Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement für
Umwelt, Verkehr, Energie und Kommunikation UVEK

**Bundesamt für Energie BFE**

energie trialog
SCHWEIZ

**Policy summary** 5. Oktober 2009

---

# The Effect of Energy Efficiency Enhancement on Innovation and Competitiveness.

## Studie im Auftrag des Energie Trialog Schweiz und des Bundesamtes für Energie

---

**Auftraggeber:**
Bundesamt für Energie BFE
Forschungsprogramm Energiewirtschaftliche Grundlagen
CH-3003 Bern
www.bfe.admin.ch

Energie Trialog Schweiz
Lagerstrasse 33
8021 Zürich
www.energietrialog.ch

**Auftragnehmer:**
Institut CREA de macroéconomie appliquée
Université de Lausanne
Faculté HEC – Bâtiment Internef
CH-1015 Lausanne - Dorigny
http://www.hec.unil.ch/crea

**Autoren:**
Olivier Cadot
Université de Lausanne, Institut CREA
Quartier UNIL-Dorigny
Faculté HEC - Bâtiment Internef
CH-1015 Lausanne
olivier.cadot@unil.ch
T. +41 21 692 34 63
Camille Gonseth
Université de Lausanne, Institut CREA
Quartier UNIL-Dorigny
Faculté HEC - Bâtiment Internef
CH-1015 Lausanne
camille.gonseth@unil.ch
T. +41 21 692 33 54
Philippe Thalmann
EPFL ENAC INTER REME
BP 2137 (Bâtiment BP)
Station 16
CH-1015 Lausanne
philippe.thalmann@epfl.ch
T. +41 21 693 73 21

**BFE-Programmleiterin** Nicole Mathys
**BFE-Vertrags- und Projektnummer**: 153509 / 102719

# Policy summary

## *Scope of the research*

Whereas much of the media debate about policies to save energy and reduce $CO_2$ emissions has been cast in terms of a trade-off between environmental and economic efficiency, in the mid-nineties Michael Porter and Claas van der Linde suggested that this debate was incorrectly framed. Their conjecture was, in essence, that stricter environmental regulations could facilitate a transition from "extensive" growth (growth fuelled by using more factors of production) to "intensive" growth (growth fuelled by more efficient use of factors), and was backed by Porter's vast "clinical" and case-study experience. Porter and van der Linde's pioneering conjecture is now known as the "Porter hypothesis" and has been widely discussed in academic and policy circles. In a nutshell, it is a "win-win" argument according to which tightening environmental regulations induces innovation, which in turn improves *both* environmental *and* economic efficiency. However, the Porter Hypothesis is controversial. First, it has no theoretical backing, being a conjecture borne of casual observation. Second and perhaps more importantly, its empirical validity has been widely debated. It is a fact that empirical analyses looking at the effect of environmental standards and energy prices (the two can be loosely taken as having potentially similar effects) on innovation or productivity have not settled yet the issues related to the Porter hypothesis. This debate matters not just academically: It is also highly relevant for the formulation of environmental policy. If more stringent environmental or energy standards reduce the ability of domestic firms to compete with foreign ones, the international regulatory environment is likely to be a race to the bottom in which every country tries to undercut others by loose environmental standards. Loose environmental standards are, in this context, a sort of hidden industrial policy, and only binding international treaties can provide the commitment mechanism needed to stop the race to the bottom. If, by contrast, stringent environmental standards promote profitable innovation, as per the Porter Hypothesis, policymakers can shift attention from "environmental diplomacy" to the design of unilateral policies *at home*. Moreover, environmental policy will spread by contagion, and first movers are likely to set the tone for others, capturing the environmental-policy agenda in a way that can be beneficial to home firms.

## *Methodology*

Due to the late availability of easily accessible data on R&D and patents, most of the attention has been devoted, in the last decade, to finding a causal relationship between energy prices or regulation on one hand and innovation on the other. However, studies of this type would never provide full testing of the Porter hypothesis: Showing that regulation triggers innovation is important in itself, but it is not enough to show that regulation can enhance competitiveness. In this respect, investigating the link between energy prices or regulation and *productivity* is closer to the spirit of the Porter hypothesis. Measuring productivity has a long history in economics and, in the report, our first task is devoted to construct an index of total factor productivity (TFP) at the industry level that reflects the efficiency with which productive inputs are used. Our focus on industries (rather than on firms) is purely motivated by data availability since international comparisons at the industry level are possible using currently available databases. Indeed, we were able to build, based on these databases, a large panel of industries tracked for most OECD countries over a long period of time. In contrast, international firm-level data sources are not suitable for carrying out productivity analysis.

In a second step, we look at the reaction of our constructed index of industry-level TFP to contemporaneous energy-price shocks rather than to specific changes in environmental regulation (which may be difficult to measure if the regulation does not affect any prices). We use the economic equivalence between cost-raising emissions regulations such as energy and $CO_2$ taxes and energy-price shocks to estimate their (common) effect on TFP. Therefore, we might think of our approach as analysing the response of industries and their TFP to changes in energy prices as a proxy for efficient price regulation capable of triggering innovation.[1] Our use of a panel data set of manufacturing industries located in OECD countries is one of the key features of our empirical approach as it permits us to model for (unobserved) differences in behaviour across industries. Moreover, our model specification allows the effect of energy-price shocks on TFP to vary according to the level of R&D and worker skills. We assume that both characteristics make industries better able to adapt to outside developments like unforeseen energy-price shocks or regulatory changes. Beyond the use of panel data at the industry level, the primary originality of our approach therefore comes from our postulate that industries with higher R&D expenditure or more skilled labor forces are better able to cope with energy-price shocks (and thus with environmental-regulation shocks) than others.

## *Empirical results*

The cost of our approach is that the combination of TFP and R&D data, together with the need to control for observed confounding variables (i.e. variables whose effect on the TFP can be mixed up with the effect of other explanatory variables), reduces the sample's size drastically, from about 14'000 to 322 observations. In spite of this, we find very robust support for the Porter Hypothesis, with a positive partial effect of energy prices on productivity for 70% of the national manufacturing sectors included in our sample. Because of their relatively high level of innovative activity, industries like chemical products, transport equipment, or radio, television and communication equipment should have greater aptitude to adapt to unforeseen changes in the business environment than others. Our results are in line with this expectation since their productivity generally increases with a rise in energy prices. As it turns out, we also find sometimes large positive impacts of energy price shocks on productivity in the "coke, refined petroleum products and nuclear fuel" and "other non-metallic mineral products" industries, two sectors particularly exposed to energy prices due to their high energy intensity, possibly because they are characterized by low-hanging fruits in terms of improvements in both production processes and environmental performance. Results are stronger when using R&D as the measure of adaptive capacity than when using labor skills, possibly because our chosen estimation technique uses only the within-industry (time) variation of the data, whereas the skill composition of industries varies little over time.

Regarding the underlying mechanism, our results suggest that two effects work at cross-purposes. First, an energy-price rise directly reduces TFP if it forces industries to invest in new, more expensive (but energy-saving) capital equipment to produce

[1] Note also that, in OECD countries, energy taxation choices are already important determinants of energy prices variations, both over time and across countries (cf. section 5 in the final report).

the same amount of output as before (and if energy savings are passed on to consumers). But it also generates unexpected efficiency gains in industries that can harness brainpower to adapt their production processes. Because the latter effect is contemporaneous, it is unlikely to be driven by R&D itself. Rather, it is likely that R&D spending proxies for the reactivity of management to energy-price shocks and for the active search for more efficient processes, whether through true knowledge creation, knowledge absorption, or better organization. It also appears from our analysis that the induced efficiency gains are often large enough to more than fully offset the costs associated to energy-price shocks at the industry level. We already mentioned the fact that we find a positive net effect of energy prices on TFP in 70% of the national industries included in our sample. Again, this provides very strong evidence in favor of the Porter Hypothesis, at least in the "adaptive-capacity" formulation adopted here.

The nature of the results described above was not altered when we estimated a dynamic rather than a static model. The dynamic specification differs from the static one by the inclusion of a lagged 1 year energy price variable whose effect on industry TFP was found to be positive. This result provides additional insights as to the underlying mechanism being at work. It suggests a sort of adjustment between industries where low-tech industries learn from measures (or even adopt measures) that have been undertaken in the more reactive ones. It might also suggest that some innovation is induced that reduces, with a one year delay, the detrimental impact of rising energy prices on TFP. Could this positive lagged effect be driven by a selection effect? In the long run, in a heterogeneous-firm setting, higher energy prices are likely to induce the exit of the least productive firms in each industry; in addition, only the most productive ones could afford the fixed cost of higher R&D spending. Thus, energy-price shocks would generate a partition of firms, with the most productive doing more R&D (or starting to do R&D), the middle ones simply suffering reduced profitability, and the least productive ones exiting. This would produce a rise in industry-wide average productivity. Only firm-level analysis could tell whether this selection (between-firm) process is at play and whether it is the most important quantitatively. However, it is a long-run phenomenon that is unlikely to be driving the contemporaneous and 1 year lagged effects that we identify so strongly in the industry-level data.

## *Conclusion and policy implications*

In conclusion, our results lend support to the Porter Hypothesis and provide a clue to the underlying mechanism. We try to get at the causal effect of energy prices on TFP using a set of observations made annually on a large number of manufacturing industries located in OECD countries. We find that (i) rising energy prices have the potential to reduce TFP at the industry level, but (ii) when combined with the amount of R&D spending, rising energy prices increase TFP at the industry level, which means that sectors that spend more on R&D are those that take advantage of higher energy prices. When both channels – direct and mediated by R&D spending – are taken into account, higher energy prices raise productivity in most industries.

The policy implications of our findings are straightforward. Emission-regulation shocks, inasmuch as they raise the cost associated with the use of fossil fuels, can be expected to have a negative direct effect on TFP but a positive one for those industries with the highest capacity to adapt, as proxied by their R&D spending. This suggests a policy aimed at improving the capacity of firms to adapt through R&D incentives *prior* to the adoption of stiff emission standards. If effective, R&D incentives could turn subsequent environmental regulation into the kind of win-win that Porter and van der Linde described with their case studies.