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The causal relationship between energy use and economic growth in Switzerland ☆

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ABSTRACT

This paper investigates the relationships between energy consumption and economic growth in Switzerland over the period 1950–2010. We apply bounds testing techniques to different energy types separately. Robustness tests are performed by including additional variables and restricting the analysis to the period after 1970. The results show that there exist robust long-run relationships going from real GDP toward heating oil and electricity consumption. The relationship between heating oil and GDP is in fact bidirectional, although weaker from heating oil toward GDP than in the reverse direction. When investigating the period 1970–2010 only, the estimate of the long-run income elasticity of electricity consumption loses statistical significance and that for heating oil becomes negative. Those results imply a possible decoupling between GDP growth and energy consumption, so that energy conservation policies are not necessarily expected to have a negative impact on Swiss economic growth.

1. Introduction

Potential climate change threats, geopolitical tensions and recent nuclear accidents have triggered widespread concerns about energy supply security and environmental impacts associated with energy production and consumption. As a consequence, several countries are currently proposing strong energy substitution policies and radical energy conservation measures. In this context, it is of foremost importance to assess the costs of those policies, in particular in terms of GDP, because energy is thought to be intimately related with development (e.g. see Goldemberg and Lucon, 2010). At a theoretical level, energy can be considered as a production factor contributing to GDP or alternatively as a good or service consumed by economic agents, in which case income is a determinant of the amount of energy consumed. The literature distinguishes four potential causal relationships between energy consumption and GDP (see Payne and Taylor, 2010). First, the "growth hypothesis" considers a unidirectional causality running from energy consumption to GDP. In this situation, a decrease in energy consumption has a negative impact on growth. Second, the "conservation hypothesis" assumes a unidirectional causality running from GDP to energy consumption, in which case energy conservation policies have no impact on GDP growth. Third, the "feedback hypothesis" expects bidirectional causality between energy consumption and GDP, implying that they are jointly determined. Fourth, the "neutrality hypothesis" assumes no causal relationship, i.e. independence between energy consumption and GDP.

Chontanawat et al. (2006) and Ozturk (2010) summarize the results of about 100 empirical studies and show there is no consensus on the direction of the energy–GDP causality nexus, if any. Given the variety of countries and periods under analysis and the different empirical approaches used, it is difficult to provide general policy recommendations on the impact of energy and environmental policies. This is also confirmed by the latest meta-analysis on the subject (Chen et al., 2012).

Chontanawat et al. (2008) investigate causality between energy consumption and GDP for 30 OECD countries and 78 non-OECD countries. Causality from energy to GDP is found to be more prevalent in the OECD countries than in non-OECD countries. Other outstanding studies include Bowden and Payne (2009), who compute sector-specific causalities for the US, and Lee et al. (2008), who control for differences in capital stocks. Huang et al. (2008) introduce the possibility of nonlinear relationships and find that economic growth depends on several "threshold-variables" such as CO_2 emissions, energy efficiency, the ratio of industrial energy consumption to total energy consumption, and per-capita energy consumption. Focusing on nuclear energy consumption and using a panel cointegration test for 16 countries,

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Apergis and Payne (2010) find a bidirectional relationship with GDP in the short run, but a unidirectional causality running from nuclear energy consumption to economic growth in the long run. When countries are studied individually, it however becomes clear that no general conclusion can be drawn, even among high-income countries (see Wolde-Rufael and Menyah, 2010). According to Ozturk (2010), a general conclusion from the energy consumption–GDP literature is that there is no consensus, neither on the existence nor on the direction of causalities.

In this paper, we investigate the relationship between energy consumption and GDP in Switzerland. This country is an interesting case because of the peculiarities of its economy, its energy supply and its geographical characteristics. Switzerland is one of the richest countries in the world and two thirds of its workers are employed in the service sector. Since the energy intensity in the service sector is relatively low, one would expect Switzerland to be less energy dependant than other countries possessing larger manufacturing and agricultural sectors.[1] Recently, Filippini and Hunt (2011) identified Switzerland as one of the most energy-efficient (and less energy-intensive) countries in the OECD. Electricity supply comes from nuclear (about 40%) and hydropower (about 60%). Greenhouse gas emissions from electricity generation are thus remarkably small. Currently, about one third of greenhouse gas emissions come from the transport sector, 20% from each the households and the industry sector, 10% from each the agriculture and the service sector, and 5% from waste. Concerning transport activities, Switzerland is also a special case, with a well-developed public transport system offering a very high quality service. However, large parts of the country are mountainous regions, where there is no real alternative to private cars. Electricity generation is called to change radically in the near future: in May 2011 the Swiss Federal Council (the executive power) and the Parliament decided to phase out nuclear energy by closing the five power plants currently in operation between 2019 and 2034. Although serious efforts in renewable energy are planned, strong energy efficiency improvements and energy conservation measures are needed in any case. During the transition period, additional fossil fuel-based electricity production (cogeneration facilities, gas-fired combined-cycle power plants) might be needed. At the same time, CO_2 emissions reduction targets are maintained. In this context, it is of particular relevance to assess the relationship between energy consumption and GDP.

Although we are not aware of specific studies on the relationship between real GDP and energy consumption in Switzerland, Swiss data are used in some international databases and several multi-country papers report separate results for Switzerland. An overview of these results is provided in Table 1.

The five papers in the top panel of Table 1 find that in Switzerland total energy consumption has a statistically significant impact on GDP. The first and the last studies of the top panel find bidirectional causality between energy and GDP, while the other studies show causality from energy to GDP only. The bottom panel of Table 1 lists papers investigating specific energy types. Focusing on electricity consumption, Narayan and Prasad (2008) find a cointegrating vector and hence a long-run relationship between electricity consumption and GDP. They could however not identify any causal relationship. Focusing on nuclear energy consumption, Yoo and Ku (2009) find bidirectional causality, while with a very similar dataset but using a modified version of Granger causality tests and introducing physical capital and labour as additional variables, Wolde-Rufael and Menyah (2010) unexpectedly find a negative unidirectional causality from nuclear energy consumption to real GDP. They argue that this negative impact might be due to production shifting toward less energy intensive sectors or to excessive nuclear energy consumption in unproductive sectors.

Table 1
Results for the energy-GDP nexus in Switzerland, from multi-country studies.

Studies	Data	Results
Total energy consumption (EC)–real GDP		
Chontanawat et al. (2006)	1960–2000 (per capita)	Cointegrating equation, bidirectional causality
Lee (2006)	1960–2001	Unidirectional causality from EC to GDP
Huang et al. (2008)	1960–2002	Positive significant relationship from EC to GDP
Acaravci and Ozturk (2010)	1960–2005 (per capita)	Unidirectional causality from EC to GDP (and bidirectional short-run causality)
Narayan et al. (2010)	1980–2006	Positive bidirectional causal relationship
Electricity (ELC) or nuclear energy consumption (NEC)–real GDP		
Narayan and Prasad (2008)	1960–2002, ELC	Cointegrating equation, but no causality
Yoo and Ku (2009)	1969–2005, NEC	Not cointegrated but bidirectional causality
Wolde-Rufael and Menyah (2010)	1971–2005, NEC	Negative unidirectional causality from NEC to GDP

Notes: EC: energy consumption, ELC: electricity consumption, NEC: nuclear energy consumption, GDP: real GDP.

It is somehow surprising to observe such different results for the same country, but since all these papers are multi-country studies, they do not focus on Switzerland and differences in results are not discussed. Extending previous studies and taking the suggestions by Zachariadis (2007) into account, the present paper investigates the energy–GDP relationship for Switzerland thoroughly. With respect to the existing literature, the novel features introduced in this paper are i) the very long observation period including most recent data (1950–2010); ii) the fractional integration methodology using bounds testing, as suggested by Ozturk (2010); iii) the analyses conducted for each energy type separately and iv) robustness checks using price data for each energy type.

The remainder of the paper is structured as follows. Section 2 presents the empirical approach and the data. Section 3 discusses the main results. Section 4 proposes robustness checks by introducing additional control variables in the regressions and restricting the analysis to the period 1970–2010. Section 5 concludes and suggests further research directions.

2. Data and empirical approach

We use annual data from 1950 to 2010.[2] Fig. 1 displays the evolution of total energy consumption per capita and Swiss real GDP per capita in Swiss Francs (CHF).[3] We use per-capita values to abstract from changes in population size and therefore follow the suggestion by Zachariadis (2007), i.e. per-capita variables should be matched with per-capita variables. Total energy use per capita grew relatively fast from 1950 until the first oil shock, then less rapidly until 1990, and it eventually stabilised in the last couple of decades. In Fig. 2, total energy consumption per capita is decomposed into different energy types. It shows in particular that since 1970 the evolution of total energy consumption is mostly driven by the regular decrease in heating oil consumption, in combination with the increase in fuel, electricity, and gas.

Stern (2000) points out that substitution from lower (e.g. coal) to higher-quality energy types (e.g. electricity) may take place during the growth process. However, although such substitution is important for countries like Korea (see Oh and Lee, 2004), it is not very relevant for Switzerland given the limited substitution possibilities. Indeed, heating oil is used for heating, fuel is used for transport, while electricity is mostly used for the remaining activities. The only significant substitution takes place in house heating from heating oil toward natural gas, waste incineration, heat pumps (i.e. electricity)

[1] For this reason, we conduct a causality analysis including the share of workforce employed in the service sector as an additional variable (Section 4).

[2] Descriptive statistics are provided in Appendix Table A1.

[3] As of April 23rd, 2012, CHF 1 = EUR 0.832 = USD 1.094.