

Pollution, renewable energy sources and unemployment: evaluating the presence of an environmental trilemma

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ABSTRACT

In advanced economies, the greatest obstacle to achieving the objective of reducing pollution is represented by the potential negative effects on employment. The paper aims at evaluating if the objective of reducing pollution causes job losses rendering the process of transition toward a green economy less desirable. These issues can be presented in the form of a "trilemma" or in the form of an exchange of three alternatives in the use of polluting energy sources, renewable energy sources and unemployment. It describes how pollution reduction, the use of renewable energy sources and unemployment combine together so that a rise in one trilemma variable should be traded-off with a drop of the weighted sum of the other two. The results of the investigation on 12 Eurozone countries from 2004 to 2016 validate the existence of the "trilemma" suggesting that unemployment resulting from plant dismissal can be offset through the increase in the alternative of renewable energy sources.

Keywords: Pollution, Environment, Unemployment, Trilemma, Panel data

Mathematics Subject Classification: 91B76, 62P20,

Journal of Economic Literature (JEL) Classification : Q50, Q52, C23.

1. INTRODUCTION

The issue of the environmental protection is at the centre stage of the political and economic debate. Environment preservation is said to be, at least in the official institutional statements, at the highest steps of the scale of policy values. However, these official statements do not always match with the economic policy choices. In Europe, despite a sensible switch toward environmental protection strategies has been registered, it seems to be not enough to grant a trend reversal. The Europe2020 strategy sets for the year 2020 three objectives in the section of climate change and renewable energy that are interrelated and mutually supporting one another: the first target is a 20% reduction, in respect to the year 1990 in the greenhouse gas emission (GHG); the second target is the achievement of the 20% percentage of renewable energy in gross final energy consumption; the third target is a 20% cut in energy consumption compared to a 2020 (Eurostat 2019, p.44). However these targets have been just partially reached. The GHGs reduced from the year 2008 of 12.5%, while the share of renewable energy increased of 17.5%. Furthermore, the final energy consumption remained above the targeted

level (1582 million tons of oil equivalent against a target of 1483 for primary energy consumption, 1123 million tons of oil equivalent against a target of 1086 for final energy consumption. Eurostat, 2019).

The most significant obstacle to the achievement of environmental objectives lies in the widespread belief that they are in contrast with economic growth. In particular, the reduction of polluting industrial activities is said to increase unemployment and to be detrimental for economic and social conditions of the country specialized in the sector involved. However, while job destruction especially occurs in 'brown' sectors, in evaluating the overall effect of polluting plant dismissals, it has to be considered that those activities get replaced by green sectors (OECD, 2017). The size of this trade-off, of course, depends on the specific policy implemented and on the constraint imposed at national level. Further constraints to the transition toward a green economy may arise from the cross national effects of polluting activities, as they represent a disincentive to impose the contraction of polluting sector if neighbour countries do not follow the same route.

In the past decades, Europe – as many advanced countries in the world - experienced a long period of sustained growth through an intensive use of natural resources. Despite having implemented an environmental regulation aimed at reducing the exploitation of natural resources and protecting human health in advance of other countries, (in 1987 with The Single European Act¹) the level of pollution remains still high (Eurostat, 2019). With the Green New Deal, announced in 2019, the European Commission promises to transform the Old Continent in a "climate neutral" one (i.e. to reach zero GHG emissions) for the year 2050, investing in new technologies and supporting the process of abandoning fossil energy sources. With a process of national co-financing, this two-tier system is supposed to support growth, create new jobs without causing unsustainable social costs.

The social costs associated to the transition toward a "green economy" inspired this paper. Especially in advanced economies, it is feared that the transformation process may be achieved at expenses of lower income and increasing unemployment. The trade-off is supposed to be present both inside each single country and across nations due to the inability to switch at least in the short term from fossil to renewable the energy sources. This can generate a self-fulfilling long-lasting conflict between environmental and social sustainability.

The aim of the paper is to evaluate if the reduction of pollution and the replacement of fossil energy sources with renewable ones causes social costs in term of job losses, rendering the process of transition toward the environmental sustainable production mode less desirable. The idea is to measure if, looking at the phenomenon from a macroeconomic perspective, a lower level of GHG emissions induced by polluting plant closure are associated to an increase of unemployment even when renewable energy sources increase. The study of this phenomenon can be articulated in the form of a "trilemma" or as an exchange of three alternatives in the combination of the factors of production.

Through an intuitive empirical method it is measured if - for 12 Eurozone countries from 2004 till 2016 - the weighted sum of three indexes representing the factors of production is equal to a constant value.

¹ The Single European Act introduced the subsidiarity principle i.e. only taking measures at European level where they are more effective than at the level of an individual country.

The underlying idea is to measure if the maximization of one of the three indicators is traded off by one of the other two or by a weighted sum of them. The results show the existence of the trilemma that evidences the presence of a trade-off between environmental protection and polluting production strategies with a stable value for labour force. Furthermore, the dynamics of the indicators through the period considered show that almost in each country there has been a substitution between pollution and the use of renewable energy sources, with a labour market rather stable dynamic. The empirical technique detects the dynamics of the indicators in a macroeconomic context and it is not intended as a mean to identify a causality relationship: it is just a way to observe if reduction of pollution is gained at expenses of higher unemployment at an aggregate level or if it can be preserved using alternative energy sources.

This result supports the conclusion that the level of unemployment is independent by the energy sources adopted and that environmental friendly production strategies can substitute polluting ones with limited costs in terms of employment. This result is consistent with the theory that capital and labour combine together in fixed terms to realise a given output and that natural resources should be considered substitutes. However, natural resources can be exploited in a way not detrimental for the future generations on the basis of the available technology. The implementation of eco-friendly technologies should be, therefore, the target the policy authority should have to preserve environment.

The outline of the paper is the following: the next paragraph describes the trade-off between employment and production strategies and proposes the algebraic procedures to build up the indicators to measure the alternatives. Section 3 contains the empirical analysis and, after the description of the methodology adopted, provides results (section 3.1) and robustness check (section 3.2). Finally, section 4 draws conclusions.

2. THE TRADE-OFF AND ITS MEASURES

The concept of trilemma is borrowed from international economic policy theory. It was used to measure to what extent the policy objectives of free capital mobility, fixed exchange rates and monetary policy autonomy can be reconciled in an open economy context. (Mundell 1963, Fleming 1962). The use of the trilemma alternatives, and the trade-off between them, was first estimated by Aizenman et al. (2008 and 2013) and then extended to other policy alternatives by Canale (2015) and Canale et al. (2018). The broad concept is that policy authorities choose between two out of three policy objectives, since they all three cannot be targeted altogether. However, this theoretical perspective and estimation method has never been applied to environmental issues: the extension represents a powerful framework to evaluate to what extent the objectives of employment preservation, environmental issues and polluting productions can be reconciled. The evaluation of how the three issues combine together, will allow to detect the social costs in terms of unemployment of alternative use of production factors. Figure 1 better explains the meaning of the proposed trilemma. The triangle drawn in the picture is a stylized representation of how the production factors combine together.

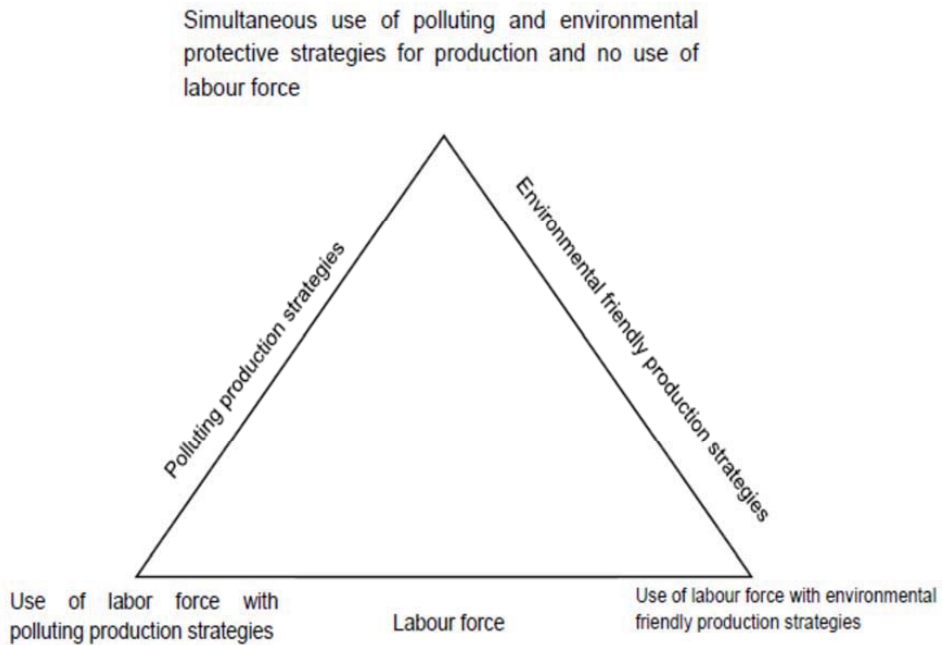


Figure 1. The trade-offs between pollution, environment and labour force

On the left side, labour as a production factor is combined together with polluting production strategies without any use of environmental friendly production strategies. On contrary on the right side, the opposite situation is represented: the use of environmental protection strategies assures to preserve a certain rate of unemployment completely excluding pollution. Finally, at the top of the trilemma triangle a hypothetical situation in which simultaneous use of polluting and environmental protective strategies for production do not need labour force. The combination of alternative strategies for production is the result of the available techniques not coordinated in terms of environment, but simply driven by the need to increase output and satisfy aggregate demand. The existence of this “environmental trilemma” will provide information about how production factors combine together and will allow to evaluate to what extent the use of environmental friendly production strategies produce social costs.

To evaluate the presence of this “trilemma”, the idea is to measure if three indexes representing the use of polluting production factors, environmental friendly production strategies and unemployment add-up to a constant, so as to demonstrate that a weighted rise of two of them cannot be associated with a simultaneous weighted rise of the third one.

The first indicator PPS – polluting production strategies – represents a proxy of the degree of pollution in each country. It is based on the GHG emissions indicator calculated for each country by Eurostat (the entire dataset is available at <https://ec.europa.eu/Eurostat>). They are all expressed in term of CO₂ equivalent, referred to the 1990 base year. It is one of the EURO2020 strategy indicators used to monitor progress towards the EU's target of 'reducing the GHG emissions by at least 20 % compared with 1990 levels' by 2020. To identify an index lying between zero and 1 allowing the comparison across

countries, it is normalized subtracting its minimum value $GHG_{i,min}$ and dividing the result by the maximum range in the time span considered $GHG_{i,max} - GHG_{i,min}$.

$$PPS_{i,t} = \frac{GHG_{i,t} - GHG_{i,min}}{GHG_{i,max} - GHG_{i,min}} \quad (1)$$

When the PPS index assumes the value of zero, the GHG emissions are at their lowest value within the period considered, while when the index assumes the value of one, pollution is at its maximum.

The second indicator EFPS – environmental friendly production strategies - is based on the share of renewable energies on total energy consumption in each country in the period considered. As for the previous indicator, it is collected from the Eurostat database (<https://ec.europa.eu/Eurostat>). As in the case of the GHG gas emissions this indicator is calculated for monitoring the progress towards renewable energy targets of the Europe 2020 strategy. It is represented by the following:

$$EFPS_{i,t} = \frac{RE_{i,t} - RE_{i,min}}{RE_{i,max} - RE_{i,min}} \quad (2)$$

As in the previous case, the EFPS it ranges from zero to 1 depending on the share of renewable for energy consumption in each country. The value 1 is for the maximum share of renewable energy reached in the period, while 0 registers the opposite situation.

Finally the third index UN is based on the rate of unemployment and is represented by the following:

$$UN_{i,t} = \frac{Un_{i,t} - Un_{i,min}}{Un_{i,max} - Un_{i,min}} \quad (3)$$

The UN index normalizes the rate of unemployment in each country so that the maximum rate of unemployment in the period is reached when the value is one, while the minimum when the value is zero. Data, as in the previous cases, are collected from Eurostat (<https://ec.europa.eu/Eurostat>, table code *une_rt_a*).

The three indexes are normalized considering the values occurring in each country, so that the relevance of the trade-off is underlined for each geographical entity, whatever the absolute original value of each indicator. The trade-off – separately for each country - is supposed to work as follows: when, for example, polluting industries are forced to close to comply with environmental regulation an increase in unemployment is going to occur if alternative investments are not carried out. On contrary if the use of renewable energy increase it is the signal that investments in non-polluting activities are increasing, so that unemployment can remain stable. It can be derived also that unemployment can be reduced with a more than proportional increase in renewable energy as compensation of polluting activities shut down. If the hypothesis of the trilemma were not true, it could happen that for example a reduction of pollution is associated to a more than proportional drop in the use of labour force with no

proportional increase in the use of renewable energy sources or, at the opposite, that an increase of renewable energy sources is associated with constant values of the other two variables.

3. ESTIMATING THE TRADE-OFF

In the panel estimation, 12 EMU countries are considered: they are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Spain, and Portugal. Annual data from the EUROSTAT ranging from 2004 to 2016 are used. In order to evaluate how much binding the trilemma is, the following equation is estimated:

$$I_{i,t} = aPPS_{i,t} + bEFPS + cUN_{i,t} + \varepsilon_{i,t} \quad (4)$$

where $I_{i,t}$ is a vector of ones representing the arbitrary constant value set to estimate the existence of the constraint according to which the weighted sum of the indexes of the equations (1), (2) and (3) adds up to 1. In equation (4) a , b and c are the parameters (weights) to be estimated and $\varepsilon_{i,t}$ is the normally distributed error term. These coefficients would be expected to take a positive and significant value in the case of a linear relationship, otherwise the hypothesis is not valid. A similar technique is used by previous authors (Aizenman et al 2008, 2013 and 2014, Hutchison et al (2012) Yu Hsing, 2012, Canale (2015) and Canale et al (2018) to estimate if the weighted sum of three indicators add up to a constant and if a drop of one of them is associated to a rise in one or both the other two. The idea was to estimate the existence of a "trilemma" or a constraint among three policy variables and to verify if they are in alternative with one another. Here it can be said that the estimates verify the presence of a trade-off among environmental policy choices and unemployment. When in each single country, a reduction of GHG emission occurs as a consequence of dismissal of polluting plants, it is supposed to be accompanied by an increase of unemployment. However, if an increase in investments using renewable energy and environmental friendly production strategies are implemented, this effect can be mitigated. As a second step the estimated coefficients are connected to the true values of the three indicators allowing to evaluating how binding the trilemma is for the whole period for the whole group of countries in the following form $a * PPS_{i,t} + b * EFPS_{i,t} + c * UN_{i,t}$, where the asterisk tells us that we are referring to the estimated value of the coefficient. If the trilemma is binding, this sum would assume a value around 1.

Besides verifying the goodness of fit, this procedure will allow to detect the presence of changes in the trade-off. The advantage of the approach used in these estimates is the taking into account the reciprocal dynamics, without the need of paying attention to endogeneity issues. It has to be recalled that this estimate does not represent a relation of dependence, but allows describing time dynamics of in the variables in a constrained context to bring out the alternatives.

3.1 Empirical results

Table 1 shows the findings of the pooled panel estimation of the equation (4). It shows that the supposed constraint does exist for the whole sample. The coefficients are positive and significant and take the value of 0.938***, 0.845*** and 0.201*** for PPS, EFPS and UN respectively.

Table 1. PPS, EFPS and UN indexes: estimation results

	Coefficient	Mean	Weight	R ²
PPS	0.964*** (0.023)	0.476	0.446	0.98
EFPS	0.932*** (0.041)	0.512	0.432	
UN	0.201*** (0.033)	0.509	0.102	
Note: *** p<0.01, ** p<0.05, * p<0.1.				

Multiplying the estimated coefficients (first column) by the average value of each indicator (second column), the contribution of each index to the constraint is then obtained (third column). The first thing to observe is that pollution and renewable energy have similar weights in the constraint (0.446 for PPS and 0.432 for EFPS). The weight to the constraint of the UN index is 0.102 telling us that the contribution in the average is rather low in respect to the other two indicators in the years considered. Summing these three values up, the total explanatory power of the estimate is calculated and corresponds to the R² (forth column). The weighted sum of the three indexes, for the whole sample, explains about 98% of the constant. To examine the dynamics of the indicators and evaluate how the contribution of each index changed through the time span considered, each estimated coefficient is multiplied by the true value of each indicator. The values obtained, together with the estimated value of the dependent variable and the arbitrary constant equal to one are plotted for the mean of the whole sample (Figure 2).

The difference between the arbitrary constant and the estimated dependent variable will tell us how much binding the trilemma is, while the dynamics of the three indicators describe how each single contribution changes.

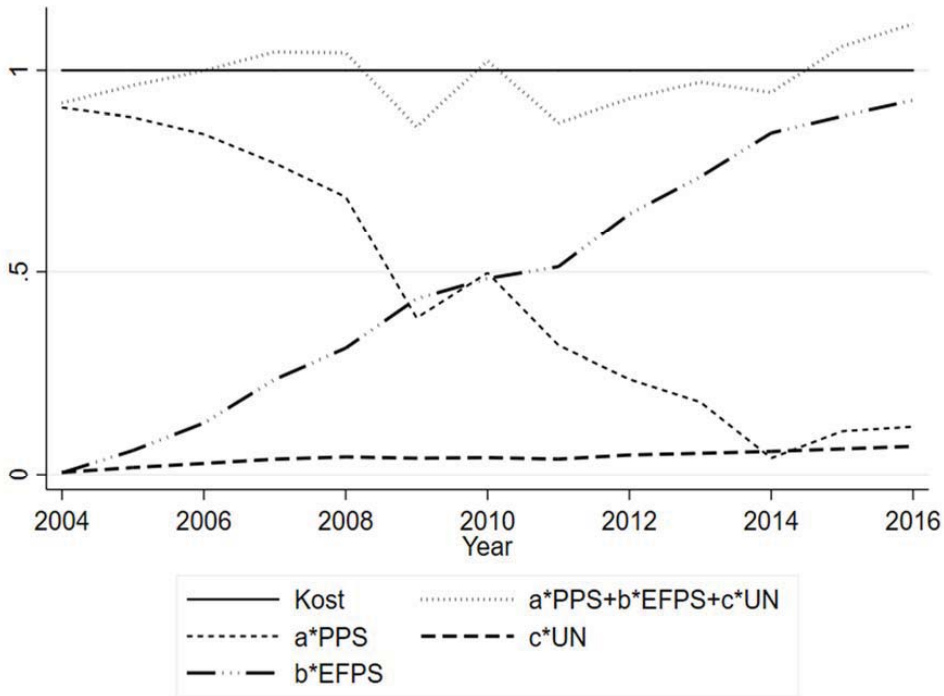


Figure 2. The dynamics of the alternatives in the whole sample

Source: own elaboration on Eurostat data

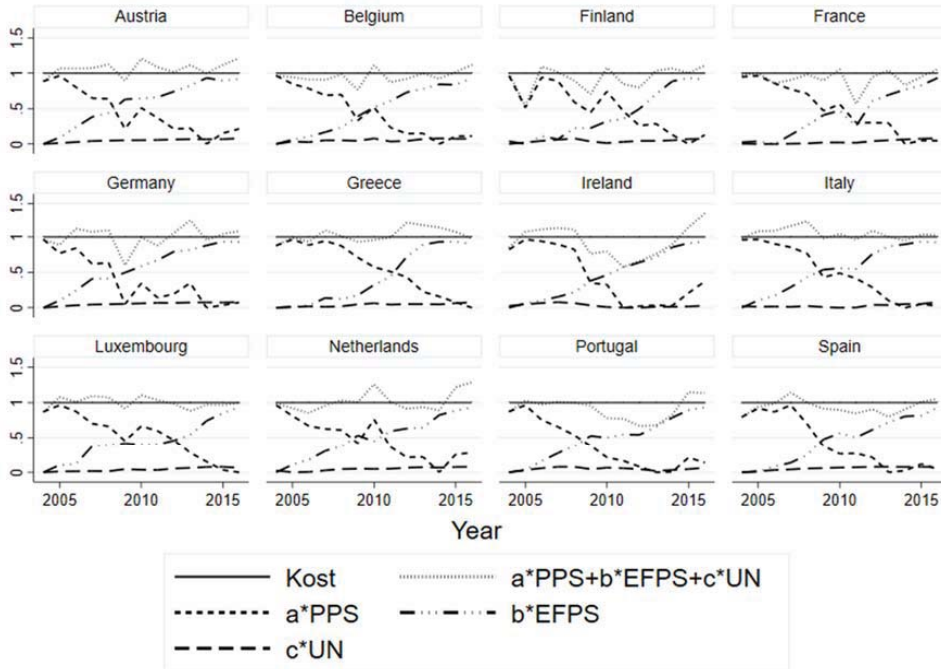
It is observable – with the exception of the years immediately after the crisis (end of 2008 to 2010)- a continuous decrease in the panel average of the PPS index. A trend inversion is also detectable in the panel average value of PPS in the last two years. Opposite considerations can be done for the index EFPS representing the share of renewable energy. The index continuously rise from the beginning to the end of the sample proving the progressive substitution inside the constraint between polluting and non-polluting strategies. The positive contribution to the trilemma of the UN indicator tells us that the other two policy objectives can be reconciled at a cost of a slight increase in the unemployment indicator. However, the UN index does not vary a lot telling us that the substitution between polluting and environmental friendly production strategies are not reached at expenses of a marked increase in the unemployment contribution to the trilemma. Lastly, the dependent variable resulting from the estimates is very near to the arbitrary constant set at one. This is true more or less for the whole period despite some little differences should be taken into account. In particular, as a consequence of the behaviour of the PPS indicator, a slight divergence of the estimated dependent variable is present in the year immediately after the financial crisis. It can be read as a negative shock on the use of production factors in the context of decreasing growth.

In short, the three indicators move in a compensative way summing up to a mean of the dependent variable very near to 1 supporting the theoretical hypothesis of the trade-offs between, pollution,

environment protection with a rather constant value of unemployment. An approximate constant level of the unemployment indicator is associated to a substitution between polluting production strategies and environmental friendly ways of production.

To demonstrate the validity of the trilemma, the description for the whole sample is replicated separately for each single country in Figure 3. A quick look allows confirming the same dynamics as for the whole sample, despite some differences should be considered.

Figure 3. The dynamics of the alternatives by country



Source: own elaboration on Eurostat database

We leave the reader to interpret the graph taking into account that some differences may derive from specific environmental policy strategies implemented in each single country. However, for each country the three indicators move in a compensative way summing up to a mean of the dependent variable very near to 1.

3.2 Robustness check

To validate the existence of the relation among the trilemma variables equation (4) is rearranged so in the three following forms:

$$UN_{i,t} = \alpha_0 + \alpha_1 EFPS_{i,t} + \alpha_2 GHG_{i,t} + u_{i,t} \quad (5)$$

$$EFPS_{i,t} = \beta_0 + \beta_1 UN_{i,t} + \beta_2 GHG_{i,t} + u'_{i,t} \quad (5')$$

$$GHG_{i,t} = \gamma_0 + \gamma_1 EFPS_{i,t} + \gamma_2 UN_{i,t} + u''_{i,t} \quad (5'')$$

In these three forms, each index is moved once at a time on the left side of the equation while the other two stay on the right side. GHG, EFPS and UN are the indexes defined in (1) and (2) and (3) respectively, α_0 , β_0 and γ_0 are the constant term comparable to the fixed value set at one in equation (4) that the sum of the three indicators have to reach. The coefficients α_1 and α_2 for equation (5), β_1 and β_2 for equation (5') and γ_1 and γ_2 for equation (5'') are the coefficient to be estimated to validate the trilemma. Finally the $u_{i,t}$, $u'_{i,t}$ and $u''_{i,t}$ are the error terms. The three equations do not represent a causality relationship but just a way to further detect the co-movements of the three indicators (in the opposite direction) and investigate on the reciprocal dynamics of unemployment, GHG emissions and renewable energy expenditure indicators. Significant values of the constants and negative and significant values of the coefficients of the two indexes indicated as independent variable in the right side of the equation would further support the existence of an inverse relationship running between pollution and environment protection to reach a certain level of unemployment. Before implementing the estimates, the Pesaran (2004) test for the presence of cross-sectional dependence in the error terms was performed (7.336***). The presence of cross sectional dependence suggests using the Driscoll and Kraay (1998) methodology, releasing consistent estimates both in presence of heteroscedasticity and cross sectional autocorrelation of the error terms. The findings are presented in table (2). They show that the constants are significant, positive and near to one ($\alpha_0 = 0.942^{***}$ and $\beta_0 = 0.978^{***}$ and $\gamma_0 = 0.993^{***}$), whereas the coefficients of interest, indicating the contribution to the constraint of each index, are negative and significant ($\alpha_1 = -0.184^{***}$, $\beta_1 = -0.045^{***}$ and $\gamma_1 = -0.849^{***}$ for the first indexes; $\alpha_2 = -0.709^{***}$, $\beta_2 = -0.928^{***}$ and $\gamma_2 = -0.160^{***}$ for the second indexes). These findings suggest that the estimates presented in the previous section are valid and that a decrease in each indicator dynamic is associated with a decrease of the weighted sum of the other two.

Table 2. Robustness check of the trade-off

Dep. Var. UN		Dep. Var. EFPS		Dep. Var. GHG	
α_0	0.942***	β_0	0.978***	γ_0	0.993***
α_1 EFPS	-0.184***	β_1 UN	-0.045***	γ_1 EFPS	0.849***
α_2 GHG	-0.709***	β_2 GHG	0.928***	γ_2 UN	0.160***
Note: . *** p<0.01, ** p<0.05, * p<0.1					

4. Conclusions

The paper examines how three indicators capturing pollution, environment protection and unemployment combine together in twelve Eurozone countries. In evaluating the dynamic of these three

indicators it has been evidenced that the index capturing the use of labour force remains rather stable while the other two appear to be substitutable. In particular, a decreasing pollution index is associated to an increasing index of renewable energy use. This is valid both for the twelve countries considered as a whole that for each single country separately. Therefore, the transition toward a green economy is not realized at expenses of decreasing employment. These results pave the way to the interpretation that unemployment is independent from the ecological footprint the factors of production leave. The choice between the energy to be used seem to be driven by other factors such as the cost of production and the available technology.

This paper provides some elements to remove the fear of transformation affirming that when reducing greenhouse gas emission while increasing the use of renewable energies, employment is not markedly affected. Unemployment at aggregate level seem to be rather influenced by external factors such as technological constraints, aggregate demand and the optimal level of production.

If this is the case policy strategies should orientate firms to choose production strategies using renewable energy and reducing the ecological footprint in order to change the strategy to increase growth.

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