HOW DEPENDENT IS GROWTH FROM PRIMARY ENERGY? AN ASSESMENT FOR OECD COUNTRIES

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Overview

At least since the seminal work by Solow, various factors have been explored in order to explain growth, involving essentially capital accumulation, be it productive capital, human capital, etc. This paper examines yet another factor that has been largely ignored by mainstream economics: the role of primary energy use in the GDP growth of OECD countries in the last decades. Indeed, most of the macroeconomic literature assumes a priori that the output elasticity of energy should be equal to its cost share --accordingly, energy output elasticity should lie between 0.08 and 0.1, in "normal" times (cf. e.g. Blanchard-Galí (2007) and the literature therein, this equality is sometimes called the "cost-share theorem").

This paper starts by providing three theoretical arguments showing that there are good reasons for which, in general, the cost-share theorem fails to hold. As a consequence, the output elasticity of energy can no more be postulated: it must be empirically estimated. We then propose an econometric strategy in order to estimate the output elasticity of primary energy use in OECD countries since 1970. By contrast with what the cost-share theorem would predict, our findings show that this elasticity lies between 0.5 and 0.7 in most OECD countries. Our estimation is based on an error correction model, and this high level of elasticity turns out to be statistically robust and significant. In addition, we perform Granger causality tests which show that primary energy consumption Granger causes growth (the reserve being not true). This confirms, on a wider set of countries, the results on the causality between energy consumption and growth obtained in Stern (2011b, 2013a, 2013b).

Methods

The analysis is based on a panel data covering the period from 1970 to 2011 for 15 countries. For each country, we consider the long-run equation:

$$y_{it} = \beta_{0i} + \beta_{1i} c_{it} + \beta_{2i} e_{it-1} + \beta_{3i} k_{it} + \varepsilon_{it}$$

where i=1,…, 15 refers the countries, t=1970,…, 2011 reflects the time period, y_{it} is the logarithm of the GDP per capita, c_{it} is the logarithm of the energy consumption per capita e_{it} is the logarithm of energy efficiency and k_{it} is the logarithm of the gross capital formation per capita.

First and second generation co-integration tests confirm the existence of a long run cointegration relationship. Based on the existence of a long-term relationship we make an estimation of this relationship in cooperation with the short-term dynamics by an error correction model (ECM). We use the Pooled Mean Group (PMG), Mean Group (MG) and Common Correlated Effects Mean Group (CCE-MG) estimators to estimate the ECM. The results are reported in Table 1.

Results

Table 1. Selection of the estimation method

Model:	PMG	MG	CCE - MG
Dependent variable: ΔY_{it}			
Energy consumption per capita *(C_{it})*	**0.6740 (0.062)*****	**0.6075 (0. 126)*****	**0.6102 (0.165)*****
Energy efficiency *(E_{it-1})*	**0.6036 (0.070)*****	**0.5833 (0. 279)****	**0.4864 (0.183)*****
Capital formation per capita *(K_{it})*	**0.1244 (0.022)*****	**0.1972 (0.082)****	**0. 1643 (0. 036)*****
Convergence coefficient (Y_{it-1})	**-0.6230 (0.124)*****	**- 1.6958 (0.814)****	**-0.9554 (0.189)*****
Hausman test p value	**0. 0.419**		

Notes: *** significant at the 1% level; ** at the 5% level; * at the 10% level. Standard errors are given in parentheses. The lag structure is ARDL (1, 1, 2, 1).

The estimated error correction coefficients are negative and highly significant, indicating that, after an exogenous shock, the system moves back toward equilibrium. Moving from MG to PMG (i.e., imposing long-run homogeneity) reduces the standard errors and significantly reduces the measured speed of convergence. This restriction cannot be rejected at the 1% level by the Hausman test statistics; the PMG estimators are hence consistent and more efficient than MG estimators. The results, however, do not vary significantly with respect to the estimation method. Estimated long-run elasticities of energy consumption, energy efficiency and capital formation per capita are statistically significant. They turn out to be

Table 2. Panel causality test results

Dependent Variable	**Sources of causation (independent variables)**				
	Short run				*Long run*
	ΔY	**ΔE**	**ΔC**	**ΔK**	**ECT**
ΔY	-	1.26	**23.03*****	**190.86*****	**-0.325*****
ΔE	**1228.4*****	-	**8702.6*****	**9.53*****	**-0.959*****
ΔC	0.41	0.16	-	0.44	-0.628
ΔK	**47.59*****	2.35	**39.13*****	-	**-0.158*****

Notes: Wald chi-squared test statistics for short-run causality. The lag length is one. ECT represents the coefficient of the error-correction terms. ∗∗∗, ∗∗ and ∗ indicate that the null hypothesis of no causation is rejected at the 1%, 5% and 10% levels, respectively.

The short-run and long-run causality tests reveal several interesting results. First, the results show that energy consumption is exogenous to the other variables in the model. There is unidirectional Granger causality from primary energy use to economic growth in both the short and long-run. Energy also indirectly affects the economy growth through its positive impact on capital formation.

Conclusions

Primary energy consumption is a key explanatory factor of growth in OECD countries, whose long-run output elasticity is approximately 0.6. Such findings provide a firm empirical ground for the rejection of the conventional calibration of energy output elasticity according to the energy cost-share theorem. They amply confirm and complement, on a wider set of countries, similar findings obtained by Stern (2010, 2011a), and with a different econometric strategy.

References