BANCO CENTRAL DE RESERVA DEL PERÚ

Dutch disease and fiscal policy

Fabrizio Orrego* y Germán Vega**

* Banco Central de Reserva del Perú.
** Universidad de Piura.

DT. N° 2013-021
Serie de Documentos de Trabajo
Working Paper series
Diciembre 2013

Dutch disease and fiscal policy*

Fabrizio Orrego †   Germán Vega ‡

December 11, 2013

Abstract

We study the implications of the so-called Dutch disease in a small open economy that receives significant inflows of funds due to an extraordinary increase in the international price of minerals. We consider three sectors, the tradeable sector, the booming sector and the non-tradeable sector in an otherwise standard real-business-cycle model. We find that the booming sector, that benefits from high international prices, induces the Dutch disease, that is, the tradeable sector declines, the real exchange rate appreciates, wages increase and the non-tradeable sector improves. We then introduce fiscal policies that aim to alleviate the consequences of the Dutch disease. One particular rule that boosts the productivity of firms seems to offset the effects of the Dutch disease.

Resumen

En este trabajo estudiamos la denominada enfermedad Holandesa en una economía pequeña y abierta que recibe significativos influjos de fondos debido a un incremento extraordinario del precio de minerales. Consideramos tres sectores, el sector transable, el sector en auge y el sector no transable, en una economía estándar de ciclos económicos reales. Encontramos que el sector en auge, que se beneficia de las elevadas cotizaciones internacionales, induce la enfermedad Holandesa, esto es, el declive del sector transable, la apreciación del tipo de cambio real, el incremento de los salarios y la mejora del sector no transable. Luego introducimos reglas de política fiscal que persiguen aliviar las consecuencias de la enfermedad Holandesa. Una regla particular que incrementa la productividad de las firmas parece contrarrestar los efectos de la enfermedad Holandesa.

Keywords: Small open economy, Dutch disease, fiscal policy.
JEL classification codes: F31, F41, E62

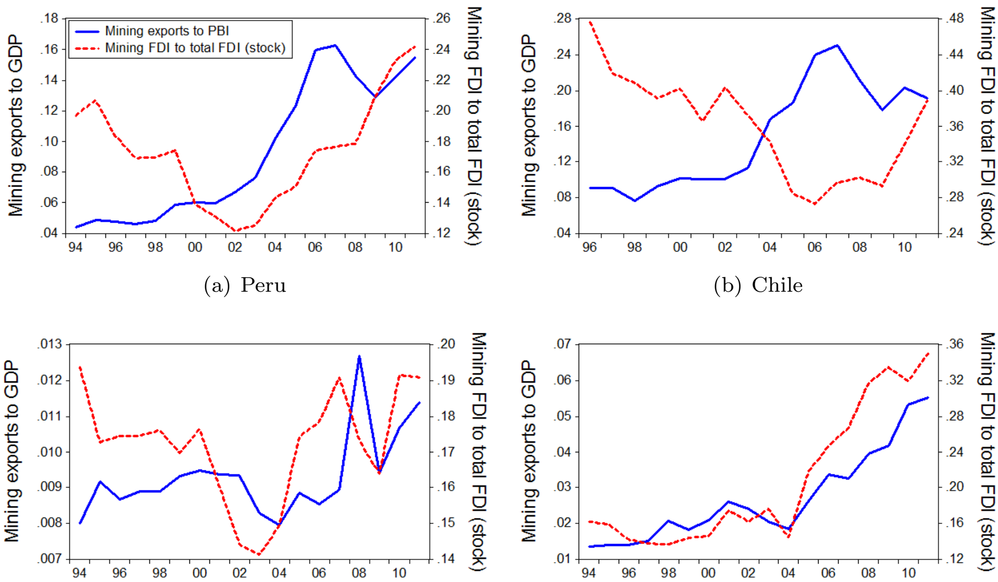
*We are grateful to Gonzalo Llosa and seminar participants at the Central Bank of Peru and the XXXI BCRP Research Conference for valuable comments and suggestions. The usual disclaimer applies.

†Research Department, Central Bank of Peru, Jr. Miro Quesada 441, Lima 1, Peru; and Department of Economics, Universidad de Piura, Calle Mártir José Olaya 162, Lima 18, Peru. Email address: fabrizio.orrego@bcrp.gob.pe

‡Department of Economics, Universidad de Piura, Calle Mártir José Olaya 162, Lima 18, Peru. Email address: german.vega31@gmail.com

1 Introduction

In the last decade, several exporters of minerals have benefited from extraordinarily high international prices. Figure 1 shows the case of four countries that belong to the top 10 exporters of copper. We observe that exports of copper significantly increased after 2003-2004 and foreign direct investment in the mining sector picked up shortly after in all countries. Figure 2 shows a close relationship between the share of copper exports and the ratio of non-tradeable GDP to total GDP. Furthermore, Figure 3 shows a clear mapping between the ratio of non-tradeable GDP to total GDP and the real exchange rate. All in all, these figures make us suspect of the existence of the so-called Dutch disease, which may have been induced by high international copper prices.



(a) Peru (b) Chile

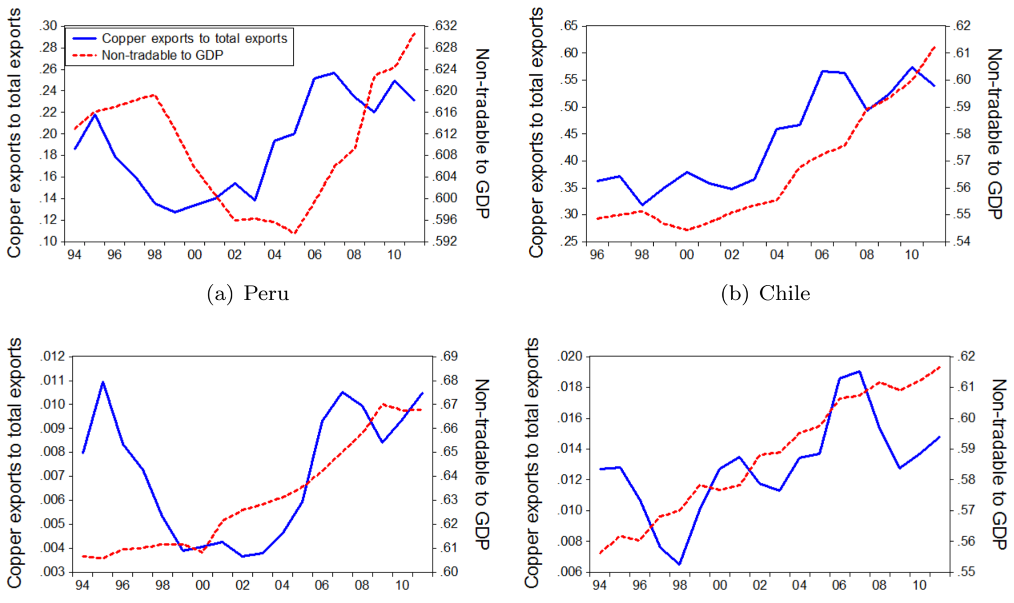
(c) Canada (d) Australia

Figure 1: Mining exports and FDI in mining sector. Solid line: Ratio of mining exports to total exports. Dashed line: Ratio of FDI in mining sector to total FDI. Source: Central Banks and World Bank.

In this paper, we study how the Dutch disease phenomenon emerges. We use a small open economy model with three sectors, a tradeable sector, a booming sector (that exports minerals) and a non-tradeable sector. Firms in the first two sectors produce goods that are traded at world prices. Output in the first two sectors use a factor specific to each sector and labor, but firms in the non-tradeable sector use only labor. Firms in the booming sector produce only for export and there is an exogenous rise in the price of its product on the world market. Then we find that if the government accumulates capital, and boosts the productivity of all sectors in the economy, then the effects of the Dutch disease may be ameliorated.

Our three-sector model follows the spirit of early papers that analyze the Dutch disease, for instance, Bruno and Sachs (1982), Corden and Neary (1982) and Corden (1984). As in Suescun (1997), the source of the disease in our model is the booming sector and the extraordinarily high price of copper. Other papers that blame the massive inflows from abroad are Lartey (2008a), Lartey (2008b) and Acosta, Lartey and Mendelman (2009).

We introduce fiscal policies in the spirit of Baxter and King (1993) in order to offset the effects of the so-called Dutch disease. We do not assess the role of monetary policy, because in our model prices are fully flexible. However, recently several papers such as Lama and Medina (2012) or Hevia, Neumeyer and Nicolini (2013) have reconsidered the role of monetary policy to ameliorate the effects of the Dutch disease, since these papers argue that monetary policy can overrule the negative externality that is assumed to exist in the tradeable sector.



(a) Peru (b) Chile

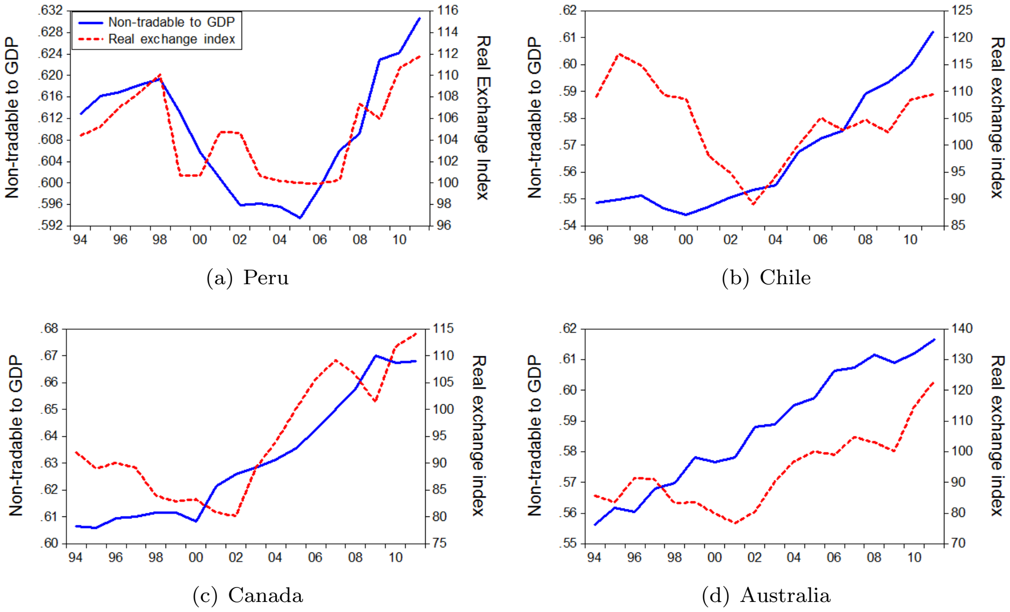
(c) Canada (d) Australia

Figure 2: Copper exports and non-tradable production. Solid line: Ratio of copper exports to total exports. Dashed line: Ratio of non-tradable production to total production. Source: Central Banks and World Bank.

The plan of this paper is as follows. Section 2 introduces the model. Section 3 presents the solution of the model. Section 4 shows the impulse response functions. Section 5 concludes.

2 The model

We embed a three-sector model, the booming sector, the tradeable sector and the non-tradeable sector, into a frictionless standard small open economy which is populated by households, firms and government. Firms in the first two sectors produce goods that are traded at world prices. Output in the first two sectors use a factor specific to each sector and labor, but firms in the non-tradeable sector use only labor. Since labor is perfectly mobile, the market wage is the same in all sectors. We further assume, in the spirit of Corden (1984), that firms in the booming sector produce only for export and there is an exogenous rise in the price of its product on the world market which induces a Dutch disease. We finally evaluate different fiscal rules that



(a) Peru

(b) Chile

(c) Canada

(d) Australia

Figure 3: Non-tradable production and real exchange rate. Solid line: Ratio of non-tradable production to total production. Dashed line: Effective real exchange rate. Source: Central Banks and World Bank.

may offset the consequences of the Dutch disease on the tradeable sector.

2.1 Households

A representative household wants to maximize the discounted value of his lifetime utility from consumption and labor:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \exp\left[-\sum_{\tau=0}^{s-t-1} \kappa \log\left(1+\overline{C}_t-\eta\frac{\overline{L}_t^{\nu}}{\nu}\right)\right] U(C_s, L_s) \tag{1}$$

where the instantaneous utility function is:

$$U(C_t, L_t) = \frac{\left(C_t - \eta\frac{L_t^{\nu}}{\nu}\right)^{1-\sigma}}{1-\sigma}$$

The functional form owes to Greenwood, Hercowitz and Huffman (1988). Moreover, as is standard in open economy models, the aggregate consumption good C_t comprises both tradeable consumption $C_{T,t}$ and non-tradeable consumption $C_{NT,t}$, in the following fashion:

$$C_t = \left[\gamma^{\frac{1}{\theta}}\left(C_{T,t}\right)^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}}\left(C_{NT,t}\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, \tag{2}$$

where $\gamma \in [0,1]$ is the share of tradeable consumption in the consumption index and $\theta > 0$ is the elasticity of intertemporal substitution between tradeables and non-tradeables. For later reference, the consumer price index is:

$$P_t = \left[\gamma + (1-\gamma)\left(P_{NT,t}\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}, \tag{3}$$

where the price of tradeable goods serve as a numeraire and $P_{NT,t}$ is the price of non-tradeable goods.

In the financial side, the household is allowed to trade a risk-free one-period bond B_t that pays the international interest rate r_t, as well as shares of firms in the tradeable sector, $s_{T,t}$ and the booming sector, $s_{B,t}$. Thus, the budget constraint is:

$$P_tC_t+v_{T,t}s_{T,t}+v_{B,t}s_{B,t}+B_t = W_tL_t+(v_{T,t}+d_{T,t})s_{T,t-1}+(v_{B,t}+\rho d_{B,t})s_{B,t-1}+(1+r_t)B_{t-1} \tag{4}$$

where $v_{T,t}$ and $v_{B,t}$ are the stock prices in the tradeable sector and the booming sector, respectively. On the other hand, $d_{T,t}$ and $d_{B,t}$ represent the dividends paid by firms in the tradeable sector and the booming sector, respectively. Notice that the latter are affected by a scalar ρ that ensures determinacy. Finally, L_t is the household's labor supply and W_t is the nominal market wage expressed in terms of the domestic tradeable good.

In an interior solution, the first order conditions of the optimization process are:

$$\lambda_t = \exp\left[-\kappa \log\left(1+\overline{C}_t - \eta\overline{L}_t^{\nu}/\nu\right)\right] \mathbb{E}_t\lambda_{t+1}(1+r_{t+1})P_t/P_{t+1} \tag{5}$$

$$v_{T,t}\lambda_t = \exp\left[-\kappa \log\left(1+\overline{C}_t - \eta\overline{L}_t^{\nu}/\nu\right)\right] \mathbb{E}_t\lambda_{t+1}(v_{T,t+1}+d_{T,t+1})P_t/P_{t+1} \tag{6}$$

$$v_{B,t}\lambda_t = \exp\left[-\kappa \log\left(1+\overline{C}_t - \eta\overline{L}_t^{\nu}/\nu\right)\right] \mathbb{E}_t\lambda_{t+1}(v_{B,t+1}+\rho d_{B,t+1})P_t/P_{t+1} \tag{7}$$

$$C_{T,t} = \gamma\left(P_t\right)^{\theta} C_t \tag{8}$$

$$C_{NT,t} = (1-\gamma)\left(\frac{P_t}{P_{NT,t}}\right)^{\theta} C_t \tag{9}$$

$$\eta L_t^{v-1} = \frac{W_t}{P_t} \tag{10}$$

where λ_t is the marginal utility of consumption. Notice that equation (5) is a standard Euler equation. Equations (6) and (7) reflect optimality conditions related to financial purchases. In these cases, the marginal utility of forgoing one unit of stock must be equal to the (discounted) expected utility of the real return of the stock. Consumption in the tradeable sector and non-tradeable sector are given by (8) and (9), respectively. On the other hand, equation (10) determines labor supply. Notice that the functional form of the utility function guarantees that income effects are negligible, that is, the labor supply curve does not bend backwards.

2.2 Production sectors

In this section we characterize the behavior of firms in the tradeable sector, the booming sector and the non-tradeable sector. Labor is perfectly mobile across sectors, but capital in the tradeable sector and the mining sector is specific. Non-tradeable firms use only labor.

2.2.1 Tradeable sector

Unlike Lama and Medina (2012) or Hevia et al. (2013), we do not consider an externality in the production function of firms in the tradeable sector. Instead, we assume a plain Cobb-Douglas technology with constant returns to scale:

$$Y_{T,t} = A_{T,t} K_{T,t-1}^{\alpha} {L_{T,t}}^{1-\alpha} \tag{11}$$

where $A_{T,t}$ is the total factor productivity in the tradeable sector, α measures the intensity of capital in the production function and $K_{T,t}$ and $L_{T,t}$ are the inputs in the production function. Capital follows a standard law of motion:

$$K_{T,t+1} = I_{T,t} + (1-\delta) K_{T,t}, \tag{12}$$

where δ is the depreciation rate. Also there are convex adjustment costs given by:

$$\frac{\phi}{2} \left(\frac{I_{T,t}}{K_{T,t-1}} - \delta \right)^2 K_{T,t-1}$$

where ϕ measures the relative importance of adjustment costs. The firm's problem is to maximize the discounted value of dividends d_s, that is, revenue minus expenditures:

$$\max_{K_{T,t}, I_{T,t}, L_{T,t}} \quad \mathbb{E}_t \sum_{s=t}^{\infty} \Lambda_{T,s} \left[(1-\tau) Y_{T,s} - I_{T,s} - \frac{\phi}{2} \left(\frac{I_{T,s}}{K_{T,s-1}} - \delta \right) K_{T,s-1} - W_s L_{T,s} \right]$$

subject to equations (11) and (12). Notice that the (stochastic) discount factor is:

$$\Lambda_{T,t} = \exp \left[-\kappa \log \left(1 + \overline{C}_t - \eta \frac{\overline{L_t}^{\nu}}{\nu} \right) \right]^{s-t} \frac{\lambda_t}{\lambda_{t+1}} \frac{P_t}{P_{t+1}}$$

Furthermore, after iterating equation (6) we have a standard result in asset pricing:

$$v_{T,t} = \mathbb{E}_t \sum_{s=t}^{\infty} \Lambda_{T,s} d_{T,s}$$

In an interior solution, the optimal decisions of the firm in the tradeable sector give rise to the following conditions:

$$\begin{aligned} Q_{T,t} = \mathbb{E}_t \Lambda_{T,t+1} \Bigg\{ & \alpha(1-\tau) \frac{Y_{T,t+1}}{K_{T,t}} \\ & + \left[\frac{\phi}{2} \left(\frac{I_{T,t+1}}{K_{T,t}} - \delta \right)^2 - \phi \left(\frac{I_{T,t+1}}{K_{T,t}} - \delta \right) \frac{I_{t+1}}{K_t} \right] + Q_{t+1}(1-\delta) \Bigg\} \end{aligned} \tag{13}$$

$$Q_{T,t} = 1 + \phi \left(\frac{I_{T,t}}{K_{T,t-1}} - \delta \right) \tag{14}$$

$$W_t = (1-\alpha)(1-\tau) \frac{Y_{T,t}}{L_{T,t}} \tag{15}$$

Equation (13) is a standard investment Euler equation and describes the dynamics of the shadow price of capital $Q_{T,t}$. Moreover, equation (14) determines the current value of $Q_{T,t}$ and equation (15) shows the labor demand in the tradeable sector.

2.2.2 Mining sector

Firms in the booming sector first use an investment unit to decide upon the optimal composition of local investment and foreign investment. This modeling device is in line with Figure 1, in which we observe that the mining sector receives capital from abroad in the form of foreign direct investment.

Investment unit.- The investment unit produces one unit of investment using local investment $I_{H,t}$ and foreign investment $I_{F,t}$. Firms in the tradeable sector supply local investment and foreign investment comes from abroad. Investment in the booming sector $I_{B,t}$ aggregates the two types of investment via a CES function:

$$I_{B,t} = \left[\mu^{\frac{1}{\rho}} \left(I_{H,t}\right)^{\frac{\rho-1}{\rho}} + (1-\mu)^{\frac{1}{\rho}} \left(I_{F,t}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, \tag{16}$$

where $\mu \in [0,1[$ is the share of local investment in the mining sector and $\rho > 0$ is the elasticity of substitution between the two types of investment. If the price of local investment serve as a numeraire and $P_{FI,t}$ stands for the price of foreign investment, the cost minimization problem of the investment unit is the following:

$$\min_{I_{H,t}, I_{F,t}} I_{H,t} + P_{FI,t} I_{F,t}$$

subject to equation (16). In an interior solution, we obtain demands for each type of investment:

$$I_{H,t} = \mu (P_{I,t})^{\rho} I_{B,t} \tag{17}$$

$$I_{F,t} = (1-\mu)\left(\frac{P_{I,t}}{P_{FI,t}}\right)^{\rho} I_{B,t} \tag{18}$$

Production unit.- Firms in the booming sector produce only for export. Because firms want to maximize the discounted value of dividends, they had better establish an optimal demand for capital, given the external demand and export prices. On the other hand, firms inelastically demand labor in each period, given the capital stock and factor productivity, regardless of the market wage or the tax system. The production function and the law of motion of capital are:

$$Y_{B,t} = A_{B,t} K_{B,t-1}^{\alpha} L_{B,t}^{1-\alpha} \tag{19}$$

$$K_{B,t} = I_{B,t} + (1-\delta) K_{B,t-1} \tag{20}$$

where $A_{B,t}$ is the total factor productivity in the booming sector, α measures the intensity of capital in the production function and $K_{B,t}$ and $L_{B,t}$ are the inputs in the production function. In the booming sector, there are convex adjustment costs given by:

$$\frac{\phi}{2}\left(\frac{I_{B,t}}{K_{B,t-1}}-\delta\right)^2 K_{B,t-1}$$

where ϕ measures the relative importance of adjustment costs. If the price of investment in the mining sector $P_{I,t}$ is given by:

$$P_{I,t}=\left[\mu+(1-\mu)\left(P_{FI,t}\right)^{1-\rho}\right]^{\frac{1}{1-\rho}}$$

then the firm's problem in the booming sector is to maximize the discounted value of dividends $d_{B,s}$, that is, revenue minus expenditures:

$$\max_{K_{B,t},I_{B,t}} \mathbb{E}_t\sum_{s=t}^{\infty}\Lambda_{B,s}\left[(1-\tau)P_{B,s}Y_{B,s}-P_{I,s}\left(I_{B,s}+\frac{\phi}{2}\left(\frac{I_{B,s}}{K_{B,s-1}}-\delta\right)K_{B,s-1}\right)-W_sL_{B,s}\right]$$

subject to equations (19) and (20). As in the previous subsection, we find after iterating equation (7) that:

$$v_{B,t}=\mathbb{E}_t\sum_{s=t}^{\infty}\rho\Lambda_{B,s}d_{B,s}$$

The optimality conditions with respect to capital and investment are the following:

$$\begin{aligned}Q_{B,t}=\mathbb{E}_t\Lambda_{B,t+1}\Bigg\{&\alpha(1-\tau)P_{B,t+1}\frac{Y_{B,t+1}}{K_{B,t}}\\&+P_{I,t+1}\left[\frac{\phi}{2}\left(\frac{I_{B,t+1}}{K_{B,t}}-\delta\right)^2-\phi\left(\frac{I_{B,t+1}}{K_{B,t}}-\delta\right)\frac{I_{B,t+1}}{K_{B,t}}\right]+Q_{B,t+1}(1-\delta)\Bigg\}\end{aligned} \tag{21}$$

$$Q_{B,t}=P_{I,t}\left[1+\phi\left(\frac{I_{B,t}}{K_{B,t-1}}-\delta\right)\right] \tag{22}$$

where $Q_{B,t}$ is the shadow price of capital in the booming sector. Notice that there are three differences with the problem of the firm in the tradeable sector, namely the price of minerals $P_{B,t}$ and the price of investment, $P_{I,t}$. Furthermore, the demand for labor is completely inelastic.

2.2.3 Non-tradeable sector

The production function in the non-tradeable sector is linear in labor:

$$Y_{NT,t}=Z_tL_{NT,t}, \tag{23}$$

where Z_t is the labor productivity and $L_{NT,t}$ is the demand of labor in the non-tradeable sector. The static optimization problem of the firm yields the following equilibrium condition:

$$(1-\tau)\frac{Y_{NT,t}}{L_{NT,t}}=\frac{W_t}{P_{NT,t}}, \tag{24}$$

where τ stands for the income tax.

2.3 Government

Because we deal with flexible prices, we do not assess the usefulness of monetary policy. Instead, we study the effects of several fiscal rules in the presence of the Dutch disease. As in Baxter and King (1993), we assume that government spending affects the utility of the representative household:

$$\tilde{U}(C_t, L_t, \Gamma_t) = \frac{\left[C_t - \eta \frac{L_t^{\nu}}{\nu}\right]^{1-\sigma}}{1-\sigma} + \Gamma(C_{G,t}, I_{G,t})$$

where I_G stands for investment expenditures and C_G represents consumption expenditures. The government collects the income tax and distributes the revenue, measured in terms of the local tradeable good, between I_G and C_G. Since we disregard the dynamics of public debt, the government budget constraint reduces to the following condition:

$$\begin{aligned} \tau Y_t &= G_t \\ &= I_{G,t} + C_{G,t} \end{aligned} \tag{25}$$

Now we will explain the nature of each component of the right hand side of equation (25).

Investment.- Investment expenditures help build the stock of public capital K_G that depreciates itself at a rate δ. They are mainly infrastructure projects such as railroads, bridges and homeland security. The corresponding law of capital accumulation is:

$$K_{G,t+1} = I_{G,t} + (1-\delta)K_{G,t} \tag{26}$$

Public investment behaves like a positive externality since it raises the productivity in all sectors of the economy. Consequently, the production functions in the tradeable sector, booming sector and non-tradeable sector are, respectively:

$$\tilde{Y}_{T,t} = \tilde{A}_{T,t} K_{t-1}^{\alpha} {L_{T,t}}^{1-\alpha} \tag{27}$$

$$\tilde{Y}_{B,t} = \tilde{A}_{B,t} K_{B,t-1}^{\alpha} {L_{B,t}}^{1-\alpha} \tag{28}$$

$$\tilde{Y}_{NT,t} = \tilde{Z}_t L_{NT,t} \tag{29}$$

where the new total productivity factors now include the externality induced by the public infrastructure:

$$\tilde{A}_{T,t} = A_t K_{G,t-1}^{\psi}$$
$$\tilde{A}_{B,t} = A_{B,t} K_{G,t-1}^{\psi}$$
$$\tilde{Z}_t = Z_t K_{G,t-1}^{\psi}$$

Consumption.- For the case of consumption expenditures, the government may buy goods from either the tradeable sector or the non-tradeable sector. We assume that the share of expenditures in each sector mimics that of the consumption basket of the households:

$$C_{GNT,t} = \gamma C_{G,t} \tag{30}$$

$$C_{GNT,t} = (1-\gamma)\frac{C_{G,t}}{P_{NT}} \tag{31}$$

Hence public purchases may be written as:

$$C_{G,t} = C_{GT,t} + P_{NT,t} C_{GNT,t} \tag{32}$$

Fiscal rules.- Now we consider three fiscal rules that differ in the composition of public expenditures:

1. Rule I: Public expenditures G_t only buy consumption goods, following equations (30) and (31). Public investment is zero.

2. Rule II: Public investment only generate positive externalities in the non-tradeable sector. Thus, the production function in the non-tradeable sector is consistent with equation (29). Public expenditures G_t buy consumption goods.

3. Rule III: Public investment generates positive externalities throughout the economy. Production functions are consistent with equations (27), (28) and (29). Public expenditures G_t buy consumption goods.

2.4 Aggregation and market clearing conditions

In this section, we state the equilibrium conditions of the model. In equilibrium, we have that $C_t = \overline{C}_t$ and $L_t = \overline{L}_t$. Furthermore, for simplicity, we assume that adjustment costs in the booming sector and the public investment are expressed in terms of tradeable goods. The market clearing conditions in the goods market and the labor market are:

$$Y_t = Y_{T,t} + P_{NT,t} Y_{NT,t} + P_{B,t} Y_{B,t} + I_{G,t} \tag{33}$$

$$\begin{aligned} Y_{T,t} &= C_{T,t} + C_{GT,t} + I_{G,t} + I_{H,t} + BoT_{T,t} \\ &\quad + P_{I,t}\left[\frac{\phi}{2}\left(\frac{I_{B,t}}{K_{B,t-1}} - \delta\right)^2 K_{B,t-1}\right] + \frac{\phi}{2}\left(\frac{I_{T,t}}{K_{T,t-1}} - \delta\right)^2 K_{T,t-1} \end{aligned} \tag{34}$$

$$Y_{NT,t} = C_{NT,t} + C_{GNT,t} \tag{35}$$

$$L_t = L_{T,t} + L_{B,t} + L_{NT,t} \tag{36}$$

The demand for local tradeable goods does not necessarily match the local supply and the difference is captured in the balance of trade without minerals or $BoT_{T,t}$. We also need to define some variables such as exports of minerals ($X_{B,t}$), external demand for exports ($Y_{RoW,t}$), real exchange rate (RER_t), balance of trade (BoT_t) and current account (CA_t). Since firms in the booming sector produce only for export, it must be the case that $X_{B,t} = Y_{B,t}$ in equilibrium.

$$X_{B,t} = \gamma_B P_{B,t}^{\varpi} Y_{RoW,t} \tag{37}$$

$$RER_t = \frac{1}{P_t} \tag{38}$$

$$BoT_t = BoT_{T,t} + P_{B,t} X_{B,t} \tag{39}$$

$$CA_t = r_t B_{t-1} + BoT_t - P_{FI,t} I_{F,t} \tag{40}$$

Equation (37) shows that nominal exports of minerals depend on both the international price and the demand of the rest of world. Moreover, equation (38) suggests that an increase of RER_t implies a real depreciation. On the other hand, equation (39) shows all transactions with international partners. Finally, equation (40) shows the current account of the small open economy.

2.5 Exogenous variables

There are two types of exogenous variables in this model. On the one hand, there are internal exogenous variables such as total factor productivity of the tradeable sector ($A_{T,t}$), the booming sector ($A_{B,t}$) and the non-tradeable sector (Z_t). On the other hand, we have exogenous variables that are determined in international markets such as the price of the booming sector ($P_{B,t}$), the price of international investment ($P_{FI,t}$), the country risk premium (r_t^*) and the stance of the world economy ($Y_{RoW,t}$). All exogenous variables follow stationary autorregressive processes that are mutually uncorrelated.

3 Solution of the model and calibration

In this section we solve for the non-stochastic steady state. First we consider the case without government expenditures (in this version of the model there are 31 endogenous variables and 7 exogenous variables). We show there is a unique stationary equilibrium. Given the assumptions on utility and production, we are able to get a closed form solution. To begin with, we assume that all exogenous variables are equal to unity:

$$A_T = A_B = Z = P_B = Y_{RoW} = r^* = P_{FI} = 1$$

We first find wages and prices. Thus we use the optimality conditions of the tradeable firm, that is, equations (13), (14) and (15):

$$\begin{aligned} K_T &= \frac{\alpha Y_T}{r+\delta} \\ Q_T &= 1 \\ L_T &= \frac{(1-\alpha)Y_T}{W} \end{aligned}$$

Now we plug both L_T and K_T in the production function (11) and solve for W:

$$W = (1-\alpha)\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}}$$

Notice that equation (23) implies that the price of non-tradeable goods is equal to the equilibrium wage:

$$P_{NT} = (1-\alpha)\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}}$$

Then we use equation (3) in order to solve for the price index:

$$P = \left[\gamma + (1-\gamma)\left[(1-\alpha)\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}}\right]^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

We use equation (10) to find the labor supply:

$$L = \left(\frac{1}{\eta}\frac{W}{P}\right)^{\frac{1}{\nu-1}}$$

From equation (5) we may solve for consumption of the household:

$$C = (1+r)^{1/\kappa} - 1 + \eta L^{\nu}/\nu$$

With aggregate consumption at hand, we find both tradeable and non-tradeable consumption using (8) and (9). Furthermore, from equations (23) and (35) we find the value of non-tradeable output and non-tradeable labor.

In the booming sector, output is determined by equation (37). Then we find capital and labor in the booming sector using equations (21) and (19). Investment in the booming sector is determined by equation (20). Furthermore, since the price of capital is equal to unity because of equation (22), we find that:

$$I_B = \delta K_B.$$

And, consequently, domestic investment and foreign investment may be written as:

$$I_H = \mu I_B$$
$$I_F = (1 - \mu) I_B$$

Labor in the tradeable good is:

$$L_T = L - L_{NT} - L_B,$$

We then find capital and output in the tradeable sector. With these variables, we find the real exchange rate, the balance of trade and the current account. Finally, bond holdings are determined by the budget constraint of the household (4):

$$B = PC - WL - d_T - d_B$$

Once we add government expenditures, we follow a similar procedure in order to solve for the non-stochastic steady state.

3.1 Equilibrium

We solve the model up to a first-order approximation around the non-stochastic steady state. We use Dynare in Matlab. The equations we need are:

1. Household's problem: (4), (5), (6), (7), (8), (9) and (10).
2. Firm's problem in tradeable sector: (11), (12), (13), (14) and (15).
3. Firm's problem in non-tradeable sector: (23) and (24).
4. Firm's problem in booming sector: (17), (18), (19), (20), (21) and (22).
5. Domestic prices: (3).
6. Market clearing: (35), (34), (33) and (36).
7. International economy: (37), (38), (39) and (40).
8. Public expenditures: (26), (30), (31).
9. International interest rate.
10. Definition of dividends in tradeable sector and booming sector.
11. All exogenous variables.

3.2 Calibration

Table 1 depicts the baseline calibration in this paper. Few parameters are fairly standard in the literature, such as α, ν and δ. We also assume that $\sigma = 2$ to ensure certain curvature of the utility function. The international interest rate is 0.0101, which means that the discount factor is 0.99 in any stationary equilibrium. We follow Devereux, Lane and Xu (2006) and set the share of tradeable consumption equal to 0.45. As in Acosta et al. (2009), the elasticity of substitution θ between tradeables and non-tradeables is 0.4. Since it turns out that this parameter is important, we perform robustness checks with alternative values of 0.2 and 0.8 (available upon request). We also follow Acosta et al. (2009) in order to set the elasticity of exports equal to 0.9.

Furthermore, the elasticity of substitution between domestic investment and foreign investment, ρ, is equal to 1.5. We calibrate κ and γ_B so as to match the ratios of balance of trade to GDP and exports of minerals to GDP. Finally, we assume that capital adjustment costs are equal to 3.

Parameters of standard model			
Parameter	Value	Description	Source
σ	2	Elasticity of intertemporal substitution	Lartey (2008a)
κ	0.02	Adjustment in discount factor	Match BoT/GDP
ν	1.455	Inverse of elasticity of labor supply	Mendoza (1991)
η	1	Disutility in labor supply	Lartey (2008a)
α	0.33	Share of capital in production	Standard in SoE
ϕ	3	Adjustment cost in capital	Acosta et al. (2009)
γ	0.45	Share of tradeable goods in consumption	Devereux et al. (2006)
θ	0.4	Elasticity of substitution	Acosta et al. (2009)
δ	0.05	Depreciation rate	Standard in SoE
μ	0.8	Share of domestic inv. in booming sector	Lartey (2008a)
ρ	1.5	Elasticity of substitution in investment	Lartey (2008a)
r	0.0101	Foreign interest rate	Equivalent to β 0.99
ω	1	Elasticity of exports	Acosta et al. (2009)
α_B	0.33	Share of capital in mining sector	Standard in SoE
γ_b	0.2455	Adjustment in foreign demand	Match Exports/GDP
τ	0.13	Tax rate	Match G/GDP
τ^c	0.68	Share of government purchases	Match Peruvian data
ψ	0.1	Intensity of public externality	Imply no productivity gain

Table 1: Baseline parameterization

In the presence of fiscal rules, we set the tax rate in order to match the ratio of public expenditures to GDP of Peru in the period 1994-2012 (0.13). The share of government purchases is 0.68, consistent with Peruvian data. We further assume that ψ is equal to 0.1 in order not to overestimate the effects of the positive externality of public capital. Because we want to compare among the different fiscal rules, we calibrate κ and γ_B to ensure that the ratios of balance of trade to GDP and exports of minerals to GDP are equal to -0.02 and 0.08, respectively, as in the data. Table 2 depicts the parameters associated to each fiscal rule.

In order to evaluate the calibration, we plug the parameters in the equations that characterize the non-stochastic steady state without fiscal expenditures and calculate several ratios with respect to GDP. Table 3 shows the comparison between the ratios obtained from the model and the real ratios calculated with Peruvian data from 1994 to 2012 (we use quarterly data that have been previously seasonally adjusted and detrended). The main differences that arise are the low ratio of investment and the high ratio of consumption, because the model, by construction, does not have capital in the non-tradeable sector, which reduces the aggregate amount of investment. The ratio of non-tradable consumption to total consumption is close to the real ratio and the share of non-tradable labor is greater than 0.6, which is a stylized fact in small open economies. In any stationary equilibrium, the current account is zero, and the balance of trade and exports of minerals roughly match the data.

On the other hand, Table 4 depicts a similar comparison, but this time the model includes fiscal expenditures. We consider Rule I and hence no positive externalities are created. The calibration matches the ratio government purchases to GDP observed in the data. Even though the ratios in the steady state roughly match the ratios obtained with Peruvian data, we are left to check that sample autocorrelations and standard deviations are also similar. We consequently calibrate the variance and persistence of each shock, such that we also match the unconditional moments of main economic aggregates.

4 Results

Baseline model.- We perturb the model with a 10% (transitory) increase in $P_{B,t}$. Figure 4 depicts the responses of the relevant endogenous variables in the economy. Profits in the mining sector increase and households get more dividends. Wages also increase and households happen to consume more non-tradeable goods as well as tradeable goods. Since the price of tradeables is fixed, the higher price of non-tradeables induces a real appreciation of the exchange rate. This real appreciation deteriorates the competitiveness of the tradeable sector.

Hence, the tradeable sector decreases on impact (the higher consumption of tradeables lead to a deficit in the balance of trade of tradeable goods), but both the non-tradeable sector and the booming sector (mining sector) increase. Moreover, we observe a reduction of labor demand in the tradeable sector. These ingredients suggest that an international increase in the price of minerals contributes in this economy with the emergence of the Dutch disease.

Fiscal rules.- Figure 5 depicts the IRFs associated with Rule I, together with the IRFs from the baseline model. The IRFs suggest that Rule I strengthens the effects of the Dutch disease. On the one hand, the non-tradeable sector is better off with Rule I and the tradeable sector decreases more than in the baseline scenario. Notice that Rule I further appreciates the real exchange rate, since the increase in the non-tradeable price index is greater than in the baseline case. However, Rule I has a negligible effect on GDP, relative to the baseline case.

Then, Figure 6 depicts the IRFs associated with Rule II, together with the IRFs from the baseline model. When public investment generates a positive externality in the non-tradeable sector, there are noticeable effects on several variables in the economy. Rule II softens the effects of the Dutch disease, for example, in the case of output in the non-tradeable sector and tradeable sector. Furthermore, the appreciation of the real exchange rate is smaller (since the non-tradeable price index converges to zero more rapidly).

Figure 7 depicts the IRFs associated with Rule III, together with the IRFs from the baseline model. When public investment generates a positive externality in all sectors, the impact of higher commodity prices on output is highly persistent. Rule III offsets the effects of the Dutch disease. Firms in both the non-tradeable sector and the tradeable sector are better off. Households receive higher wages. The real exchange rate suffers less on impact. More importantly, capital in the tradeable sector eventually reaches a higher level than in the baseline case. The intuition is that Rule III accumulates public capital that positively affects the productivity of capital in the tradeable sector.

5 Final remarks

We study a small open economy with three sectors, the tradeable sector, the booming sector and the non-tradeable sector. We show that after an unanticipated increase in the price of exports, there is a real appreciation of the exchange rate, a deterioration of the tradeable sector and more favorable conditions for the non-tradeable sector and the booming sector. Then we evaluate the usefulness of alternative fiscal rules that aim to offset the effects of the so-called Dutch disease. We find that the government may do so through the accumulation of public capital that affects positively the productivity of all firms in the economy. In this fashion, fiscal rules counteract the Dutch disease, as originally suggested in Corden (1984).

However, we are left to pursue several avenues. First, we need to study persistent increases in the international price of exports. Second, we need to compare the fiscal rules in terms of a welfare function. Third, we may want to contrast the effects of the Dutch disease with other sources of real exchange appreciations, such as the typical Balassa-Samuelson effect, and rank the associated welfare gains or losses. We are currently undertaking all these issues. Finally, we are also improving the budget constraint of the government by adding dynamics to the evolution of public debt.

References

Acosta, P., E. Lartey, and F. Mendelman, "Remittances and the Dutch disease," *Journal of International Economics*, 2009, *79*, 102–116.

Baxter, M. and R. King, "Fiscal policy in general equilibrium," *American Economic Review*, 1993, *83* (3), 315–334.

Bruno, M. and J. Sachs, "Energy and resource allocation: A dynamic model of the Dutch disease," *The Review of Economic Studies*, 1982, *49* (5), 845–859.

Corden, M., "Booming sector and Dutch disease economics: Survey and consolidation," *Oxford Economic Papers*, November 1984, *36* (3), 359–380.

Corden, W. and J. Neary, "Booming sector and de-industrialisation in a small open economy," *Economic Journal*, 1982, *92* (368), 825–848.

Devereux, M., P. Lane, and J. Xu, "Exchange rates and monetary policy in emerging market economies," *Economic Journal*, April 2006, *116* (511), 478–506.

Greenwood, J., Z. Hercowitz, and G. Huffman, "Investment, capacity utilization and the real business cycle," *American Economic Review*, 1988, *78* (3), 402–417.

Hevia, C., A. Neumeyer, and J. Nicolini, "Optimal monetary and fiscal policy in a New Keynesian model with a Dutch disease: The case of complete markets," Working Paper, Universidad Torcuato Di Tella 2013.

Lama, R. and J. Medina, "Is exchange rate stabilization an appropriate cure of the Dutch disease?," *International Journal of Central Banking*, March 2012, *8* (1), 5–46.

Lartey, E., "Capital inflows, Dutch disease effects, and monetary policy in a open small economy," *Review of International Economics*, 2008, *16* (5), 971–989.

_ , "Capital inflows, resource reallocation and the real exchange rate," *International Finance*, 2008, *11* (2), 131–152.

Mendoza, E., "Real business cycles in a small open economy," *American Economic Review*, 1991, *81* (4), 797–818.

Suescun, R., "Commodity booms, Dutch disease and real business cycles in a small open economy: The case of coffee in Colombia," Borradores de Economia 73, Banco de la Republica 1997.

Parameter configuration of alternative fiscal rules				
	Valores			
Parameter	Baseline model	Rule I	Rule II	Rule III
κ	0.019	0.03	0.028	0.025
γ_b	0.245	0.142	0.152	0.184
τ	0	0.13	0.13	0.13
τ_c	0	1	0.69	0.69
ψ	0	0	0.1	0.1

Table 2: Different parameter configurations of fiscal rules. The rest of parameters remains the same. The values of κ and γ ensure a ratio of BoT/GDP equal to -0.02 and exports of minerals to GDP equal to 0.08 in all specifications, similar to Peruvian data between 1994 and 2012.

Comparison of model without public purchases and Peruvian data		
Variable	Model	Data
Consumption	0.89	0.80
Investment	0.13	0.22
Balance of Trade	-0.02	-0.02
Exports of minerals	0.08	0.08
Current account	0	-0.02
Non-tradable sector	0.56	0.6
Ratio non-tradable labor	0.65	0.6

Table 3: We compare the ratios from the model with the real ratios obtained with Peruvian data between 1994 and 2012. Here we consider the baseline model without fiscal expenditures.

Comparison of model with public purchases and Peruvian data		
Variable	Model	Data
Consumption	0.78	0.7
Investment	0.11	0.18
Government expenditures	0.13	0.13
Balance of Trade	-0.02	-0.02
Exports of minerals	0.08	0.08
Current account	0	-0.02
Non-tradable sector	0.48	0.6
Ratio non-tradable labor	0.64	0.6

Table 4: We compare the ratios from the model with the real ratios obtained with Peruvian data between 1994 and 2012. Here we implement Rule I.

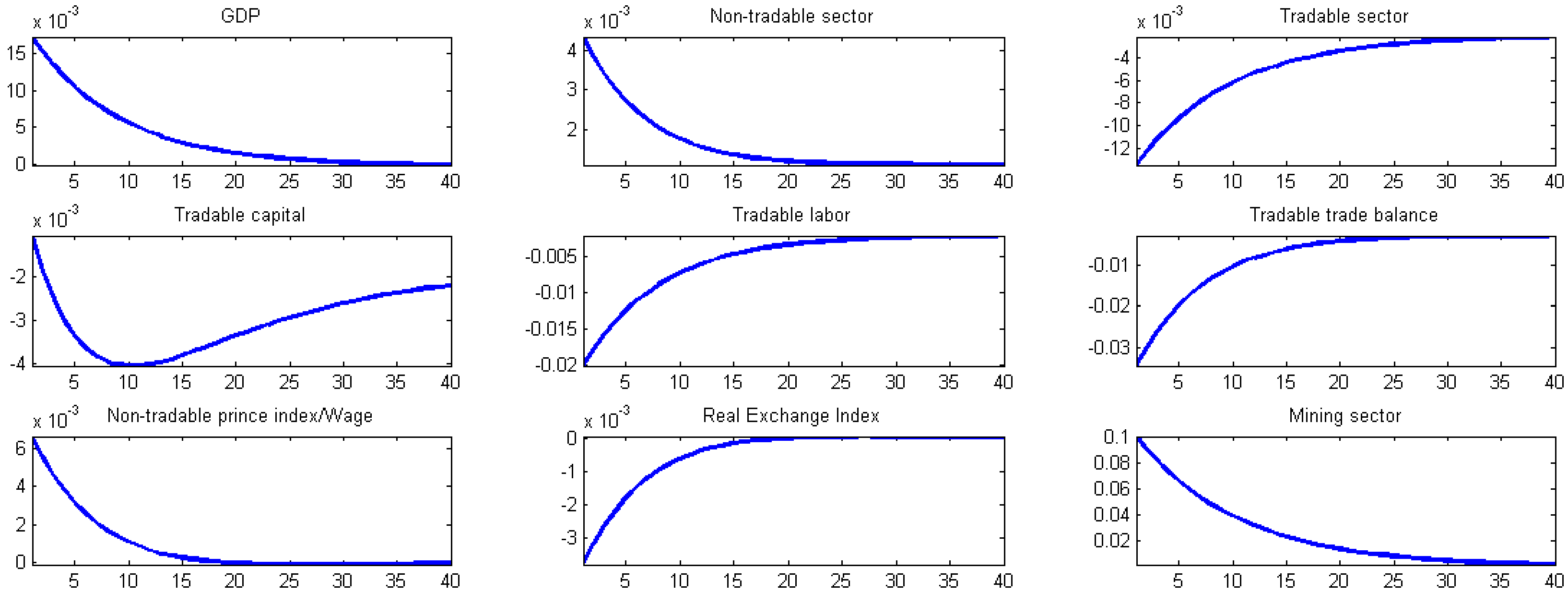


Figure 4: IRFs when international prices of minerals increase 10% in the baseline model (without fiscal expenditures).

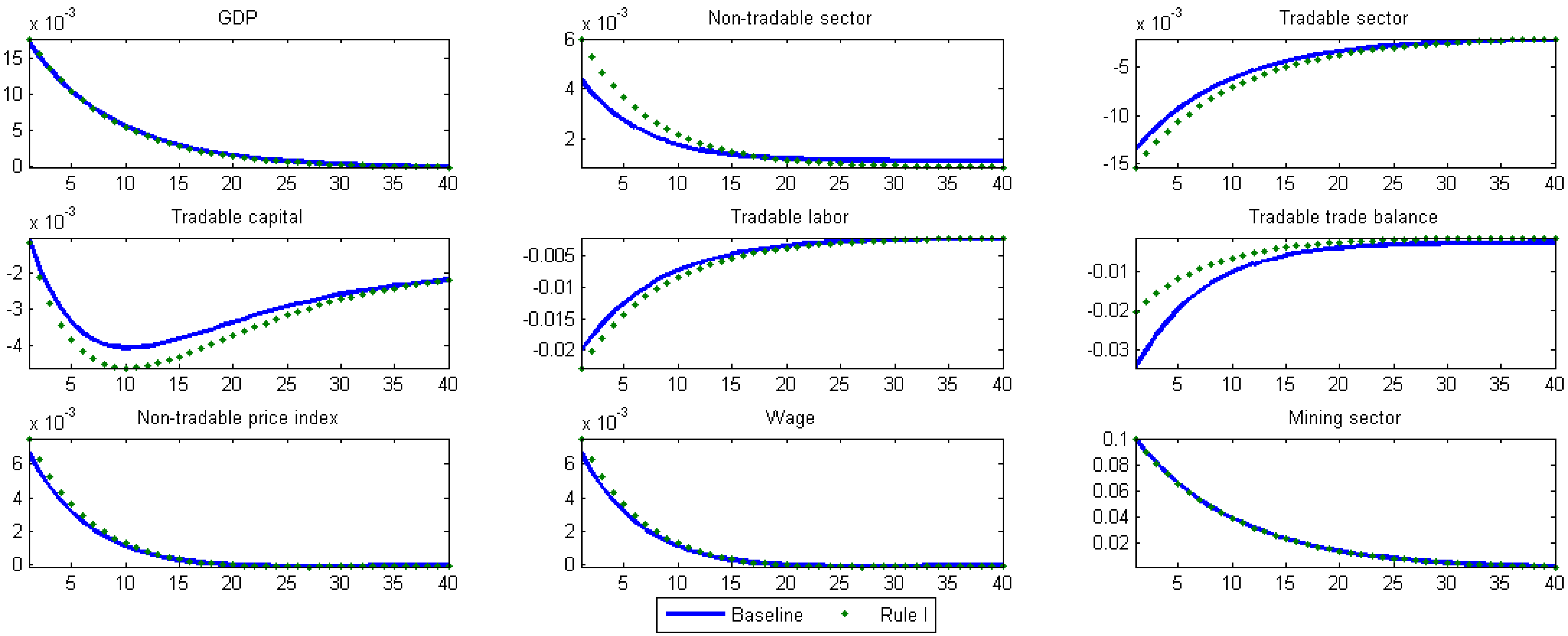


Figure 5: IRFs when international prices of minerals increase 10% in the model in which Rule I has been implemented. Solid line is associated with the baseline model and the dotted line is associated with fiscal purchases.

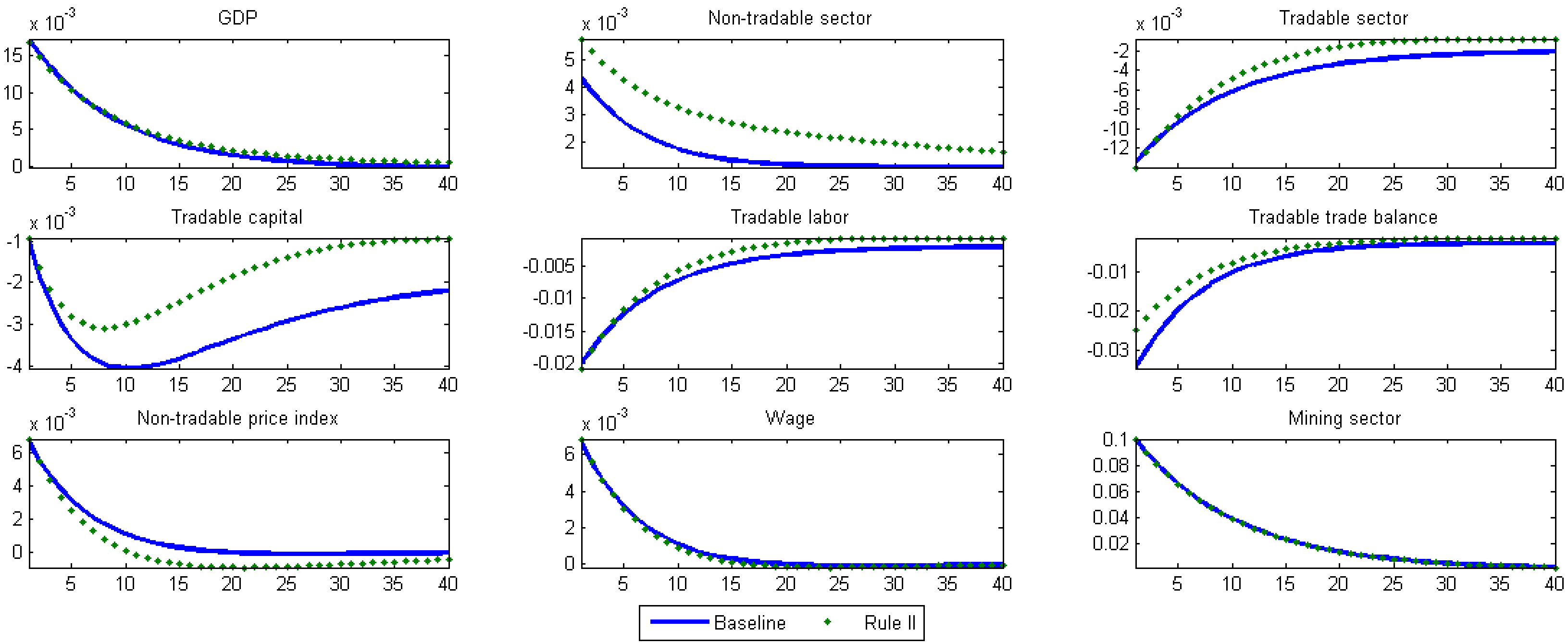


Figure 6: IRFs when international prices of minerals increase 10% in the model in which Rule II has been implemented. Solid line is associated with the baseline model and the dotted line is associated with positive externality in the non-tradeable sector.

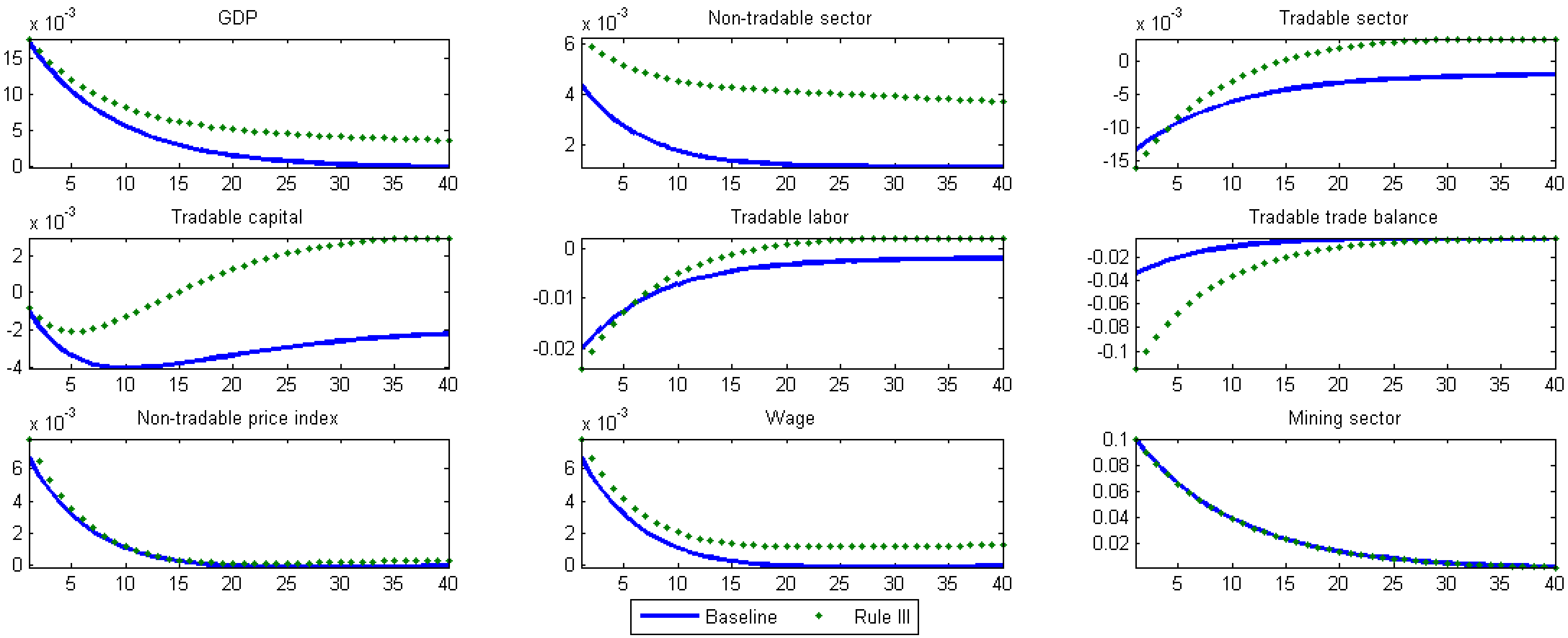


Figure 7: IRFs when international prices of minerals increase 10% in the model in which Rule III has been implemented. Solid line is associated with the baseline model and the dotted line is associated with positive externality in all sectors.