Revisiting the Commodity Resource Curse: a financial perspective

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1 Introduction

The commodity cycle starting at the turn of this century has reversed in the last couple of years. The boom phase in commodity prices has boosted growth and economic performance in resource rich economies, but the reversal has severely impacted their growth rates and macroeconomic stability, particularly in emerging markets.

Commodity prices are characterized by longer cycles (of around thirty years or supercycles, see -Erten and Ocampo (2013)- than overall business cycles. Since 1960, see Figure 1, two supercycles can be identified in the energy and food sectors: one from the mid-seventies to the end of the nineties and the current supercycle which peaked around 2010.[1]. The

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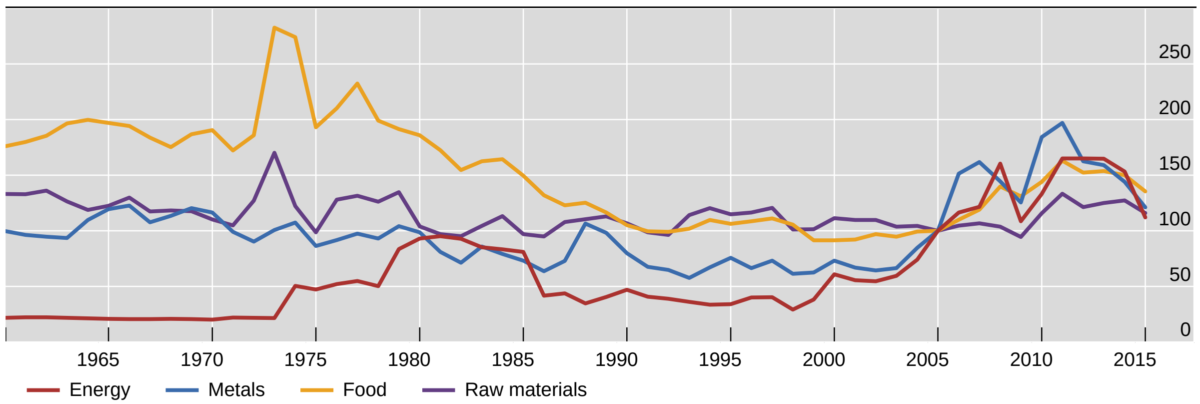
[1] In the group of metals and industrial raw materials there is evidence of just one supercycle, the second one.

length of the commodity price cycles suggests than shocks in this sector are persistent but they might eventually reverse.

World commodity prices[1]

2005= 100



[1] In real terms. Trade-weighted average of U.S. prices of the commodities in the group deflated by the advanced economy manufacturing price index. Normalisation to 100 in 2005. 2015 is average of first half of the year.

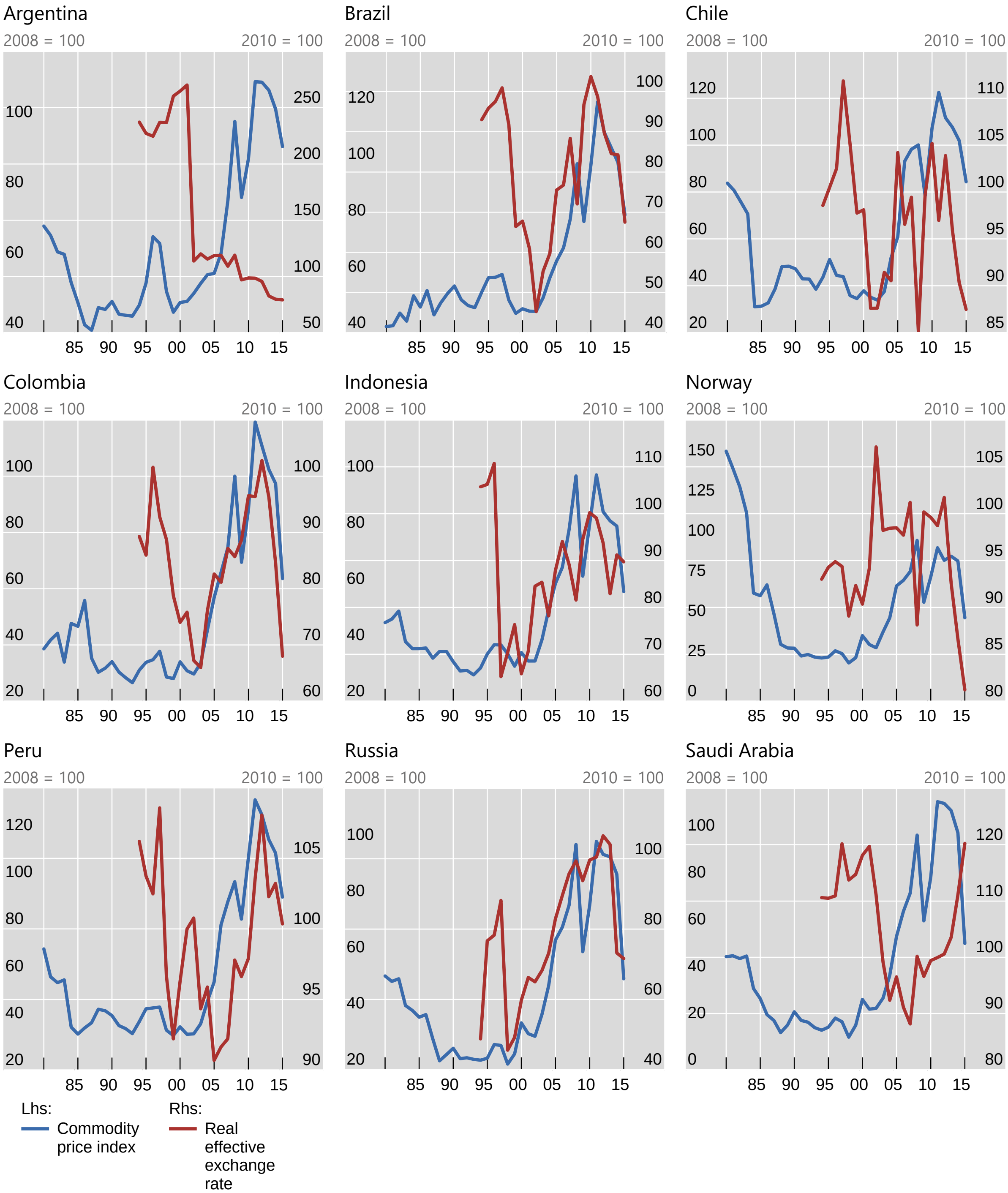
Source: IMF, "Adjusting to lower commodity prices", *WEO*, October 2015.

Figure 1:

In this paper we are interested in re-examining the link between commodity boom and resource allocation by emphasizing the international financial dimension of this interaction. Our focus is in understanding how the access to international financial markets shapes the allocation of resources within an economy subject to commodity price cycles.

Indeed, the impact of commodity booms on resource rich economies has a long tradition in economic analysis. More precisely, the commodity resource curse or Dutch disease underscores the perverse impact that a positive commodity shock in the economy through resource reallocation (see Corden and Neary, 1982). An increase in commodity prices represents a positive terms of trade shock that pushes up domestic relative prices and income.

Real effective exchange rate and commodity price indices[1]



[1] Real effective exchange rate broad indices at end of year.

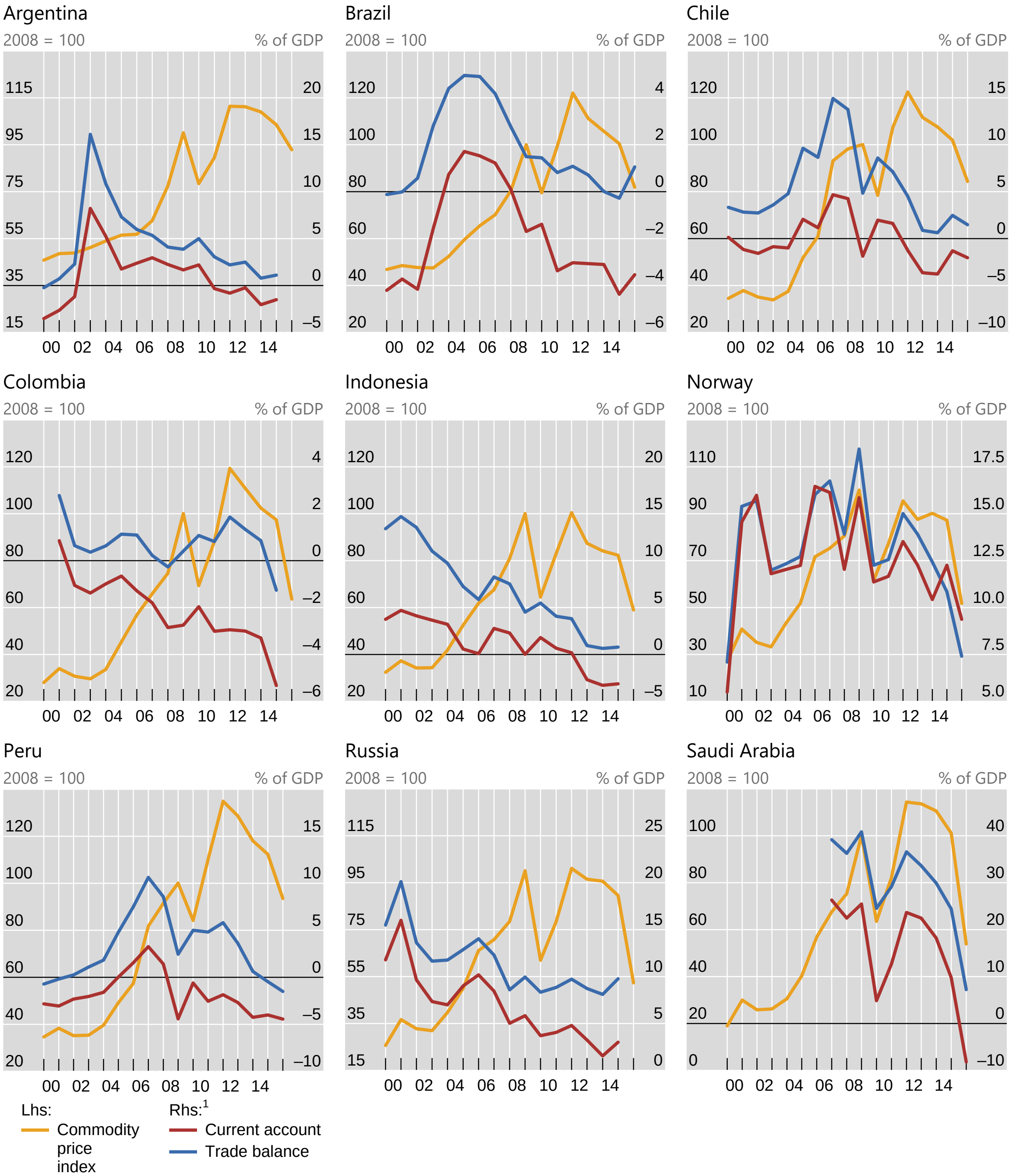
Sources: FAO; IMF, *Primary Commodity Prices*; UN Comtrade database; World Bank; Bloomberg; Datastream; national data; BIS; BIS calculations.

Figure 2:

Figure 2 displays the close correlation, in most cases, between commodity prices and the real exchange rate for a group of commodity exporters, in particular during the last supercycle. The increase in internal relative prices negatively affects the rest of the tradable sector and increases domestic demand, both of tradable and non-tradable goods. As a result, there is a reallocation of factors out of the tradable sector and into the commodity and the non-tradable sector.

Here we want to emphasize few more facts that characterize commodity rich economies. Figure 3 reports the evolution of the current account, the trade balance and the commodity price index for a selected group of commodity exporting countries during the last supercycle.

Current account and trade balance and commodity price index



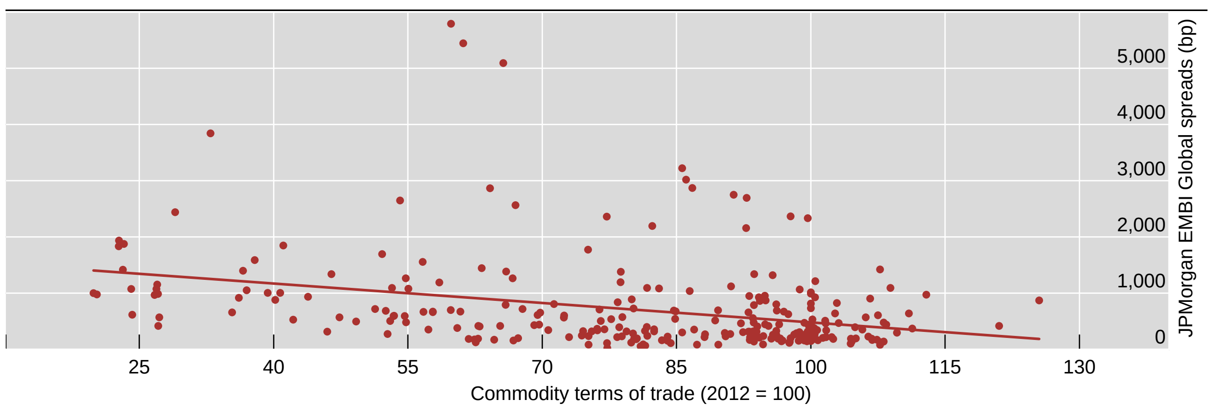
[1] End of year cumulative sum of current account and trade balance as shares of end of year cumulative GDP.

Sources: FAO; IMF, *Balance of Payments Statistics* and *Primary Commodity Prices*; UN Comtrade database; World Bank; Bloomberg; Datastream; national data; BIS calculations.

Figure 3:

In an open economy, the exports of traded is expected to decline and a higher overall domestic demand of traded can be satisfied by higher imports. The trade and current account balances impact is, in principle, undefined as the worsening of the tradable balance could be more than offset by the expected large improvement in the commodity balance. The usual profile of the external balances –see figure 3- is an inverted U-shaped: an initial increase followed by a deterioration of the trade and current account balances, as the increased domestic demand and the reduction in tradable exports dents the initial boost coming from commodity exports. In terms of the financial account this means that, on impact, the country improves its net debtor position and experiments capital outflows. Furthermore if the initial debtor position is in foreign currency, the increase in domestic relative prices would reduce external debt. These two factors would facilitate financing and, as a matter of fact, a negative correlation between terms of trade and risk premia exists, as figure 4 shows.

Sovereign bond yield spreads and the commodity terms of trade[1]



[1] Data are for commodity-exporting emerging market and developing economies for which JPMorgan EMBI Global spreads are available.

Source: IMF, "Adjusting to lower commodity prices", *WEO*, October 2015.

Figure 4

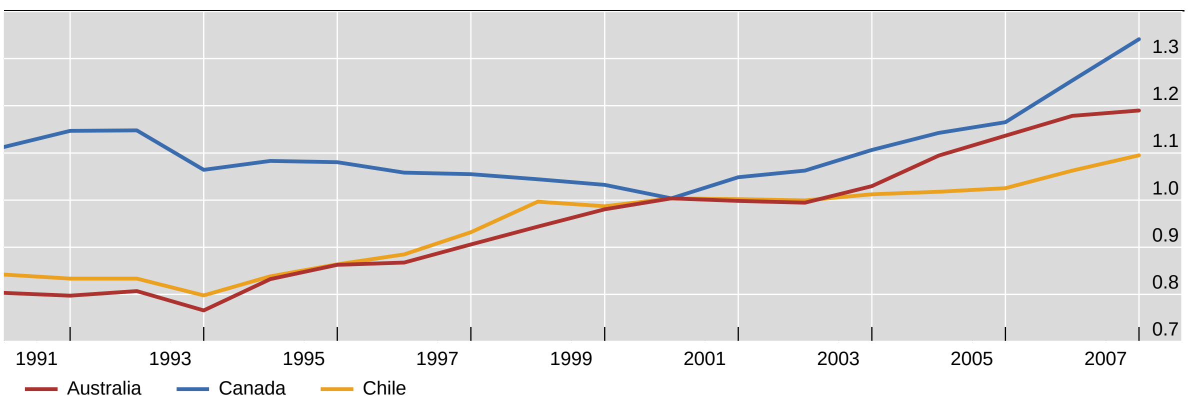
Also, the relaxing of the financing constraint facilitates the turnaround of the current account to the point that commodity booms can lead to external imbalances even before its peak.

The deeper meaning of the disease from the commodity booms is that they can also inhibit long term growth. A large share of the tradable goods are manufactures, which tend to enjoy higher productivity growth, as they are more prone to convey technological progress than other sectors. As a result, a commodity price boom may reduces the ability to grasp the productivity gains from technology and depresses long-term growth.

The evidence on Dutch disease is mixed (see IMF (2015), box 2.1 for a survey), both on the sectoral reallocation and on long-term growth inhibition.[2] More recent evidence, using more disaggregated data (Ismail (2010) tends to find more support for the reallocation hypothesis.

Ratio of non-tradables output to manufacturing output, relative to that of commodity importers[1]

2000 = 1



[1] Shows the evolution in commodity exporters of the ratios of output, capital, and labour in non-tradables to those in manufacturing, scaled by the average ratio across a sample of commodity importers in the same year. An increase in the trend of a ratio beginning in 2000 relative to the pre-2000 trend indicates that the reallocation from manufacturing to non-tradables in commodity exporters intensified relative to that in importers during the commodity boom.

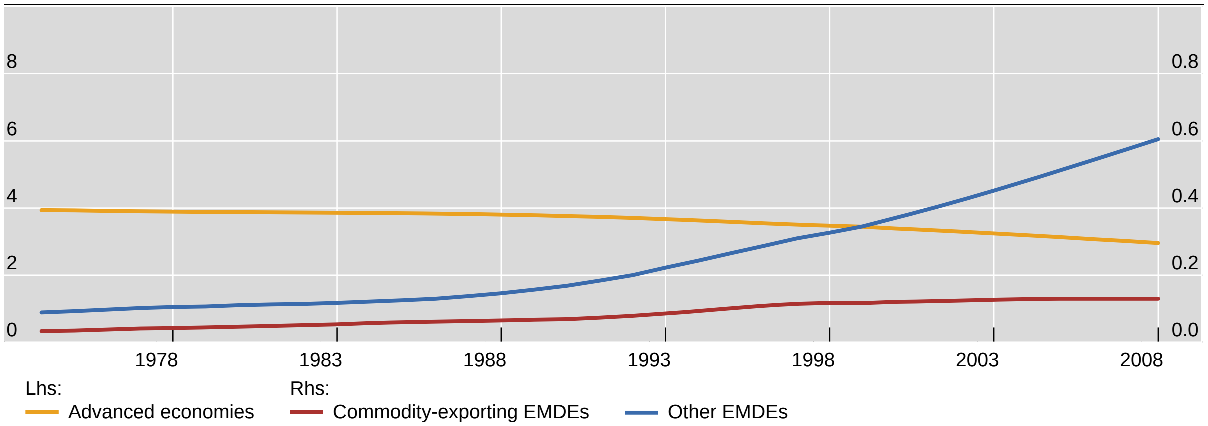
Source: IMF, “Adjusting to lower commodity prices”, *WEO*, October 2015.

Figure 5

[2] Older studies (Spatafora and Warner (1995), Bjorland (1988) find no evidence of a reduction in manufacturing following the commodity boom, and the latter actually finds that that sector benefited in Norway from oil discoveries and high prices.

Average market share in global manufacturing exports[1]

In per cent



[1] Five-year moving average.

Source: IMF, "Adjusting to lower commodity prices", *WEO*, October 2015.

Figure 6

While in Figure 5, commodity exporters display an increasing trend in the ratio of non-traded to manufacturing relative to commodity importers, the commodity boom at the turn of the century has not exacerbated the trend, except for Canada. An indirect gauge, suggested by IMF (2015) is the share of global manufacture exports from emerging markets resource rich economies, relative to the rest of emerging markets (Figure 6). Regarding long term growth, the evidence is elusive, too (see the survey by Magud and Sosa (2013)).

In theoretical models, this result is attained by introducing positive growth externalities in the manufacturing sector, as in Krugman (1987) or Matsuyama (1992). Benigno and Fornaro (2014) construct a model with this type of characteristics, albeit their curse in their model is related to the financial channel.

In this paper, we develop a model of the commodity curse and explore the financial channels to study the interaction between commodity cycles and access to international financial markets. We take as starting point the three-sector closed economy model of Corden and Neary (1982) and we introduce three main extensions: we allow for open financial account to examine a first financial channel through the capacity to save or borrow from abroad and the role of net foreign asset position; second, we consider the case of debt elastic interest rate to capture fluctuations in the risk premium caused by changes in the net foreign asset position; third, to assess possible long-run consequences on growth, we allow for dynamic productivity gains in the traded sector as in Benigno and Fornaro (2014).

We first focus on the economy in which there are no dynamic productivity gains and study the impact of a temporary commodity price shock. The first result is that, independently of the financial structure) there is a possibility for complete de-industrialization of the traded sector as long as its technology displays constant return to scale. Secondly we show that under financial account openness, wealth effect driven by accumulation of net foreign asset following a commodity price boom leads to permanent shift in resources out of the traded goods sector. Finally, when we introduce dynamic productivity gains into the traded sector, the economy might be subject to a growth trap in which there is no growth and no convergence towards the world technological frontier.

We then studies the welfare implications of commodity price boom in the context of our model economy. In the simplest case in which there are no dynamic productivity gains, a commodity price boom is always welfare improving. On the other hand in the presence of growth externalities, an increase in commodity prices can be welfare reducing as the economy shifts resources, during the boom, out of the traded sector where the productivity gains are concentrated. Moreover we show that a commodity boom under open financial account can be more costly from a welfare point of view relative to the financial autarky case. Since agents do not internalize the effects of the growth externalities, the wealth effect coming from higher commodity prices, induce them to borrow to consume more, an effect that further shift resources out of the traded good sector.

Related literature: The Dutch Disease literature started developing after the discovery of vast sources of natural gas in the Netherlands in the 1960s, and it refers to the implications of natural resource discoveries and their price increase on economic performances. Income originated by ownership of a natural resource tends to generate adverse effects on the economy through exchange rate appreciation, factor reallocation and de-industrialization. In particular, increased export of the commodity induces an appreciation of the domestic currency. As a consequence, the internationally traded sectors of the economy find it more difficult to compete in the international markets and end up being impaired by this so that resources are relocated out of the traded sector (Corden and Neary [8]).

However, absent some form of frictions, this relocation of resources would be entirely efficient and the Dutch disease wouldn't really constitute a "disease". The idea that the manufacturing sector is the driving force of the economy and that de-industrialization leads to an impoverishment of the country is supported by empirical findings that resource-rich economies tend to show lower growth rates than economies endowed with few natural resources. Theoretically, this is built into models through the introduction of a spillover, a learning-by-doing effect, increasing returns to scale or other forms of positive externalities in the tradable sector of the economy.

A pioneering paper by Krugman [17] shows how comparative advantage evolves over time when a learning-by-doing externality is introduced, leading to dynamic economies of scale. In this case, the shift in country's comparative advantage from the manufacturing sector to the production of natural resources will entail a problem when eventually, the natural resource will run out and the lost manufacturing sector will not come back. In Krugman (1987) there is no explicit consideration given to the oil sector, but the increased inflow of foreign currency that follows natural resource discoveries is approximated with a direct transfer payment from the foreign to the home country. Results show that if the transfer is in place for long enough, or is quantitatively large enough, firms that relocated abroad while the transfer is in place will not move back in the home country after the transfer is removed. The home country market share and relative wages will permanently be impaired by this.

Magud and Sosa [19] provide a thorough review of the Dutch Disease literature and point out that even though a foreign exchange inflow reduces manufacturing output and net exports, there are no indications in the literature that this will eventually lead to a lower growth rate. They discuss the link between the Dutch Disease and theories on the impact of exchange rate misalignment on growth. They remark that the negative effects of the Dutch Disease on economic performance only follows from assuming that the manufacturing sector has some special characteristics. If this is not the case, the exchange rate appreciation that follows the discovery of natural resources would not be an overvaluation, but just an equilibrium phenomenon. This implies that the negative impact that an exchange rate overvaluation has on growth would not be a factor reducing economic growth either.

Other related papers study the business cycle and policy implications of commodity price fluctuations.

García-Cicco and Kawamura [12] evaluate alternative policy measures to counteract the Dutch Disease effects that arise following a change in oil prices. The policies assessed, in particular, are: rules for government expenditures, capital controls and taxes on domestic lending. They develop a Small Open Economy model where they include financial frictions, a learning by doing externality and a fraction of non-Ricardian (credit constraint) consumers. The model has four sectors: non-tradable goods, importable and exportable goods and a commodity. The relevant assumptions for the result of the Dutch Disease of actually being a "disease" are the externality in exportable goods production and the presence of an external finance premium. They find that from a welfare evaluation point of view, the inefficiencies related to the Dutch Disease are not central in establishing which policy is preferable.

The model used by Hevia, Nicolini, et al. [14] is a Small Open Economy model for commodity exporters with price and wage rigidities. Optimal monetary and exchange rate policies in reaction to an oil shock are considered. They show that there is room for welfare improvement with respect to a full price stability policy, if there is a high degree of nominal wage rigidity. The paper builds on previous findings in Hevia and Nicolini [13] where no wage rigidities was included and results pointed in the opposite direction. If the government has access to state contingent taxes, the optimal monetary policy implies complete price stability. The externality in the manufacturing sector can be dealt with using a subsidy. If taxes are not state and time contingent, a second best policy does not depart sizably from price stability.

Medina and Soto [20] use a very similar model in which a domestically produced commodity is entirely exported, both prices and wages are sticky, but a portion of consumers are non-Ricardian. They use this model to investigate the relevance of credibility and transparency of monetary and fiscal policy in insulating the economy from the negative effects of oil price fluctuations. Their findings show that the impact of commodity shocks is magnified by the lack of transparency and credibility.

Bergholt (2015) uses a rich model applied to the Norwegian economy to study the conduct of optimal monetary policy for an oil exporting economy in which the oil sector affects the rest of the economy through the supply chain channel. This channel is modeled by considering the case in which producing oil requires intermediate home goods produced in the manufacturing and the service sector. He finds that this supply chain channel does not alter the standard monetary policy prescriptions.

2 Model

We first start from a model that borrows from the original paper by Corden and Neary (1982). The framework that we adopt is one of a three sectors small open economy that produces two goods (that we interpret as commodity and a consumption good) which are traded at exogenously given world prices and a third non-traded goods the price of which equalize domestic demand and supply. This structure is similar to the early paper by Corden and Neary (1982). There are few difference with respect to that paper: on the external side we are going to study an economy in which there are trade imbalances (the current account is different from zero). Secondly, we are allowing for dynamic productive externalities in the tradeable good sector as in Krugman The characterization of the commodity good is such that the goods is produced using labor as variable input, serve as inputs in the other production processes but it is not directly consumed.

We consider a perfect foresight infinite-horizon small open economy. Time is discrete and indexed by t. The economy is populated by a continuum of mass 1 of identical households and by a large number of firms operating in three sectors.

Households

The representative household derives utility from consumption and supplies inelastically L units of labor each period. The household's lifetime utility is given by

$$\sum_{t=0}^{\infty} \beta^t U\left(C_t\right). \tag{1}$$

In this expression, $\beta < 1$ is the subjective discount factor and C_t denotes the consumption of a composite good. C_t is defined as a CES aggregator of tradable C_t^T and non-tradable C_t^N consumption goods. We assume that the period utility function is isoelastic:

$$u\left(C_t^j\right) \equiv \frac{1}{1-\rho}\left(C_t^j\right)^{1-\rho}.$$

The consumption basket, C_t, is a CES aggregate of tradable and nontradable goods

$$C_t \equiv \left[\omega^{\frac{1}{\kappa}}\left(C_t^T\right)^{\frac{\kappa-1}{\kappa}} + (1-\omega)^{\frac{1}{\kappa}}\left(C_t^N\right)^{\frac{\kappa-1}{\kappa}}\right]^{\frac{\kappa}{\kappa-1}}. \tag{2}$$

where $0 < \omega < 1$ denotes the share of expenditure in consumption that the household assigns to the tradable good and κ is the elasticity of intratemporal substitution between traded and nontraded goods.[3]

[3] The assumption of a Cobb-Douglas aggregator of tradable and non-tradable consumption goods ensures

The budget constraint of the household is

$$C_t^T + P_t^N C_t^N + \frac{B_{t+1}}{R_t} = W_t L + B_t + \Pi_t^O + \Pi_t^N + \Pi_t^T. \tag{3}$$

The budget constraint is expressed in units of the tradable good, whose price is constant and normalized to 1. The left-hand side represents the household's expenditure. We define P_t^N as the relative price of the non-tradable good in terms of the tradable good, so $C_t^T + P_t^N C_t^N$ is the household's consumption expenditure expressed in units of the tradable good. B_{t+1} is the stock of one-period risk-free bonds purchased by the household at price $1/R_t$. R_t is the gross world interest rate, which is exogenous from the perspective of the small open economy.

The right-hand side represents the income of the household. Throughout the paper, we focus on equilibria in which firms in both sectors produce.[4] This means that firms in both sectors pay the same wage W_t, and so $W_t L$ is the labor income received by the household. B_t is the gross return on the stock of bonds purchased by the household at time $t-1$. Finally, domestic firms in all sectors are wholly owned by domestic households and Π_t^j (with $j = O, N, T$) denotes the profits received from firms by the representative household.

Each period the representative household chooses C_t^T, C_t^N and B_{t+1} to maximize utility (1) subject to the budget constraint (3). The first order conditions of this problem are:

$$C_T : u'(C_t) C_{C^T} = \mu_t, \tag{4}$$

$$C_N : u'(C_t) C_{C^N} = \mu_t P_t^N, \tag{5}$$

$$B_{t+1} : \mu_t = \beta R_t E_t \left[\mu_{t+1} \right]. \tag{6}$$

where μ_t denotes the Lagrange multiplier associated with the budget constraint, i.e. the household's marginal utility of wealth. By combining the optimality conditions (4) and (5),

the existence of a balanced growth path. See footnote **??** for further discussion.

[4] This is always the case in the numerical simulations presented below.

we obtain the standard intratemporal equilibrium condition that links the relative price of non-tradable goods to the marginal rate of substitution between tradable and non-tradable goods:

$$\frac{(1-\omega)^{\frac{1}{\kappa}}\left(C_t^N\right)^{-\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}}\left(C_t^T\right)^{-\frac{1}{\kappa}}} = P_t^N. \tag{7}$$

According to this expression, P_t^N is increasing in C_t^T and decreasing in C_t^N. In what follows we will use P_t^N as a proxy for the real exchange rate.

The last first order condition (6) is the standard Euler equation which determines the intertemporal allocation of tradable consumption between a generic period t and the subsequent period $t+1$.

Firms

Firms operate in three sectors: one sector produces the tradable good, one produces the commodity good (oil) and the other one produces the non-tradable good. This structure resembles Croden and Neary (1982) and Hamann et al. (2015) in which the commodity goods is used as an input in the production process of the traded and non-traded goods.

Tradable sector. In the tradable sector there is a large number of firms that produce using labor L_t^T and the stock of knowledge A_t, according to the production function

$$Y_t^T = A_t^T\left(L_t^T\right)^{\alpha^T}(M^{O,T})^{1-\alpha^T}, \tag{8}$$

where Y_t^T is the amount of tradable goods produced in period t, L_t^T is the amount of labor used, and $M^{O,T}$ is the amount of the commodity goods used in the production of the traded good.

Knowledge is non-rival and non-excludable and so it can be freely used by firms producing tradable goods. Hence,profits can then be written as

$$\Pi_t^T = Y_t^T - W_t L_t^T - P_t^O M_t^{O,T},$$

where W_t denotes the wage rate in units of tradeable goods, P_t^N is the relative price of non-tradeable and P_t^O is the relative price of the commodity good. Profit maximization implies that

$$\alpha^T \frac{Y^T}{L^T} = W \tag{9}$$

$$(1-\alpha^T)\frac{Y^T}{M^{O,T}} = P_t^O \tag{10}$$

These expressions say that at the optimum firms equalize the marginal profit from an increase its variable input, the left-hand side of the expression, to its marginal cost, the right-hand side.

Under perfect competition we have that

$$1 = \frac{(W_t)^{\alpha^T}\left(P_t^O\right)^{1-\alpha^T}}{A_t^T\left(\alpha^T\right)^{\alpha^T}\left(1-\alpha^T\right)^{1-\alpha^T}},$$

that defines the real marginal cost for the traded sector. We note that the real marginal cost is a

Knowledge accumulation. One of the key feature of our small open economy is the endogenous process of knowledge accumulation. In particular, the stock of knowledge available to firms in the tradable sector evolves according to

$$A_{t+1}^T = A_t^T\left(1 + cL_t^T\left(1 - \frac{A_t^T}{A_t^*}\right)\right), \tag{11}$$

where $c > 0$ is a parameter determining the impact of the sectoral labor allocation on productivity growth, and A_t^* denotes the stock of knowledge of the world technological leader, which grows at the constant rate g^*.[5]

The stock of knowledge in a generic period t depends not only on the past knowledge, but also on the amount of labor employed in the tradable sector. This formulation captures the idea that human capital contributes to the absorption of foreign knowledge, as in Nelson and Phelps [21] and Benhabib and Spiegel [1]. Moreover, in our model the tradable sector is the source of convergence in productivity, in the spirit of the empirical findings of Duarte and Restuccia [9] and Rodrik [23].

Let us start by considering the implications for the steady state. In steady state both A and A^* grow at the common rate g^*. Denoting by $a_t = A_t/A_t^*$ the proximity of the country to the world technological frontier we have that in steady state

$$\bar{a} = 1 - \frac{g^*}{c\bar{L}^T},$$

where an upper bar denotes the steady state value of the corresponding variable. This equation implies that in steady state the proximity of the economy to the world technological frontier is increasing in the stock of workers employed in the tradable sector.[6]

Moreover, the allocation of labor across the three sectors also influences the transition toward the steady state. In particular, in the numerical simulations we will consider the case of a country that starts below its steady-state proximity to the frontier, i.e. $a_0 < \bar{a}$. In this case, during the transition to the steady state the stock of knowledge of the economy grows at a rate higher than the one of the world technological frontier. As we will show, a higher amount of labor employed in the tradable sector implies faster convergence toward the steady state.

As mentioned above, we assume that knowledge is a non-rival and non-excludable good.

[5] The assumption of an exogenous world technological frontier means that the economy under consideration is too small to have an impact on the evolution of the world's stock of knowledge.

[6] This equation also tells us that in order to have a positive productivity in steady state c has to satisfy the condition $c > g^*/\bar{L}^T$. We limit the analysis to values of c such that this condition holds.

This assumption, combined with the presence of a large number of firms in the tradable sector, implies that firms do not internalize the impact of their actions on the evolution of the economy's stock of knowledge. This is a typical growth externality: firms do not internalize the social value of allocating labor to the tradable sector, because they don't consider the impact of their actions on the growth rate of aggregate productivity.

Non-tradable sector. There is a representative firm producing a homogeneous non-traded good in a perfectly competitive environment. The firm chooses two inputs, labor and oil , according to the production function

$$Y_t^N = A_t^N \left(L_t^N\right)^{\alpha^N} \left(M^{O,N}\right)^{1-\alpha^N}. \tag{12}$$

Y_t^N denotes the output of the non-tradable good, A_t^N is total factor productivity specific to the non-traded sector, L_t^N is the amount of labor employed by firms in the non-tradable sector and $M^{O,N}$ is the amount of commodity used in the production of the non-traded good. Profits[7] in the non-tradable sector are

$$\Pi_t^N = P_t^N Y_t^N - W_t L_t^N - P_t^O M_t^{O,N}.$$

Profit maximization implies that

$$\alpha^N \frac{P_t^N Y^N}{L^N} = W \tag{13}$$

$$(1-\alpha^N)\frac{P_t^N Y^N}{M^{O,N}} = P_t^O \tag{14}$$

Under perfect competition we have that

$$P_t^N = \frac{\left(W_t\right)^{\alpha^N} \left(P_t^O\right)^{1-\alpha^N}}{A_t^N \left(\alpha^N\right)^{\alpha^N} \left(1-\alpha^N\right)^{1-\alpha^N}}$$

[7]With constant return to scale and perfect competition, profits are zero in equilibrium.

Combining the optimality conditions of the firms in the two sectors (9) and (13) we obtain a link between the relative price of non-traded goods and the marginal product of inputs.

$$P_t^N = \frac{\alpha^T Y^T}{L^T}\frac{L^N}{\alpha^N Y^N} = \frac{(1-\alpha^T)Y^T}{M^{O,T}}\frac{M^{O,N}}{(1-\alpha^N)Y^N}$$

This equation highlights the fact that in the model productivity advances in the tradable sector correspond to real exchange rate appreciations. This is the classic Balassa-Samuelson effect. In fact, the real exchange rate is just a function of relative productivities, and it does not depend directly on the intratemporal allocation of consumption.[8] This is important because in our model the inefficient allocation of resources does not translate into a misaligned real exchange rate.[9]

Commodity Sector The commodity sector produces under a decreasing return to scale technology using just labor as a variable input according to the following production function:

$$Y_t^O = A_t^O \left(L_t^O\right)^{\alpha^O} \tag{15}$$

Y_t^O denotes the output of the commodity good, A_t^O is total factor productivity specific to the commodity sector and L_t^O denotes the amount of labor employed by firms in the commodity sector In this setting the price of the commodity good is taken as given and firms maximizes profits defined as:

$$\Pi_t^O = P_t^O Y_t^O - W_t L_t^O.$$

Profit maximization implies

$$\alpha^O \frac{P_t^O Y^O}{L^O} = W. \tag{16}$$

[8]See Jeanne [16] for a discussion of capital account policies in a model in which the real exchange rate is determined by the sectoral allocation of consumption.

[9]Of course, the literature has not yet converged on a clear definition of exchange rate misalignment. Here we refer to a misalignment of the real exchange rate as a deviation of the real exchange rate from the trend implied by the Balassa-Samuelson effect, as done for example by Rodrik [22] in its empirical analysis.

From this expression we note that an increase in the price of the commodity good leads to an increase in the demand of the labor for a given wage. We will refer to this effect as the resource movement effect (as in Corden and Neary) as mobile resources (in this case labor) are directed toward the commodity sector.

Market clearing and competitive equilibrium

Market clearing for the non-tradable good requires that the amount consumed is equal to the amount produced:

$$C_t^N = Y_t^N. \tag{17}$$

Combining equation (17), with the households' budget constraint (3), the equations for firms' profits and the equilibrium condition $\Pi_t = \Pi_t^T + \Pi_t^N + \Pi_t^O$, we obtain the market clearing condition for the tradable good

$$C_t^T + \frac{B_{t+1}}{R_t} = B_t + P_t^O Y_t^O - P_t^O M_t^{O,N} + Y_t^T - P_t^O M_t^{O,T}. \tag{18}$$

$$C_t^T = Y_t^T - \frac{B_{t+1}}{R_t} + B_t + P_t^O \left(Y_t^O - M_t^{O,T} - M_t^{O,N} \right). \tag{19}$$

Here we note that when the commodity good is not used as an input in the production process of traded and non-traded goods, its only possible use is to be exported. On the other hand when it is used as an input in the production process, it might happen that depending on its price, it might be optimal for the country to import the commodity good and not producing it. This equation can be rearranged to derive the current account. In fact, the end-of-period net foreign asset position of the country is equal to the end-of-period holdings of bonds of the representative household divided by the world interest rate[10]

$$NFA_t = \frac{B_{t+1}}{R_t}.$$

[10] We follow the convention of netting interest payments out of the net foreign asset position.

The market clearing condition for the tradable good can then be rearranged to obtain the law of motion for the stock of net foreign assets, that is the current account

$$NFA_t - NFA_{t-1} = CA_t = Y_t^T - C_t^T + B_t\left(1 - \frac{1}{R_{t-1}}\right) + P_t^O\left(Y_t^O - M_t^{O,T} - M_t^{O,N}\right),$$

The current account is given by net exports, $Y_t^T - C_t^T$, plus net interest payments on the stock of net foreign assets owned by the country at the start of the period, $B_t(1 - 1/R_{t-1})$.

Finally, in equilibrium labor supply by households must equal labor demand from firms

$$L = L_t^T + L_t^N + L^O. \tag{20}$$

2.1 Dynamic equilibrium conditions and balanced growth path

The equilibrium conditions that define the dynamic equilibrium of the model for the case of financial account openness are given by the following set of equations: (note that the price of commodity is exogenous to the small open economy).

From the household optimization problem we obtain the Euler equation and the intratemporal allocation of consumption between traded and non-traded goods.

$$u'(C_t)C_{C^T} = \beta R_t u'(C_{t+1})C_{C^T},$$

$$P_t^N = \frac{(1-\omega)^{\frac{1}{\kappa}}\left(C_t^N\right)^{-\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}}\left(C_t^T\right)^{-\frac{1}{\kappa}}}.$$

From tradeable firms:

$$\alpha^T\frac{Y^T}{L^T} = W$$

$$(1-\alpha^T)\frac{Y^T}{M^{O,T}} = P_t^O$$

From non-tradeable firms:

$$\alpha^N \frac{P_t^N Y^N}{L^N} = W$$

$$(1-\alpha^N)\frac{P_t^N Y^N}{M^{O,N}} = P_t^O$$

From commodity sector:

$$\alpha^O \frac{P_t^O Y^O}{L^O} = W$$

Market clearing conditions

$$C_t^N = Y_t^N.$$

$$C_t^T = Y_t^T - \frac{B_{t+1}}{R_t} + B_t + P_t^O \left(Y_t^O - M_t^{O,T} - M_t^{O,N} \right)$$

$$L = L_t^T + L_t^N + L^O.$$

Technology evolution

$$A_{t+1}^T = A_t^T \left(1 + cL_t^T \left(1 - \frac{A_t^T}{A_t^*} \right) \right),$$

and the three technology constraints (the production functions)

We are now ready to define a perfect-foresight equilibrium as a set of processes C_t^T, C_t^N, P_t^N, B_{t+1}, Y_t^T, L_t^T, $M^{N,T}$, $M^{O,T}$, Y_t^N, L_t^N, $M^{T,N}$, $M^{O,N}$, Y_t^O, L_t^O, $M^{T,O}$, $M^{N,O}$, W, A_{t+1} satisfying (**??**) and (4)-(20), given the exogenous processes $\left\{R_t, A_t^*, P_t^O\right\}_{t=0}^{\infty}$ and initial conditions B_0 and A_0^T, A_0^N, A_0^O.

The equilibrium under financial autarky replaces the current account equation with the balanced trade condition in which

$$C_t^T = Y_t^T + P_t^O \left(Y_t^O - M_t^{O,T} - M_t^{O,N} \right)$$

We also consider the case in which the interest rate on foreign debt is debt-elastic:

$$R_t = R^* + \psi(e^{-\frac{B_t}{A_t^* P_t^T}}) \text{ for } B_{t+1} < 0$$

$$R_t = R^* \text{ otherwise}$$

Balanced Growth Path We now determine the conditions that define the balanced growth path of our economy. We assume that the balanced growth path, where all variables grow at a constant rate g, exists. In the balanced growth path we have that

$$P_t = P, \; P_t^N = P^N$$

$$R_t = R$$

$$L_t^T = L^T, L_t^N = L^N, L_t^O = L^O$$

From (6), assuming isoelastic utility function with constant elasticity of intertemporal substitution we obtain

$$g_C = (\beta R)^{\frac{1}{\rho}} = g,$$

where g_C denotes the growth rate of aggregate consumption. From (8) we get the growth rate of traded output as

$$g_{Y^T} = g_{M^{O,T}} = (g_{A^T})^{\frac{\alpha^T}{1-\alpha^{O,T}}} = g,$$

where $g_{M^{O,T}}$ and g_{A^T} denote, respectively, the growth rate of the commodity input and technological progress in the traded sector. From (12), we obtain the growth rate of non-traded output as

$$g_{Y^N} = g_{M^{O,N}} = (g_{A^N})^{\frac{\alpha^N}{1-\alpha^{O,N}}} = g,$$

where $g_{M^{O,N}}$ and g_{A^N} denote, respectively, the growth rate of the commodity input and technological progress in the non-traded sector. From (15) we obtain the growth rate of the commodity sector as a function of its own technological progress, g_{A^O} :

$$g_{Y^O} = g_{A^O} = g.$$

We note here that under a balanced growth path we need to impose constant return to scale.

From any wage equation

$$g_W = g, \tag{21}$$

From (**??**)

$$g_B = g, \tag{22}$$

From (**??**)

$$g_{A^*} = g, \tag{23}$$

From (**??**)

$$g_{A^T} = g, \tag{24}$$

3 Revisiting the commodity resource curse

In this section we consider an episode in which commodity prices increase temporarily: in particular we assume that the price of commodity goods increases by 50% for 10 years and then returns to its initial value. This experiment is meant to capture in a simple way long-lasting swings in commodity prices.

Our experiment is different from the exercise conducted in Corden and Neary (1982): they focus on comparative static analysis in which they study a permanent change in oil prices or equivalently permanent shift in the technology in that sector. Motivated by historical evidence on significant swings in commodity prices [see Figure 1], here we examine temporary changes rather than permanent ones. As we shall see, this aspect becomes relevant for understanding the allocation effects of commodity price booms since temporary changes in prices lead to current account adjustments that have long-run effects on the economy.

In what follows, before presenting our results, we briefly describe our parametrization strategy and then discuss different simple cases.

3.1 Parameters

Table 1: Parameters

Parameter	Symbol	Value
Growth rate of the technological frontier	g^*	0.015
World interest rate	R	1.04
Discount factor	β	0.976
Endowment of labor	L	1
Initial NFA	B_0	0
Initial TFP of the technological leader	A_0^*	6.4405
Initial TFP in traded sector	A_0^T	4.1384
Initial TFP in the non-tradable sector	A_0^N	1
Initial TFP in the commodity sector	A_0^O	3
Constant in knowledge accumulation process	c	0.167
Share of tradable goods in consumption	ω	0.414

We study the properties of the model using numerical simulations. We solve the model using a standard shooting algorithm.[11] [12]Our framework is too simple to lend itself to a

[11]More precisely, we make a guess for the path of consumption of the traded good. Using the guess we solve the model and check whether the intertemporal resource constraint of the economy is satisfied. If this is not the case, we update the guess for the consumption of the traded good.

[12]A solution satisfies equation **-** and the transversality condition $\frac{\beta^t B_t}{C_t} \to 0$. For any given C_0, we can solve contemporaneous variables and simulate a sequence of C^t so that the equation systems is satisfied by construction. It remains to find the initial consumption $C_0 = C_0^*$ such that the transversality condition is satisfied.

careful calibration exercise, hence our strategy consists in choosing reasonable values for the parameters in order to illustrate the model's properties, while we leave the study of a more realistic framework for future research.

A period in the model corresponds to one year. We follow Benigno and Fornaro (2014) for the parametrization of the growth process. We set the growth rate of the technological frontier to $g^* = 0.015$, to match the average annual growth rate of TFP in the United States between 1960 and 1995 as computed by Benhabib and Spiegel [1]. In the benchmark parameterization the world interest rate is assumed constant and equal to $R = 1.04$. The discount factor is set to $\beta = 0.976$, so that in steady state consumption of tradable goods grows at the same rate of the world technological frontier. This essentially means that the economy shares the same discount factor as the rest of the world. The endowment of labor is normalized to $L = 1$. We assume that the economy starts with a net foreign asset position such that $\frac{B}{GDP} = 0$ or $\frac{B}{GDP} = -30\%$ depending on the exercise that we run, where GDP stands for gross domestic product and is measured in units of traded goods.

The initial values for the stock of knowledge of the home country and of the world technological leader are chosen following the TFP estimates reported by Benhabib and Spiegel [1]. In particular, we set the initial stock of knowledge of the technological leader to $A_0^* = 6.4405$, which corresponds to TFP in the US in 1995. The initial stock of knowledge for our small open economy is set to $A_0 = 4.1384$, as in Benigno and Fornaro (2014). This calibration

This can be done by a bi-section algorithm. If $C_0 > C_0^*$, $\frac{\beta^t B_t}{C_t} \to -\infty$. As a result, if $\frac{\beta^t B_t}{C_t} \to -\infty$ in a simulation, we find the upperbound of $C_0^u > C_0^*$. If $C_0 < C_0^*$, $\frac{\beta^t B_t}{C_t} \to \infty$. As a result, if $\frac{\beta^t B_t}{C_t} \to \infty$ in a simulation, we find the lowerbound of $C_0^l < C_0^*$. As long as we have the initial two bounds we can simulate from $C_0 = \frac{C_0^u + C_0^l}{2}$ and update the upperbound or lowerbound according to the transversality condition. The gap between upperbound and lowerbound closes by one half in each iteration. The iteration stops either until the gap of the bounds is small enough or until $\frac{\beta^t B_t}{C_t}$ is close enough to 0 for a large periods of simulation.

When a balance growth path (BGP) exists, another terminal condition can be $\frac{B_{t+1}}{B_t} \to \beta R_t$. It is a sufficient condition for the transversality condition to satisfy. This is because, noting the Euler equation $C_{t+1} = \beta R_t C_t$, so $\frac{B_t}{C_t} \to$ constant and $\frac{\beta^t B_t}{C_t} \to 0$.

It turns out the terminal condition $\frac{B_{t+1}}{B_t} \to \beta R_t$ leads to more precise solution of C_0^* for a finite T period simulation. This is because, the finite period approximation of $\frac{\beta^t B_t}{C_t} \to 0$ is equivalent to $B_T = 0$, while $B_T > 0$ is indeed the case. This advantage even carries to the senario when BGP fails to exist.

implies an initial proximity to the frontier equal to $a_0 = 0.6426$. Moreover we set in the technology parameter for the commodity sector to $A_0^O = 3$ but we study the adjustment of the economy under different scenarios for higher TFP in the commodity sector ($A_0^O = 3.5$).

We set c and ω to match two historical statistics for Spain: the evolution of TFP between 1960 and 1995 and the ratio of non-tradable-to-tradable GDP in 1986. We simulate the model using as initial conditions $A_0 = 1.8502$ and $A_0^* = 3.7648$, the estimates of TFP in 1960 respectively in ???? and in the US provided by Benhabib and Spiegel [1]. At this stage, we set the other parameters following Benigno and Fornaro (2014) as a way to illustrate the properties of the model In particular we set $c = 0.167$, the share of tradable goods in consumption is chosen equal to $\omega = 0.414$ so that after 26 years the ratio $P_t^N Y_t^N / Y_t^T$ equals 1.69, compatible with the ratio of non-tradable-to-tradable GDP provided by Hamann et al. (2015) for the Colombian economy.[13]

3.2 Analysis

We now analyze the properties of our economy by presenting first a general result and then by examining different special cases. In the first two cases our aim is to understand how the financial channel operates and to do so we abstract from the endogenous growth component of our model (we set $c = 0$) by studying the impact of a commodity price booms under financial account openness and financial account autarky. Then we examine the case of endogenous growth along with financial account openness to understand the interaction between growth and financial account.

Our first result, though, is independent on the structure of financial markets and the existence of the endogenous growth component and is related to the pattern of specialization determined by changes in the exogenous terms of trade between commodity and traded goods (i.e. P^O). The following proposition states that following commodity price changes it

[13] Their value is equal to 1.76.

is possible for our economy to specialize completely in the production of commodity good.

The following proposition holds

Proposition 1 *Under a constant return to scale production function and perfect competition in the traded sector, then for sufficiently high value of P^O, the economy does not produce traded goods.*

Proof. In the appendix ■

Our result about the pattern of specialization is related to the Ricardian theory of comparative advantage. When the relative price of the commodity goods exceeds its relative costs, then resources tend to move towards the commodity sector. In the absence of non-traded goods, all labor will shift towards the commodity sector and the economy will specialize in the production of the commodity good. In the presence of non-traded goods, part of the labor supply is allocated to the production of non-traded goods that are consumed within the domestic economy, while the rest will be absorbed by the commodity sector. Conversely if the price of the commodity goods drops beyond a critical level our economy will import the commodity goods for production purposes and will specialize in the production of traded goods.

We note here that our result on the pattern of specialization depends on the assumption of constant return to scale technology in the traded good sector only. We do not need constant return to scale in the commodity sector. Moreover if we would assume decreasing return to scale in the traded sector, we would get an interior solution and the economy will always produce both traded and commodity goods.

As we noted above our proposition is independent of the financial market structure: it holds under financial autarky and financial openness. It is also independent on the presence of the endogenous growth component. Similar to the Ricardian economy, supply side factors matter for determining the pattern of specialization. The demand side here will determine the variable labor supply available to the commodity and traded sector: indeed changes in the commodity price will affect the demand of non-traded consumption that will determine the amount of labor allocated to the non-traded good sector and as such the residual amount that will be available to the other two sectors.

3.2.1 The effects of a commodity price boom: the no growth case

We now study the response of our economy when there is no endogenous growth. We focus on two cases: first we study the response of our economy under financial autarky and then under open financial account. To illustrate these cases we simplify our economy by further considering the case in which $\alpha^N = \alpha^T = \alpha^O = 1$ and there is no initial debt level, $B_0 = 0$ with $\beta R = 1$.

Under financial autarky we have that

$$C_t^T = Y_t^T + P_t^O Y_t^O = A^T L_t^T + P_t^O A^O L_t^O$$

with

$$W_t = A^T \text{ as long as } L^T > 0,$$

and

$$P_t^N = \frac{A^T}{A^N} \text{ as long as } L^T > 0.$$

Since the commodity technology exhibits constant return to scale we also have that

$$W_t = P_t^O A_t^O$$

that determines the demand of labor in the commodity sector for a given wage rate. Non traded goods production and consumption will be determined by the intratemporal equilibrium condition, where without loss of generality we have assumed $\omega = 0.5$ and $\kappa = 1$

$$P_t^N = \frac{C_t^T}{C_t^N} = \frac{A^T L_t^T + P_t^O A^O L_t^O}{A^N L^N}$$

and labor market clears

$$1 = L = L_t^T + L_t^N + L_t^O$$

Under the knife-edge case in which $P_t^O = \frac{A^T}{A_t^O}$ all goods are produced (we have an interior solution). When $P_t^O \neq \frac{A^T}{A_t^O}$ then either only traded goods are produced ($P_t^O < \frac{A^T}{A_t^O}$) and the economy is an autarky economy or only commodity goods are produced ($P_t^O > \frac{A^T}{A_t^O}$) and the economy exports commodity goods to finance traded good consumption. [14]

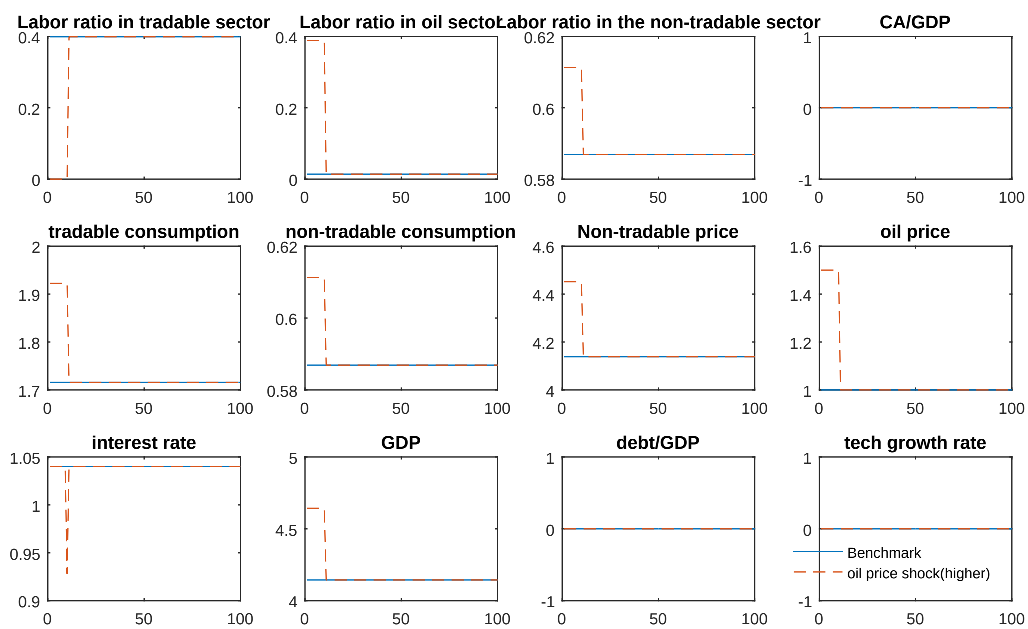


Figure 7: commodity boom under financial autarky

Figure 7 summarizes the adjustment of the economy following an increase in commodity prices for 10 periods under financial autarky in the general model. Similar to the analysis

[14] In the latter case $P_t^N = \frac{C_t^T}{C_t^N} = \frac{P_t^O A^O L_t^O}{A^N(1-L^O)} > \frac{A^T L_t^O}{A^N(1-L^O)}$ and a sufficient condition for the economy to experience an appreciation of the real exchange rate is that $L_t^O > \frac{1}{2}$.

in Corden and Neary (1982), there are two effects. The resource allocation effect and the spending effect. The boom in the commodity sector raises its marginal product of labour, drawing resources out of the other sectors. The spending effect follows from the increase in real income following the commodity price boom and leads to a higher consumption of traded and non-traded goods.

In our economy and under our parametrization, the resource movement effect leads to an increase in the labor share employed in the commodity sector and a full de-industrialization as labor share in the traded sector drops to zero. Because of the spending effect, households consume more of both traded and nontraded goods. Higher non-traded goods consumption is accommodated by a shift of resources towards the non-traded sector while the increase in traded consumption is obtained by importing traded goods from abroad and financing them by commodity exports. Once the commodity boom ends the economy goes back to its initial state. An interesting aspect of the adjustment mechanism is that when the economy experiences a period of complete de-industrialization (the traded labor share goes to zero), then the real exchange rate initially appreciate and then goes back to its initial value once the boom ends.

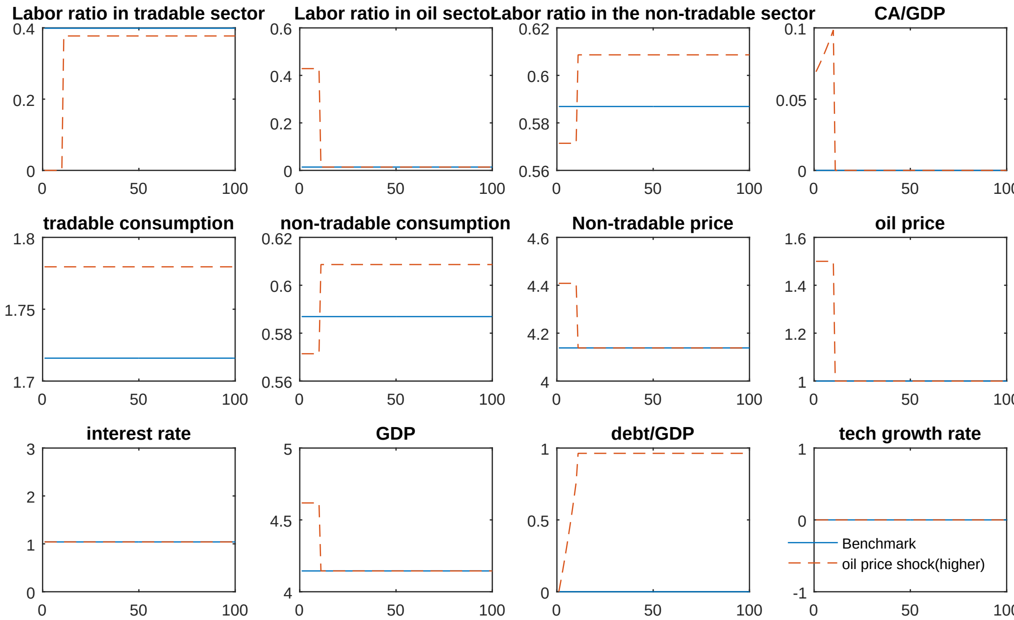


Figure 8: commodity boom under financial openness

Figure 8 focuses on the case in which the financial account is open. There are few interesting aspects of our analysis. When a country borrows and lend from abroad, accumulation or decumulation of net foreign assets (as long as the world interest rate is positive) give rise to a wealth effect. This wealth effect plays a key role in determining the pattern of production and the resource allocation. among the three sectors of our economy. Indeed we show that even under a temporary commodity price boom there is going to be a permanent shift of resources out of the traded goods sector. When the economy is richer (due to temporary higher commodity prices) it runs a current account surplus and smooth tradeable consumption. The increase in tradeable consumption leads to an increase in nontraded consumption and a shift of resources towards the commodity and non-traded goods sector. When the commodity boom ends, the only way for the economy to sustain higher non-traded consumption is by shifting resources in the non-traded good sector out of the traded sector. The wealth effects generated from the financial channel has permanent consequences in terms of resources allocation.

Moreover, similar to the case of financial autarky, and depending on the size of the commodity boom, the economy could experience a period of complete de-industrialization that generates fluctuations in non-traded consumption and the real exchange rate despite the possibility of smoothing consumption and even when all technologies are constant return to scale.

3.2.2 The effects of a commodity price boom: growth case

We now study the response of our economy when the traded sector experiences dynamic productivity gains and the economy converges eventually to the world technology frontier. As before we distinguish between financial autarky and financial openness.

In general the presence of dynamic productivity gains, and in particular the anticipation of these gains, induce agents to borrow as the economy is expected to converge towards the balanced growth path as long as the economy starts below its steady state proximity to the foreign technological frontier. This effect results into a current account deficit that counterbalance the effect of a temporary commodity price boom (which tends to generate a current account surplus).

In Figure 9, we represent the adjustment of the economy following a temporary commodity price boom (dashed line). The solid line shows the transitional dynamic of the economy without commodity price boom. In the latter case, the stock of knowledge grows faster than the growth rate of the world technological frontier. Indeed, initially, annual productivity growth is above 2 percent, higher than in the steady state (1.5 percent). As the economy approaches the steady state, we observe an increase in the share of labor allocated to the traded sector and a declining share to the commodity and non-traded sector. Note here that the economy cannot borrow from abroad.

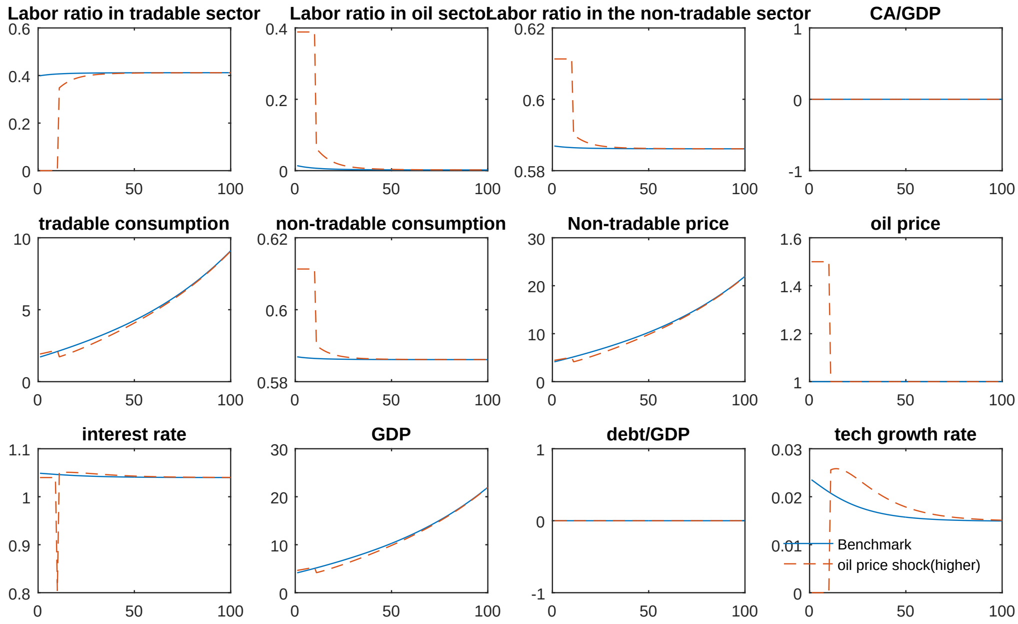


Figure 9: commodity boom under financial autarky, with growth

When there is a commodity price boom, the transition towards the steady state is delayed and in the extreme case of complete de-industrialization, there is no productivity growth as long as the economy experiences the boom since labor is reallocated towards the commodity and the non-traded sectors. In Figure 10 we show a more extreme situation in which a temporary commodity boom triggers a permanent growth trap in which labor is reallocated out of the traded sector permanently.

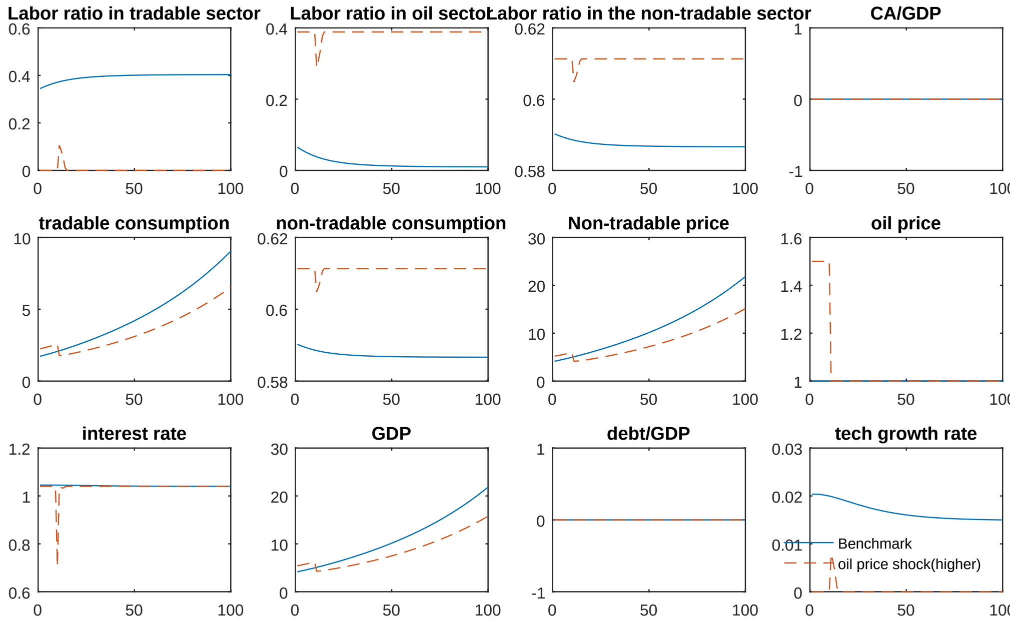


Figure 10: commodity boom under financial autarky, growth trap

In generating figure 10, we have changed the initial condition on the oil technology by making it more productive (from $A_0^O = 3$ to $A_0^O = 3.5$). Under a balanced growth path equilibrium, the oil technology grows at the rate $g = 1.5\%$. When there is a commodity price boom that triggers a process of specialization out of the traded sector, the technology gap between traded and commodity sector increases so that once commodity prices are back to the initial level it is no longer profitable to keep producing the traded goods. Under this scenario, the economy can end up in a growth trap in which it never catch up with the world technology frontier. There are few aspects of this result that we want to emphasize: under our parametrization, if there were no commodity shock, the economy will converge towards the balanced growth path so the commodity boom is the causal factor in determining the outcome. Alternatively, the possibility of a growth trap depends crucially on the initial conditions of the technology in the traded versus the commodity sector. In our example, the commodity price boom makes the traded sector non-profitable but it might well happen that for higher TFP in the commodity sector the economy converges towards a growth trap even in the absence of an external shock.

Finally, in figure 11, we show the response of the economy under financial openness.

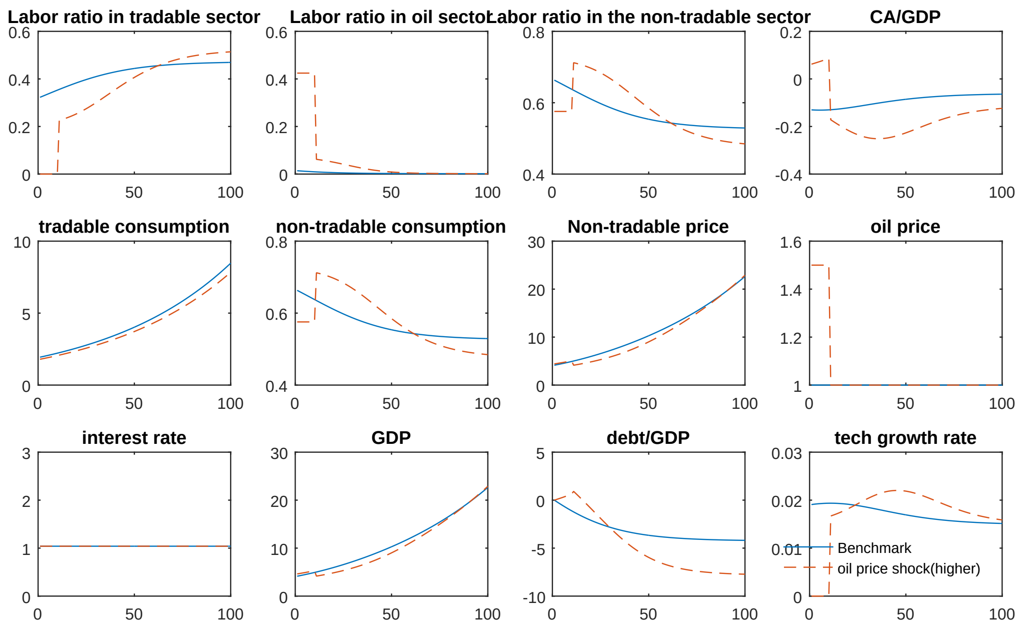


Figure 11: commodity boom under financial openness, with growth

We note that a commodity boom leads to an improvement in the current account compared to the benchmark economy (solid line) that worsen once the boom ends. Again, during the boom, the economy stops producing traded goods but then after the boom ends, it starts allocating resources towards the traded sector and eventually the economy converges towards the world technology frontier. The key difference with respect to the case of financial autarky is that the temporary boom has permanent effect on the allocation of resources among the different sectors. The size of the commodity price boom determines the patterns of the resource allocation. In our example there is a significant increase in commodity prices and a shift of resources out of traded and non-traded sector towards the commodity sector. Under financial openness the economy initially runs a current account surplus and once the boom ends borrows as long as the economy converges towards the world technology frontier.

The commodity boom delays the catching up process and once the boom ends the economy shift resources back towards the traded goods sector and finances the consumption boom by borrowing more heavily from abroad. Higher debt eventually results in lower consumption of both traded and non-traded goods as the economy is relatively poorer (compared to the benchmark case of no commodity shock) due to the delayed convergence towards the technology frontier.

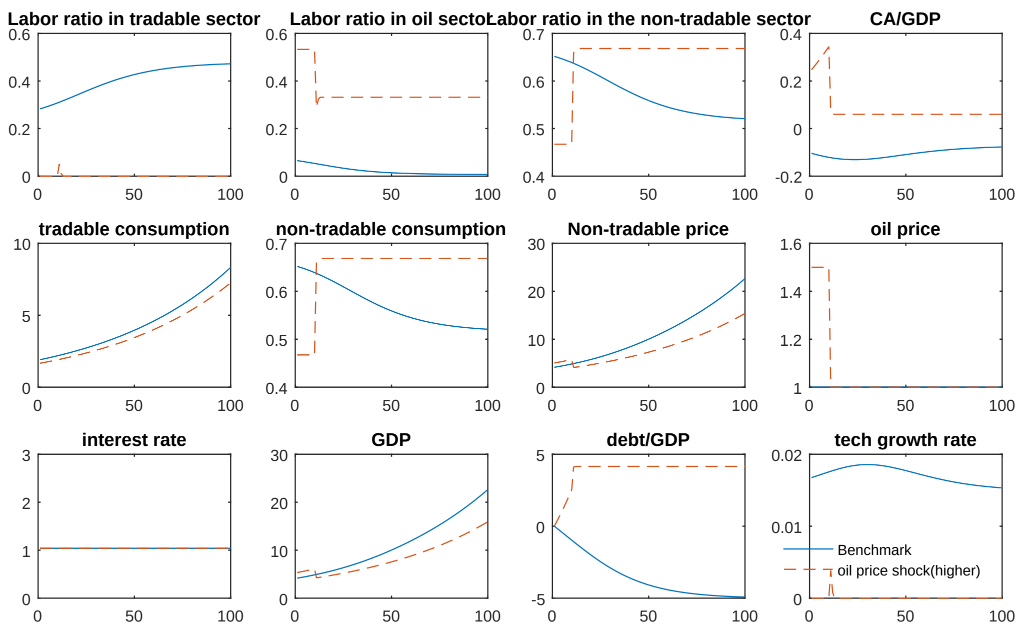


Figure 12: commodity boom under financial openness, growth trap

Similarly to what we discuss for the financial autarky case, there is now the possibility that the economy ends up in a growth trap. In Figure 12, we allow for a more productive commodity sector at the beginning of the economy (from $A_0^O = 3$ to $A_0^O = 3.5$). As before, the commodity boom triggers complete de-industrialization. When the boom ends, labor shift back to the traded sector but the rate of growth of the traded sector is not high enough compared to wage growth and eventually producing traded goods becomes non-profitable. The main difference relative to the financial autarky case, is that now there are permanent implications on resource allocation caused by wealth effects as the economy run a surplus in the current account. Indeed, when the commodity boom ends and the economy has accumulated net foreign assets, resources shift towards non-traded sector and the economy can consume higher non-traded goods compared to the boom phase.

4 Welfare

We now turn to examine the welfare effects of a boom in commodity prices on welfare. We compute the impact on welfare of ten years of high commodity prices as the percentage increase in consumption that the representative household has to receive in any future date in order to be indifferent between staying in the benchmark economy or moving to the economy with relatively higher commodity prices. Formally, the certainty equivalents η from a consumption sequence $\{C_t^T, C_t^N\}_{t=0}^{\infty}$ against the benchmark $\{C_t^{T,B}, C_t^{N,B}\}_{t=0}^{\infty}$ is defined as

$$\sum_{t=0}^{\infty} \beta^t (\omega \log C_t^T + (1-\omega) \log C_t^N) = \sum_{t=0}^{\infty} \beta^t (\omega \log[(1+\eta) C_t^{T,B}] + (1-\omega) \log[(1+\eta) C_t^{N,B}]),$$

where in our case the benchmark economy is in financial autarky with zero net foreign asset position.

In our experiments we have focused on two scenarios. In the first scenario we have studied the allocation of resources when there are no dynamic productivity gains: we have shown that, under financial openness, a temporary commodity shock can have permanent effects on resource allocation. Moreover during the temporary boom, the economy might de-industrialize and could stop producing traded goods. These adjustment are always efficient and there is no scope to improve upon the competitive equilibrium allocation.

Under this scenario, financial openness is always welfare improving as the economy accumulates foreign assets and enjoys a permanent increase in consumption. Moreover a commodity price boom has a positive welfare effects on the economy.

The second scenario allows for dynamic productivity gains in the traded sector. We learnt that depending on initial conditions, the economy could end up in a growth trap. In Figure 13, we plot the certainty equivalence consumption gains/losses as we vary the initial technological factor in the commodity sector.

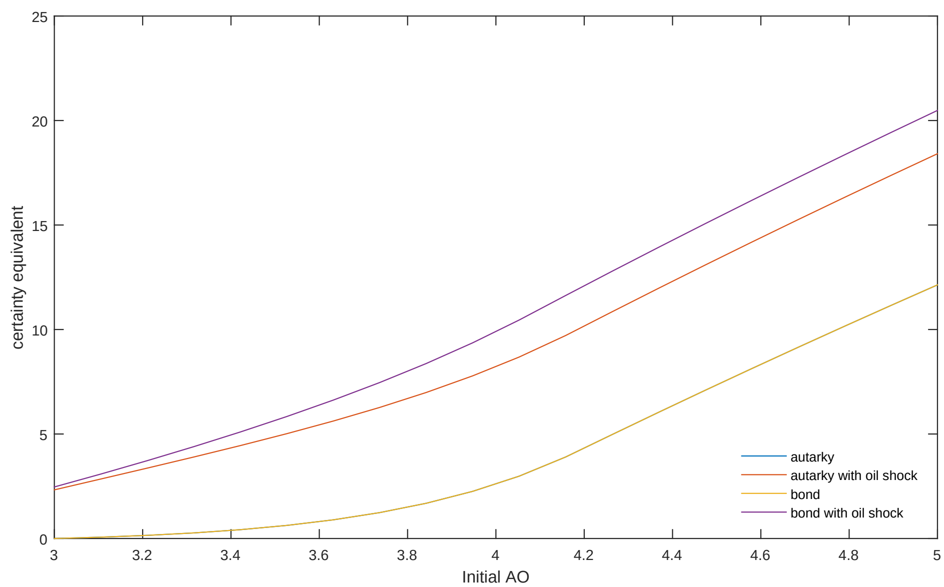


Figure 13: certainty equivalents when there are no growth and catch up

Conditional on our parametrization, welfare gains and losses are nonlinear.

Let's consider the case of financial autarky first. As technology in the commodity sector improves, we observe a decrease in utility that becomes steeper as the technology in the commodity sector reaches the value of $A_0^O = 3.8$. This happens because as the economy is more productive in the commodity sector, labor shifts into that sector and technology growth in the traded sector is delayed. When the economy ends in a growth trap, the losses becomes bigger. This effects dominates as long as the economy produces traded goods. When it stops (approximately this happens for values of A_0^O higher than 3.8) then the economy enjoys positive benefits from higher technology in the commodity sector.

A similar pattern arises when we examine welfare gains and losses under financial openness. One aspect to emphasize here is that, depending on the initial value of A_0^O the economy could be worse off under financial openness relative to financial autarky. Under our parametrization, this occurs for values of A_0^O just below 3.8. The ability to borrow leads to a increase in consumption and in particular of non-traded consumption that shift labor out of the traded sector delaying the process of convergence. Eventually, for higher values of A_0^O, when there are no dynamic productivity gains and the economy is in a growth trap, opening up to international financial markets is beneficial for the standard consumption smoothing argument.

Finally we examine the extent to which commodity price booms are beneficial for our small open economy. As in the case of no commodity price boom, welfare gains and losses are U-shaped and for relatively low value of A_0^O, the autarky economy dominates in consumption equivalent terms, the economy under financial openness. For both financial autarky and financial openness, a temporary commodity price boom has a negative effects on welfare for relatively low value of A_0^O. Indeed for higher commodity prices, there is a shift of labor out of the traded sector that delays the convergence process. For higher values of A_0^O, the economy does not produce traded goods (i.e. it enters a growth trap) and eventually benefits from higher commodity prices since they generate a positive wealth effects for a commodity exporter economy.

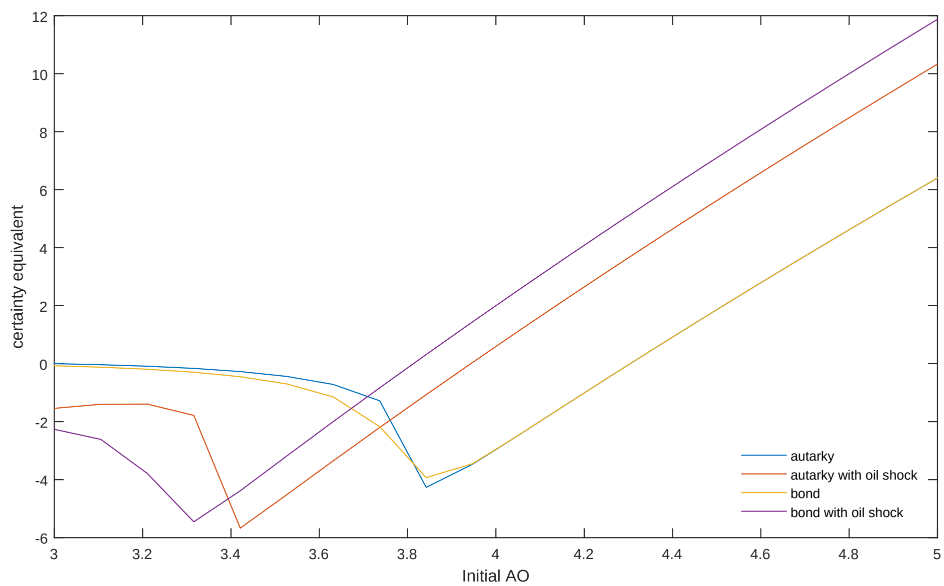


Figure 14: certainty equivalents when there are growth and catch up

5 Conclusion

[To be written]

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