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Communication

Economic effects of peak oil

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HIGHLIGHTS

- ▸ National and sectoral economic effects of peak oil until 2020 are modelled.
- ▸ The price elasticity of oil demand is low resulting in high price fluctuations.
- ▸ Oil shortage strongly affects transport and indirectly all other sectors.
- ▸ Global macroeconomic effects are comparable to the 2008/2009 crisis.
- ▸ Country effects depend on oil imports and productivity, and economic structures.

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ABSTRACT

Assuming that global oil production peaked, this paper uses scenario analysis to show the economic effects of a possible supply shortage and corresponding rise in oil prices in the next decade on different sectors in Germany and other major economies such as the US, Japan, China, the OPEC or Russia. Due to the price-inelasticity of oil demand the supply shortage leads to a sharp increase in oil prices in the second scenario, with high effects on GDP comparable to the magnitude of the global financial crises in 2008/09. Oil exporting countries benefit from high oil prices, whereas oil importing countries are negatively affected. Generally, the effects in the third scenario are significantly smaller than in the second, showing that energy efficiency measures and the switch to renewable energy sources decreases the countries' dependence on oil imports and hence reduces their vulnerability to oil price shocks on the world market.

1. Introduction

The recent crisis in Libya, sanctions against Iran and the imminent oil supply shortage as well as high energy price fluctuations in the past years elucidate that energy security is becoming just as important as efficiency and sustainability of energy production. This was already stressed in a study by the Bundeswehr Transformation Centre of the German Federal Ministry of Defence (ZTB, 2010), which recognised that fossil fuels, especially oil, are not only necessary for a functioning of the global economy, but also for strategic issues. While the World Energy Outlook (IEA, 2011) as well as many others expects world oil production paths that are able to meet world oil demand in the coming decade, the discussion about peak oil today shows that these projections might be too optimistic. Comparing projections of world-wide oil supply of LBST (2010), which assumes that oil production has recently peaked, to projections of oil demand from e.g. WEO 2010 (IEA, 2010), shows that it might well be possible that oil supply shortages arise and grow over the next decade. That is, given the IEA oil prices, oil supply will not match oil demand, which obviously implies oil price increases until demand equals constrained supply.

There is an on-going vivid debate about whether peak oil is real and now (e.g. Aleklett et al., 2010) or just a myth for the next decades (Radetzki, 2010). Recent pessimistic contributions include Murray and King (2012), who argue that "oil's tipping point has passed". Kerr (2012) is quite optimistic for growing US oil production due to unconventional oil, but he still expects growing dependency on OPEC oil and limited supply on a global level. Tverberg (2012) points at the link between oil supply limits and the financial crisis. On the other hand, Mill (2012) sees no oil supply shortage, but argues that "oil demand will peak long before oil supply". According to Owen et al. (2010) part of the dissent can be resolved by clear definitions. Irrespective to the actual oil supply in the next decades, there can be a risk of short- or even long-term oil supply shortages (Fantazzini et al., 2011) or price shocks to balance inflexible supply and inflexible demand, which are worthwhile to be evaluated in the economic dimension.

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Given this, the paper at hand presents results of a model-based scenario analysis on the economic implications in the next decade of an oil peak today and significantly decreasing oil production in the coming years. For that the extraction paths of oil and other fossil fuels given in LBST (2010) are implemented in the global macroeconomic model GINFORS. Additionally, the scenarios incorporate different technological potentials for energy efficiency and renewable energy, which cannot be forecast using econometric methods. GINFORS then endogenously determines world-wide energy demand and energy prices. In modelling terms this means, that the oil price is increased until global oil demand equals global oil supply. The resulting oil price is by no means to be understood as the most likely oil price development; rather this exercise should be understood as an if-then-analysis in a research area that still needs extensive explorations. Given the assumption of a fixed medium term oil supply, the effects described here might be too strong.

2. Model and scenario setup

Modelling the macroeconomic effects of decreasing oil supply in GINFORS is done via matching global oil demand to global supply by adjusting the oil price. As there exists very little literature on macroeconomic effects of oil shortages directly and the oil shortage is modelled via increasing oil prices, the effects we will see in this exercise correspond to macroeconomic oil price effects. For an extensive literature review the interested reader is referred to Hamilton (2005) and Kilian (2008). According to Jones et al. (2004) the effects of oil price shocks are difficult to model at the aggregated macroeconomic level, i.e. GDP. Best suitable are sectorally disaggregated econometric models, as for example vector-autoregressive (VAR) or vector-error-correction (VEC) models, or models such as the MULTIMOD model of the IMF or the INTERLINK model of the OECD. They also give a short overview over these types of models.

To model the macroeconomic effects of this oil shortage we use the sectorally disaggregated global energy-environment-economy model GINFORS. It combines econometric-statistical analysis with input–output analysis embedded in a complete macroeconomic framework ensuring the accounting identities of the system of national accounts. GINFORS has recently been applied to various economic questions, ranging from an European environmental tax reform (Lutz and Meyer, 2010; Ekins and Speck, 2011) and environmental and economic effects of Post-Kyoto regimes (Lutz and Meyer, 2009b) to the impact of higher energy prices through international trade (Lutz and Meyer, 2009a). A detailed description of GINFORS can be found in Lutz et al. (2010) or Lutz and Meyer (2009a,b, 2010).

Fig. 1 displays the basic model structure of GINFORS. The countries' economies are either modelled with input–output models or aggregate macro models (if no OECD input–output table exist). Import demand and export prices are determined within the country models. The bilateral trade model then combines the information and gives export demand and import prices to the countries' economies. The model iterates until the convergence property of the solution is reached, which has to be fulfilled on a yearly basis.

Behavioural parameters of the model are estimated econometrically, and different specifications of the functions are tested against each other, which gives the model an empirical validation. The econometric estimations are based on times series from OECD, IMF and IEA for 1980 to 2006.

The approach is different from Kerschner and Hubacek (2009), who apply static input–output country models to assess the impact of oil supply reductions of 10%. There is no technological or behavioural change. Their supply-constrained model looks into the quantity dimension of peak oil. In contrast, our approach focuses on the price and overall macroeconomic impacts, if oil demand has to be reduced to equal the reduced oil supply applying econometrically estimated price elasticities of energy demand. These price elasticities are country, sector and fuel specific and range from 0 to -0.3 with a few outliers up to -0.5. A price elasticity of -0.3 means, that demand will be reduced by 30%, if the end-user price doubles.

The baseline scenario is comparable to the "new policy" scenario of IEA World Energy Outlook (WEO 2010). The second scenario assumes that world oil production has peaked and hence the gap between oil demand as projected in WEO (2010) and oil supply widens until 2020. Additionally to peak oil, the third scenario introduces energy efficiency and renewable energy measures according to the WEO 450 ppm scenario.

Energy demand in scenario "Peak Oil" is equivalent to energy demand in the baseline. For the supply side though it is assumed that world oil production has peaked and will significantly decline over the next decade until 2020. This shortage cannot only occur due to shrinking oil production but also due to political disruptions or military disputes as started in early 2011 in the MENA (Middle-East North-African) countries.

For the model we assume that world oil production is price independent in the medium run and decreasing after 2010. The assumption of a fixed oil supply in the short to medium run is feasible because of limited production expansion possibilities due to time and capital consuming necessary investments. In the long run oil production is less price inelastic, which should then be considered. Oil demand price elasticities are estimated in the model, as described above. Using these results, it is possible to increase the oil price until global oil demand has dropped such that it equals global oil supply. The implication of the price inelastic demand is a strong increase of the price for crude oil after 2015.

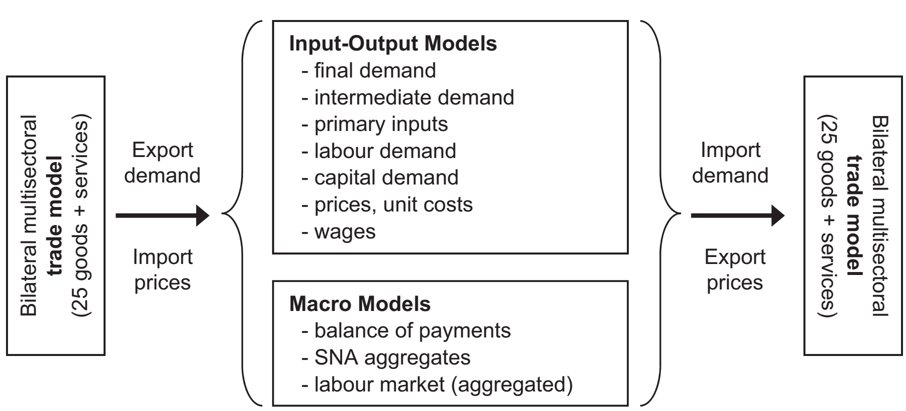

Fig. 1. GINFORS structure.