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Do the IMF's structural adjustment programs help reduce energy consumption and carbon intensity? Evidence from developing countries

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Abstract

Although the number of countries under the International Monetary Fund's (IMF) programs have increased considerably since the 1980s, a research gap exists in regard to the impacts of these programs on both energy consumption and carbon emissions in countries where the programs have been implemented. Hence, the purpose of this study is to understand and explain what is reasonable to expect of the IMF on energy and the environment. Given that the global roadmap for the energy transition calls for structural changes in favor of reducing carbon emissions, this study suggests that the IMF may have a special role to play, that is, working in tandem with national governments and environmental-related organizations to support resilient economic development models to implement this global roadmap towards the energy transition. The results based on panel econometrics models presented in this paper indicate that the IMF has not, to some extent, played such a role so far. More precisely, the results show that although IMF programs help reduce energy consumption, they do not change the energy mix or technological structures in a way that would reduce carbon emissions per unit of energy use. The findings of this study have important implications for energy and climate policymaking in developing countries.

Keywords: IMF programs; developing countries; energy consumption; CO₂ intensity of energy

JEL codes: O19; Q43; Q56

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1. Introduction

Created in 1945, the International Monetary Found (IMF) has the objective to secure financial stability, promote sustainable economic growth, facilitate international trade, and reduce poverty around the world. The role of the IMF in the global economic governance has been highlighted since the 1980s economic crises in various countries. Indeed, experiencing both extremely high inflation and worsening of balance of payments, the governements of many countries had to seek help from the IMF and implemented structural adjustment programs with the assistance of the IMF. As a result, the number of countries under IMF programs increased considerably from mid-1970s to early 2000s (see Fig. 1).¹

[Figure 1]

The role of the IMF has evolved over the last two decades and the organization has begun to act on several macroeconomic issues (Hajro and Joyce, 2009). Thus, in order to evaluate the impacts of IMF's structural adjusment programs, scholars have focused on various economic and social variables, including current account balance (Atoyán and Conway, 2006), economic growth (Bordo and Schwartz, 2000; Przeworski and Vreeland, 2000; Evrensel, 2002) and poverty (Hajro and Joyce, 2009; Oberdabernig, 2013). However, in this literature, very little attention has been paid on the potential effects of IMF programs on energy and environmental issues. Indeed, despite the growing global concerns on environmental sustainability, and more particularly despite the warnings of environmental economists in the 1990s regarding the emergency to

¹ Note that for a given year, the number of countries under an IMF program can be lower than the total number of programs in place since a country may be under several IMF programs at the same time.

take into account the environmental concerns in the structural adjustment programs (see for instance, Abaza, 1995; Kessler and Van Dorp, 1997; Cruz and Repetto, 1992), our knowledge in this field is very sketchy at present. Furthermore, taking into account the volume of current emissions from developing countries and their rapid growth trajectories, the importance of developing countries in any effective global mitigation policy is warranted (Arent et al., 2017).

An interesting, but unanswered question, is whether the implementation of IMF programs has been associated with the improvements in energy efficiency and carbon intensity of energy consumption. This study attempts to fill this void in the literature by empirically examining the impacts of IMF programs on energy and environment variables, including per capita energy use and carbon dioxide (CO₂) intensity of energy. While per capita energy use is an indicator of a country's overall trend in energy consumption, CO₂ intensity of energy measures the amount of CO₂ emissions released for each unit of energy, hence, as will be discussed further below, it captures several dimensions including environmental regulation level of a country, its energy structure, and more specifically, variations in the fossil fuel mix used in a country. Specifically, this study assesses whether IMF programs affect, and if so, positively or negatively, both energy consumption and CO₂ intensity in the countries where IMF programs have been implemented. For this purpose, as shown in Figure 1, we consider four IMF programs: First, Stand-By Arrangement (SBA) which provides financial aid to a member state in need of financial assistance; second, Extended Fund Facility (EFF) which involves assistance to correct structural imbalances over a more extended period compared to SBA; third, Structural Adjustment Facility (SAF) which provides medium-term concessional loans for balance of payments adjustment; and fourth, Poverty Reduction and Growth Facility (PRGF) which focuses on the objectives of poverty reduction and

growth while lending to its poorest member countries.² Based on a panel of 117 countries (low- and middle-income countries) over the period 1974-2011, our results show that although IMF programs decrease energy consumption, their effect on CO₂ intensity is not statistically significant. We demonstrate that these results are robust to different model specifications, estimation strategies, and endogeneity issues.

It is worth to introduce here the perspective that this study offers before going further with theoretical arguments on the role of IMF programs in developing countries. In order to tackle an economic crisis or recession, depending on country-specific conditions, governments may implement different policy options in line with the IMF's structural adjustment programs. The argument that we would like to put forward here is that different policy choices may lead to different outcomes with respect to energy use and resulting emissions. There may be two different effects. First, a scale or activity effect may generate a variation in total energy consumption; and second, a composition effect may generate a variation in the energy mix. Although both effects directly influence the environmental quality and more particularly the level of CO₂ emissions, only the second one has an influence on the carbon intensity of energy use. Hence, the advantage of using carbon emissions per energy unit is that by doing so, we eliminate the scale effect, which comes from variations in the amount of energy used, and thus we are able to study overall impact of the choices that the country makes, under an IMF

² Note that the Poverty Reduction and Growth Facility (PRGF) replaced the Enhanced Structural Adjustment Facility (ESAF) which was a program of financial assistance given to poor countries between 1988 and 1999. More information on the IMF's lending instruments and programs can be obtained from the IMF's factsheets: <https://www.imf.org/en/About/Factsheets/IMF-Lending>.

program, with respect to its energy mix. In other words, whatever the impact of IMF programs on the level of energy use, if carbon emissions per energy unit decrease with IMF programs, one should conclude that the overall change in the energy mix is resulted in an improvement in the environmental efficiency of the energy system. This point is important since it implies that following an IMF program, an energy-dependent country having unexploited energy sources may try to modify its energy mix in order to switch to domestic fuels. Here there can be two different scenarios. First, the country may exploit more extensively its domestic (and less energy efficient) resources such as low-calorie lignite mines, while keeping unchanged the level of energy use. In this case, while reducing energy imports could induce an improvement of the balance of payments, it is very likely that the resulting energy mix would be less environmentally friendly (in the sense of CO₂ intensity). According to a second scenario, the opposite may also be true. Indeed, the share of fossil fuels in the energy mix may decrease, and traditional fuels, such as firewood or agricultural residues, may substitute fossil fuels. Such a fuel switching in the energy mix leads to a decrease in the carbon intensity of energy use.

All in all, there is no straightforward answer to the question of what is reasonable to expect of the IMF on energy consumption and CO₂ intensity, and there is no *a priori* theoretical or empirical basis to support the impact of IMF programs on these variables. Therefore, we believe that the contribution of this study can significantly advance the state of the art regarding the effects of IMF interventions.

The remainder of the paper is organized as follows: Section 2 reviews the literature and explores the theoretical arguments on the potential impacts of IMF programs on energy and environmental issues. Section 3 presents data and empirical methods used in this paper. Section 4 summarizes the results, examines their robustness

and provides further model extensions. Section 5 contains a discussion of the findings, and Section 6 concludes the paper with some policy implications.

2. Theoretical links between IMF programs, energy consumption and the environment

Potentially the effect of the IMF's structural adjustment policies on energy consumption and environment is ambiguous *a priori*. It can be positive, negative, or neutral. The complexity of determining whether or not positive impacts of IMF programs on both energy consumption and environmental quality outweigh negative ones is the result of the difficulty that scholars encounter in assessing in which ways macroeconomic variables influence energy use and environment. Gueorguieva and Bolt (2003) underlined that the research on structural adjustment programs of IMF and World Bank are not quantitative; they are most often based on case-country studies, which do not lead to definitive conclusions or general recommendations regarding energy or environmental issues. In response to this argument, Dreher and Ramada-Sarasola (2006) undertook an empirical study on the impacts of the number of projects of international organizations on different indicators of air and water pollution (e.g. CO₂ and sulphur dioxide (SO₂) emissions or biochemical oxygen demand) as well as on the global environmental governance. In this perspective, Dreher and Ramada-Sarasola (2006) have the approach closest to our own. Although their contribution is noteworthy in the understanding of environmental issues in relation to international organizations, our study differs from theirs in several respects. First, and most importantly, Dreher and Ramada-Sarasola (2006) do not take into account energy consumption, which is central to our study. We use per capita energy consumption in our framework and explicitly address the question of whether IMF programs have a direct impact on this variable.

Second, their study is mostly concerned with environmental governance and does not pay special attention to CO₂ emissions. In this paper, we use carbon intensity of energy use instead of overall CO₂ emissions. As indicated by Groba (2014), carbon intensity provides a better measure of the stringency of environmental regulations. This is simply because as total CO₂ emissions are highly correlated with economic activity, they do not provide us with information regarding structural changes in the economy regarding the dynamics of energy consumption. Put another way, by using carbon intensity we can investigate whether or not the economy is being decarbonized following IMF intervention in the country. Furthermore, theoretically, a developing country with a relatively low energy intensity can be characterized by a high carbon intensity if energy demand is mostly satisfied by “dirty” energy sources. This issue can be empirically investigated only by considering countries’ carbon intensity, which is also one of the key variables that the climate change scenarios produced by the International Panel on Climate Change (IPCC) rely on. Last but not least, it should be added that our findings are robust to several econometric issues that we will discuss in the next section.

To cope with the aforementioned difficulty, the empirical literature investigating the relationship between economic growth, energy consumption and environmental indicators has followed two major avenues. In the first one, the causal links between these variables are studied using time series or panel data models. There are four testable hypotheses in these studies: growth hypothesis, conservation hypothesis, feedback hypothesis and neutrality hypothesis and each of them has different economic, environmental and energy policy implications.³ Although this reasoning can be justified

³ The growth hypothesis suggests that energy is a necessary factor for production and therefore, energy conservation policies may influence economic growth. However, the conservation

in a *ceteris paribus* framework, the link can be influenced by many factors such as energy and environmental policies implemented in a country, availability of energy sources, economic performance or technical progress. Since all these factors are closely related to countries' development levels, in the second avenue of research, the focus is shifted towards an exploration of a non-linear relationship between economic development and environmental degradation. The hypothesis tested is called the environmental Kuznets curve (EKC) hypothesis since Grossman and Krueger's (1991) seminal study, and it suggests that the pattern of environmental degradation (measured by the level of polluting emissions such as CO₂ or by the level of energy consumption) has an inverted U-shape with respect to economic development. As indicated by Jobert et al. (2014), such a pattern can be formed by implementing "environmental policies, measures and practices (such as regulations, more efficient use of energy, investments in abatement technologies, fuel switching or renewable energy facilities) or by also changing the composition of domestic economic activities" (Jobert et al., 2014, p. 1461). In fact, such a change may occur either in the form of a smooth transition to a low-carbon or less energy-intensive economy or in response to structural changes probably following an economic crisis. Although both cases can produce similar results in terms of reducing energy intensity and/or polluting emissions, the intentions and motivations are not the same. In the former case, economic reasons along with increasing public concerns over energy and environmental issues (e.g. energy costs, security of supply, awareness to environmental degradation and to global warming), and international negotiations on

hypothesis suggests causality running in the opposite direction, that is, economic growth may increase energy consumption. The remaining two hypotheses namely feedback and neutrality hypotheses postulate, respectively, bidirectional causality indicating the energy-economy interdependence and no causal link between economic activities and energy consumption.

the mitigation of climate change exert pressure on governments to implement effective and appropriate energy and environmental policies. However in the latter, a reduction in energy use (and in emissions, if it takes place) can be explained on purely economic grounds. Indeed, in such a case, deterioration of economic conditions is of major concern to policy makers who call, in most of the cases, for the intervention of the IMF. As it will be further discussed below, the economic adjustment process following the IMF's requirements may lead to variations in energy intensity or energy balance (share of different energy sources in total energy consumption), which can, in turn, influence the carbon intensity of energy use. These issues bring once again into question whether the implementation of IMF programs constitutes an energy-conservation mechanism, or whether it must be viewed as an energy-neutral policy having no significant effect neither on countries' energy consumption levels nor on their environmental quality. It is to these questions that this paper is addressed. In what follows, we discuss the channels through which the IMF's actions in its reform programs and economic remedies may affect countries' energy balances and resulting CO₂ emissions.

2.1. Subsidy removal and price stability

The IMF programs are generally accompanied by a removal or reduction of subsidies on a wide range of commodities including petroleum products as receiving countries are in general faced to a severe budget deficit accompanied by a worsening of income distribution (Dartanto, 2013). While granting of subsidies may worsen fiscal deficit, this political instrument promotes consumption of energy products, and thus, is very likely to discourage energy saving and investment in renewable energies (Schwanitz et al., 2014). For this reason, removal of fuel subsidies is one of the structural changes required for the roadmap for the energy transition towards an efficient energy use.

Indeed, withdrawal of subsidies in the energy sector, by increasing the price (cost) of energy services for consumers (producers), should lead to a more efficient use of energy sources, and a reduction of overall energy consumption (IMF, 2013). In line with this argument, Hughes and Lovei (1999) have assessed the impact of the reduction of perverse incentives and distortions including subsidies in the energy sector in the countries of Central and Eastern Europe (CEE). The authors showed that the top performer countries in economic reforms have efficiently reduced their energy consumption. However, in the laggard countries, meaning that the ones which were struggling to adopt these reforms in the energy sector, energy consumption has remained at a relatively high level (Hughes and Lovei, 1999). From the same perspective, Anderson and McKibbin (2000) showed that removing distortions in coal markets improves not only countries' economic performances but also overall environmental quality.

In support of the arguments above, it should be noted that price stability, which is one of the primary goals of IMF interventions, promotes economic stability (Bernanke, 2006). In general, economic stability, when it is accompanied by steady economic growth, improves resource management and on the other hand, increases standard of living and demand for better environmental quality (Kessler and Van Dorp, 1997). In this context, by creating stable economic and business environments the expected influence of IMF programs on both the energy efficiency and environmental quality should be positive.

2.2 Exchange rate devaluation

An essential component in the IMF's programs is the devaluation of local currency. There is "a strong association between adoption of Fund programs and sustained real

depreciation of the exchange rate” (Killick, 2003, p. 109). In this case, it is evident that the price of imported energy products increases in local currency terms. This should lead to a reduction of the consumption of energy products, which may, in turn, positively affect the environmental quality by reducing CO₂ emissions. However, such a price increase may also lead to a substitution effect. Therefore, an exchange rate devaluation may be followed by an increase in the demand for domestic energy products in raw materials other than fossil fuels (such as wood or organic residues) that can satisfy the same needs for domestic heating or other uses (Arcand et al., 2008). In this respect, Arcand et al. (2008) found that a depreciation of the exchange rate increases deforestation in developing countries. The rationale behind this finding is that, under the IMF's structural adjustment programs, economic agents might reduce their consumption of usual source of energy in order to increase their wood consumption. Although overall, there may still be a reduction in energy use, this reduction would be likely to have a significant adverse effect on the environmental quality as it would increase deforestation, which, as a consequence, would reduce CO₂ absorption capacity of forest soils. Related to this perspective, it is worth noting that although the IMF's deflationary policies lead to short-term stabilization of the balance of payments (Sarkar, 1991), by increasing short-term unemployment and poverty, they may result in over-exploitation of natural resources. That is why the net impact of these policies on the environment may be negative.

2.3. Rural exodus and increased urbanization

Another way in which IMF programs can affect energy balance is by inducing rural exodus. The idea is that neoliberal reforms implemented under IMF programs have usually hurt small-scale rural farmers. For instance Perz (2000) studied the relationship

between neoliberal reforms adopted in Brazil and rural-to-urban migration in the country. The results show that a large-scale rural exodus was indeed caused by neoliberal reforms that were undertaken during the economic crises in the 1980s.

The progress of urbanization has been well studied in the regional, environmental and energy economics literature (see for instance, Karanfil and Li (2015), Sadorsky (2014), Wang et al. (Forthcoming)). The main focus of this strand of the literature is on the impacts of transitions of population densities between different locations (i.e. urban *versus* rural) and resulting changes in lifestyle choices on energy consumption, pollution, or more specifically, on greenhouse gas (GHG) emissions in relation to energy use. From this literature, it can be seen that the reported results are not conclusive whether urbanization has an effect on energy consumption and CO₂ emissions. To illustrate this point, following Høltedahl and Joutz (2004), one can argue that urbanization process increases the accessibility to energy services (or more specifically to electricity use) and that in consequence, migration from rural to urban areas may raise energy consumption. Moreover, in accordance with Elgin and Oyvatt (2013) and Njomgang (2003), it can be suggested that such an increasing trend in the density of population in the urban areas in the developing countries may lead to an expansion of informal economic activities that use, in general, less efficient and environmentally unfriendly energy sources. For instance, in a recent paper, using panel cointegration techniques, Li and Zhou (2019) show that urbanization has increased CO₂ emissions in China at both national and regional levels. However, one can easily make a counter argument to these two suggestions. A migration process indeed increases density of population, but this can be considered to be tantamount to relatively shorter travel distances, which may induce a decrease in energy use and a reduction of emissions resulting from reduced energy requirements (Poumanyong and Kaneko,

2010; Chen et al., 2008). At this point, Sadorsky (2014) shows that these two opposing effects of urbanization on both energy use and CO₂ emissions may cancel each other out and that the net impact of urbanization may be considered to be insignificant.

2.4. Trade liberalization

IMF programs have often promoted the growth of tradable goods. In many developing countries, industries producing tradable goods are characterized by an intensive use of natural resources and high levels of carbon intensity. For instance, using Logarithmic Mean Divisia Index (LMDI) method Wang and Feng (2018) show that industrial activity is the leading promoting factor of CO₂ emissions in China. Another recent paper by Du et al. (2018) used the same method and confirmed this result. In the context of our study, the underlying mechanism that may drive these findings is that a scale effect may result from IMF programs increasing the use of energy sources, emissions of pollutants, and leading to a significant acceleration of the depletion of natural resources. From this perspective, IMF programs may lock countries into patterns that are environmentally unsustainable. At this point it should be added that the environmental unsustainability of economic practices is more widespread in many developing countries having relatively poor definition of property rights and regulatory restrictions on natural resource use. This is because the lack of sufficient regulatory control leads to a free access to the forest for the purpose of obtaining fuel woods. At this point, Njomgang (2003) indicates that the fact that IMF programs have not addressed these legal issues related to free market system is a source of conflict with traditional legal systems, and that the abuse in the use of operating licenses leads to overexploitation of natural resources and accelerated resource depletion.

To promote the growth of tradable goods, IMF programs are designed to implement market-oriented reforms including trade liberalization and limitation of state intervention in various sectors (Biglaiser and DeRouen, 2011; Nepal and Jamasb, 2015). The consequences of such reforms may be multiple and have significant impacts on the environmental quality. First, there is no doubt that tightening governments' budget constraints leads to a degradation of overall public services including those related to environment. Second, market oriented reforms are very likely to impact negatively the revenues of government officials and elites who may tend to subvert these reforms. This would lead to higher corruption (Yeh, 2011). All these facts reduce the effectiveness of all public services including environmental ones. With regard to the effect of trade liberalization on energy consumption, it can be shown that there is a complex but significant effect. Onursal and Gautam (1997) examined the effects of IMF's trade liberalization programs (i.e. reduction of tariffs) on several environmental variables in Mexico. The authors first find that trade liberalization has increased imports of cars. Then, in order to provide an interpretation of this result with respect to environmental variables, they suggested that this situation may give rise to a dual effect: while the increase of the number of imported cars may result in an increased overall energy consumption, the increasing market share of new cars may also slow down the growth of energy consumption since recent vehicles are expected to be more energy efficient and thus more environmentally friendly.

2.5. Scale, technique, and composition effects

IMF programs can also indirectly influence energy and environmental performances of receiving countries. According to Grossman and Kruger (1991) there are three effects that contribute to the overall environmental impact of economic growth and

international trade. The first one is the scale effect, which suggests that more economic activity means more income but also more energy use and less environmental quality. Consistently with this reasoning, using LMDI method Román-Collado et al. (2018) found that the activity effect is one of the main drivers of Colombia's energy consumption. The same reasoning holds also at the regional level. For instance, Jia et al. (2018) considered the city of Nanchang in China and employed the LMDI to show that economic output is mainly responsible for the growth of CO₂ emissions in the city. It should be noted that the relationship between the level of economic activity and energy consumption (or CO₂ emissions) may not be linear. More specifically, the income-energy or income-environment relationships may follow an inverted U-shaped curve, which is known as the EKC hypothesis as mentioned above.

The second effect is called technique effect and it is mainly based on the endogenous growth theories (see for instance Romer (1990)), which postulate that technical progress and human capital accumulation increase factor productivities and therefore economic performances. At this point, international trade and foreign direct investments (FDI) may serve as main channels for technology and knowledge transfer (Stack et al., 2017). With its role as guarantor of financial stability, the IMF's programs can promote trade and FDI, providing thus access to more energy and environmentally efficient technologies and production processes.

The third effect is the composition effect and it is based on the theory of comparative advantages. If IMF programs help countries benefit more from their comparative advantages, depending on its international comparative advantages, each country may specialize in the production of "clean" or "dirty" goods. As a result, some

countries may move towards an environmental-friendly path of economic growth while some others may tend to have a less sustainable development.

It is clear that these three effects may counteract one another. In consequence, the overall impact of IMF programs on both energy use and environmental quality may be, once again, ambiguous. This can be discovered only by means of rigorous empirical study, to which the following sections of this paper are devoted.

3. Data and empirical methods

Our study aims to investigate the potential impacts of IMF programs on energy consumption and carbon intensity of energy use in developing countries. To capture this issue, we consider a number of different econometric models that should fit into our topic while allowing us to consider the robustness of our empirical findings to model specification. We first begin by an investigation of the bivariate relationship between IMF programs (IMF) and per capita energy use (E), which constitutes our base regression model. This base regression should allow us to answer the question whether there is a simple correlation between IMF programs (IMF) and per capita energy use (E). However, in this regression a number of factors that may affect the IMF programs-energy use relationship are not controlled for, this may create spurious correlation. To address this potential concern, we add some other explanatory variables, namely, per capita real GDP (GDP) and its square (GDP2), and the share of industrial value added in GDP (IVA). The GDP variable captures the scale of economic activity or income. The larger the scale of economic activity the higher is the energy consumption, *ceteris paribus*. On the other hand, the GDP2 variable embodies all other aspects of the economy that may change as GDP grows (e.g. structural changes in the economy and policy changes regarding energy and environmental regulation). As such, including GDP2 in the

model enables us to consider the potential nonlinear effect of country development on energy use and to test the aforementioned EKC hypothesis. On the other hand, the share of industrial value added in GDP is accounted for in order to control for both structural differences between countries and the impact of the composition effect on the energy consumption. More specifically, we take into account explicitly the variations in energy use due to variations in the share of industrial sector in the economic activity. As indicated also by Hübler and Keller (2010), this variable measures the reliance of the economy on the industrial sector and it may be expected that a higher industry share raises energy intensity.

The variable of IMF programs is drawn from Dreher (2006) who provides a comprehensive database, which reported IMF programs, and which is widely used in the empirical works (see Dreher, 2006). The variable *IMF* is defined as a dummy that equals one if an IMF program has been in effect for at least five months in a specific year. On the other hand, as mentioned previously, to study the impacts of IMF programs on environmental pollution, carbon intensity of energy use (*CI*) is also involved in the analysis. As will be discussed below, this variable, which is given by the ratio of CO₂ emissions to energy consumption, provides a good indicator of both intertemporal changes and cross-sectional differences in energy mix and technology. More specifically, it measures the role of fossil fuels in covering the energy demand, thus enabling us to see whether energy consumption is low-carbon or carbon intensive. If the carbon intensity of energy consumption is found to decrease with IMF programs, then the interpretation would be that IMF programs enables a diversification of energy mix towards clean sources, and *vice versa*.

As it is depicted in Fig. 2, the relationship between per capita energy

consumption and carbon intensity of energy use is not stable. There is considerable heterogeneity regarding carbon intensity for the countries having less than 2000 kilograms of oil equivalent (kgoe) per capita. Similarly, significant heterogeneity exists with respect to per capita energy consumption for the countries having between 2 and 4 kg of CO₂ emissions for 1 kgoe energy consumption. This heterogeneity makes it important and relevant to study the effects of IMF programs on both energy use and carbon intensity.

[Figure 2]

The data for carbon intensity (in kg of CO₂ per kgoe) as well as the other remaining variables, i.e. per capita energy consumption (in kgoe), per capita GDP (in constant 2005 USD), and the industry share in GDP (as percentage of GDP) are drawn from the World Development Indicators of the World Bank. According to the availability of the data our analysis is based on an unbalanced panel of 117 low and middle-income countries over the period from 1974 to 2011. It is important to note that the choice of the sample size and period is dictated by the availability of data on IMF programs based on Dreher (2006). Descriptive statistics are reported in Table A.1 in Appendix A. Definitions of certain variables in Table A.1 will be given below when we extend our model to include more variables.

The augmented model can be defined as the one that includes all explanatory variables, and it is estimated from the following equation:⁴

$$E_{it} = \alpha_1 + \beta_{11}IMF_{it} + \beta_{12}GDP_{it} + \beta_{13}GDP_{it}^2 + \beta_{14}IVA_{it} + \lambda_t + u_{1it} \quad (1)$$

⁴ In this section we present only the models in which energy consumption is the dependent variable. The carbon intensity models are presented in the next section.

where the subscripts i and t denote respectively countries (cross-section dimension) and years (time dimension), α is a constant term, and λ_t represents a dummy variable that takes the value of 1 if the observation is for year t and 0 otherwise. It is worth noting that, for each regression, λ_t is created in order to control for temporary shocks that are common to all countries. It is thus a year fixed effect. On the other hand, u_{it} is an idiosyncratic disturbance to the country i in year t , which is assumed to be an i.i.d random variable. In a first step, we estimate Eq. (1) in a pooled ordinary least square (OLS) framework. . The pooled OLS method on Eq. (1) allows us to exploit cross-section and time series dimension of the IMF programs and per capita energy use. Indeed, this method is likely to provide a long-run relationship between the variables involved in the analysis (Burke and Yang, 2016).

Although pooled OLS estimations provide a useful starting point for the econometric analysis, it is well known from the literature that the observed relations in a pooled OLS model may result from some unobservable country characteristics, and thus it may lead to incorrect estimates (see for instance, Baltagi, 2005). In other words, pooled OLS results can be misleading because country-specific characteristics, which can affect country performance in regard to the relationship between IMF programs and per capita energy use, are not accounted for. That is why, in the second step, we need to estimate a fixed effects version of the model presented in Eq. (1). Then the model takes the following form:

$$E_{it} = \alpha_2 + \beta_{21}IMF_{it} + \beta_{22}GDP_{it} + \beta_{23}GDP_{it}^2 + \beta_{24}IVA_{it} + \lambda_t + \mu_i + u_{2it} \quad (2)$$

where μ_i is the time-invariant country-fixed effect that captures any unobserved heterogeneity among the countries.

At this point it should be mentioned that despite its importance, the empirical literature on the evaluation of IMF programs has not yet reached a methodological consensus (Mumssen et al., 2013). While some authors suggest using fixed effects or pooled OLS (see Hajro and Joyce, 2009), some others try to approximate the counterfactual by using the generalized evaluation estimator (GEE) or the before-after method. Some remaining authors combine selection model and impact evaluation methods.⁵ The main point of disagreement in the empirical literature comes from the question of how the selection bias should be addressed. In fact, a sample selection bias may be induced by using data that come from endogenous sample selection (Heckman, 1979). More specifically, in the case of the data used here, the selection bias problem may arise, as IMF programs are often undertaken in countries that are already confronted to economic difficulties or will probably experience problems in the near future. That is why, within the framework of this study, whatever the methodological approach adopted, the estimations should be rigorously conducted to ensure that the obtained results and conclusions on the impacts of IMF programs on the energy use and its carbon intensity are only due to IMF programs, that is, no selection bias should occur.

In fact, there are several reasons for which it is very unlikely that the findings of this paper suffer from these methodological problems. When we try to assess the impacts of IMF programs on both energy and environmental performances in low and middle-income countries, these countries should not be chosen based on an energy-environment criterion. In other words, there should be no country that requests IMF financial assistance directly for energy or environmental concerns. And that is exactly

⁵ We do not discuss each of these approaches here to conserve space. See Mumssen et al. (2013) for a review of these issues.

what happens. Indeed, it is mainly when economic conditions worsen that a country leads to the IMF's doorstep. Moreover, in the equations of selection for IMF-supported programs used in the literature none of the variables involved in our models have been included (see Mumssen et al., 2013).

Even though the fixed effects estimator is capable of controlling for unobserved country-specific time-invariant effects in both energy use and IMF variables, it may fail to consider the possible simultaneity of these variables. Let us explain this in more detail. The idea is that there may be a number of reasons for which countries may request IMF assistance. Any estimation strategy that does not account for such reasons may produce inconsistent results. Furthermore, some of those reasons may be correlated with some of the structural characteristics of the countries, and such a correlation has the potential to affect our ability to measure accurately the impacts of IMF programs. To put in another way, against the framework of this research and its findings, one can argue that IMF programs and energy consumption or resulting CO₂ intensity can be simultaneously affected by something that is not taken into account in the analysis, which, in consequence, gives rise to an endogeneity bias. To avoid such an endogeneity problem in the energy use – IMF programs nexus, we need to use the generalized method of moments (GMM).

It should be also added that another source of error in both pooled OLS and fixed effects models can simply result from an omission of a relevant variable in the econometric specification. This is the well-known omitted variable bias in econometric research. To deal with this potentially important issue, the GMM is, once again, the most appropriate estimator. For this purpose, let us consider the following equation:

$$E_{it} = \alpha_3 + \beta_{31}E_{it-1} + \beta_{32}IMF_{it} + \beta_{33}GDP_{it} + \beta_{34}IVA_{it} + \lambda_t + \mu_i + u_{3it} \quad (3)$$

where E_{it-1} is the lagged value of the dependent variable E . Admittedly, the introduction of E_{it-1} in the regression enables to account for omitted variables. However, the presence of the fixed effects involves a correlation between the lagged energy consumption (E_{it-1}) and the residual (u_{3it}), which biases the results of fixed effects models. That is why the system-GMM estimator should be employed in order to correct for this potentially biasing effect. To this aim, this paper uses the two-step system-GMM estimator developed by Blundell and Bond (1998) for dynamic panel data. We use also a finite-sample correction suggested by Windmeijer (2005), who shows that this correction makes the two-step robust GMM estimator more efficient than the one-step estimator. Note finally that our estimations deal with the problem of instrument proliferation that is raised by Roodman (2009) who also provides a number of techniques for reducing the instrument count.

4. Results

In this section we first consider per capita energy consumption as the dependent variable and present the results on the effects of IMF programs on this variable. Then we consider CO₂ intensity of energy use in order to examine whether IMF programs affect environmental degradation. We adopt the perspective that the variations in CO₂ intensity result from changes in the energy mix that stems from replacement of appliances and production equipment as new technologies become available or new regulatory requirements come into effect.

4.1 Preliminary results

Table 1 presents the results from the pooled OLS estimations (see columns 1 to 4 in Table 1). Time dummy variables (i.e. year fixed effects) are included in all the four

estimations. As we suggested above, we also use alternative specifications in order to ensure that the results hold for different model structures, especially those that involve the structural variables that are commonly known to be related to energy consumption, such as per capita GDP or the share of industrial value added in GDP.

[Table 1]

Column 1 of Table 1 exposes the results for the bivariate regression between the variables *IMF* and *E*. Only time dummies and constant are added as control variables in this first regression. The result highlights a significant and negative correlation between IMF programs and per capita energy consumption. This result suggests that IMF programs tend to reduce energy use in low- and middle-income countries.

After this basic IMF–energy relationship, we add one by one other control variables. The results are given in Table 1 from columns 2 to 4. The first immediate conclusion that can be drawn is that the inclusion of these control variables to the base model does not change the significance of the negative correlation between IMF programs and energy consumption. Second, the relationship between GDP and energy use follows an inverted U-shaped pattern as previously shown in the empirical literature on energy-EKC (see for instance, Galli, 1998; Luzzati and Orsini, 2009). Actual data and estimated inverted U-shaped pattern are presented in Fig. 3.

[Figure 3]

Finally, from Table 1 it follows also that the share of industrial value added in GDP is significant and positive. This suggests that we are in the presence of a composition effect, and *ceteris paribus*, the industrialization of economies leads to an increase in energy use.

4.2 Controlling for unobserved heterogeneity

The pooled OLS technique controls for time fixed effects. However, it is unable to account for non-observable and observable time-invariant characteristics that may influence the level of energy use in a given country. It is worth noting that these influential factors are mainly related to countries' structural characteristics, such as resource endowment, level of technological development, population density, climate and geographic situation. In order to address this heterogeneity issue, we employ panel fixed effects estimation procedure and the results are presented in Table 1 (columns 5-8).

Overall, the fixed effects results are similar to those obtained above by the pooled OLS regressions, that is, we have the negative influence of IMF Programs on per capita energy consumption. Moreover, both the energy-EKC hypothesis and the composition effect are validated.

Suppose now that IMF programs do not have an immediate impact on the current level of energy use but have an impact on future energy use. This may be a reasonable assumption as technological changes and regulations may require time to be effectively integrated into the economy. In this case, an alternative specification may be to use in the regressions one-year lagged values for IMF programs instead of current ones. Based on both OLS and fixed effects estimations we find that the results obtained from this specification (see Table B.1 in Appendix B) confirm those previously reported in Table 1. We conclude that no matter which variable is used (current or past values of IMF

programs), the reducing impact of IMF programs on energy use remains strongly in evidence.

4.3 Environmental concerns and carbon intensity

The results that we have obtained so far suggest that structural adjustment process following the IMF's requirements leads to a decline in per capita energy consumption. However, on the basis of these results alone, we cannot conclude whether these IMF programs have also an impact on environmental quality. It is apparent from the related literature that following economic crisis or energy shortages energy use and energy intensities are reduced. This creates incentive to diversify the energy mix, and in general, the most common practice is to substitute imported energy sources with domestically produced fuels, which reduces the dependence on external energy supplies (Liaskas et al., 2010). Nevertheless, it is not *a priori* clear whether the reduction of energy consumption has assisted in controlling CO₂ emissions and whether this positive effect was reinforced or counterbalanced by changes of other factors, such as structural shifts in the economy, fuel mix, and regulatory framework. More specifically, when energy consumption decreases, theoretically there may be three possible effects that may lead to a rise or a fall in CO₂ emissions, namely changes in the output mix, in the input mix, and in the state of technology. These changes may involve a substitution of less environmentally damaging outputs, inputs or technologies for more damaging ones, which leads an economy to evolve into a less carbon-intensive growth path, and *vice versa* for a more carbon-intensive one (see Stern, 2002; Arcand et al., 2008). Obviously, in the first case, the overall impact of IMF programs on the environment is expected to be positive.

It should be noted that fossil fuels are still dominant in the global energy mix, and as we already mentioned, they have traditionally been supported by subsidies that amounted to 523 billion US dollars in 2011, which is six times more than the subsidies to renewables (IEA, 2012). One of the reasons of granting energy subsidies is based on the aforementioned growth hypothesis, that is, since energy shortages can impede economic growth, governments try to promote economic development by lowering energy prices which, in consequence, results in decreased production costs for producers and reduced energy bills for households. Another reason is that poverty subsidies are often intended to benefit the poorer members of the population, in particular, through the employment opportunities that result from accelerated economic development, and through the subsidies specifically applied to the forms of energy used by low-income households.

To rigorously examine this alternative framework we rewrite Eqs. (1) and (2) using CO₂ emissions intensity of energy use (*CI*) as the dependent variable. This leads to the following equations:

$$CI_{it} = \alpha_4 + \beta_{41}IMF_{it} + \beta_{42}GDP_{it} + \beta_{43}GDP_{it}^2 + \beta_{44}IVA_{it} + \lambda_t + u_{4it} \quad (4)$$

$$CI_{it} = \alpha_5 + \beta_{51}IMF_{it} + \beta_{52}GDP_{it} + \beta_{53}GDP_{it}^2 + \beta_{54}IVA_{it} + \lambda_t + \mu_i + u_{5it} \quad (5)$$

Eq. (4) is estimated using the pooling method whereas Eq. (5) is estimated using fixed effects. The pooled estimation results presented in Table 2 show a negative effect of IMF programs on CO₂ intensity of energy. Combined with our previous findings, this result suggests that the implementation of IMF programs not only reduces energy consumption in developing countries it has also a positive impact on environmental quality. However, this result does not hold when we consider the fixed effects results.

This suggests that further econometric analysis is required to determine whether IMF programs have an influence on carbon intensity, and this is what the following section deals with.

[Table 2]

4.4 Endogeneity issues

Dealing with endogeneity problems is one of the challenges raised by recent empirical studies. Against this study, as we already discussed, one can argue that IMF programs and both energy use and its CO₂ intensity can be simultaneously affected by something that is not accounted for in this study. Another source of concerns can come from the omission of a relevant variable in the econometric specification. We estimated the two-step system-GMM to address these issues and obtained the results given in Table 3.

[Table 3]

The results of Table 3 do not reject the negative impact of the variable *IMF* on per capita energy use, confirming thus our previous results. However, we do not find a robust impact of the variable *IMF* on CO₂ intensity of energy use, which confirms our fixed effects results. Therefore we can reasonably conclude that the IMF programs do not modify energy mix or technological structures in a way that would reduce CO₂ emissions per unit of energy use. As a result, these programs, although efficient with respect to energy consumption, cannot be considered as a complement to environmental policies.

Our findings can be further illustrated in Fig. 4, which shows the evolution of the

shares of different energy sources in total primary energy used in the countries in our sample. We see that there is a decreasing trend in the share of oil while coal and natural gas seem to be the alternative fuels to oil. This is important since it shows that the energy mix and the resulting carbon intensity have been evolving considerably during this period. More specifically, a fossil-intensive energy source (oil) has been losing share, while both a less fossil-intensive source (natural gas) and a more fossil-intensive source (coal) have been gaining share. Moreover, although there has been a slight improvement, the contribution by all forms of renewable energy to overall energy consumption remains negligible in these countries. Having such an evolution in the energy mix along with the theoretical arguments discussed above, one should not be surprised to find that the overall impact of IMF programs on the carbon intensity of energy use is insignificant.

[Figure 4]

4.5 Further extensions

Although the above estimated models capture main relationships between energy use and macroeconomic variables, some additional variables may be included in the model in order not only to study further relationships but also to investigate whether the results remain the same after controlling for these additional variables. Following, among others, the studies of Gurgul and Lach (2014), Kar and Majumdar (2016), Osman et al (2016), Jobert et al. (forthcoming), the variables that will be considered here are trade openness (*TRADE*), which is calculated as the total sum of exports and imports divided by GDP, inward foreign direct investments as percentage of GDP (*FDI*), and gross fixed capital formation at constant 2010 US dollars (*K*). Data for these variables are taken from the World Development Indicators of the World Bank and their descriptive

statistics are given in Table A.1 in Appendix A.

As we discussed above, the variables *FDI* and *TRADE* may contribute both to energy consumption and CO₂ emissions via three different channels (i.e. scale effect, technique effect, and composition effect). On the other hand, by using the variable *K* we control for the variations in physical assets of the country which may affect energy use and carbon intensity.

Table C.1 in Appendix C presents the results obtained by considering these additional variables in both pooled OLS and fixed effect regressions. We see that our variable of interest (*IMF*) is significant and negative in all model specifications. In consequence, controlling for different variables has not affected our main conclusion, that is, IMF programs help reducing energy consumption in low- and middle-income countries.

It follows also from Table C.1 that trade openness, fixed capital formation and FDI increase energy consumption. However, when we control for unobserved heterogeneity (columns 4-6), only the impact of fixed capital formation remains significant. This result is in line with some of the empirical work suggesting that capital and energy are complement (see Koetse et al. (2008) for a discussion on this issue).

5. Discussion of the results

Countries requesting IMF assistance have to implement a wide range of macroeconomic stabilization and structural reform measures. More specifically, the efforts should mainly concentrate on creating a market-oriented open economy and strengthening public finances. GDP growth, inflation, balance of payments, international reserves, the ratio of external debt to GDP, the debt service ratio (i.e. debt service payments (principal

and interest) divided by export earnings) are the indicators that the IMF monitors particularly closely. On the other hand, energy consumption in receiving countries is somewhat related to most of these indicators. As a result, although energy use is not the IMF's primary concern, IMF programs may still have a significant impact on it. Let us give some examples to illustrate this point. In order to strengthen public finances, the IMF usually requests that governments limit the growth of government spending. The immediate impact of this policy change is a decline in domestic aggregate demand, which, in turn, decreases total energy consumption. Another example is when a country is dependent on imports for a large fraction of its primary energy supply, greater use of local energy sources may allow a reduction in energy imports and consequently improve the balance of payment position. In this study, based on panel estimation techniques that are robust to endogeneity issues, the results show that indeed, IMF programs help reduce energy consumption in countries under IMF arrangements.

It is clear from the above that the IMF is mainly concerned with economic performance and fiscal health, which may affect energy demand through various channels. On the other hand, the performance of receiving countries with regard to environmental issues is not at the top of the IMF's agenda. Gandhi (1998) confirms the IMF's position by stating that "it had not, given its basic mandate, been active in helping countries pursue and support their environmental objectives" Gandhi (1998). In such a context, what would be the aggregate impact of the aforementioned measures on the carbon intensity of energy use is a question for which there is no straightforward answer; each country would likely have a different reaction depending on its economic structure, resource endowment, or other country-specific characteristics. Hence, the resulting emission profiles would be quite heterogeneous. For instance, high and volatile inflation rates distort intertemporal choices and thus reduce the incentives to preserve

environment as both producers and consumers discount highly the future environmental costs of their activities (Fischer, 1996). An inflation-targeting regime along with stable macroeconomic conditions under an IMF program may provide greater incentives to care for the environment. Nevertheless, in the absence of adequate environmental policies, IMF programs may have detrimental environmental impacts as well. For example, raising taxes on (or removing subsidies to) a specific fuel affects the carbon intensity of the energy mix mainly due to fuel substitution. Similarly, an exchange rate depreciation following the IMF's prescriptions may raise the values of carbon-intensive goods that generate export earnings. The producers may then be encouraged to increase their supplies of these goods, and in consequence, the production in the country shifts to a more carbon-intensive growth path. This situation is very likely to arise in countries where environmental regulations are very lax or nonexistent (see Jobert et al., Forthcoming). The insight emerging from these examples is that policy prescriptions and reforms required by the IMF may have both positive and negative impacts on the environment, which may cancel each other out. The results of our empirical work in this paper confirm this proposition, that is, IMF programs have no robust significant impact on the carbon intensity of energy use.

6. Conclusions and policy implications

The main hypothesis tested in this study is that by affecting economic, institutional and social environments, IMF programs may have an impact on the energy use and resulting CO₂ intensity in the countries that the IMF loans money to. The interest in testing this hypothesis stems from the fact that although there has been substantial progress in our knowledge of the effects of the IMF's structural adjustment programs on

macroeconomic variables of receiving countries, we know very little about the impacts of these programs on energy use and environmental quality.

Two main results emerge from our study: first, IMF programs help reduce energy consumption in the countries where they are implemented; and second, those programs do not change the energy mix or technological structures in a way that would reduce carbon emissions per unit of energy use. While these results constitute a robust quantitative assessment of the effects of the IMF's involvement in energy and environmental issues, they also have an important policy implication for shaping and framing future IMF interventions in developing countries. With these results in mind, in the rest of this concluding section we elaborate on the implications of our findings.

It is well understood that energy subsidies are very badly targeted (Coady et al., 2015), and yet the main emphasis regarding the impacts of the IMF's fuel subsidy reforms has been so far on the distribution of welfare. However, energy efficiency and CO₂ emission reduction continue to be prominent on the international policy agenda. The Paris Agreement adopted by the 21st Conference of Parties (COP21) under the United Nations Framework Convention on Climate Change (UNFCCC) has been entered into force on November 2016 with the aim of strengthening the global response to the threat of climate change. As was the case for previous climate agreements, it recognizes the differences between developed and developing countries with respect to both their responsibilities in global warming and capabilities to mitigate emissions. On this issue, the Agreement's Article 9(1) states: "Developed country Parties shall provide financial resources to assist developing country Parties with respect to both mitigation and adaptation" (UNFCCC, p. 13). Furthermore, according to the Article 11(3) "Developed country Parties should enhance support for capacity-building actions in developing

country Parties” (UNFCCC, p. 15). It is evident that climate change should be seen as one of the primary concerns in developing countries as people living in these countries are the most vulnerable to the impacts of climate change. Moreover, although historically these countries are not responsible for global warming, their emissions are growing sharply and are “expected to account for up to 70% of the global increase in emissions in the period 2002-2030” (Lema and Lema, 2013, p.301). In consequence, to prevent and mitigate climate change, the efforts should be directed towards improving energy efficiency and decreasing carbon intensity in developing countries. The same perspective is also highlighted by Yang et al. (2018) who show that fossil-fuel-intensive development paths that developing countries have been following may result in higher cost of climate change with irreversible damages to the environment. Thus the authors suggest that clean development of emerging economies should be seen as one of the key objectives of global climate policy. This is in line with our findings and recommendations that IMF programs may represent a good opportunity for successful collective action on climate change. The IMF should work with both national governments and environmental-related organizations (e.g. the United Nations Division for Sustainable Development) to support resilient economic development models to implement the global roadmap towards the energy transition in developing countries.

It has already been recognized by the IMF that “wherever environmental policies are lacking, there is a possibility that macroeconomic reforms may run counter to environmental preservation. But even then, the solution is not to give up on macroeconomic stability. Rather, countries should be encouraged to tackle the root causes of environmental degradation – the market, policy, and institutional failures – to ensure that households and businesses adequately internalize the costs of environmental damage” Fischer (1996). The IMF should thus encourage the countries

under its programs to adopt policies that would provide ‘win-win’ outcomes for both the economy and the environment. For instance, removing subsidies on energy sources, and adjusting energy prices to their opportunity costs⁶ would decrease energy use and reduce the fiscal burden. On the other hand, carbon tax policies are needed to prevent economic agents from using more carbon-intensive energy sources following subsidy removals. It should be added that as governments can use the revenues from carbon taxes to decrease (or remove) other distortionary taxes, a carbon tax policy may lead to a double dividend, by both improving the environmental quality and reducing welfare losses due to a distortionary tax system (see Goulder, 1995).

With the obvious need for an efficient response to the urgent threat of climate change the importance of cooperation between developed and developing countries involving technology development and transfer as well as climate- and development-related finance flows should be well understood. We believe that the points raised in this paper need to be placed high on any research agenda on energy and climate policy in developing countries.

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⁶ The conventional way of estimating opportunity costs or shadow prices of the goods that are subject to international trade, such as energy sources, is to use their international market prices or border prices.

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Appendix A. Descriptive statistics

[Table A.1]

Appendix B. Impact of one-year lagged IMF programs on energy use

[Table B.1]

Appendix C. Extensions of the model

[Table C.1]

Figures

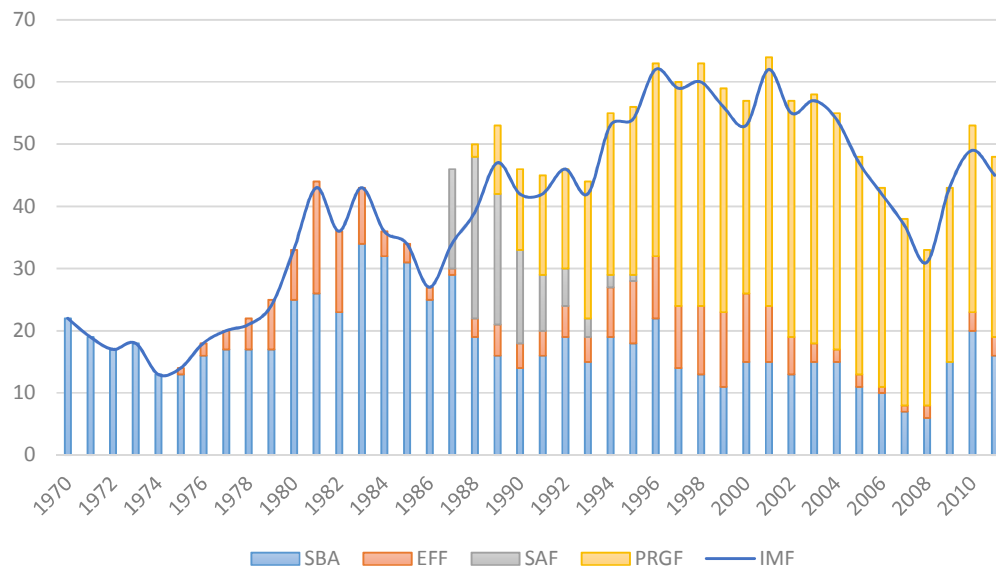


Figure 1. Number of countries under an IMF program

Notes: The acronyms for the IMF programs are SBA: Stand-By Arrangement; EFF: Extended Fund Facility; SAF: Structural Adjustment Facility; PRGF: Poverty Reduction and Growth Facility. IMF denotes the number of countries under at least one of the IMF programs for at least five months in a specific year.

Source: Authors' calculations based on Dreher (2006)

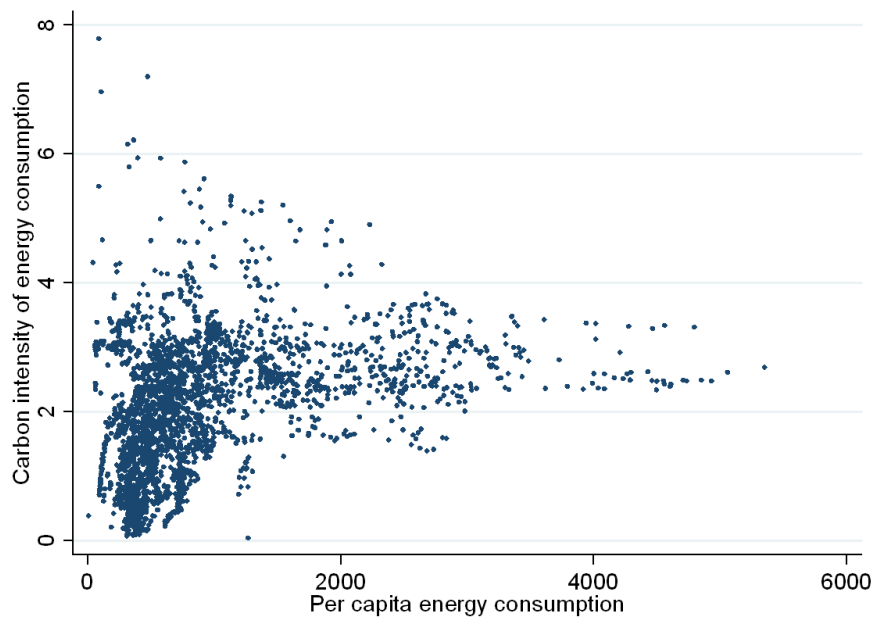


Figure 2. Energy use and carbon intensity

Notes: Per capita energy consumption is in kgoe, carbon intensity is in kg of CO₂. Sources: Authors' calculations based on World Development Indicators.

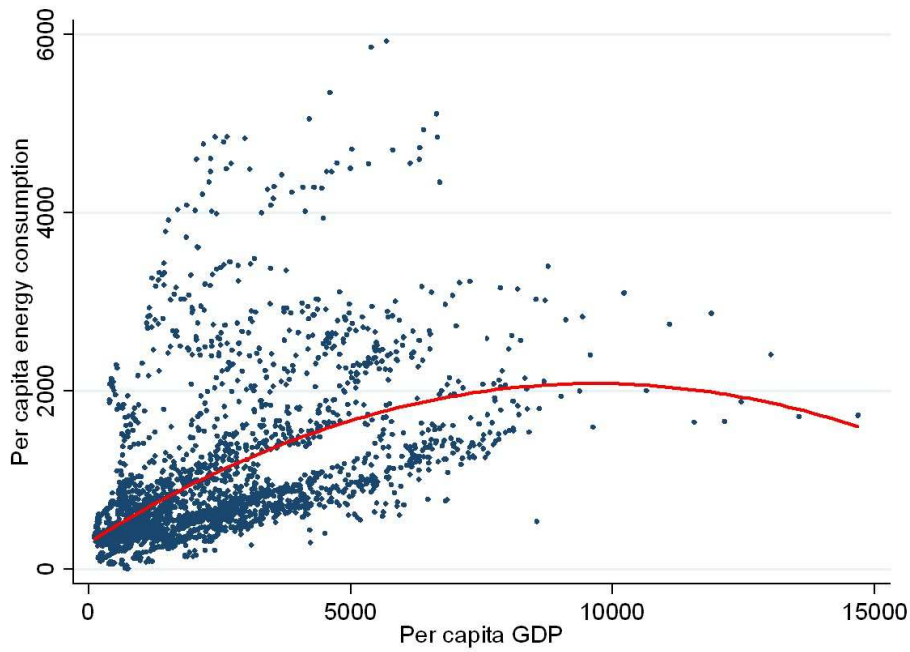


Figure 3. Relationship between energy consumption and GDP

Notes: Per capita energy consumption is in kgoe, per capita GDP is in constant 2005 USD. The red line shows predicted values of per capita energy consumption. Sources: Authors' calculations based on World Development Indicators.

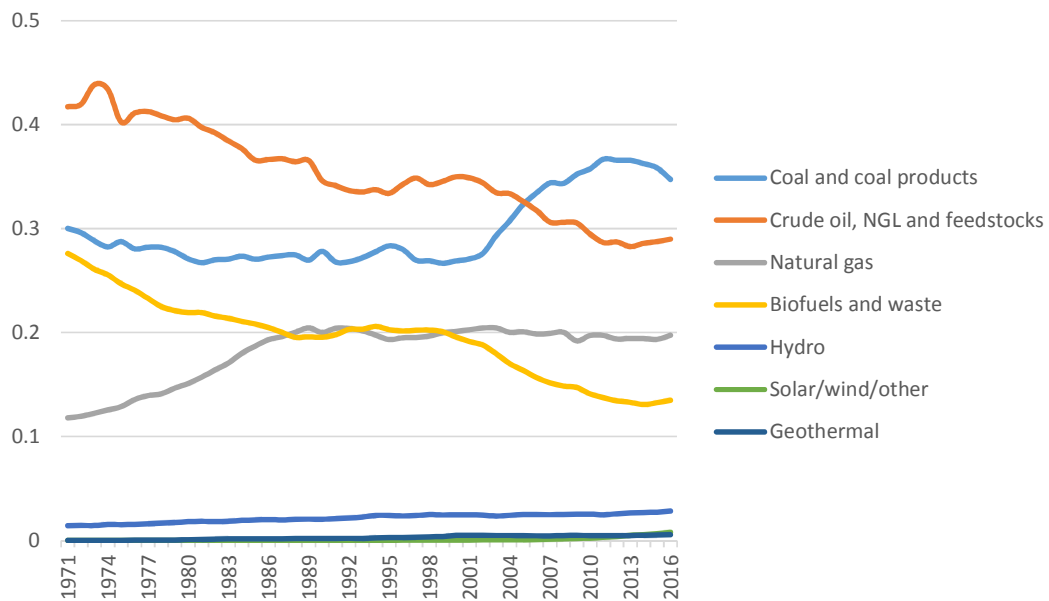


Figure 4. Energy consumption by source

Notes: Shares of energy sources in total primary energy supply. Source: Authors' calculations based on IEA's World Energy Balances.

Tables

Table 1. Pooled OLS and Fixed effects regressions of per capita energy consumption

VARIABLES	Pooled OLS estimates				Fixed effects estimates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	E	E	E	E	E	E	E	E
IMF	-287.2*** (-10.03)	-162.6*** (-6.826)	-114.3*** (-4.572)	-110.4*** (-4.442)	-106.3*** (-4.747)	-68.49*** (-3.576)	-68.30*** (-3.958)	-66.12*** (-3.842)
GDP		0.224*** (29.74)	0.192*** (25.17)	0.284*** (18.53)		0.199*** (6.326)	0.204*** (6.651)	0.346*** (5.218)
IVA			16.79*** (12.22)	15.36*** (11.36)			9.001*** (2.648)	8.168** (2.4)
GDP ²				-1.23e-05*** (-6.898)				-1.38e-05*** (-2.769)
Time dummy	yes	yes	yes	yes	yes	yes	yes	yes
Constant	675.5*** (9.946)	249.1*** (6.49)	-217.7*** (-3.370)	-259.5*** (-3.911)	817.0*** (18.58)	458.1*** (6.237)	161.1 (1.192)	20.1 (0.131)
Number of obs.	2938	2938	2647	2647	2938	2938	2647	2647
R ²	0.061	0.324	0.361	0.369	0.118	0.281	0.337	0.357
Number of ids.					118	118	115	115

Notes: Robust t-statistics are in parentheses. ** and *** indicate significance at the 5% and 1% levels, respectively.

Table 2. Pooled OLS and fixed effects regressions of CO₂ intensity

VARIABLES	Pooled OLS	Fixed effects
	CI	CI
IMF	-0.166*** (-4.408)	0.0368 (1.372)
GDP	0.000487*** (12.94)	0.000316*** (3.288)
IVA	0.0170*** (8.928)	0.0148*** (3.228)
GDP ²	-3.93e-08*** (-6.894)	-1.64e-08 (-1.452)
Time dummy	yes	yes
Constant	0.846*** (5.157)	1.189*** (5.766)
Observations	2534	2534
R ²	0.320	0.113
Number of id.		114

Notes: Robust t-statistics are in parentheses. *** indicates significance at the 1% level.

Table 3. GMM regressions of energy consumption and CO₂ intensity

VARIABLES	E	CI
E _{t-1}	0.837*** (15.73)	
CI _{t-1}		0.732*** (5.204)
IMF	-12.84** (-2.038)	-0.00614 (-0.278)
GDP	0.0568*** (3.562)	6.82e-05*** (2.746)
IVA	2.747 (0.971)	0.0107*** (2.767)
Constant	-55.65 (-0.504)	0.0472 (0.148)
Observations	2531	2416
Number of id	113	111
AR (1) : p-value	0.000	0.001
AR (2) : p-value	0.667	0.652
Hansen OID: p-value	0.235	0.522
Nb. of instruments	12	12

Notes: Robust t-statistics are in parentheses. ** and *** indicate significance at the 5% and 1% levels, respectively.

Table A.1. Descriptive statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
E	2938	947.0534	842.5705	9.714774	5928.793
CI	3071	2.047257	1.203705	0.0419001	13.27845
GDP	4451	2079.1	2088.17	50.04221	14678.61
IVA	4079	27.94129	12.15663	1.882058	84.37613
IMF	5472	0.287463	0.452620	0	1
FDI	4125	3.103704	7.3471	-82.89209	217.9205
TRADE	4267	74.02911	38.59571	.020999	375.3786
K	2757	3.00e+10	1.31e+11	-3.74e+07	2.99e+12

Source: Authors' calculations based on the World Development Indicators of the World Bank and Dreher (2006).

Table B.1. Pooled OLS and fixed effects regressions of per capita energy consumption using lagged IMF programs

VARIABLES	Pooled OLS	Fixed effects
	E	E
IMF _{t-1}	-123.00*** (-5.000)	-71.50*** (-4.015)
GDP	0.285*** (18.58)	0.348*** (5.290)
IVA	15.24*** (11.31)	8.051** (2.381)
GDP ²	-1.24e-05*** (-6.946)	-1.39e-05*** (-2.803)
Time dummy	yes	yes
Constant	-244.3*** (-3.695)	27.30 (0.179)
Observations	2647	2647
R ²	0.370	0.358
Number of ids.		115

Notes: Robust t-statistics are in parentheses. ** and *** indicate significance at the 5% and 1% levels, respectively.

Table C.1. Pooled OLS and Fixed effects results for the extended energy models

VARIABLES	Pooled OLS estimates			Fixed effects estimates		
	(1)	(2)	(3)	(4)	(5)	(6)
	E	E	E	E	E	E
IMF	-113.9*** (-4.500)	-98.38*** (-3.321)	-54.02* (-1.824)	-68.26*** (-3.693)	-63.83*** (-3.116)	-30.52* (-1.960)
GDP	0.277*** (18.06)	0.319*** (18.19)	0.326*** (18.02)	0.325*** (4.998)	0.269*** (3.656)	0.254*** (3.589)
IVA	14.66*** (10.33)	12.92*** (7.222)	9.755*** (6.058)	6.559* (1.754)	8.203 (1.61)	4.913** (2.174)
GDP ²	-1.20e-05*** (-7.032)	-1.68e-05*** (-8.577)	-1.70e-05*** (-8.645)	-1.20e-05** (-2.574)	-8.56e-06* (-1.682)	-8.34e-06* (-1.742)
TRADE	1.832*** (4.382)	1.982*** (4.564)	1.404*** (3.099)	0.592 (0.58)	0.774 (0.617)	0.83 (0.88)
K		4.50e-10*** (3.585)	3.92e-10*** (4.462)		4.04e-10*** (3.319)	3.14e-10*** (4.516)
FDI			7.032* (1.942)			-1.682 (-0.505)
Time dummy	yes	yes	yes	yes	yes	yes
Constant	-332.6*** (-4.732)	-406.6*** (-4.148)	-305.4*** (-2.668)	48.42 (0.316)	-27.14 (-0.135)	-23.14 (-0.122)
Number of obs.	2,539	2,018	1,915	2,539	2,018	1,915
R ²	0.367	0.377	0.4	0.357	0.401	0.485
Number of id.				113	94	93

Notes: Robust t-statistics are in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.