**Understanding the energy productivity diversification after the Global Financial Crisis**

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**ABSTRACT**

**Keywords:** growth instability frontier, energy productivity, industrial diversification

**INTRODUCTION MOTIVATION AND BACKGROUND**

 Sector diversification of a region (“risk” factor) is related to its growth rate (“return” factor). Considering that more diversification reduces risk, model predicts that larger regional aggregation show less instability, as they benefit from more industrial diversification. A large strand of literature on the relationship between economic growth and structural diversification has shown that there exists an efficient frontier at a more aggregated regional level and that optimal combination of growth and instability can be influenced by appropriate industrial policies that modify regional industrial structure.

Surprisingly, there has not been in the literature an analysis of the growth - risk opportunities in terms of energy productivity growth.

The aim of the project is to investigate whether such growth-instability relationship exists in OECD countries using WIOD DATA in the recent period of slow growth and whether it has been influenced by the structural changes induced by the Global financial crisis after 2007 and the consequent wide fluctuations in oil prices.

This is potentially interesting for policy making, where Governments' efforts to spur economic growth using renovated industrial policy strategies have to take into account the strategic issue of energy productivity growth opportunities, which is driven by industrial and technological diversification.

**METHODS**

The starting point is the assumption of a region production activity, which is explicitly characterized by some energy productivity (EP). In analogy with the Markowitz (1952) model, where investors minimize portfolio variance for a given level of expected return, this paper considers that the economic activity is characterized by some return, defined as the overall EP growth rate, some uncertainty, defined as the sector variability of EP growth rate, and some portfolio structure, defined as the sector composition of economic activity.

In view of these assumptions, the variance of EP growth rate to be minimized can be expressed as follows. s’Vs where V is the sector growth covariance matrix and s is a sector shares vector; EP growth rate of i-th region *gi* can be viewed as the sector growth rates sum weighted by each sector relative importance: *gi = Σj sj gj* .

Standard optimization yields the efficient frontier:

*v2gi = (a-2bgi + cgi2) / (ac – b2) (1)*

In eq. (1), *a, b, c* are the relevant parameters.

In the mean-standard deviation space, this latter equation defines a parabolic function of efficient portfolios. The idea is that this is the frontier of portfolios with minimum variance (see Figure 1).

Figure 1 – The standard efficient portfolio frontier

gi

Standar deviation of gi

Admissible Solutions

Efficient Frontier

0

The interpretation of the return variable is the growth rate of a sector EP and the interpretation of the variance is the structural composition of the EP or diversification of the energy and industrial structure. In this way it becomes clear the trade-off between high EP growth and concentration or diversification of the production structure. A region specialized in a narrow range of high EP growth sectors has a higher growth but also a higher risk of downturn, if that sector growth ceases for whatever exogenous reasons.

In addition, if a region is small and is dominated by a single sector, i.e. it is not diversified, then the portfolio effects vanishes, because the growth rate of the region will be determined by the dominant sector growth rate.

These considerations render this model very actual for the current strategic policy stance in the energy field, in the wider framework of oil price fluctuations and new environmental policies.

**RESULTS AND DISCUSSION**

We use WIOD DATA official value added (VA), energy inputs and GDP accounting data for a specified period of T years (2000-2012), a specified number of sectors M, and for 40 countries.

The total number of observations is Tx40.

For the variable EP (which is defined as the energy to VA ratio) in real terms, we compute regional annual growth rates and its sector standard deviations.

The empirical equation to estimate the efficient frontier defined above can be expressed as:

*SDit = ai + b1 gi + b2 gi2 + eit (2)*

where *SDit* is the standard deviation of the i-th region, *ai* is the regional fixed effect, *gi* is the annual growth rate of the i-th region and *eit* captures the residual error.

We implement different econometric estimation procedures (fixed, random effect and stochastic frontier). Hausman test can be used to detect whether there is significant difference between fixed and random effect models.

The validity test should show in which cases the portfolio frontier convexity assumption is accepted.

Econometric tests have to performed and discussed to show the significance, sign and magnitude of estimated coefficients *b1* and *b2* values in the period of estimation.

Expected results according to theory are that the first (*b1*) is negative and the second (*b2*) is positive.

An interesting implication of the analysis is to test for parameter stability in some sub-periods. This can be done with a Chow test for structural breaks.

The sub-period can be chosen according to exogenous events, such as the periodization before and after the Global financial crisis (before and after 2007), or the periodization of relevant policy strategy changes in the country/Region.

Empirical results show whether there has been stability or evolution to transition toward a new economic era of the regional economic structure.

The econometric tests will show whether the null hypothesis of parameter stability can or cannot be rejected.

The significance value of the coefficient *b2* is important to assess the pattern of diversification. If the coefficient value is significantly greater than unity, this shows an increasing degree of regional diversification. If this coefficient changes in the sub-periods, for instance increases in the post crisis period, there is evidence that Country industrial structure is reacting and adapting to the crisis with an increasing regional diversification.

**CONCLUSIONS**

In conclusion, the existence of a well-defined convex efficiency frontier for the OECD enertgy productivity structure provides useful suggestion for policy intervention since it emphasizes how the economic performance, in terms of energy productivity growth, of a given region must be analyzed not only in terms of growth levels but also in terms of economic structure stability.

In this sense, knowledge of how the efficiency frontier for energy usage in the OECD has been affected by the crisis can provide to policy makers important information to shape appropriate intervention differentiated at the regional level in order to cope with the consequences of economic growth slowdown induced by the crisis.

The policy lesson is to help new policy scope toward trade enhancement and joint development efforts to exploit efficiently the relative comparative advantages with respect to the rest of the world.

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