Box 3
A LASTING SHOCK TO OIL PRICES: IMPLICATIONS FOR MONETARY POLICY IN GENERAL EQUILIBRIUM MODELS

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The macroeconomic consequences of the recent plunge in international oil prices pose a challenge to an inflation targeting strategy in small, open economies that export this commodity. On the one hand, there would be a negative impact on economic activity, national revenue, and aggregate demand, as manifest in a lower rate of growth. On the other, we would see depreciation of the exchange rate and its upward effect on prices and inflation.

One question prompted by the drop in international prices is whether it is expected to be temporary or permanent, since the implications for monetary policy are different with permanent shocks compared to those resulting from temporary shocks.

The macroeconomic effects of temporary shocks tend to be offset by countercyclical policies and are well documented in the literature on economic cycles. These shocks do not imply a long-term adjustment in the economy and, consequently, their occurrence does not change long-term prices and quantities. However, permanent shocks do prompt long-term changes in prices and quantities, so their effects are less understood.

Considering the possibility of a persistent shock to the price of oil and the limited documentation about its effects, it is crucial to assess its implications in general equilibrium models, which allow for capturing all the channels the shock can pass through. With that in mind, the results of three macroeconomic models of monetary policy in an oil economy are summarized in this section. The models were developed by *Banco de la República* and calibrated with data for Colombia.

The first, known as Fisco,[1] is a fiscal and monetary dynamic stochastic general equilibrium model designed for Colombia. One of its main features, besides the existence of nominal price rigidities and incomplete exchange rate pass-through to inflation, is that the mining sector generates revenue for the private sector and the government. Moreover, in the economy represented by the model, the central bank and the government are independent agents. The central bank's objective is to meet a core inflation target, and the interest rate is the instrument used to that end. The government's goal is to maintain a certain level of structural fiscal balance (as percent of GDP). To do so, it has multiple instruments such as tax rates and government spending. The government covers its expenses with taxes levied on the private sector, with mining revenue, and with internal and external borrowing. The government's operating expenses have an impact only on aggregate demand, while government investment affects aggregate demand as well as the production of companies, since public capital is a factor of production.

As shown in Graph B3.1, with a persistent drop in international oil prices, the Fisco model predicts a permanent GDP reduction, under both flexible prices[2] and sticky prices, due to the permanent reduction in household income level. Real depreciation and a deficit in the current account of the balance of payments are observed as well. In the case of sticky prices, the drop in GDP is even greater, since prices of goods will take longer to adjust, causing a further contraction in demand and, therefore, a negative output gap. In this case, since GDP at sticky prices experiences more of a decline than GDP at flexible prices, more depreciation is required at sticky prices to adjust the current account. The decline in demand means less consumption of all goods (domestic and imported) and, therefore, a reduction in their respective price. However, depreciation causes the price of imported goods to

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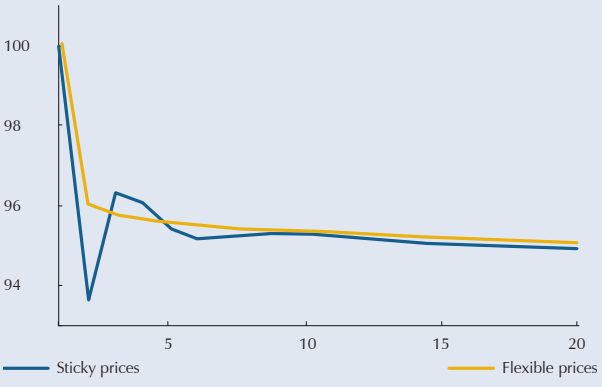
1 Rincón, H.; Rodriguez, D.; Toro, J.; Tellez, S. (2014). "Fisco: modelo fiscal para Colombia," *Borradores de Economía*, Vol. 855, *Banco de la República*.

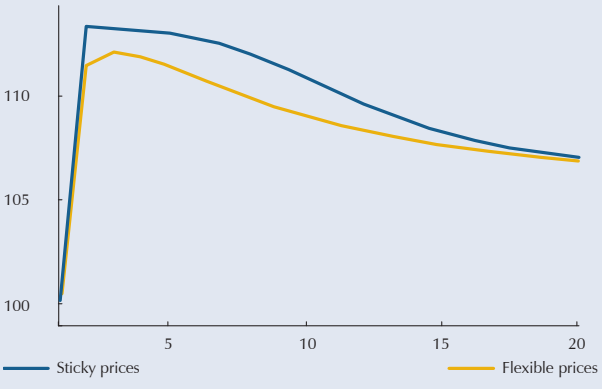
2 GDP at flexible prices is the output obtained if all prices and wages in the economy were flexible and no real rigidities existed. Within the framework of general equilibrium models, it can be understood as potential GDP. For further details, See "ReTable 2: El producto potencial, su uso y métodos de estimación en Colombia," *Informe al Congreso*, *Banco de la República*, March 2014.

Graph B3.1
Effects of a Permanent Drop in International Oil Prices with the Fisco Model

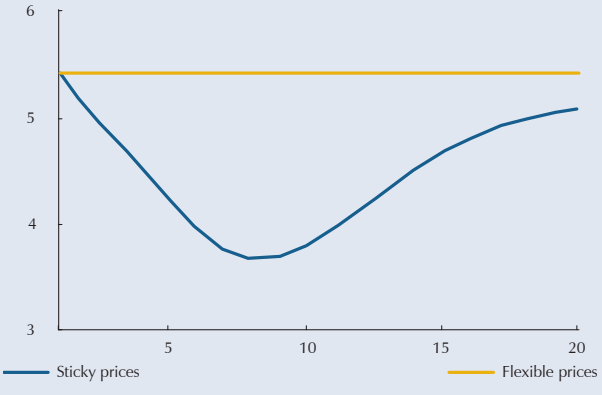
A. GDP



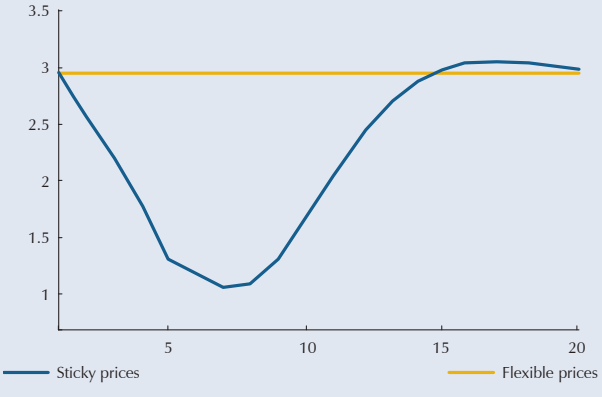
B. TReal exchange rate



C. Policy interest rate



D. Total inflation



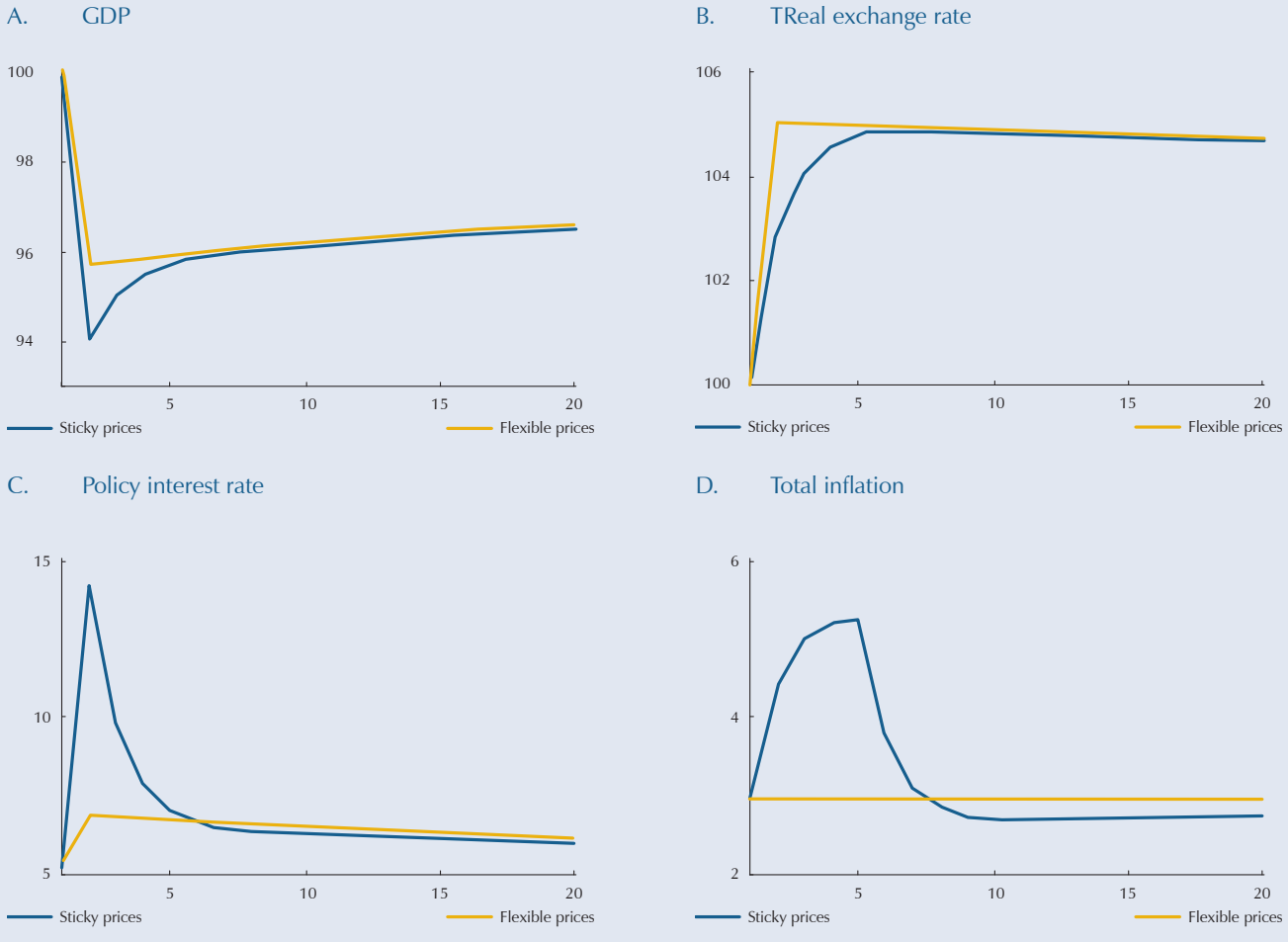
Sources: *Banco de la República*; authors' calculations

increase, creating an ambiguous effect on the consumer price index (CPI). In the case of Fisco, the econometric estimates imply a greater share of domestically produced goods in the consumer basket, which generates a dominant effect for their prices within the CPI and, consequently, a decline in total inflation. As a result, the central bank responds to the drop in output and the reduction in total inflation by lowering its interest rate.

The second model is a simple Keynesian model of an open economy. It assumes oil is an extractable resource, and emphasizes the importance of the real exchange rate channel and the role of risk premiums.[3] One of the main features of this model is that the economy can be financed in international markets and has oil reserves. It optimally extracts a certain amount of those reserves for export to the international market for crude oil, at a specific price. External sales represent a source of income for families. The non-oil economy consists of two sectors: tradables (fixed supply, but one that households demand at international prices, which are presumed to be flexible) and non-tradables (this sector uses labor and "fuel" to produce non-tradable services for which there is a household demand). The Central Bank uses a Taylor rule that is intended to stabilize inflation around a long-term target. All prices in the economy are denominated in pesos, so the model captures both the effect of rising inflation generated by nominal depreciation (pass through), as well as the increase in the value of net exports in pesos. The interest rate confronting agents in international markets depends not only on the ratio of external debt to GDP, but also on the value of the oil reserves. The

3 Bejarano, J .; Hamann, F .; Rodriguez, D. (2015). "Monetary policy implications for an oil-exporting economy of lower long-run international oil prices," *Borradores de Economía,* 871, *Banco de la República*.

Graph B3.2
Effects of a Permanent Drop in International Oil Prices with the Simple Neo-Keynsian Model



Sources: *Banco de la República*; authors' calculations

labor supply in the non-tradable sector depends entirely on the real wage.

As shown in Graph B3.2, the simple Keynesian model, like Fisco, predicts a permanent decline in household income caused by the drop in international oil prices, which leads to a permanent reduction in GDP under flexible and sticky prices. Similarly, there is real depreciation. In this case, it is caused not only by the decline in the economy's external debt, but also by the drop in the level of prices for non-tradable goods, generated by the decline in aggregate demand. Likewise, there is a negative output gap that responds, as with Fisco, to the rigidity of prices; in this case, from the non-tradable sector. As for inflation, the prediction in the neo-Keynesian model is radically different from that of Fisco, due to the extent of pass-through in the economy. With this model, although there is a drop in the level of prices for non-tradable goods and services, the increase in the price level of tradable goods predominates, because of real depreciation and perfect pass through (since there are no nominal rigidities in the tradable-goods sector). Accordingly, the central bank faces a dilemma when deciding on monetary policy, as it is confronted with a scenario where there is a drop in output, but an increase in the overall level of inflation. Therefore, its response depends on the relative importance of these variables in its policy rule. With the neo-Keynesian model, this rule depends exclusively on the behavior of total inflation, which is why the model proposes an increase in the interest rate.

The third, a neo-Keynesian model that includes the financial sector, abides by the previous model but also assumes a variable supply of tradable and non-tradable consumer goods and the existence of production of tradable and non-tradable capital goods. Employment can vary freely between both sectors. Additionally, there are some finan-

cial intermediaries that capture household savings and can channel them to companies in the form of loans to tradable and non-tradable sectors. The remaining elements of this model are identical to the previous one, except for gasoline as production input.

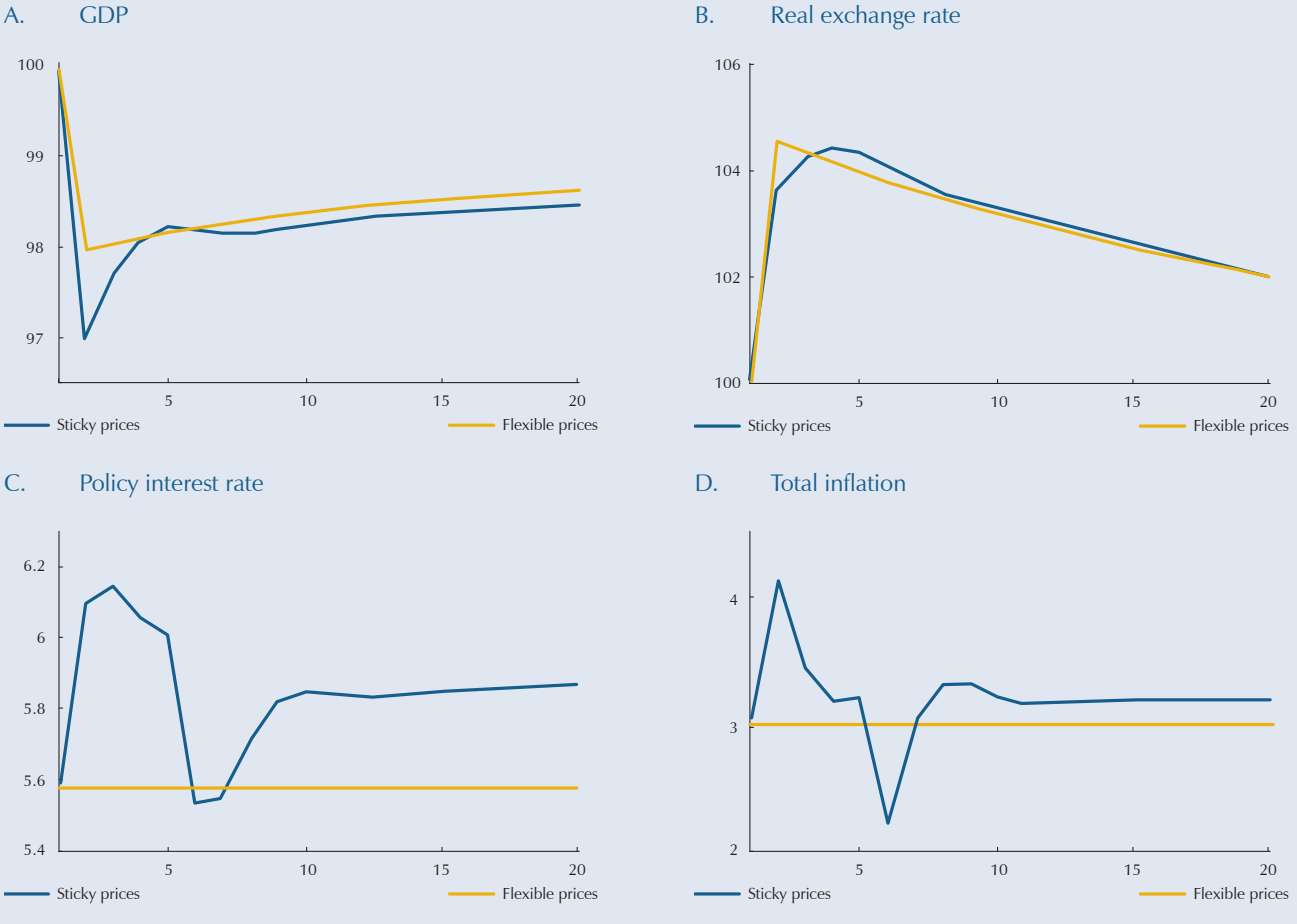
In this model, as shown in Graph B3.3, the drop in international oil prices has the same effect on GDP and on real depreciation as in the other two models, given the pass-through mechanisms described earlier. As for inflation and the policy interest rate, there is an increase in both of these variables, because in this model, as in the simple neo-Keynesian model, there is a dominant effect of pass through and a policy rule that depends solely on inflation.

Three main conclusions can be drawn from the results of the three models, where it is presumed the oil shock will be permanent. First, a permanent reduction in the level of household income implies a drop in GDP at flexible prices in the economy. In other words, there is a contraction in potential GDP. In the short term, the slow adjustment in prices implies more of a drop in aggregate demand, causing negative output gaps and, consequently, declines in the level of prices for local goods.

Secondly, the current account deficit and the drop in prices for non-tradable goods would bring about real depreciation. This depreciation leads to an increase in prices for imported goods in the Fisco model and tradables in the case of the simple neo-Keynesian model and the neo-Keynesian model including the financial sector.

Third, the ultimate effect of the shock to inflation will depend on the dominant mechanism between the increase generated by nominal depreciation (pass through) and the reduction in prices for domestically produced goods. In the case of the two neo-Keynesian models, pass through is the dominant effect, which implies an increase

Graph B3.3
Effects of a Permanent Drop in International Oil Prices with the Neo-Keynsian Model, including the Financial Sector



Sources: *Banco de la República*; authors' calculations

in inflation. On the contrary, the dominant effect in the Fisco model is a reduction in the level of prices for goods produced locally, in which case inflation declines.

Lastly, as a result of this shock, the central bank pays attention to a negative output gap, which could pose a policy dilemma, depending on the dominant effect between the change in price for tradable goods and that of non-tradables. If inflation in tradable goods is high and dominates the decline in prices for non-tradable goods and services, the bank will have to take action to deal with inflation that exceeds its long-term target. The policy response will depend on the importance the central bank gives to price stability and economic growth. Since this is the scenario contemplated by the two neo-Keynesian models, and assuming the central bank only cares about total inflation, then the policy recommendation with this model is to raise the interest rate. Conversely, if inflation in tradables is dominated by inflation in non-tradables, there would be no dilemma and, therefore, the policy response would be to reduce the interest rate. The latter is precisely the situation illustrated by the Fisco model.