Modelling the effect of higher energy prices on the EU economy

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Abstract:
Russia's invasion of Ukraine has led to strong economic repercussions globally. In particular, turbulences on international energy markets and reduced flows of natural gas from Russia to the EU have led to a sharp increase of energy prices. In this paper, we investigate the effect on Europe resulting from higher energy prices and the role of policy responses for mitigating potential adverse effects. We differentiate here between impacts in the short run, where we look at the more immediate effects of high prices on the EU economy and European households, and the medium to long run where we look at policies that reduce the dependence of fossil energy imports, in particular from Russia.

Introduction

Russia's invasion of Ukraine has led to strong economic repercussions globally. The repercussions on international energy markets and reduced flows of natural gas from Russia to the EU have led to a sharp increase of energy prices. As of 2021, Russia was responsible for about 45% of coal imports into the EU, about 35% of natural gas imports and about 30% of petroleum oil. These shares were considerably higher in several member states and fixed pipeline infrastructure for oil and gas made adjustments of trade patterns more difficult. Due to sanctions and export reductions from Russia, trade in fossil fuels substantially declined over very short time spans. In this paper, we show some modelling results that were aiming to inform policy makers on the impacts of the immediate consequences of energy shortages and resulting high energy prices as well as policy options to e.g. address adverse outcomes for poorer households. In addition, we investigate policy options more targeted at a longer term to reduce European fossil fuel dependence from Russia.

While the high import share of Europe for fossil fuels from Russia made Europe vulnerable to supply disruptions and the high uncertainty let to high volatility in spot market prices, the energy price shock was not restricted to fossil energy imports into Europe. Competition for available gas, coal, and oil resources increased prices around the globe, but the price increases were not uniform. For example, the shock affected in particular importing regions that competed for liquefied natural gas (LNG) that was not subject to long term contracts. The increased demand for available liquefied natural gas therefore also influenced the (marginal) price of natural gas imports in other regions (IEA, 2022). This price increase was much less pronounced in regions that were exporting. This regional differentiation of price increases also influences regional competitiveness, especially in energy intensive industries.

In addition to regional spill overs, spill overs between energy carriers occurred due to substitution and interlinked energy markets. In particular, the transmission of higher energy prices from natural gas to electricity were very evident in Europe. The marginal pricing thus lead to higher prices of (wholesale) electricity prices and stimulated a discussion on decoupling electricity and gas prices. In our modelling, we take into account this connection between prices and show that increases in electricity prices can have large economic consequences, as it used widely across the economy.

In this paper, we investigate the effect on Europe resulting from higher energy prices taking into account spillovers across regions and fuels. We also analyse the role of policy responses for mitigating potential adverse effects. We differentiate here between impacts in the short run, where we look at the more immediate effects of high prices on the EU economy and European households, and the long run where we look at policies that reduce the exposure of fossil energy imports, in particular from Russia. The scenarios are carried out with the computable general equilibrium (CGE) model JRC-GEM-E3 (Capros et al., 2013; see Weitzel et al., 2023 for a recent application), implementing several shocks to represent development of international energy markets. The recursive dynamic model is tailored to assessing energy and climate related policies and is calibrated to the GTAP-Power database Chepeliev (2020). The CGE modelling is complemented by assessments of distributional consequences, drawing on household budget survey (HBS) data provided by Eurostat.[1]

There have been several paper to assess the economic consequences of energy shortages (Bachmann et al, 2022), impacts on consumers due to high energy prices (Guan et al., 2023; Kalkuhl et al., 2022) and the economic effects of sanctions against Russia in energy trade (Chepeliev et al., 2022; Perdana et al., 2022;) and beyond (Mahlstein et al., 2022; Rose et al, 2023). We add to this

[1] https://ec.europa.eu/eurostat/web/microdata/household-budget-survey

literature by showing how modelling can provide some policy relevant insights on short term effects and discuss the role that policy can play in the short and the medium/long-term.

Short run implications (and policy options)

The short term reduction of energy flows obviously affects the economic activity as energy becomes scarcer and hence more expensive. However, different modelling approaches can point to quite different level of impacts on the economy-wide level of output (Bachmann et al, 2022). Besides assessing the sensitivity of outputs at the macro level, we are interested in assessing the impact on different economic sectors in terms of output and employment, taking into account the heterogeneous development of fuel prices in different regions and resulting effects on regional competitiveness. In addition, we investigate the role of price transmission between gas and electricity – in a standard CGE model the gas price affects electricity only in a minor way as the cost of gas in is a relatively minor share of total production costs of the electricity sector. Finally, high prices of energy will affect consumers both directly through higher energy purchase cost as well as indirectly as higher energy prices in the production of other goods are passed through to final consumers. The effect of higher energy prices is not felt differently by households, as poorer households spend more of their income on energy. We therefore also analyse the distributional consequences of higher energy prices. The next section will discuss the setup of the modelling to be more tailored to short term effects before presenting some findings.

Method to assess short term implications

To assess the short run implications (with a time horizon of a year or less), we reduced the flexibility of the model to adjust to higher energy prices compared to the standard model version which is more tailored to describe changes in longer time horizons. This was done by reducing *all* elasticities of the standard model by half.

Initial model runs were imposing trade barriers (tariffs) at the border, to reduce the flow of Russian gas into Europe. However, while trade flows between Russia and the EU could be reduced, it was difficult to induce large price spikes and physical responses were not necessarily realistic. For example, the model suggested that the EU would response by importing substantial additional capacities from Norway (and other countries) in excess of available production capacities. At the same time, Armington trade with constant elasticity of substitution (CES) functions did not account for substitution of physical quantities in the correct ratio due to different prices of pipeline gas from Russia and LNG from the US. As in our analysis we were more concerned about the effects on the EU and production side rather than reproducing reasonable trade responses to market disruptions, we chose a different route to implement the shocks.

Higher energy prices were modelled by a mark-up charged by energy producers in different regions. As the price spike observed in 2022 was not uniform globally (IEA, 2022), we also added a counterbalancing subsidy financed by revenues of this price mark-up for domestic use on markets in which the price increase was lower to achieve reasonable price signals at the use side. As a rule of thumb, markets that were competing for LNG (e.g. East Asia, Europe) had higher prices than exporting countries (e.g. USA). In this way, a heterogeneous increase in gas prices lead to a general contraction of output and output reductions in gas intensive sectors in particular.

In a stylized scenario, we doubled the price of gas using the mark-ups resulting in higher costs for gas importing countries described above. To assess the relevance of the spillovers to the electricity market, we also assessed an additional scenario in which a mark-up was introduced on electricity production – this was chosen to be half as high as the one for gas, because it would not affect purchases under long-term contracts with an agreed price. The mark-up thus reflects the windfall profit earned by some generators with low generation costs.

Results

Table 1 shows the macroeconomic impacts observed from a gas price shock. It becomes obvious that a gas price shock is magnified by a spillover to electricity prices, in fact the price shock of the electricity shock is larger than of the original gas shock despite the larger magnitude of price increase of gas vs. electricity.

Table 1 – Macroeconomic impacts in the EU of energy price shocks (%)

Results for EU	Gas price x2	Gas price x2 Elec. price x 1.5
GDP	-0.34	-1.66
Consumption	-0.78	-2.41
CPI	0.53	1.42

Table 2 reports sectoral impacts of energy price shocks on output. The changes result both from lower demand for energy intensive products which exhibited the highest price changes and a loss of international competitiveness (relative to producers in regions less affected by the price change). In addition, as higher energy prices reduce the available income for consumption, demand for goods with a high income elasticity also declines. This would also indicate that employment in the affected sectors is at risk (Figure 1).

Table 2 – Sectoral impacts of energy price shocks for gas and electricity (change in EU27 output)

Ferrous metals	-5.8%
Non-ferrous metals	-15.0%
Chemical Products	-3.4%
Energy intensive manufacturing	-3.4%
Other manufacturing	-2.4%
Other (incl. services)	-1.0%

Figure 1 – EU sectoral employment impacts of energy price shocks

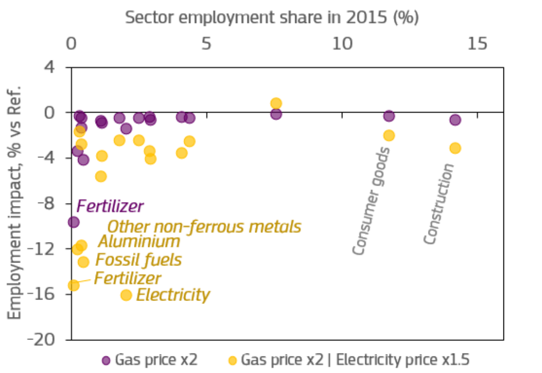
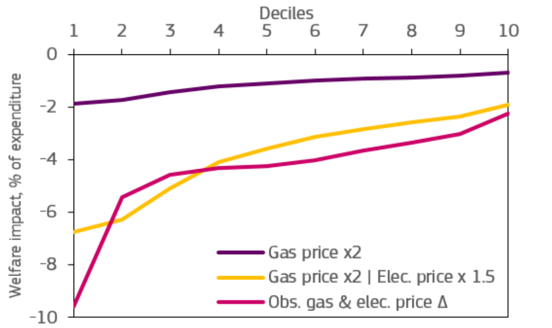


Figure 2 – Distributional impacts by EU household income deciles



The results also indicate that the impacts are concentrated in EU member states that are more energy intensive – in Europe, these are typically economies with a lower per capita income (see also Figure 3 below). Further, also within countries, the price changes of energy are concentrated among poorer households as these tend to spend a higher share of their income on energy (see also Kalkuhl et al., 2022 for a more detailed analysis of Germany). Without any policy measures such as (targeted) transfers, higher energy prices could increase the number of people in energy poverty and therefore also has important implications for policy interventions.[2] Figure 2 shows the resulting impacts by income deciles for the two scenarios used above, as well as a scenario using observed price shocks for gas and electricity purchased by households.

Long run implications

In addition to the short run impacts, we assess the role of policy measures to decarbonize and/or foster reduced import dependency. In response to the war and the energy crisis with reduced flow of natural gas from Russia, the EU has implemented various policies aiming to phase out the imports of fossil energy from Russia in the coming years. The strategy consists of substituting to alternative supplies through increased LNG imports as well as increased deployment of renewables and energy efficiency measures (RePowerEU; European Commission 2022). Policies that increase energy efficiency and reduce the consumption of fossil energy can reduce the impact of a higher price trajectory that is expected to persist for some years. Such policies can also be helpful to make the economy more resilient against a sudden energy price shock in the future.

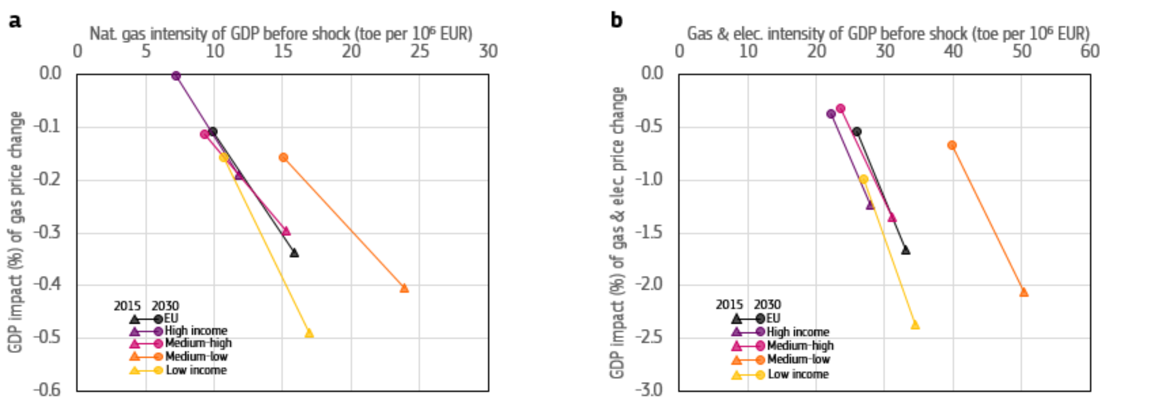
Method to assess long run implications

In order to assess the impact of an unexpected energy price shock, we repeat the exercise from above, but use a snapshot of the economy for 2030 that is calibrated to have advanced the decarbonization.

Results

The modelling results show that climate policy can increase the resilience to energy price shocks: Applying a price shock to the current economy (using a 2015 snapshot) and a counterfactual economy that has delivered on the European Green Deal in 2030, including on the 55% emission reduction target, indicates that the price shock leads to smaller adverse impacts on a more decarbonized economy. Furthermore, the gains in resilience are particularly visible in countries with currently higher energy intensity of GDP. Figure 3 shows that the GDP impact of the price shock depends on the energy intensity and is reduced in a 2030 economy that has delivered on the mitigation target.

Figure 3 – Economic impact of energy price shocks



Nonetheless, assuming a new price trajectory of higher energy prices for the next years puts the EU economy on a path with lower GDP and higher unemployment for the next years. If policy reacts to this by fostering additional renewables and energy efficiency, this could however limit the adverse impacts from higher energy prices.

[2] By now many countries have implemented emergency measures to shield households from higher energy prices (Sgaravatti et al. 2022).

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