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Strategic behaviours and the policy response to commodity price shocks


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Commodity prices have once again become prominent in the policy debate and policy makers are facing the problem of calibrating the best response to higher commodity prices. The policy problem might be more complex if commodity producers internalize the policies implemented by commodity importers. In this column, we analyse the problem of a central bank that needs to react to commodity-driven inflation under strategic interactions. In other terms, both the central bank and the monopolistic commodity exporters act strategically considering each other actions. Despite the central bank should always target inflation, in a strategic environment a somewhat larger degree of commodity price fluctuations should be allowed. That would prevent the monopolistic exporter to gain too much market power and increase prices further in the future.

Introduction

The optimal response to commodity-driven supply shocks is again prominent in the policy debate. The conventional wisdom in the literature used to be that supply shocks are temporary in nature and therefore monetary policy should look through them (Blanchard and Galì (2007))[1] while fiscal policy should take actions to protect households and firms in the short run. This result might however not hold in the presence of policy uncertainty (Filardo et al. (2020))[2] or market power and strategic behaviours.

Indeed, when individual agents choose strategically, that is if *"...it is assumed that each participant acts independently, without collaboration or communication with any of the others"* (Nash (1951))[3], they try to anticipate the actions of other players to maximise individual expected benefits. One of the main findings of the game theory literature is that this behaviour might lead to outcomes that are inferior to what would be achieved via coordination, i.e. if agents agree ex-ante on choices that maximise the global welfare of the society. Commodity exporters, in this case, could make use of their market power[4] to react to policies by importing countries and preserve monopoly rents. As a result, not accounting for strategic interactions might reduce the effectiveness of policy interventions.

Strategic interactions in a commodity price model

In a recent paper, Ferrari Minesso and Pagliari (2022)[5], we present a new toolkit (DSGE Nash) to solve for the Nash equilibria of global games in macroeconomic models. The toolkit solves numerically the Nash game between agents by means of a user-friendly input structure, which can accommodate a large range of models and solution algorithms. In a nutshell, given a set of equilibrium strategies for each agent, DSGE Nash computes the best reaction function of every single player, which is the set of optimal responses of one player to each combination of strategies played by the others. The Nash equilibria of the game are then found at the intersection of the best reply functions of all participants.

We apply our toolkit to study the policy problem of a central bank in a commodity-importing country in model à la Nakov and Pescatori (2010)[6]. Specifically, the model includes a large dominant commodity exporter, which has market power in price setting, and a fringe of competitive commodity producers that supply commodities at the marginal cost of production if market prices are sufficiently high. The larger is the fringe, the lower is the share of total commodity supply controlled by the dominant exporter, thus reducing her market power.

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[1] Blanchard, O. J. and Galì, J. "The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so different from the 1970s?". In International Dimensions of Monetary Policy, NBER Chapters, pages 373–421. National Bureau of Economic Research, Inc, 2007.

[2] Filardo, A. J., Lombardi, M. J., Montoro, C., and Ferrari, M. M. "Monetary Policy, Commodity Prices, and Misdiagnosis Risk". International Journal of Central Banking, 16 (2):45–79, 2020.

[3] Nash, J. "Non-cooperative Games". Annals of Mathematics, 54(2), 1951.

[4] This behaviour is typically documented for OPEC, see The Economist, "OPEC defies Joe Biden with a big output cut", 5th October 2022 and Alonso Alvarez, I., Di Nino, V. and Venditti, F. "Strategic interactions and price dynamics in the global oil market", Working Paper Series 2368, European Central Bank, 2020.

[5] Ferrari Minesso, M. & Pagliari, M, S. "DSGE Nash: solving Nash games in macro models". Working Paper Series 2678, European Central Bank, 2022. The toolkit is available on the authors' websites.

[6] Nakov, A. and Pescatori, A. "Oil and the Great Moderation". Economic Journal, 120 (543):131–156, 2010.

In the model commodities are used both in production and consumption by the importing economy. For this reason, on the one hand, commodity price fluctuations reduce households' consumption, as higher commodity prices change the relative costs of goods in the consumption basket. On the other hand, commodity price shocks also affect firms' price setting decisions through the marginal costs of production. Large increases in the price of commodities may therefore lead to high inflation in the model. In this environment, the central bank can indirectly influence the price of commodities by controlling aggregate demand via the interest rate. The dominant commodity exporter, instead, sets the commodity price by choosing a specific mark-up level over the marginal extraction cost. The presence of a fringe of smaller producers limits the monopolistic behaviour of the dominant exporter by supplying commodities at the margin.

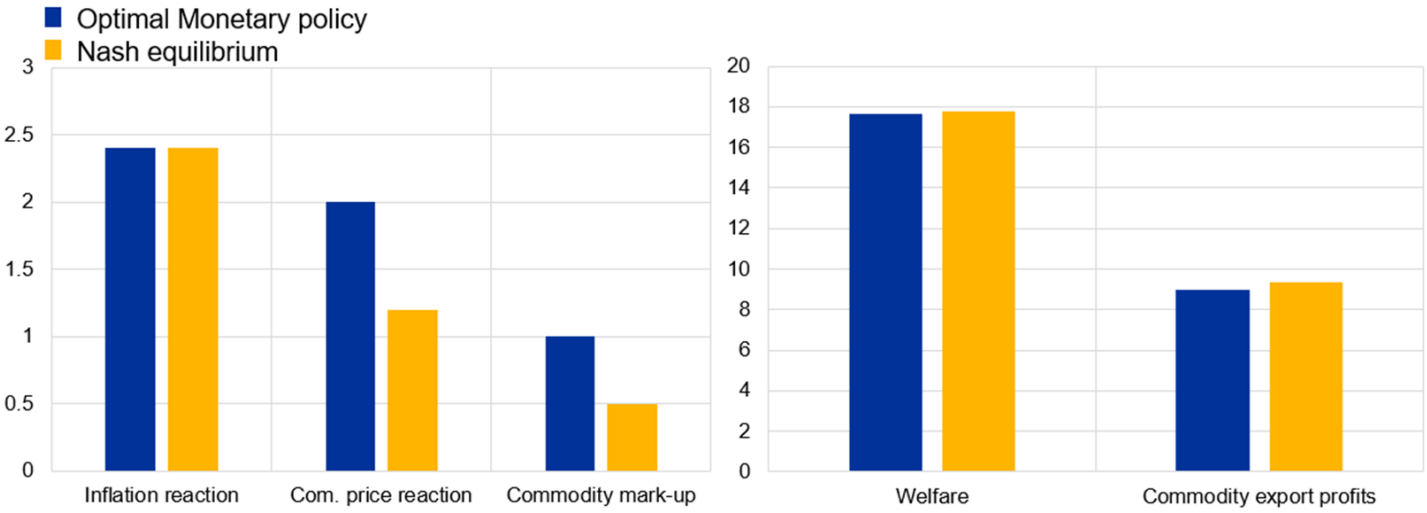
We use the model to investigate what would be the optimal *systematic response* of the central bank in the importing economy to changes in commodity prices if the dominant producer reacts to policy changes by adjusting its price mark-up. In other terms, both the commodity exporter and the central bank include each other's actions among the constraints of their optimization problems. While keeping equilibrium prices too high is expensive for the importing economy, it allows for a larger share of fringe producers to operate, thus reducing the dominant exporter's market power. Conversely, low commodity prices improve domestic welfare but keep a large share of fringe producers out of the market, thus allowing the dominant exporter to leverage on her position to influence price dynamics. Similarly, from the exporter's standpoint, higher prices increase profits at the intensive margin, but reduce her market power as smaller producers are able to operate. Therefore, the optimal commodity price level for both participants should not be excessively high or low, though for different reasons.

Formally, this is a global game where each player can choose a strategy (the monetary policy rule for the central bank and the steady-state mark-up for the dominant exporter) to maximize a policy objective (welfare or commodity export profits respectively).

The Nash equilibrium

Figure 1 reports the solution of the game. We solve for both the Nash equilibrium (yellow bars) and the equilibrium under optimal monetary policy without strategic interactions (blue bars, baseline scenario). If commodities account for a large share of consumption and production inputs, strategic interactions become relevant and lead to a unique Nash equilibrium. Absent any reaction from the commodity exporter, the central bank would strongly react to commodity price swings in order to minimize the volatility of the domestic business cycle. This outcome is optimal in a non-strategic environment, but it becomes inefficient when agents act strategically. The strong reaction of monetary policy, indeed, would eventually strengthen the dominant exporter's position, by keeping a large part of the fringe outside the market because of lower prices. This configuration would not be a Nash equilibrium, since the dominant exporter would significantly increase prices in response to a reduced competition. For this reason, in the equilibrium the central bank tolerates somewhat bigger fluctuations in the commodity price to allow some of the smaller producers to remain operative. As a result, the dominant exporter finds it optimal to reduce her mark-up by about 50% compared to the optimal policy environment, with the aim of preventing a further expansion in the competing fringe and a worsening of her market position. In a context of strategic interactions, both players internalize these dynamics in their decisions, which in turn leads to the Nash equilibrium. By definition, in this equilibrium both players must have no incentive to deviate. The central bank and the exporter are then both slightly better off relative to the alternative scenario, as exemplified by welfare and profits values on the right-hand panel of Figure 1. Finally, it is worth noticing that the reaction to inflation remains stable in both cases, which implies that for the central bank it is always optimal to target price stability.

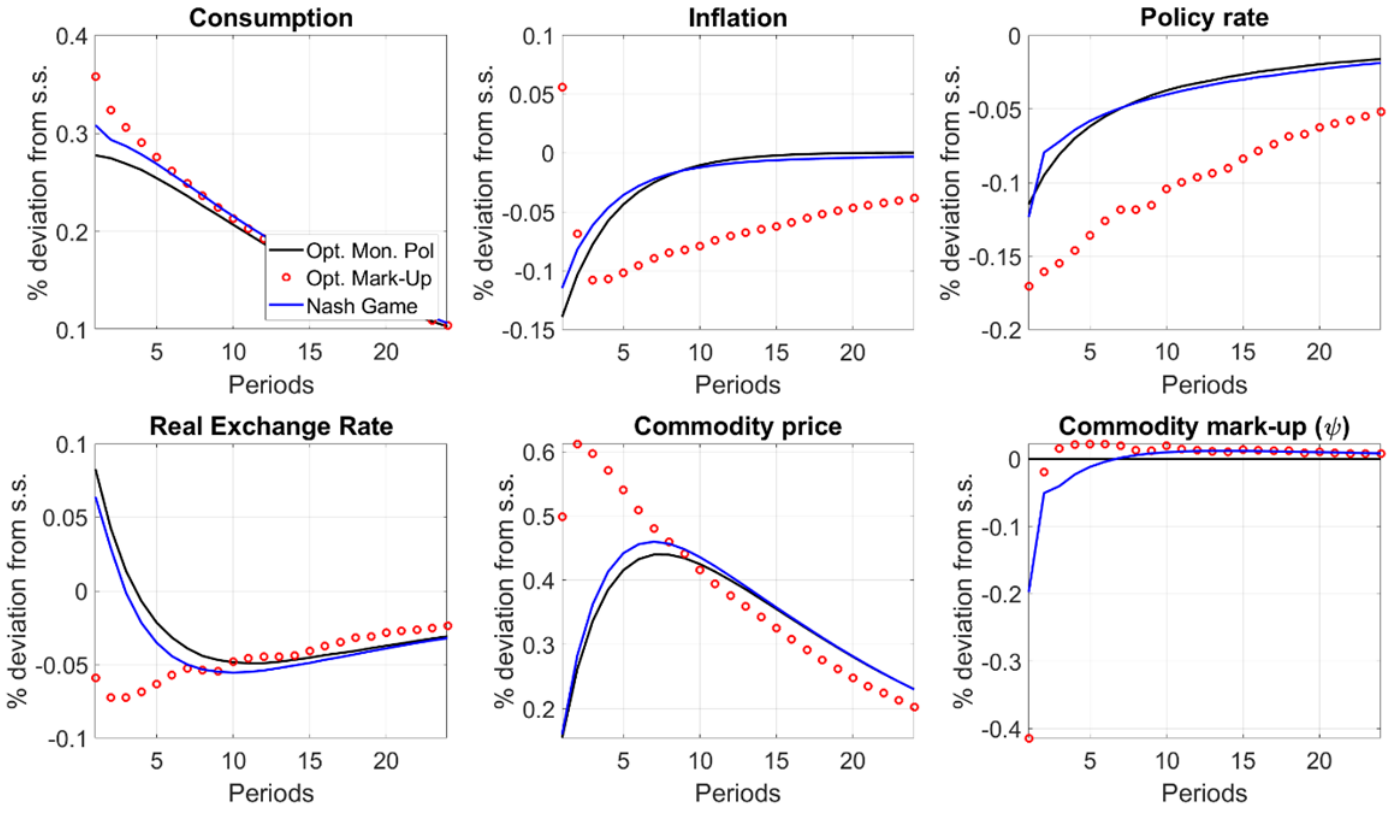
Figure 1: Taylor rule coefficients in the Nash equilibrium and under optimal monetary policy without strategic interactions



Notes: the panel on the left reports the optimal coefficients on inflation and commodity price in the Taylor rule of the domestic central bank as well as the price mark-up set by the dominant commodity exporter. The panel on the right reports welfare for the importing economy and commodity trade profits for the dominant exporter. Welfare and profits are computed based on a second-order solution of the model with pruning. Welfare is expressed in consumption equivalents relative to the baseline calibration of the model as in Filardo et al. (2020).

Because the Nash equilibrium entails a different steady state, also the response of the economy to specific shocks will differ from the baseline setting. As an example, Figure 2 displays the effects of a total factor productivity shock, which increases production and households' income and, hence, commodity demand. In the Nash equilibrium (blue line) volatility is significantly smoothed and dynamics are very close to the optimal monetary policy scenario without strategic interactions (black line). Conversely, if the competitive producer could set the mark-up without the central bank reacting, commodity price fluctuations would be much larger (red dotted line). This in turn would induce a significantly higher inflation volatility.

Figure 2: Impulse responses to a total factor productivity shock



Notes: impulse responses for the optimal parameters under independent actions by the domestic central banks, the dominant commodity exporter and the Nash equilibrium of the game. Reponses are computed by solving the model at second order with pruning.

Conclusion

Our analysis delivers three main messages that might prove useful to policymakers. First, central banks should always target inflation, regardless of whether strategic interactions are accounted for or not. This is optimal both when policies are optimized in isolation and when considering strategic behaviours. Second, if commodities are relevant for the domestic economy, commodity price developments should also enter the information set of policymakers, given their impact on consumption and prices. Finally, in a strategic environment a somewhat larger degree of commodity price fluctuations should be allowed to prevent the exporter to gain too much monopolistic power. A very strong commitment to sterilize commodity price swings could indeed make commodity markets more concentrated by excessively decreasing prices. This in turn would lead to a stronger role of dominant commodity producers and higher prices in future, thus partially offsetting the effect of monetary policy. On the contrary, if the commodity market is more competitive, dominant players have lower market power and control over global prices. Such dynamics could not be explored if strategic interactions were excluded from the model's solution algorithm and our results highlight how such behaviours play a crucial role in shaping a central bank's response to commodity price shocks.

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