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The effects of oil price shocks in a new-Keynesian framework with capital accumulation

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HIGHLIGHTS

- We estimate and analyze the impact of oil price shock in a New-Keynesian model.
- The output elasticity of oil is above 10%, stressing its role in US growth.
- An increase in oil efficiency significantly lowers the effects of an oil shock.
- Oil consumption and efficiency have been key engines for US growth since the 1980s.

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ABSTRACT

The economic implications of oil price shocks have been extensively studied since the 1970s. Despite this huge literature, no dynamic stochastic general equilibrium model was available that captures two well-known stylized facts: (1) the stagflationary impact of an oil price shock, together with (2) the influence of the energy efficiency of capital on the depth and length of this impact. We build, estimate and simulate a New-Keynesian model with capital accumulation, which takes the case of an economy where oil is imported from abroad, and where these stylized facts can be accounted for. Moreover, the Bayesian estimation of the model on the US economy (1984–2007) suggests that the output elasticity of oil might have been above 10%, stressing the role of oil use in US growth at this time. Finally, our simulations confirm that an increase in energy efficiency significantly attenuates the effects of an oil shock—a possible explanation of why the third oil shock (1999–2008) did not have the same macro-economic impact as the first two ones. These results suggest that oil consumption and energy efficiency have been two major engines for US growth in the last three decades.

1. Introduction

The two episodes of low growth, high unemployment, low real wages and high inflation that characterized most industrialized economies in the mid and late 1970s are usually viewed as the paradigmatic consequences of large price "shocks" that affect various countries simultaneously.[4] Despite the huge literature

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[4] As was rightly noticed by one anonymous referee, the word "shock" is misleading despite its widespread use. The first oil "shock" that was considered by some as a possibility as early as December, 1971, and by May, 1973, had become the single most likely scenario focussed upon by one major oil MNC. The second oil "shock" was first considered as a possibility in March, 1976, and in September, 1976, was vigorously discussed in a scenario group meeting under the heading 'Producer Miscalculation/Middle East "accident'. The accident focussed by some was the downfall of the Shah. The 1999/2008 "shock" really took off post-9/11. That said, given the conventional methodology of DGSE models, where exogenous events, such as sharp oil price rise, are treated as shocks, we have opted to bear with this terminology.

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devoted to the implications of oil prices, to the best of our knowledge, no dynamic general equilibrium model was available that captures the next two stylized facts: (1) the stagflationary impact of sharp oil real price rise, together with (2) the various impacts of capital accumulation: in addition to the well-known hysteresis effect (Khramov, 2012), the potential role of capital as a new channel for monetary policy through the non-arbitrage relation involving the rental rate of capital and the Central Bank's interest rate and, above all, the role of capital energy efficiency in dampening the impact of an oil price rise.

The present paper introduces energy into an otherwise standard New Keynesian model in the same way as Blanchard and Galí (2009) and Blanchard and Riggi (2013), to which it adds capital accumulation. Energy is understood as being just oil, which is imported from abroad at an exogenous world price. Oil imports are paid for with exports of output. For simplicity, the balance of trade is assumed balanced at every date, so that exports adjust to the cost of imports.[5] Oil is consumed by households and used as an input in the production of intermediate goods. As a matter of fact, and this might be viewed as the main contribution of this paper, when estimated on the US (1984–2007), the output elasticity of oil use turns out to be significantly larger than what is currently assumed in the macro-economic literature.[6] More specifically, we find an elasticity between 11% and 12%. In particular, this is much higher than the cost share of oil, which is usually less than 3%. Our finding confirms the standpoint that has been defended by several authors, including Kümmel et al. (2010), Kümmel (2011), Lindenberger and Kümmel (2011) and Ayres and Voudouris (2014), according to whom the importance of energy in the fabric of economic growth is amply underestimated in the traditional Solowian approach.[7]

As a result, our specification does react to an oil shock by a short-run decrease in real GDP and some inflation.[8] Next, the introduction of capital accumulation turns out not to impair the stylized facts just alluded to. Capital even amplifies the response of the economy to an oil real price rise. Our third, and most important, conclusion is that a reduction of output elasticity of energy suffices to imply a significant reduction of the effect of a shock on macroeconomic performances. This is the way the reduction of the sensitivity of industrialized countries to the oil price rise in the 2000s is accounted for in this paper.

When addressing these issues, we keep an eye on the events of the past decade that seem to call into question the relevance of oil price changes as a significant source of economic fluctuations. Since the late 1990s indeed, the global economy has experienced an oil shock of sign and magnitude comparable to those of the 1970s but, in contrast with the latter episodes, GDP growth and inflation have remained relatively stable in much of the industrialized world until the financial turbulences of 2007–2009 (cf. e.g., Sánchez, 2008; Blanchard and Galí, 2009; Kilian, 2008; Hamilton, 2009). In Blanchard and Galí (2009), a structural VAR analysis suggests that the effects of oil price rises have recently weakened because of the decrease in real wage rigidities, a smaller oil share in production and consumption, and improvements in the credibility of monetary policy. While these three properties did most probably play a role, this paper explores the explanatory power of yet another channel—namely the change in energy efficiency in the industrial sector during the 1980s, as a consequence of the first two oil shocks. At first glance, it seems that the impact of energy efficiency is already taken into account through the decline of energy share in added value, analyzed in Blanchard and Galí (2009).[9] As we argue in the next section, however, these two parameters—cost share and energy elasticity—should be viewed as decoupled variables, in general. Consequently, if the energy efficiency of a country can no more be captured through its energy cost share, we need an explicit modeling of the efficiency of capital. This is yet another motivation for having added a capital accumulation dynamics to the standard DSGE model.[10] The decoupling of energy efficiency from the energy share cost then opens the door for a reexamination of why the 2000s have been so different from the 1970s.

Our findings are twofold: (1) the improvement of energy efficiency might well have been a powerful explanatory factor for the muted impact of the rise in real oil price experienced during the early 2000s in comparison with the 1970s, but (2) oil elasticity did not decrease during the first decade of this century in the U.S. We make the first point by studying the impulse response function of our DSGE model. And the second is made by various estimations of oil output elasticity within different time intervals. As a consequence, one reason for the muted impact of the third oil price sharp increase can indeed be attributed to the significant improvement in oil use efficiency, which, as we show, occurred in the U.S. around 1979. But such a progress did not take place later on.[11]

Among the 2000s oil shock literature, recently, in addition to Blanchard and Galí (2009), a last contribution is worth noticing, namely Blanchard and Riggi (2013). The latter performs an estimation of a Macroeconomic DSGE model and confirms that a large decrease of real wage rigidities and an increase of the credibility of the monetary policy must have contributed to dampening the shock. Together with an estimation based on indirect inference, Blanchard and Riggi (2013) *calibrate* the production function as being constant return to scale with an output elasticity of oil set equal to 0.015 for the period pre-1984 and 0.012 for the post-1984 period, the output elasticity of labor being therefore 0.985 and 0.988, respectively.

By contrast, in the present paper, using a Bayesian approach, most parameters are estimated, including oil's output elasticity. The latter turns out to lie between 0.11 and 0.12. That is, a 10% increase of oil consumption leads to a 1.1% or 1.2% increase of output—an elasticity 10 times larger than the one supposed by Blanchard and Riggi (2013). Our finding also contrasts with the literature where oil output elasticity is usually identified with the energy cost share, hence close to 0.03. Where does the gap between our output elasticity, α_e, and the cost share come from? In

[5] As in Blanchard and Galí (2009) and Blanchard and Riggi (2013), we assume that the real price of imports (oil) is some exogenous stochastic process. The exchange rate is therefore not explicitly modeled.

[6] One can note that between 1984 and 2007 the U.S. economy was mostly an oil importer country. However, the assumption that U.S. only use imported oil does not interfere with the estimation of the output elasticity of oil. Indeed, the latter involves only GDP growth and the growth of oil usage. Whether the oil used is domestically produced or imported from abroad is independent from our elasticity estimation.

[7] Thus, the addition of capital is important not just because it adds realism to the modeling approach, but also because it improves the reliability of our empirical estimation of output elasticity with respect to energy. Absent capital, this elasticity could be suspected to capture the (hidden) indirect spillover of capital.

[8] For simplicity, we did not add a growth trend to our model. Were we to do so, our results would be a short-run decrease of the real GDP with respect to the long-run growth trend.

[9] Profit-maximization and perfect competition in frictionless markets imply indeed the equality of energy output elasticity with the cost share of energy. Since the inverse of output elasticity may be taken as a proxy for energy efficiency, it might seem that the improvement of energy efficiency is reflected through the decline of energy share.

[10] See, e.g., Khramov (2012) and the references therein.

[11] This is in line with one of the conclusions in Blanchard and Galí (2009) and Blanchard and Riggi (2013), where, based on the postulated identity between the cost share and oil elasticity, a presumed reduction of the latter was identified as an explanatory candidate. The difference is that we identify the late 1970s as being the unique moment where a significant break through in oil efficiency took place, while these authors conclude from the decline of the oil cost share in the early 2000s, that oil efficiency also recently improved.