMM 1964 to 2014 (ten years averages)

Variables	(1) Ln(Y)	(2) Ln(Y)	(3) Ln(Y)	(4) Ln(Y)
Ln(K(t-1))	0.677***	0.673***	0.634***	0.687***
	(0.0443)	(0.0555)	(0.0552)	(0.0609)
Ln(L(t-1))	0.321***	0.322***	0.234***	0.358***
	(0.0808)	(0.0734)	(0.0807)	(0.0648)
Ln(F(t-1))		0.0198		
		(0.0608)		
Ln(U(t-1))			0.130*	
			(0.0701)	
Ln(CO2(t-1))				-0.00617
				(0.0601)
Dln(K)	0.744***	0.678***	0.714***	0.697***
	(0.0553)	(0.0991)	(0.0894)	(0.103)
Dln(L)	0.617***	0.429***	0.375**	0.498***
	(0.138)	(0.155)	(0.146)	(0.136)
Dln(F)		0.171***		
		(0.0592)		
Dln(U)			0.249***	
			(0.0759)	
Dln(CO2)				0.136**
				(0.0547)
Observations	468	327	347	347
Number of id	158	121	139	139
Country FE	YES	YES	YES	YES
Hansen Test	0.06	0.49	0.92	0.76
Intruments	36	50	50	50
Arellano Bond AR(1)	0.493	0.617	0.780	0.465
Arellano Bond AR(2)	0.982	0.847	0.828	0.937

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Furthermore, variables in lags and levels represent the relations of long term between inputs and output. Comparing results presented in column (1) in both Table 3 and Table 4 we confirm that shares of capital and labor are 67.7% and 32.1% almost the same in both approaches. Taking the results of Hansen-test for instrumental variables we cannot reject the validity of the instruments for endogeneity and, at the same time we cannot reject the hypothesis of no serial autocorrelation in first and second order as defines the Arellano Bond-test. In other words, all the statistics showed that we found a stable long term relation between GDP and capital-labor function.

In contrast, Fossil Fuel energy consumption and CO2 emissions are not statistically significant in the long term in spite to present the expected sign in the case of Fossil Fuel and a wrong direction in CO2 emissions coefficients. Apart from that, column (3) shows the expected direction of variables and the statistically significance of all variables, From that we can confirm that the share of energy use in the production function for countries that presented INDCs compromise are 13% of the aggregated product. This result also presents the validity in the instrumental variable using for endogeneity and does not reject the hypothesis of absence of serial autocorrelation in first and second order.

TFP and TFP-E estimation

Already justified and estimated shares of inputs productive factors in the previous section, now we can calculate the traditional a-la Solow TFP and the proposed measure of TFP-E both constitutes the principal objective of this paper.

Rewriting equation (5) and adding the numerical results found in Table 4 we obtain

$$gTFP_{it} = gGDP_{it} - (0.677gK_{it} + 0.321gL_{it}) \quad (8)$$

Where $gTFP_{it}$ is the rate of growth of TFP of the country "i" in the year "t" that is equal to the rate of growth of its GDP minus the sum of the participation of capital and labor for every year. It is important to remember that those shares represent the average of the model in a potential scenario.

Additionally the expression that incorporate the energy variables in equation is:

$$gTFP - E_{it} = gGDP_{it} - (0.634gK_{it} + 0.234gL_{it} + .130gEnergyUse_{it}) \quad (9)$$

Taking equations (8) and (9) we obtain the following figure comparing average growth of GDP and the average growth of TFP and TFP-E by country in the period of 1970 and 2014.

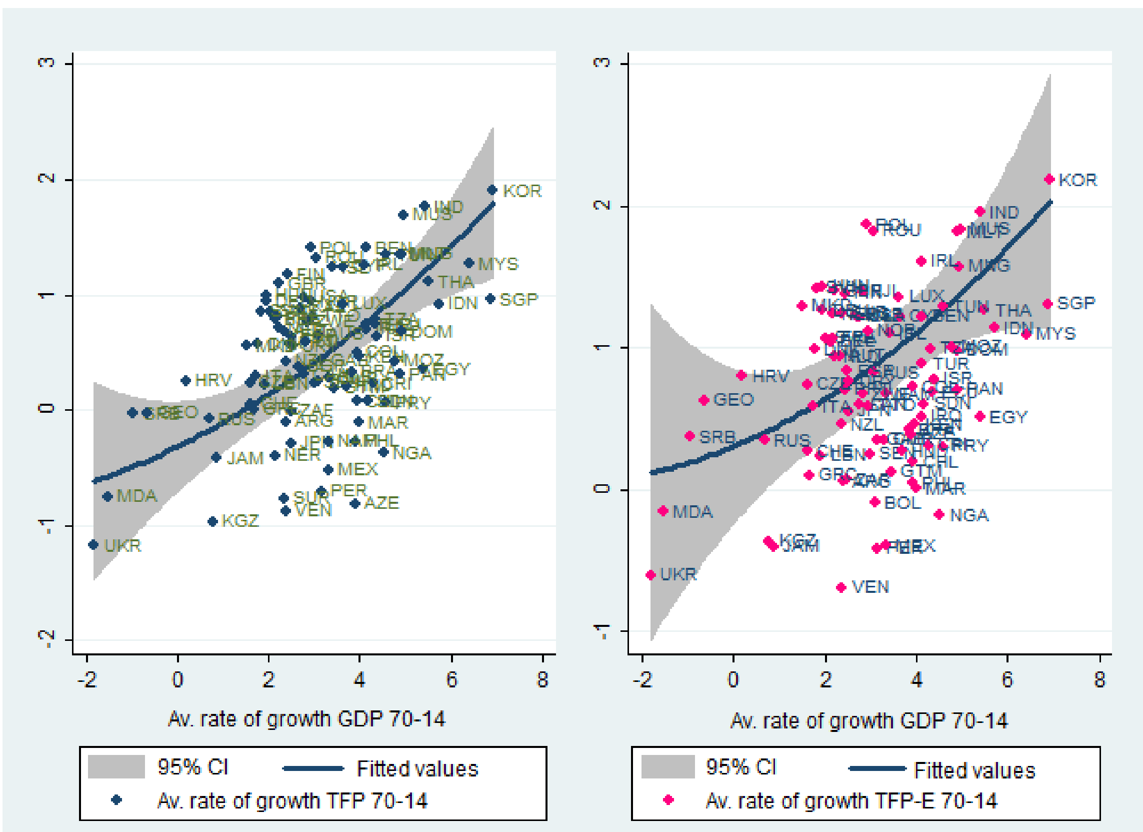

Figure 4: Average growth of TFP & TFP-E with GDP growth by country

From figure 4 it is easy to appreciate that the relation between output growth and productivity is direct. Growth in long term is determined by the technical progress and one of the contributions of this paper is that we found the participation of energy use in this process.

Productivity and INDCs targets

At this point, we will build a quantitative exercise in order to determine the gap that countries must accelerate their efforts achieving higher rates of productivity in accordance with their INDCs reductions of CO2 emissions targets. This exercise is conducted as follows.

First, we obtain historical growth performance of macroeconomic and energy variables in the period of 1970 to 2014. We calculated the average rate of growth from Figure 3 and Figure 4 and we set with this information the base line until 2030, year that most countries have like the top of their commitments.

Second, we obtain macroeconomic projections from the World Economic Outlook (FMI) until 2021 and we follow the last rate of growth until 2030. The intuition of this assumption is that in the long term economies growth at their potential rate. Assumptions for capital and labor are made in base of the econometric result obtained above.

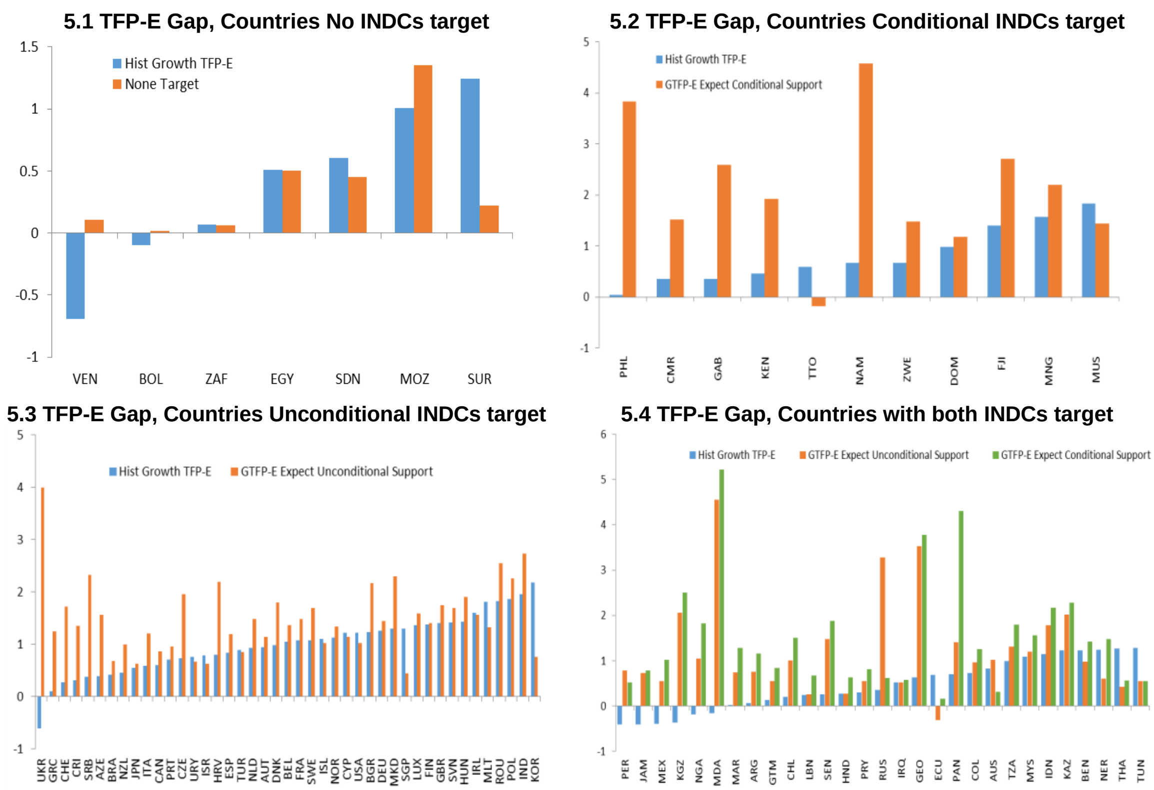

Figure 5: Historical TFP-E growth and expected rate to accomplish INDCs target until 2030 by country

Third, growth rate of CO2 emissions is calculated conditional to each target and the relations with Energy Use. One of the key objectives to introduce energy in the production function is that technological substitution is covered by the performance of TFP-E, as we defined in equation (3) and (5). In the following figures we present the gaps for the four INDCs categories for 90 of 163 countries from previous analyses

We compared the historical growth of TFP-E and the expected technical progress required to achieve the INDCs target. Countries with negative gap, challenges themselves imposing pressure on rates of productivity. Countries with positive gap stablished INDCs goals observing their historical performance. We can infer that latest ones are in a better position to achieve their commitments.

In sum, figure 5 presents the result of the exercise. In general, 75,6% of the countries present a negative gap between their historical rate of technical progress and their expectation of productivity performance, conditional to their expected rate of GDP growth and their commitment of INDCs reduction CO2 emissions target. In average the rate of growth of TFP-E for this group is 1.53% by year until 2030. This result means a gap of 1.03 percent points higher that the historical rate (0.50%).

The rest of the countries, 24.4% sign their commitments in concordance with their historical technical progress, and conditional to their macroeconomic and technical progress, they would achieve with no problems their targets.

5. The complementarity of SDG's and TFP-E

As we defined at the beginning of the discussion, the productivity is the measure of our ignorance. Trying to close this lack of definition we analysis the correlation of TFP-E and the novel SDG composed index.

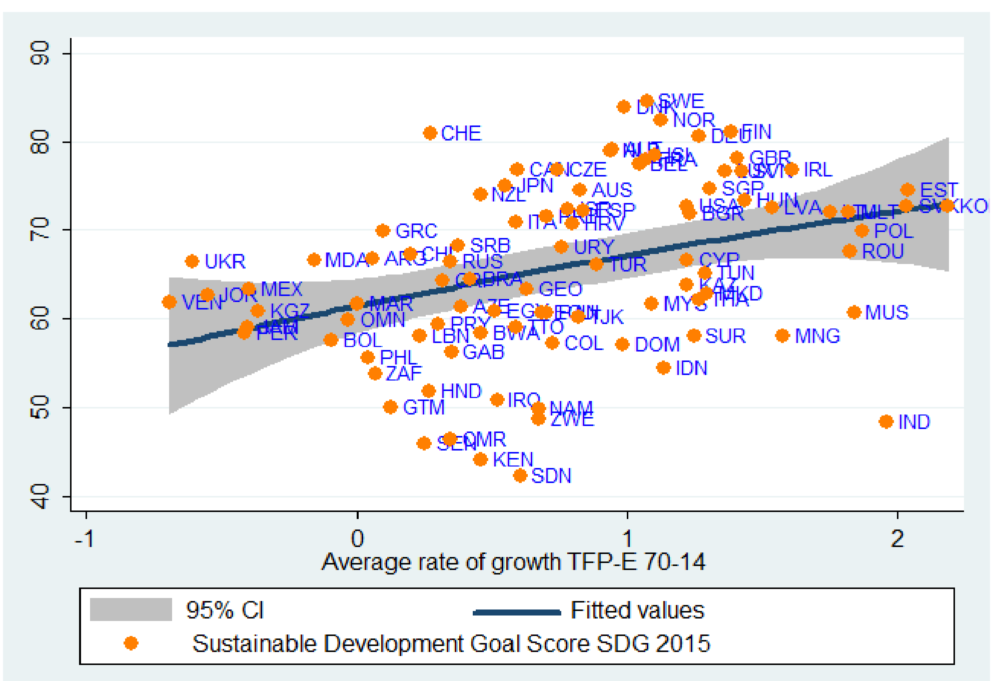

Figure 6: Average TFP-E growth 70-14 and SDG score 2015

Certainly SDG's index is presented for first time, but in the future these indicators that cover 17 goals definitely would be a good source of productivity analysis. In figure 6 we can appreciate that the relation of TFP-E and a highest score in the SDG are positive correlated and indicates the relation in both directions.

6. Conclusions

This paper presented the total factor productivity with energy-emissions (TFP-E) estimation for 163 of 189 countries that committed to achieved INDCs targets in the recent signed Paris Agreement on climate change. For this propose, three main contributions were discussed: First, an econometric strategy estimation was applied obtaining consistent and stables input shares for productive factors of production. Second, TFP-E indicator was calculated combining shares estimated and historical time series of macroeconomic and energy-emissions variables. And Third this paper calculated the require gap between the historical average TFP-E performance with the expected growth of TFP-E under assumptions of economic growth and CO2 reduction emissions. Finally, a brief comment was made regarding SDGs score indicator and its complementarity with productivity approach.

The econometric strategy presented to alternative panel data models. The fixed effects model showing that capital share varies from 60.7% to 66.8% in average; and labor share could vary between 21.1% and 34.3%. Additionally, when energy-emission variable is introduced, the corresponding share varies from 8.6% to 12.9%. On the top of that, the second panel data model using a GMM system estimation showed that for traditional two input function shares were 67.7%(K) and 32.1%(L) both in the range previously founded; what is more, when energy-emissions is introduce only the use of energy has good properties to found a stable long term relation with shares 63.4%(K), 23.3%(L) and 13.0(E). These results emerged after the verification of statistical significance of variables used in other studies.

TFP-E estimation shows that this measurement follows the traditional TFP a-la Solow indicator. Main differences emerge because of the importance of the energy use. Results in this paper were built for each country taking as a benchmark the average general share calculated in the econometric section plus the individual labor shares obtaining the capital share as a residual under, this is possible because of the verified assumption that constant returns of scale were present.

The third evidence contribution of this paper showed that 75.6% of the countries need to focus their efforts trying to increase significant their TFP-E growth rates, in average 1.03 percent points in order to accomplish their own INDCs announced target. Independent of the type of INDCs committed, only 24.4% of the countries stablished a plausible target based in their historical productive rate of growth.

Finally, the positive relation between SDGs score by country and TFP-E measure is verify implying that efforts in a broad sense of sustainability is required not only to aims to hold the increase in the global average temperature, but also taking care of other environmental, social and economic goals in order to guarantee a global sustainability development.

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